CHAPTER 5
Cross-Linguistic Investigation of Consonant Harmony

1. INTRODUCTION
Articulatory Locality, the main thesis of this dissertation, asserts that the correct notion of locality in phonology is defined in terms of contiguity of actual articulatory gestures, and not in terms of the geometric notion of tier-adjacency. We have seen that in general in a VCV sequence the two vocalic gestures are articulatorily contiguous, while in a CVC sequence, the two consonantal gestures are not contiguous. There is, then, a basic asymmetry between V gestures and C gestures: V-to-V contiguity in a VCV sequence, versus no C-to-C contiguity in a CVC sequence.

One of the principal motivations for pursuing this notion of locality is that it appears to provide an initial handle on the statistical gulf separating vowel harmony and consonant harmony: cross-linguistically, vowel harmony is very frequent while consonant harmony is rather limited. A nearly correct prediction of Articulatory Locality is that V-to-V contiguity, i.e. locality, should yield assimilations between the two vowels in a VCV sequence, while absence of C-to-C contiguity should yield no assimilations between the two consonants in a CVC sequence. Only nearly correct, indeed, because there are clear cases of assimilation between the two consonants in a CVC configuration. These cases are known as ‘consonant harmony’. In Chumash, for example, the form šapitšo-it ‘I have good luck’, when it appears with another suffix like -us, surfaces as [sapitso-us] ‘he has good luck’. The assimilation, as described by Beeler (1970), turns the blade-alveolar fricative s and its corresponding affricate tš to the tip-alveolar fricative s and affricate ts, respectively, when followed by another tip-alveolar. Assimilation apparently occurs despite the presence of intervening vowels and consonants, and no effects are reported on these intervening sounds. Consonant harmony, then, is another apparent case of action à distance.
The present chapter documents the existence of consonant harmony in several American Indian, African, Australian, and Indo-Aryan languages. From this empirical survey, consonant harmony emerges as a phenomenon with a recurring set of properties, raising a number of issues within phonological theory not adequately addressed heretofore. The most striking property of consonant harmony is its limitation to the class of sounds produced with the tip-blade, roughly corresponding to the first 4 cm of the tongue. Specifically, I argue that in all cases of consonant harmony, assimilation occurs in terms of one of the following two features. The first feature, TT CO for ‘Tongue Tip Constriction Orientation’, specifies the shape of the tip-blade on the mid-sagittal dimension. TT CO controls the orientation angle of the tongue tip-blade with respect to the tongue dorsum. The second feature, TT CA for ‘Tongue-Tip Constriction Area’, specifies the shape of the tip-blade on the cross-sectional dimension. TT CA controls the cross-sectional area of the channel created by the approximation of the tip-blade to the palate.

We are now in a position to take a closer look at Articulatory Locality, to see that in fact it does not predict that total absence C-to-C assimilations in a CVC sequence. Articulatory Locality predicts no C-to-C assimilations, except in the case of a consonantal gestural parameter which is able to propagate through the vowel and thus affect the consonant on the other side of the vowel. TT CO and TT CA, the two spreading features in consonant harmony, are precisely the consonantal parameters that can propagate through a vowel for two reasons. First, the tip-blade is independent from the tongue dorsum with which vowels are articulated. Its mid-sagittal or cross-sectional shape can be sustained during the production of a vowel. Second, the precise shape of the tip-blade, mid-sagittal or cross-sectional, has no significant effect on the acoustic quality of the intervening vowel. The conclusion and main result of this chapter is that the cross-linguistic characteristics of consonant harmony provide a strong argument for the correctness of Articulatory Locality.¹

Sections 2 and 3 illustrate the two cases of consonant harmony, involving TT CO and TT CA respectively. TT CO harmony is found in Chumash, a Hokan language of California, and TT CA harmony is found in Tahltan, a Northern Athabaskan language of British Columbia. I argue that the apparent action à distance character of consonant harmony in these languages is superficial, and that the harmony involves strictly local spreading of the tip-blade configuration, propagating through intervening vowels, in accordance with the demands of Articulatory Locality. Central to the discussion of each case is an illustration of how the propagating
features can spread through intervening segments, giving rise to the observed transparency effects.

The next few sections focus on an elucidation of further properties of consonant harmony in various languages of the world. Athabaskan languages of North West America and Alaska receive a large share of this discussion. In the literature on these languages, consonant harmony is referred to as a ‘pan-Athabaskan’ phenomenon. Nevertheless, I identify a number of such languages which lack consonant harmony, especially within the Northern substock of the family. A comparative study of their phonological structure affords a deeper understanding of the phenomenon and provides additional evidence for the correctness of the overall approach taken in this chapter. Northern Athabaskan languages are discussed in section 4 and Southern Athabaskan languages in section 5.

Essentially the same type of consonant harmony seen in the Athabaskan family is also found in a number of other languages of North America, Africa, and Europe. Section 6 lists these languages, and for the sake of completeness, discusses the phenomenon in particular for the case of Kinyarwanda, a Bantu language of Africa.

Section 7 turns to the rule of n-retroflexion in Sanskrit, a notorious case of consonant harmony. Despite the attention this phenomenon has received, an account of some of its essential properties has heretofore remained elusive. I argue that harmony in Sanskrit involves strictly-local spreading of TTCO, and I show how a gestural analysis, based in fact on the testimonies of the ancient Indian grammarians, fully explains the properties of the phenomenon. Section 8 completes the cross-linguistic survey of consonant harmony by discussing its instantiations in some aboriginal languages of Australia. Here harmony will also be of the TTCO type, but slightly different from the Sanskrit case of TTCO harmony, due to differences in the phonological inventories of Sanskrit and the Australian languages.

With the empirical basis of the phenomenon thus broadly established, section 9 turns to a comparative discussion of consonant harmony, and provides a set of constraints that account for the cross-linguistic variation observed in this phenomenon.

Section 10 considers previous analyses of consonant harmony. I argue that the main problem with those analyses is that they lack the correct set of assimilating features. As a consequence of this they miss key generalizations about the phenomenon, such as the limitation of consonant harmony to coronal sounds. This and other generalizations will be shown to fall out from the gestural analysis developed in the present chapter.
In the past, certain phenomena from three different areas of research, sound symbolism, child language phonology, and consonant dissimilation, have been thought to be cases of consonant harmony. In section 11, I show that each of these phenomena does not share signature properties of consonant harmony, and must therefore receive separate treatment. Their inclusion under the name ‘consonant harmony’ would therefore only obscure the coherence of the real phenomenon as it emerges out of the cross-linguistic investigation of the present chapter.

Finally, section 12 recapitulates the narrow range of properties of consonant harmony and the equally restricted typology of the phenomenon. The chapter concludes by emphasizing once more the relevance of the results for Articulatory Locality.

2. CHUMASH
Chumash is a language of southern California once spoken in a territory running about 150 miles along the coast from just northwest of Los Angeles. The language was also spoken on three offshore islands, San Miguel, Santa Rosa, and Santa Cruz. Beeler’s (1970) data come from a single speaker of the Barbareno dialect. At the time Beeler recorded his data, the Chumash family had been considered dead for a generation. Harrington (1974), my second source on Chumash, had done extensive work on the Chumashan Indians for more than 50 years, and his data come from the Venturenño dialect. I know of no differences between these two dialects of relevance to the present discussion.

The consonants and vowels of Chumash are given in (1) below. The glottalized and aspirated versions of a consonant C are denoted as \( C^\prime \) and \( C^h \) respectively. The underlined segments are those whose status appears uncertain.
1. Sound inventory (Beeler 1970)

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<tr>
<th>Consonants</th>
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Beeler characterizes the distinction between [s-š] as an apical vs. laminal contrast: [s] is the apical and [š] is the laminal fricative. Similarly, [c] and [ć] are the apical and laminal affricates, respectively. Harrington (1974) also provides information on the acoustics and articulation of these sounds. He writes:

Chumashan, like English, recognizes only two sibilant articulations: one high, narrow, sharp—s and the s affricatives; one low, broad, dull—š and the š affricatives ... In addition to the simple s and š, as in English “see” and “she,” respectively, the Ventureno has aspirated sʰ and šʰ, which are simply s and š followed by h. The affricatives are c, č, cʰ, čʰ, č', čʰ'. The s and š in these consonant diphthongs have the same articulation as independent s and š. (p. 3)

Beeler’s and Harrington’s descriptions seem consistent with each other. First, Harrington’s characterization of the [s-š] difference as ‘high’ vs. ‘low’ seems to correlate well with the description of Beeler; the [s] is produced with the tip of the tongue raised to create a constriction at the alveolar region, and hence high, while the [š] is formed with the blade of the tongue and the tip down behind the lower incisors, and hence low. The other information provided by Harrington, although compatible with the apical-laminal characterization of Beeler, also suggests a possible alternative. Harrington’s terms ‘narrow’ vs. ‘broad’ have an articulatory interpretation in terms of the cross-sectional area of the channel which is characteristic of these articulations. As I have argued in detail in the
previous chapter, the cross-sectional area of the channel can serve as the basis for a contrast between two fricatives, with the [§] fricative having a broader channel than the [s] fricative. Finally, Harrington’s terms ‘sharp’ for [s] vs. ‘dull’ for [§] seem to describe the special character of the acoustic distinction created by these two articulations. The wider and somewhat more retracted channel of [§] results in dental wake-turbulence of lower frequency compared to that of [s] (Catford 1977: p. 154).³

Without access to articulatory data the choice between these two alternatives will have to be arbitrary. Following Beeler (1970), I choose to express the distinction between [s] and [§] in terms of apicality-laminality. If the distinction is instead to be characterized in terms of the cross-sectional channel, then the analysis would be essentially the same as the one given in the next section for Tahltan.⁴ As for the place of articulation of these sibilants, for which Beeler and Harrington provide no explicit information, I assume, consistently with what is known about sibilant articulations in general, that [s] is formed somewhere in the alveolar zone, and [§] is a bit more retracted, perhaps still in the alveolar or in the front of the adjacent post-alveolar zone. These latter assumptions are not crucial to the present discussion.

The following data in (2) show the effects of consonant harmony, which causes all coronal fricatives and affricates in a word to agree in apicality-laminality. The direction of the harmony is right to left. The data are drawn from Shaw (1991) and Kenstowicz (1994).
2. Examples of Chumash harmony

a. \( s \rightarrow š \)

- k-sunon-us \( \rightarrow [ksunonus] \) ‘I obey him’
- k-sunon-š \( \rightarrow [kšunonš] \) ‘I am obedient’
- saxtun \( \rightarrow [saxtun] \) ‘to pay’
- saxtun-š \( \rightarrow [šaxtunš] \) ‘to be paid’
- s-ixut \( \rightarrow [sixut] \) ‘it burns’
- s-aqunimak \( \rightarrow [saqunimak] \) ‘he hides’
- s-ilaks\( ŭ \) \( \rightarrow [šilakš] \) ‘it is soft’
- s-am-amoč \( \rightarrow [šamamoč] \) ‘they paint it’
- s-kuti-waš \( \rightarrow [škutiwaš] \) ‘he saw’

b. \( ſ \rightarrow s \)

- ušla \( \rightarrow [ušla] \) ‘with the hand’
- ušla-siq \( \rightarrow [uslasiq] \) ‘to press firmly by hand’
- p-iš-anan\( ŭ \) \( \rightarrow [pišananš] \) ‘don’t you two go’
- s-iš-tiši-yep-us \( \rightarrow [sistisipyepus] \) ‘they two show him’

Another important and perhaps surprising aspect of the process is that the other coronal segments \( \{ t, n, l \} \) (and their aspirated and glottalized allophones) are transparent, in the sense that they do not trigger, block, or undergo this harmony process, as illustrated in (3), where the transparent coronal stops are shown in bold.
3. Transparent coronal segments

\[
\begin{align*}
[s\text{-api-}\text{čo-}i] & \quad \text{‘I have good luck’} \\
[s\text{-api-}\text{co-}u\text{s}] & \quad \text{‘he has good luck’} \\
[k\text{-sunon-}s] & \quad \text{‘I am obedient’} \\
[k\text{-}\text{sunon-}u\text{s}] & \quad \text{‘I obey him’} \\
[ha-s\text{-}x\text{intila}] & \quad \text{‘his Indian name’} \\
[ha-š\text{-}h\text{intila-}w\text{aš}] & \quad \text{‘his former Indian name’}
\end{align*}
\]

I will analyze the assimilation of Chumash consonant harmony in terms of what Beeler describes as the main distinction between \(s\) and \(š\), that is, the apical vs. laminal distinction. The gestural parameter implementing this distinction is TTCO or ‘tongue-tip orientation’, which, it will be recalled, specifies the orientation of the tongue tip-blade unit with respect to the tongue dorsum. The harmony can then be described as anticipatory spreading of the value of the TTCO parameter, which originates from the rightmost apical or laminal fricative or affricate, and propagates leftwards through the intervening vowel to the preceding consonant(s).\(^5\)

For example, the stem \(-\text{sunon-}\) in (2a) above is realized as \(-\text{sunon-}\) when followed by a blade sibilant as in the form \(k\text{-sunon-}\text{-š} \quad \text{‘I am obedient’}\) (versus \(k\text{-sunon-}u\text{s} \quad \text{‘I obey him’}\)). The suffix \(s\) is formed with the blade in contact at the alveolar zone, and the tongue tip lowered. This blade-up/tip-down configuration is maintained during the production of the intervening segments, causing the observed alternation in the second fricative consonant of \(k\text{-sunon-}\text{-š}\), where the apical \(s\) has turned into a laminal \(š\).

The issue that needs to be addressed next is the transparency of the intervening segments. All vowels and all consonants except the sibilant fricatives and affricates are both inert and transparent to the harmony. Consider the vowels first. The major articulator for vowels is the tongue dorsum. This articulator is independent from the tongue tip-blade unit, which can thus maintain its posture while the tongue dorsum assumes the shape required by the vowel. This independence between these two articulators has been documented in section 3 of the previous chapter. I emphasize that it is not the fricative constriction itself that is being maintained during the vowels, but the mid-sagittal posture of the tip-blade
as defined by TTCO (i.e. a tip-up shape corresponding to the apical value of TTCO or a tip-down shape corresponding to the laminal value of TTCO). It is also generally accepted that the precise posture of the tip-blade does not have any significant effect on the acoustics of vowels (see for example Harshman, Ladefoged & Goldstein 1977: p. 702). The articulatory independence of the tip-blade unit from the tongue dorsum, combined with the irrelevance of the tip-blade posture for the acoustic quality of the vowels, thus explains why vowels are transparent to Chumash harmony, allowing propagation of the tip-blade posture.

I now consider the transparency of consonants. Velars, labials, and laryngeals are transparent to the harmony process simply because these consonants are produced with an articulator independent from the tongue tip-blade, and the particular posture of the tip-blade has no significant acoustic effect on these consonants. Turning to the coronal stops, \([t, n, l]\) and their glottalized or aspirated variants (henceforth \(/T, N, L/\), their transparency is less obvious, because these sounds are formed with the tip-blade, the same articulator employed for the harmonizing fricatives and affricates. As it turns out, their transparency can still be straightforwardly explained, however. Consider for example the nasal stop \(N\). A spreading tip-up gesture superimposed on the nasal \(N\) would result in an apical closure, i.e. the sound \([\kappa]\). Analogously, a spreading laminal or tip-down gesture superimposed on \(N\) would result in a laminal closure, i.e. the sound \([\eta]\). We thus predict that the stop \(N\) should be produced in two different ways depending on which harmonic domain it happens to be in, as shown in (4a, b) below.

\[
\begin{align*}
4. & \quad \text{a. Apical domain} & \quad /- \eta - S/ & \rightarrow & \quad /- \kappa - S/ \\
& \quad \text{b. Laminal domain} & \quad /- \eta - \ddot{S}/ & \rightarrow & \quad /- \kappa - \ddot{S}/
\end{align*}
\]

The capitalized sibilant segment represents the trigger of the harmony and defines the type of the harmonic domain, apical or laminal.

I propose that the reason why the nasal \(N\) and the other coronal stops are transparent is that the two stop articulations above are not contrastive in Chumash and are thus not perceived as distinct. The exact articulation of Chumash \(/T, N, L/\) is of course unknown, but neither Beeler nor Harrington reports any apical-laminal contrasts for the Chumash stops. In fact, such contrasts are unheard of in the aboriginal languages of North America.

Consider in this connection that a very similar ‘long-distance’ assimilatory effect has been observed in English by Bladon & Nolan...
As discussed in the previous chapter, those authors report that for eight speakers of Received Pronunciation English the usually apical [n, l], and the variably apical or laminal [t, d] show a tendency to become laminal immediately before or after the laminals [s, z]. Interestingly, the same tendency is observed when [t, d] are separated from the laminal fricatives [s, z] by a vowel, which may be either stressed or unstressed, as in words like deserve, sedan, does, sat etc. In English, as in Chumash, the apical-laminal parameter does not serve as the basis for a contrast in the stops. My hypothesis is thus that, depending on the context, the Chumash speakers produced either apical [t] or laminal [j] versions of the stop T, exactly as English speakers do. This difference was not perceived, however, as it was not distinctive in the language, just as in English. In contrast to the stops, in Chumash the apical-laminal parameter is contrastive for the tip-blade fricatives. Hence, superimposing a contextual tip-down/blade-up gesture on [s] will result in [8], perceived as a different sound.

This completes the discussion of consonant harmony in Chumash. To sum up, I have proposed that the harmony consists of a continuous propagation of the posture of tip-blade articulator, described in terms of the TTCO gestural parameter. Vowels are transparent because their acoustic quality is not affected by the superimposed tip-blade gesture, while coronal stops are transparent because the language has no apical-laminal contrast for the stops. Hence, the properties of Chumash consonant harmony are fully explicated by the proposed gestural analysis in conjunction with the phonological notion of distinctiveness of phonemes.

3. TAHLTAN

Tahltan is a Northern Athabaskan language spoken by probably no more than forty speakers today in Northern British Columbia, in the vicinity of Iskut, Dease Lake and Telegraph Creek. Tahltan, like other Athabaskan languages to be discussed, has a very rich coronal consonant inventory, containing five distinct series of coronals, as shown in (5) below. The consonants that participate in consonant harmony are those of the d0, dz, and dž series. All other consonants, including the two coronal stop series /d/ and /dl/, are completely transparent to the harmony process.
5. Tahltan consonants

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<td>k^w</td>
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<td>ts^i</td>
<td>tʃ^i</td>
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Examples of the harmony are given below. Underlined in (6), I show the first person singular subject marker /-s/- surfacing as [θ] if followed anywhere in the word by any member of the [θ] series (6a), as [ʃ] if followed by any member of the [ʃ] series (6b), and as [s] elsewhere (6c).

Data are drawn from Shaw (1991) except where otherwise noted.

6. First person singular /s/

a. ɬθeθ∅eʃ 'I’m hot'
    deθk^wθ 'I cough'
    eθduuθ 'I whipped him'
    meθoθeθ 'I am wearing (on feet)'
    naθtθet 'I fell off (horse)'

b. hudišša 'I love them'
    eʃdʒni 'I’m singing'
    teneššuuš 'I’m folding it'

c. ezk'aa 'I’m gutting fish'
    ezdo 'I’m drinking'
    sezxeʃ 'I’m going to kill it'
    nəstet 'I’m sleepy'

The initial /θ/ of the first person dual subject prefix /θi(ː)-/ in (7a) also surfaces as [s] or [ʃ] before sounds of these two series, as shown in (7b), (7c) respectively.
7. First person dual subject /θ(θ)-/

a. deθigθtl ‘we threw it’
naθiboatl ‘we hang it’
θiθiθdi ‘we ate it’
b. desidzel ‘we shouted’
xaθiθets ‘we plucked it’
desit’as ‘we are walking’
nisit’ots ‘we got up’
c. iθit’otl ‘we blew it’
teedeneθidžuut ‘we chased it away’
usidže ‘we are called’

Finally, the stop and the lateral series of coronals do not trigger, block, or participate in the harmony. In the following examples the underlying form of the affix is followed by its (underlined) realization in a word with various consonant harmony domains.

8. Transparency of /s/, /n/, /l/ series

/s/ edeθdeθduuθ ‘I’m wearing (on feet)’
/s/ taθθal ‘I’m dying’
/s/ xaθeθθaθ ‘I’m cutting the hair off’
/θ/ desit’as ‘we are walking’
/θ/ nisit’ots ‘we got up’
/θ/ meθeθ’otś ‘we are breast-feeding’
/s/ yaθiθtś ‘I splashed it’
/s/ noθeθθeθθedži ‘I melted it over and over’

Summarizing the data, the attested alternations are: s → θ, s → š, θ → s, and θ → š. There seem to be no instances of š → s or š → θ. I
believe that this is because the language simply lacks an affix with underlying /s/. Hardwick brings up one aspect of the phenomenon that is not discussed in any of the subsequent treatments of Tahltan consonant harmony. She points out that the s → ŝ alternation is optional, whereas all others are apparently obligatory. This would be a rather puzzling difference. However, Hardwick also discusses another prefix, the possessive /es-/, which undergoes optional harmony even for the s → ŝ alternation, as shown by several of her examples (Hardwick 1984: pp. 43 ff.). Nater (1989: p. 28) also makes a related observation in reporting that assimilation even between strictly adjacent coronals may fail to occur in deliberately slow speech, e.g. xoθ- ‘knoll’ + tsō ‘big’ → xoštsō or xoθtsō. These qualifications suggest that the harmony may in some sense be optional for all alternations and not just for the s → ŝ one. The issue is in need of further investigation for which I currently lack the necessary resources. Whether the harmony is obligatory or optional does not affect the following discussion in any direct way, however.

To properly analyze the Tahltan harmony, we must first identify the parameter subject to assimilation. I will thus attempt to characterize the harmonizing segments, relying for their articulatory descriptions on Nater (1989), the most explicit source in this connection. For each of the three series of harmonizing sounds repeated below, I will use the voiceless fricative member as the representative of the series.

9. The three series of harmonizing sounds

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</table>

The ŝ-series is characterized by Nater as ‘predorsal-alveolar’ and ‘interdental’. Nater uses the terminology of Malmberg, whose ‘predorsal’ term corresponds to the tongue blade in the present terminology (Malmberg 1963: pp. 26, 41, 42). We can thus infer that the ŝ-series is articulated by the tongue blade making contact at the alveolar zone, and
by the tip placed between the upper and lower teeth, hence the additional ‘interdental’ characterization of this series by Nater. According to Nater, the s-series is also ‘alveolar’, and although it is reasonable to assume that it is articulated with the tip-blade, no information is given on whether the posture of the tip-blade is apical or laminal. Nater characterizes the ŝ-series as ‘prepalatal’, and again we have no information on which part of the tongue is involved in making contact at the pre-palatal zone. Given what we know in general about ŝ-type of sounds, it would be reasonable to assume that the tip-blade and perhaps some of the pre-dorsum is involved. Nater’s characterizations are summarized in (10), with my inferences shown in parentheses.

<table>
<thead>
<tr>
<th>Series</th>
<th>Place of Articulation</th>
<th>Part of tongue contacted</th>
</tr>
</thead>
<tbody>
<tr>
<td>ŝ</td>
<td>Prepalatal</td>
<td>? (Tip-blade &amp; slightly the pre-dorsum)</td>
</tr>
<tr>
<td>s</td>
<td>Alveolar</td>
<td>? (Tip-blade)</td>
</tr>
<tr>
<td>0</td>
<td>Alveolar, Interdental</td>
<td>Tip-blade</td>
</tr>
</tbody>
</table>

With this in mind, we can now attempt to identify the parameter that may be involved in the assimilations observed in Tahltan harmony. First, there is no evidence that the apicality/laminality parameter plays any significant role in distinguishing the three series of sounds. None of my sources on Tahltan refer to this parameter, and in any case, it would be problematic to assume that apicality/laminality is indeed involved in the harmony, because this parameter can only provide a binary distinction, instead of the ternary distinction needed. A second alternative would be to base the distinction among the three series of sounds on the place of articulation parameter, characterizing the three series of sounds as interdental 0, alveolar s, and prepalatal ŝ. However, given the above description, such a hypothesis would require an additional assumption: the fact that the 0 series also involves contact of the blade at the alveolar zone would have to be treated as unimportant. Moreover, as discussed in the previous chapter, the place of articulation parameter is generally a rather tenuous basis for phonological contrasts in fricative inventories.

In contrast to the difficulties faced by both apicality/laminality and place of articulation, Tahltan consonant harmony can readily be described as a case of tongue-tip constriction area (TTCA) assimilation. TTCA captures the three-way distinction among the 0, ŝ, s series by assigning to these sounds the values shown in (11).
Assuming that assimilation is in terms of TTCA correctly and directly singles out all three series of coronal fricatives θ, ɹ, s, and their corresponding affricates.

Vowels will be transparent to the spreading of TTCA for reasons by now familiar, namely, the articulatory independence of the tongue tip-blade from the tongue dorsum, and the irrelevance of the cross-sectional shape of the tip-blade to the acoustic quality of vowels. As in the case of TTCO, it is not the fricative stricture itself that is maintained during the production of vowels, but only the cross-sectional shape of the tip-blade, which by being relatively flat or grooved implements a specific value of TTCA. Here too, there exists experimental confirmation of the ability of vowels to sustain the cross-sectional shape of the tip-blade of an adjacent consonant with no significant effect on their acoustic quality. Stone et al. report results from an English subject indicating “that in the anterior tongue, [s] context caused deeper midsagittal grooves for vowels than [p] context” (Stone et al. 1992: p. 254).9

Turning to the transparency of other segments, it is clear that a cross-sectional channel of the tip-blade can be maintained during the production of non-coronal stops and fricatives, given that these consonants do not implicate the tip-blade articulator. It is less obvious how a cross-sectional channel could be maintained during the production of coronal stops. Specifically in Tahltan, a cross-sectional channel must be able to propagate through the stops /t/, /n/, and /l/. According to Nater, these stops are dental, with a complete closure of the tongue tip at the backs of the upper teeth and perhaps slightly at the front of the alveolar zone. Behind this firm closure, however, the tongue blade ought to be allowed to be in any shape, spread flat or grooved. Hence, there is a sense in which these stops may have a cross-sectional channel, which would have no effect on their acoustic qualities because the channel is shut by the front part of the tongue. Indeed, this cross-sectional channel is evident in palatograms of such denti-alveolar stops in various languages, where one can see that there is no contact by the tongue blade in the center of the palate behind the denti-alveolar constriction (see Dixit 1990 for the Hindustani stops, Stone & Lundberg 1996 for the English stops, and Dart 1991 for the Tohono O’Odham stops).

To sum up, two important properties of Tahltan harmony, the fact that
it targets three series of coronal fricatives and affricates, and the fact that all other sounds are transparent, are fully explicated by the proposed gestural analysis, that postulates that the assimilating parameter is TTCA, and that spreading proceeds through all articulatorily contiguous sounds, as dictated by Articulatory Locality. Tahltan will be our prototype of TTCA harmony.

4. NORTHERN ATHABASKAN
This section discusses consonant harmony or lack thereof in several Northern Athabaskan languages spoken in Alaska and the Northwest Territories of Canada. My interest in these languages is slightly different from those pursued in previous sections. Specifically, I will not be concerned with determining the gestural parameter subject to assimilation in their consonant harmonies. This is mainly because the evidence in these languages for deciding whether it is TTCA or TTCO which is involved in the harmony is tenuous. Rather, in the following discussion I have two goals, one related to the languages that exhibit consonant harmony, and the other related to the languages that fully or partially do not show consonant harmony.

The first goal is to confirm the recurrent properties of consonant harmony: that it involves only coronal sounds, and more specifically coronal fricatives and affricates; and that coronal stops and liquids as well as all other sounds of the language are completely transparent to the harmony.

The second goal is to explain why sometimes certain coronal fricatives do not participate in the consonant harmony. I will argue that, once again, the articulatory properties of these sounds provide a full explanation for their behavior. In essence, it turns out that these non-participating fricatives are not articulated with the tongue tip-blade, but with the tongue dorsum, the same articulator used for vowels. Hence, they will predictably behave like vowels with respect to consonant harmony, that is, they will not block, trigger, or participate in the harmony process, because they can sustain the propagating tip-blade configuration with no significant effect on their acoustic quality. Chilcotin harmony is discussed in 4.1. I return to Tahltan in 4.2 to discuss an additional series of coronal fricatives which does not participate in the consonant harmony of the language. Sekani and various dialects of Slave lack consonant harmony altogether, a phenomenon discussed in 4.3 and 4.4 respectively.

In the discussing the above languages, I will utilize as phonological evidence for the articulatory configuration of some fricatives a voicing
Cross-Linguistic Investigation of Consonant Harmony

alternation between the approximant /y/, the voiced segment, and a fricative, the voiceless segment. This alternation, widespread among Northern Athabaskan languages, is interesting because typically voicing alternations do not pair segments of different strictures. In 4.5, I suggest that the physiological reasons behind this patterning may be found in the fact that in these languages the degree of stricture of the approximant /y/ is very close to or right on the boundary between fricatives and approximants. This property of /y/ allows it to behave as the voiced counterpart of a voiceless fricative.

4.1 Chilcotin

Chilcotin is a language spoken by about 1500 people in British Columbia. Its consonant inventory is shown in (12) below (the glottal h, ? are not shown for space reasons). There are five series of coronal sounds, which I have labeled as T, L, S, Š and Š. My sources on Chilcotin are Cook (1983), (1987), (1993), and Eung-Do Cook (personal communication). In what follows, I consistently use Cook’s transcriptions.

12. Chilcotin consonants (Cook 1987)

<table>
<thead>
<tr>
<th>T</th>
<th>L</th>
<th>S</th>
<th>Š</th>
<th>Š</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>d</td>
<td>dl</td>
<td>dz</td>
<td>dž</td>
</tr>
<tr>
<td>p</td>
<td>t</td>
<td>tʰ</td>
<td>ts</td>
<td>tš</td>
</tr>
<tr>
<td>tʰi</td>
<td>tʰ</td>
<td>tʰi</td>
<td>tʰi</td>
<td>tʰi</td>
</tr>
<tr>
<td>(η)</td>
<td>iʰ</td>
<td>sʰ</td>
<td>ʃʰ</td>
<td>ʃʰ</td>
</tr>
<tr>
<td>m</td>
<td>n</td>
<td>l</td>
<td>z</td>
<td>ž</td>
</tr>
</tbody>
</table>

This language exhibits the interesting property that out of the five series of coronal sounds, three of which are fricatives, S and Š participate in consonant harmony, but Š does not. Some examples of the harmony process are given in (13) below. In (13a) the underlying ‘sharp’ sibils (s) assimilate to the rightmost ‘flat’ sibilant (š), which happens to be the stem-initial consonant. In (13b) the underlying flat sibilants become sharp, assimilating to the rightmost sharp sibilant. Finally, the examples in (13c) show that the affricate tš is neither a blocker nor a trigger of the harmony.
13. Some examples of consonant harmony

a. se-ži  [šeži]  ‘my mouth’
   se-u-že-ne-1-ts^i\n  [sužinIt\n]  ‘you listened to me’

b. nŢ-še-i-1-ts^i\l  [ňsiIt\l]  ‘I am curling my hair’
   te-že-i-1-ts^\lz  [teziIt\lz]  ‘I started to cook’

c. Ťt-še-tšis  [Ţset\lsis]  ‘I didn’t fry it’
   yɛ-stš^\n  [y׋st\n]  ‘I am pregnant’
   na-še-s-džid  [nasesdžid]  ‘I crawled’

Focusing on the transparency of the Š series to consonant harmony, I turn to articulatory and phonological evidence which shows that Š sounds are palatals. The articulatory characteristics of the five series of coronals, inferred from various descriptions of these sounds in my sources, are as shown in (14) below.
14. Articulatory descriptions

a. T
Apico-lamino dental-alveolar. There is some tip contact at the upper teeth and the blade is in contact with the alveolar zone.

b. L
Apico-lamino dental lateral affricate (same as above with a lateral closure)

c. S
Apico-lamino dental-alveolar. The tip and the lamina are raised with the tip in contact behind the upper incisors (Cook, p.c. March 1996), and the blade in contact at the alveolar and perhaps some of the post-alveolar zone.

d. Š
Lamino-postalveolar. There is laminal and perhaps some predorsal contact with the postalveolar zone.

e. Š
Dorso-palatal. The pre- and medio-dorsum of the tongue are raised against the palate.

Hence, from the articulatory descriptions there is evidence that the Š series is dorso-palatal. The second piece of evidence for this is provided by the phonology of the language. In Chilcotin, there are six pairs of voiceless/voiced fricatives that mark the imperfective vs. perfective aspect categories in the verb, as shown by the examples in (15).
The Articulatory Basis of Locality in Phonology

15. Pair

| a.  | s, z | -ts'uns | -ts'unz | ‘to kiss’ |
| b.  | ñ, ñ | -k'añ | -k'añ | ‘to stretch (oneself)’ |
| c.  | ŋ, 1 | -tsIng | -tsIng | ‘to cut down a tree’ |
| d.  | ĭ, y- | runš | -runy | ‘to cut to pieces’ |

The alternation in (15d) shows that the approximant /y/ functions as the voiced counterpart of the fricative /s/. In fact, in the phonological inventory of the language, there is no voiced fricative /z/ sound corresponding to the voiceless /s/.

The co-occurrence of the palatal character of the ň series and its non-participation in the consonant harmony is no coincidence. The latter follows precisely because these sounds are dorso-palatal, i.e. articulated with the tongue dorsum raised against the palate. In section 2 of the previous chapter, I have given descriptions of the articulatory configurations of some dorso-palatal sounds, such as the approximant [y] and the voiceless palatal fricative and the ‘cedilla c’ of IPA [ç]. It will be recalled that with these sounds the tongue dorsum is heavily arched and raised below the pre-palatal zone with some involvement of the medio-palatal zone as well. Hence, dorso-palatal fricatives involve control of the tongue dorsum, the same articulator used for vowels. They are transparent to the harmony because, like vowels, these fricatives can accept the harmonizing gestural parameter of the tip-blade articulator (TTCA or TTCO).

4.2 Tahltan

I return to Tahltan, a language which exhibits TTCA harmony. In the inventory of coronal consonants of Tahltan given in Shaw (1991), repeated in (16) below, the palatal approximant y is categorized under the column of the ň series of fricatives, which does participate in the consonant harmony; only the sounds enclosed in the table participate. This would seem to falsify the connection just proposed between the palatality of a fricative/affricate series and its non-participation in the harmony. Closer investigation, however, reveals that Tahltan is not a counterexample to that proposal, but rather supports it. The evidence for this essentially is that the inventory of Tahltan contains an additional fricative ĭ which is not included in Shaw’s inventory shown below. It is this latter fricative, rather
than š, which behaves as the voiceless counterpart of y. Hence, the š series is not palatal contrary to what the classification in (16) suggests. Tahltan, then, is like Chilcotin in having a dorso-palatal fricative C which does not participate in the consonant harmony for the by now familiar reasons.

16. Tahltan coronal consonants according to Shaw (1991)

<table>
<thead>
<tr>
<th></th>
<th>d</th>
<th>dl</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>tØ</td>
<td>ts</td>
</tr>
<tr>
<td>tʰ</td>
<td>tʰ⁰</td>
<td>tsʰ</td>
</tr>
<tr>
<td>ʰ</td>
<td>ʰ⁰</td>
<td>s</td>
</tr>
<tr>
<td>l</td>
<td>Ø</td>
<td>z</td>
</tr>
</tbody>
</table>

Hardwick (1984), the most extensive discussion of Tahltan, recognizes together with š, ž two other fricatives which she calls ‘palatals’ C, y. For example, her inventory of stem-final consonants includes both pairs š, ž and C, y (Hardwick 1984: p. 16), while stem-initially there are no examples of š, ż but only C, y, the latter deriving historically from the fronted velar series of Proto-Athabaskan (see the reconstructions in Hardwick 1984: p. 10). Nater (1989) also recognizes C, y along with š, ž.¹¹

The voicing alternations in stem-initial fricatives, also characteristic of other Athabaskan languages, provide additional support for the recognition of these two independent pairs of fricatives. Hardwick records the following inventory of voiceless/voiced stem-initial alternations.

17. Voiceless-Voiced pairs

<table>
<thead>
<tr>
<th></th>
<th>Ø</th>
<th>Ø</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>t</td>
<td>l</td>
</tr>
</tbody>
</table>
→ s z
→ C y
→ x y

---

¹¹ The symbol š is used to represent a fricative sound that is typically produced with the tongue tip touching the palate. In Tahltan, this sound is contrasted with other fricative sounds, such as z, and is associated with palatalized consonants.
The final evidence for the existence of $C$, $y$ as the palatal voiceless/voiced pair comes from another phonological regularity of Tahltan. Velar fricatives are palatalized or fronted before the front vowel /i/ (Hardwick 1984: p. 90). This process treats /$C$/ as the fronted counterpart of /$x$/ and /$y$/ as the fronted counterpart of /$\gamma$/). The $\tilde{s}$, $\tilde{z}$ pair of fricatives is not involved in this process.

To sum up, in Tahltan, palatal $y$ possesses its own separate voiceless counterpart, namely, the sound $C$. This voiceless fricative $C$ does not participate in the consonant harmony. I conclude that Tahltan in fact supports the proposed connection between the palatality of a fricative and its non-participation in the harmony process.

4.3 Sekani

The previous discussions of Chilcotin and Tahltan illustrate the connection between the palatality of a fricative and its non-participation in consonant harmony. In general terms, the only difference between these two languages with respect to consonant harmony is that whereas Chilcotin has two series of participating fricatives ($s$-$s$), Tahltan has three ($T$-$s$-$s$). I now turn to some Athabaskan languages with relatively impoverished coronal inventories. In these languages, the proposed connection between the palatality of a fricative and its non-participation in consonant harmony makes the following prediction. If only two series of coronal fricatives exist, one of which is a dorso-palatal, then there should be no consonant harmony, because dorso-palatal fricatives do not participate in consonant harmonies. Sekani, a language spoken in the northern central interior of British Columbia, will provide the first test of this prediction.

The coronal system of the language is shown in (18) below. My primary source for this language is Hargus (1988).

18. Sekani coronal system

<table>
<thead>
<tr>
<th>t</th>
<th>ts</th>
<th>t$\tilde{i}$</th>
<th>t$\tilde{s}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>t$\tilde{i}$</td>
<td>ts$\tilde{i}$</td>
<td>t$\tilde{i}$$\tilde{h}$</td>
<td>t$\tilde{s}$$\tilde{h}$</td>
</tr>
<tr>
<td>t$\tilde{h}$</td>
<td>t$\tilde{s}$</td>
<td>t$\tilde{i}$$\tilde{h}$</td>
<td>t$\tilde{s}$$\tilde{h}$</td>
</tr>
<tr>
<td>s</td>
<td>$\tilde{l}$</td>
<td>$\tilde{s}$</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>l</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The palatal y is grouped with the ŭ series, implying that the sounds of this series are palatal fricatives and affricates. Concrete evidence for this is provided once more by a voicing alternation affecting the first sound of a stem. Hargus (1988: p. 228) records the following pairs of alternating fricative sounds for noun stems: s-z, x-û, ñl, and ŭ-y. Some examples involving alternations between the sounds in the final pair are: [śin] ‘song’/ [søyine?], [ûs] ‘hill’/ [tśu tśi yis] ‘Tudick Lake hill’ etc.

Again, ŭ functions as the voiceless counterpart of y. This means that ŭ and its affricates are articulated with the dorsum raised against palate. Sekani, then, contains two series of fricatives: a dorso-palatal ŭ series and an alveolar s series. With only these two series of fricatives in the language, the proposal for the connection between palatality of a fricative and its non-participation in consonant harmony implies that Sekani should no exhibit consonant harmony, as indeed is the case.

4.4 Slave and its Dialects

Slave, called Dene in the native language, is spoken in parts of the Northwest Territories, British Columbia, and Alberta. All four main dialects of the language, Bearlake, Hare, Slavey, and Mountain, exhibit similar phonological evidence for the palatality of the ŭ series and also absence of consonant harmony. My primary sources for Slave are Rice (1989) for the four main dialects, and Howard (1963) for the Ft. Liard subdialect.

Consider the following voicing alternations affecting the stem-initial fricatives of verbs. The voiceless segment occurs after the first person singular subject marker h-, shown underlined in the forms below, and the voiced segment occurs after a vowel in the third person singular forms.

<table>
<thead>
<tr>
<th>Pair</th>
<th>First Person</th>
<th>Third person</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.  s-z</td>
<td>hehse ‘I shout’</td>
<td>heze ‘s/he shouts’</td>
</tr>
<tr>
<td>b. ŭ-y</td>
<td>rehšee ‘I grow’</td>
<td>reyee ‘s/he grows’</td>
</tr>
<tr>
<td>c. x-û</td>
<td>helxa ‘I lace’</td>
<td>heľa ‘s/he laces’</td>
</tr>
<tr>
<td>d. ñl</td>
<td>helši ‘I am’</td>
<td>hili ‘s/he is’</td>
</tr>
</tbody>
</table>

As shown in (19b), again, the fricative ŭ functions as the voiceless counterpart of the approximant y. This indicates that the fricative is a dorso-palatal and that according to our proposal it should not participate in consonant harmony. Because there is only one more coronal fricative series, the alveolar s and its affricates, it follows that consonant harmony
The Articulatory Basis of Locality in Phonology

should not be attested in this language, as in fact is the case.

In other Slave dialects, where $\tilde{z}$ is also part of the phoneme inventory, it is in free variation with $y$. In other words, the two sounds are used interchangeably, with no apparent phonological factor controlling their variation (p.c. Keren Rice, January 16, 1996). An example of the latter case is the subdialect of Slavey (a dialect of Slave), called Liard Slave, spoken in the vicinities of Ft. Liard and along the Liard river (Howard 1963). Howard characterizes the $d\tilde{z} t\tilde{s} \tilde{z} \tilde{s}$ sounds as palatal, noting that they “are frequently pronounced with a palatalized release, which is heard most clearly before the vowels e, a, o, and u.” (p. 44). But the strongest evidence for the series being palatal comes from the fact that the voiced fricative $[\tilde{z}]$ is in free variation with the palatal approximant $[y]$. For example, the word $[\tilde{z}a\tilde{h}]$ ‘snow’, may also be heard as $[y\tilde{a}\tilde{h}]$, $[n\tilde{a}\tilde{d}\tilde{e}\tilde{h}z\tilde{i}h]$, ‘I rest’ is also heard as $[n\tilde{a}\tilde{d}\tilde{e}\tilde{h}y\tilde{i}h]$ etc. For these reasons, consonant harmony, while frequent in Athabaskan languages, is not attested in Ft. Liard Slavey.

4.5 The Fricative-Approximant Alternation

The alternation between the palatal voiceless fricative $[C]$ with what is typically considered a dorso-palatal approximant or semi-vowel $[y]$ is a salient feature of several Athabaskan languages and one that deserves further commentary.

In defining the terms ‘fricative’ and ‘approximant’, Catford (1977: p. 123) notes, among other things, that oral stricture or the cross-sectional oral articulatory channel is an important characteristic of these sounds. He points out that in a fricative the articulatory channel is very small, producing turbulent airflow, irrespective of whether the sound is voiced or voiceless ($[s]$ vs. $[z]$). For an approximant, the articulatory channel is larger and flow through it is turbulent only when the sound is voiceless. When the sound is voiced the flow is non-turbulent.

These remarks can shed some light on the Athabaskan voicing alternation. Assume that there is a range of cross-sectional areas within which normal fricative sounds are produced. Catford (1977: p. 123) estimates a lower boundary of 3 mm$^2$ for exceptionally ‘tightly’ articulated $[s]$, and an upper boundary of 20 mm$^2$, which defines the critical point separating fricatives and approximants. The latter sounds cover a wider range of areas from 20 mm$^2$ to around 80-100 mm$^2$. I depict the respective intervals and their boundaries in (20) below.
20. Range of cross-sectional areas of fricatives and approximants

a. [ç]

\[
\begin{array}{ccc}
3 \text{ mm}^2 & 20 \text{ mm}^2 & 100 \text{ mm}^2 \\
\hline
\end{array}
\]

[-----------------| |------------- ------------------ ------------------ -----------]

Fricatives          Approximants

b. [y]

Assuming that voiced-voiceless allophones must have similar cross-sectional areas, there are two possibilities concerning the nature of the Athabaskan [ç - y] alternation, each of which is represented in the diagram above. Either the palatal fricative [ç] is relatively wide, as shown in (20a), so that its voiced counterpart is produced with very little turbulence, and thus falling within the range of the approximant [y], or the approximant [y] is relatively closed, as in (20b), so that when it is produced without voicing it is turbulent enough to fall within the range of the palatal fricative [ç].

In the writings of various Athabaskanists, it is possible to find evidence for (20b), that is, the existence of a relatively closed articulatory channel in the production of [y]. For example, Hoijer (1946: p. 60) describes the Chiricahua Apache [y] as “somewhat as in English young, except that it always has a slightly ‘rubbed’ or spirantal quality”. Bittle (1963: p. 81) gives a similar description of the Kiowa-Apache [y], characterizing the sound as “a front palatal semi-vowel, similar to the y of English ‘yam’ but articulated with marked friction, the front of the tongue approaching the palate more closely than in the articulation of English y.” Chiricahua Apache and Kiowa Apache are members of the southern Athabaskan stock.

In other words, in various Athabaskan languages, it seems to be the case that the approximant [y] is very close to or at the critical boundary of the cross-sectional area that defines the distinction between fricatives and approximants. From the phonological point of view, this means that [y] behaves as a voiced palatal fricative. The same conclusion, that [y] should be classified as a palatal fricative in various Athabaskan (as well as Eskimo) languages, is reached by Cook (1993), who discusses several sources of evidence from the phonology of these languages. Cook, however, does not seek the reason for this phonological behavior of [y] in its articulatory characteristics. He, instead, considers it a matter of language-particular setting of a parameter that demarcates the boundary between [+sonorant] and [-sonorant] segments. Given the sonority
hierarchy, Vowels > Glides > Liquids > Nasals > Obstruents, he proposes that Athabaskan languages place the boundary separating [+sonorant] and [-sonorant] segments between vowels and glides. Glides and all other classes below them in the sonority hierarchy would be classified as [-sonorant] sounds in these languages. The alternative interpretation presented above attempts to relate the phonological behavior of Athabaskan /y/ to its articulatory characteristics, linking the setting of the sonority parameter to the physiology of this sound.

5. SOUTHERN ATHABASKAN

According to Cook & Rice (1989), consonant harmony is found “virtually identical” in many of the Athabaskan languages. To emphasize its persistent recurrence, Cook & Rice list consonant harmony among a number of other phonological regularities which they call ‘pan-Athabaskan’. Nevertheless, I have identified a number of ‘exceptional’ Northern Athabaskan languages, such as Sekani and Slave, which do not exhibit consonant harmony, and some that do, such as Chilcotin and Tahltan, but in which not all coronal fricatives/affricates participate in the harmony. I have argued that the absence of consonant harmony or the non-participation of a coronal fricative/affricate series follows from the fact that the sounds of that series are articulated with the dorsum, instead of with the tip-blade of the tongue. The strongest evidence for this property of the non-participating sounds comes from a voicing alternation between the fricative of the series articulated furthest back, which henceforth I refer to as the ‘retracted’ fricative, and the approximant /y/.

Cook & Rice (1989) characterize the fricative voicing alternations as another ‘pan-Athabaskan’ phonological regularity. In this section, I show that when the retracted fricative does participate in the consonant harmony, then it does not participate in a voicing alternation with /y/. Hence, a further sub-generalization pervading the Athabaskan family emerges: participation of a fricative in consonant harmony and its participation in a voicing alternation with /y/ seem to be complementary. This provides further evidence for the correctness of the proposal that the cause of the lack of participation of a retracted fricative in consonant harmony is its dorso-palatal character.

The evidence in this section comes from Navajo (5.1) and the Apache languages, Chiricahua Apache (5.2), and Kiowa Apache (5.3). These languages comprise the southernmost and the smallest division of the Athabaskan stock.
5.1 Navajo
In this discussion of Navajo, my goal is to show that the retracted coronal fricative of the language does participate in its consonant harmony and at the same time does not enter into a voicing alternation with \( y \).

The consonant inventory of Navajo (Harris 1945, Sapir & Hoijer 1967, Reichard 1974, Young & Morgan 1980, Halle & Vergnaud 1981, McDonough 1991) is given below. I have provided the articulatory descriptions of the sounds from two different sources. The first is the grammar of Sapir & Hoijer (1967), which was written by Hoijer based on Sapir’s notes, and the second is the grammar of Reichard (1974). The reason why I use two different sources will become clear below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral</td>
<td>( l )</td>
<td>( tl )</td>
</tr>
<tr>
<td></td>
<td>( l )</td>
<td>( dl )</td>
</tr>
<tr>
<td>Alveolar</td>
<td>( d ) ( t ) ( n ) ( n' )</td>
<td>Alveolar</td>
</tr>
<tr>
<td>Prepatalal</td>
<td>( y ) ( y' )</td>
<td>Palatal</td>
</tr>
<tr>
<td>Fricatives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alveolar</td>
<td>( s ) ( z ) ( c/c' ) ( j )</td>
<td>Alveolar</td>
</tr>
<tr>
<td>Alveopalatal</td>
<td>( \check{s} ) ( \check{z} ) ( \check{c}/\check{c'} ) ( \check{j} )</td>
<td>Blade Alveolar</td>
</tr>
</tbody>
</table>

Navajo exhibits consonant harmony. Using Reichard’s terminology, the participating sounds are the alveolar and blade alveolar fricatives/affricates. Harmony is observed when an alveolar (blade alveolar) prefix is attached to a stem which contains another sound of the blade alveolar (alveolar) series. Prefixes which alternate between alveolar and blade alveolar include the perfective \( si-, s-, z-, \), the paradigmatic prefix \( ji-, \) the first person possessive \( si-, \) the first person singular subject \( \check{s}-, \) and the fourth person subject \( ji-, \check{s}, \check{z}-. Some examples from Halle & Vergnaud (1981) are given below.
22. Examples

- ji-di-baah  ‘he starts off to war’
- ji-sii    ‘he steams it’
- ji-z-ti    ‘he is lying’
- ji-ži-ţiš    ‘he is stooped over’

Harmony does not always occur. It is attested in normal and rapid speech much more often than in slow speech. Distance also seems to be a factor. When the two sounds are close, assimilation nearly always occurs. At greater distances assimilation occurs less often: a-ji-il-taas ‘he (4th p.) bends things’ is attested more often than a-ji-il-taas (Sapir & Hoijer 1967). Certain exceptions appear to be systematic. For example, some derivational prefixes do not change when they are attached to stems containing consonants from the trigger set, even though the target and trigger may be close. Also, stems which contain consonants from the target set show no alternation when enclitics with trigger consonants are suffixed to the stem. I refer the reader to McDonough (1991) for a detailed discussion of the morphologically conditioned complexities of harmony.

Note that whereas Sapir & Hoijer refer to the š series of coronals as ‘alveopalatals’, Reichard refers to them as ‘blade alveolars’. Reichard’s characterization is consistent with my claim that harmony only involves fricatives articulated with the tip-blade (a prerequisite to their participation in the harmony). Sapir & Hoijer’s characterization, however, suggests the possibility that these sounds are formed farther back than ‘blade-alveolars’, a view which is not necessarily consistent with the claim that these sounds are formed with the tip-blade.

As amply illustrated in the previous chapter, the matter cannot be decided by appeal to anyone’s impressionistic characterizations. I thus look at other sources of evidence that would decide between a tip-blade versus a dorsal articulation of š. Recall from the previous section that a cue to the dorso-palatality of a fricative š is its participation in a widespread voicing alternation between ů and y. From an examination of my primary sources (Harris 1945, Sapir & Hoijer 1967, Reichard 1974, Young & Morgan 1980), I found no evidence that š patterns as the voiceless counterpart of the dorso-palatal approximant y, or any other kind of evidence that would suggest that š is articulated with the tongue dorsum. Instead, voicing alternations treat š as the voiceless counterpart of ž (Young & Morgan 1981: p. 2).
To sum up, the fricative š does not enter into a voicing alternation with y, and does participate in the consonant harmony of Navajo.

5.2 Chiricahua Apache

The Chiricahuas centered around the junction of Mexico, Arizona, and New Mexico (Hoijer 1939, 1946). The coronal inventory of their language is described below. The affricates occur in three forms: unaspirated (the dz column), aspirated (the ts column), and glottalized (the ts' column). The fricatives are attested in voiced-voiceless pairs.

<table>
<thead>
<tr>
<th>Affricates</th>
<th>Fricatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>dz</td>
<td>ts</td>
</tr>
<tr>
<td>dz#</td>
<td>tš</td>
</tr>
<tr>
<td>dl</td>
<td>tľ</td>
</tr>
</tbody>
</table>

In addition, Hoijer also records the sounds, [d t l n] and a prenasal [d]. Finally, Hoijer describes the sound /y/ as a palatal semi-vowel, with more friction that the English /y/.

Chiricahua Apache exhibits consonant harmony. The coronal sounds again divide into two classes: /dz, ts, ts', z, s/, the s series, and /dž, tš, tš', ž, š/, the š series. Any sound of the s series preceding a sound of the š series assimilates to the corresponding š consonant, and any sound of the š series preceding any sound of the s series assimilates to the corresponding s consonant. The assimilation is described as optional and is conditioned by both the rate of speech and the distance between the two sounds. When the two coronals are members of the same syllable, assimilation of the first to the second always takes place, except in very slow or precise speech. If the two consonants belong to two different but contiguous syllables, assimilation takes place in rapid and normal speech but not in slow speech. As the distance between the two consonants increases, assimilation is less likely to take place.

In Chiricahua Apache, the blade alveolar š does not pattern with the dorso-palatal y. Hoijer records examples of voicing alternations that affect the final consonant of a verb. These alternations, although marginal, pair s-ž and š-ž (Hoijer 1946: p. 73), and there is no example where š functions as the voiceless counterpart of y. Once again, the participation of š in the harmony correlates with its non-participation in a voicing alternation with y.
5.3 Kiowa Apache

My data for Kiowa Apache are based on the grammar of Bittle (1963). Bittle was conducting fieldwork on Kiowa Apache between 1952 and 1955, in the vicinities of Fort Cobb, Oklahoma. During that time there were approximately 400 Kiowa Apaches of whom only 100 were fluent speakers of the language. The inventory of coronal sounds given by Bittle is shown in (24) below (C' means glottalized C).

24. Kiowa Apache coronals

<table>
<thead>
<tr>
<th></th>
<th>Affricates</th>
<th>Fricatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retroflex-Alveolar</td>
<td>dz</td>
<td>ts</td>
</tr>
<tr>
<td></td>
<td>ts'</td>
<td>z</td>
</tr>
<tr>
<td>Blade-Alveolar</td>
<td>dż</td>
<td>tś</td>
</tr>
<tr>
<td></td>
<td>ts'</td>
<td>ź</td>
</tr>
<tr>
<td></td>
<td></td>
<td>š</td>
</tr>
<tr>
<td>Lateral</td>
<td>dl</td>
<td>tł</td>
</tr>
<tr>
<td></td>
<td>tl'</td>
<td>l</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t</td>
</tr>
</tbody>
</table>

In addition to these, there are also the following sounds: an apical stop /t/, an unaspirated /d/ which is alveolar before /a/ and dental before /i, e/, an alveolar nasal /n/, and another alveolar consonant /n̥/ described by Bittle as a '[d] with a light nasal attack', or, in other words, a prenasal stop /d/. Finally, the the sound /y/ is characterized by Bittle as a palatal semi-vowel, with more friction that the English /y/.

Kiowa Apache shows a tendency for consonant harmony between the retroflexed-alveolar and the blade-alveolar series. Bittle describes the assimilation of blade-alveolars to retroflexed-alveolars (or spirants) in the following way.

Before an alveolar spirant or affricate in the same word, š and ź tend to assimilate to s and z, respectively; the assimilation of š and ź to alveolar position is incomplete, the resulting assimilated spirants being articulated in a position between the blade-alveolar position of English š and ź and the alveolar positions of English s and z. In short, Kiowa-Apache š and ź ... do not merge phonetically with Kiowa-Apache s and z. (p. 80)

He also describes the inverse assimilation in very similar terms. Two examples illustrating the tendency of alveolar spirants to assimilate to blade-alveolars are shown below in (25a-b) below (tones are not shown).
The examples in (25c-d) illustrate the assimilation in the other direction.

25.

<table>
<thead>
<tr>
<th>Example</th>
<th>Segment</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. see-(\text{-}z\text{\text{-}o})</td>
<td>([\text{\text{-}z\text{-}o}])</td>
<td>'I blew something'</td>
</tr>
<tr>
<td>b. da-si-ndi-t\text{\text{-}si\text{\text{-}i}}h</td>
<td>([\text{\text{-}si\text{-}t\text{\text{-}si\text{\text{-}i}}}])</td>
<td>'I carried a person'</td>
</tr>
<tr>
<td>c. (\text{s\text{-}i\text{-}see})</td>
<td>([\text{s\text{-}see}])</td>
<td>'my dust'</td>
</tr>
<tr>
<td>d. (\text{\text{-}i\text{-}zaa\text{-}de\text{-}bi\text{-}tsaah})</td>
<td>([\text{\text{-}i\text{-}zaa\text{-}de\text{-}tsaah}])</td>
<td>'buffalo sinew'</td>
</tr>
</tbody>
</table>

There is no evidence in Bittle (1963) that the fricative /s/ behaves as the voiceless counterpart of /\text{y}/. This is consistent with his careful articulatory characterizations of these phonemes. Bittle describes /s/ as a blade-alveolar and /\text{y}/ as a dorso-palatal. I conclude that Kiowa Apache illustrates the same property found in Chiricahua Apache and Navajo: the retracted fricative /s/ does not participate in a voicing alternation with /\text{y}/ and, as expected, does participate in the consonant harmony of the language.

6. KINYARWANDA AND OTHER CASES INVOLVING FRICATIVES

Except for Chumash, all languages discussed in the previous sections are members of the Athabaskan family. Outside Athabaskan, consonant harmony involving fricatives is attested in the following languages: Moroccan Arabic (Harris 1944, Harrel 1962), Basque (Hualde 1991, Trask 1996), Imdlawn Berber (Elmedlaoui 1992), Nifia Berber (Laoust 1918), Kinyarwanda (Kimenyi 1979), Southern Paiute (Lovins 1972), and Tzeltal (Kaufman 1971). In all these languages harmony affects only coronal fricatives and affricates and treats all other segments as transparent. Since a discussion of all these languages would not elucidate the phenomenon any further, I limit my attention here to the case of Kinyarwanda.

Kinyarwanda is an eastern Bantu language spoken in Rwanda and Burundi. The people of the latter region call the language Kirundi. The discussion in this section draws exclusively from the grammar of Kinyarwanda by Kimenyi (1979). The inventory of coronal sounds is given in (26) below. The inventory consists of a set of voiced/voiceless fricatives and affricates at the alveolar and alveopalatal places of articulation, the alveolar stops /t, d, n/, the palatal semivowel /\text{y}/, and the
palatalized versions of the velars /k, g, x, n/.

26. Coronal sounds

<table>
<thead>
<tr>
<th></th>
<th>Alveolar</th>
<th>Alveopalatal</th>
<th>Palatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>ş</td>
<td>k</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>ĺ</td>
<td>ğ</td>
<td></td>
</tr>
<tr>
<td>ts</td>
<td>tš</td>
<td>š</td>
<td></td>
</tr>
<tr>
<td>t</td>
<td>ň</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>y</td>
<td>n</td>
<td></td>
</tr>
</tbody>
</table>

Kinyarwanda shows consonant harmony, with the participating sounds being the alveolar fricatives /s, z/, on the one hand, and the alveopalatal fricatives /š, ĺ/, on the other. Some examples of this harmony are given in (27) below. These examples show the fricatives in the stems sas, sooz, and soonz, alternating between alveolar and alveopalatal.

27. Examples of consonant harmony

a. /ku-sas-a/ [gusasa] ‘to make bed’
b. /ku-sas-iš-a/ [gušašiša] ‘to cause to make the bed’
c. /ku-sooz-a/ [gusoosa] ‘to finish’
d. /ku-sooz-iš-a/ [gušoožiša] ‘to cause to finish’
e. /ku-soonz-a/ [gusoona] ‘to get hungry’
d. /ku-soonz-iš-a/ [gušoonžiša] ‘to cause to get hungry’

In describing this process, Kimenyi uses the terms ‘palatal harmony’ or ‘anticipatory palatalization’. However, from the present perspective, these terms are not accurate, since the harmony does not, in any sense of blocking, triggering, or participation, involve the palatal consonants. For instance, forms like [bašakažə] ‘they just caused to cover the roof’ and [basakaza] ‘they cause to cover the roof’ show that intervening velars which do have palatalized variants do not ‘palatalize’. Hence, the harmony process exclusively targets the coronal fricatives, confirming again the
usual generalization about consonant harmony. The series of palatal coronal sounds is transparent to the harmony because these consonants are articulated with the tongue dorsum, a different articulator from the tongue tip-blade.

7. SANSKRIT
In this section, I turn to the notorious rule of n-retroflexion in Sanskrit, also known in the writings of the ancient Indian grammarians as Nati, which literally means ‘bending, curvature’. I argue first that Nati involves strictly local spreading of the retroflex posture of the tip-blade articulator. In our typology of consonant harmony, then, Nati will be the prototype of TTCO harmony. I then proceed to discuss the blocking of Nati by intervening coronal consonants, an aspect of the phenomenon that has remained unclear in recent autosegmental analyses, but which is fully explicated under the gestural approach I am pursuing.

As with the previous languages, crucial to my discussion of Nati are the articulatory characteristics of the Sanskrit coronal consonants. These will be discussed here, drawing mainly from Allen (1953) and Whitney (1889). The consonant inventory of Sanskrit is given in (28) below. There are three series of coronal sounds, the dentals, the retroflexes, and the palatals (for the stops, C denotes the aspirated and Ch the unaspirated segment). I should add that there is also a syllabic version of the rhotic r, transcribed as r, together with its much rarer long variant ṭ.

28. Sanskrit consonant inventory

<table>
<thead>
<tr>
<th></th>
<th>Labial</th>
<th>Dental</th>
<th>Retroflex</th>
<th>Palatal</th>
<th>Velar</th>
<th>Lar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stops</td>
<td>p</td>
<td>t</td>
<td>t̪</td>
<td>c</td>
<td>k</td>
<td>h</td>
</tr>
<tr>
<td></td>
<td>ph</td>
<td>th</td>
<td>t̪h</td>
<td>ch</td>
<td>kh</td>
<td>c</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>d</td>
<td>d̪</td>
<td>j</td>
<td>g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bh</td>
<td>dh</td>
<td>d̪h</td>
<td>jh</td>
<td>gh</td>
<td></td>
</tr>
<tr>
<td>Fricatives</td>
<td>s</td>
<td>s̪</td>
<td>ŝ̪</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasals</td>
<td>m</td>
<td>n</td>
<td>ɲ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glides</td>
<td>v</td>
<td>l</td>
<td>r</td>
<td>y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the testimony of ancient grammarians, the dental
coronal sounds are articulated with a ‘flat, spread’ tongue tip, the actual term used by the ancient grammarians being ‘prastirna’, as opposed to the retroflex coronals, ‘prativeštita’, which are articulated ‘by rolling back the tip of the tongue’ (Allen 1953: p. 33), and ‘with the part next to the tip, or the underside of the tip’ (Allen 1953: p. 53). The palatal stop series was in ancient times a series of true palatal plosives, as opposed to the prepalatal affricates found in the modern Indo-Aryan languages. These sounds are described as being articulated ‘at the palate (tālu)’, and the ‘contact is made with the middle of the tongue upon the palate’ (Allen 1953: p. 52). The corresponding dental, retroflex, and palatal fricatives are articulated at the same place of articulation as the stops, but the ‘center of the articulator is open’, indicating the presence of the characteristic channel for fricatives created by the approximation of the active articulator, ‘karana’, to the passive articulator, ‘sthāna’ (i.e. the place of articulation).

With this in mind, I turn now to the discussion of Nati. The rule exhibits a peculiar set of properties given in (29), stated in the way they have come to be presented in modern-day discussions of the phenomenon (Sagey 1986, Schein & Steriade 1986, Cho 1991, Kaun 1993 etc.). As we will see below, some of these properties are in need of refinement.

29. Nati properties

   a. The rule operates ‘long-distance’
   b. Triggers = \{r s\}
      Targets = the first /n/ to the right of a trigger
      Blockers = \{retroflexes, dentals, palatales\}
   c. The target /n/ must be followed by a nonliquid sonorant

Whitney also notes that Nati applies within the domain of a word, and occasionally in compounds and across word boundaries. Some examples illustrating Nati and its failure of application are given in (30). The data are drawn from the discussions of Schein & Steriade (1986) and Kaun (1993). In the first column, I show examples where Nati applies, and in the second examples where Nati is blocked (the blocking segments are underlined, except when there is no blocker but the rule does not apply because condition 29c is not satisfied).
I consider each of the properties of the rule, beginning with the last property in (29c), which requires that the target /n/ be followed by a nonliquid sonorant. This requirement means that the rule fails to apply in the following environments: before a liquid, before an obstruent (stop or continuant), and in word-final position. Schein & Steriade (1986), in a particularly illuminating discussion of this property, show how these failures of application follow from independently necessary regularities of Sanskrit phonology. Because this property of Nati does not interact with the main focus of this section, and has been sufficiently explained elsewhere, I will not discuss it any further.

Consider next property (29a): Nati has come to be described as a prototypical case of a long-distance assimilation (Sagey 1986, Schein & Steriade 1986, Cho 1991, Kaun 1993 etc.). However, Whitney and Allen describe Nati as involving strictly local spreading of retroflexion.

In particular, Allen (1951) suggests that the apparent properties of the Nati rule, most notably its ‘long-distance’ character, should be treated with caution. This is because these properties, as we now state them, are based on the spelling of Sanskrit, which is bound to be phonetically imprecise. Elaborating on this point, Allen views the marking of retroflexion on the nasal to mean that retroflexion was present throughout the whole span from the ‘focal point’ of the retroflex fricative up to the nasal. Nati is thus not an instance of action à distance as was previously suggested by Bloch (1914), and adopted by modern autosegmental analyses.

Presenting his discussion in the prosodic framework of Firth (1948), Allen views retroflexion as a prosody, in other words, as a feature whose domain is not limited to a single phoneme, but rather spans the entire word domain to the right of its ‘focal point’, which is defined to be the first
fricative retroflex in the word. Some representations of Sanskrit words in this formulation of Nati are shown in (31) below. The prosody of retroflexion originates from the 'focal point', shown underlined in the Firthian representations, and extends throughout the entire word span to the right edge of the word.

31. Orthography Firthian representation

R

\[a. \text{br`ahman`a } \text{br\'ahmana} \]

R

\[b. \text{nis`an`n`a } \text{nis\'anna-} \]

R

\[c. \text{pus\'pam } \text{puspam} \]

The same view is expressed by Whitney who quite explicitly states in the quote below that the rule involves maintaining the retroflex posture of the tip-blade throughout the span from the trigger to the target.

We may thus figure to ourselves the rationale of the process: in the marked proclivity of the language toward lingual [AG: retroflex] utterance, especially of the nasal, the tip of the tongue, when once reverted into the loose lingual position by the utterance of a non-contact lingual element, tends to hang there and make its next contact in that position; (Whitney 1887: §189a)

More recently, Steriade has also characterized Nati as involving strictly local spreading of retroflexion, writing that "the raised tip position characteristic of retroflexes can be maintained throughout articulations that do not involve the tongue tip or the blade, i.e. during vowels, labials, and velars" (Steriade 1995b: p. 51). What remains to be explained under this view of Nati is the cluster of properties in (29b), which so far have not received a satisfactory account. I turn to a discussion of these properties next.
The triggers of Nati, as given in (29b), are the rhotic \( r \) and the retroflex fricative \( s \). Whitney, in fact, originally describes Nati as having two more triggers: the rhotic \( r \), which is the syllabic version of \( r \), and its much rarer long counterpart \( \tilde{r} \). The target of the rule, as accurately stated in (29b), is indeed just the dental nasal \( n \). Note that because Nati involves spreading of retroflexion, the potential set of triggers of the rule is the entire set of retroflexes, and also that the potential set of targets is the entire series of dentals. Any account Nati must address the observed restrictions to the class of actual triggers and targets. I postpone a formal treatment of these two properties of Nati until section 9, noting here that previous accounts have simply stated these properties as they are given in (29b), without explaining them.

Some confusion about the properties of Nati is found in the description of its blocking effects. As stated in (29b), the blockers of Nati are considered to be all the coronal sounds, which is to say, the dentals, the retroflexes, and the palatales. Whitney’s preliminary description of the blockers of Nati is indeed identical in content to this statement. He writes that Nati applies to change a dental nasal to a retroflex nasal “unless, indeed, there intervene ... a palatal ..., a lingual [AG: retroflex], or a dental” (§189). This is perhaps the reason why all modern analyses of the rule known to me have assumed that the blockers are as given in (29b). A closer examination, however, reveals that this statement needs to be refined.

Consider first the blocking of Nati by dentals together with the restriction that the rule applies only to the first nasal after the trigger. In a configuration ‘trigger ... nasal dental ... nasal dental’, the first nasal dental does not block the rule, but rather undergoes it. The statement that the second nasal does not undergo the rule is indeed true, but need not be stipulated as an independent property, because in a sense it reduces to the other property, namely, the fact that retroflex stops, like \( n \), are not triggers of the rule; only \( s, r, \tilde{r} \) and \( \tilde{f} \) trigger Nati. As I pointed out earlier, this property will be discussed in section 9.

Any other intervening dental in the configuration ‘trigger ... oral dental ... nasal dental’ will block the rule. To understand this, I assume, consistently with the testimony of the ancient grammarians, that the parameter of tongue-tip orientation or TTCo is the basis for the contrast between the dentals and the retroflexes. As discussed earlier, the articulation of a dental requires a ‘flat’ tongue tip, as opposed to the ‘rolling back’ posture assumed for retroflexion. Dentals, then, block the spreading of retroflexion because they are contrastively specified for
TTCO. What is left to be explained by any analysis of the phenomenon is the susceptibility of nasals to retroflexion, that is, the restriction of targets to the nasal dental. Dental stops and fricatives are not targets of the rule. This property will also be addressed in section 9.

Consider next the statement that retroflex coronals block Nati. This is not an accurate statement, because it is only the retroflex stops that block the rule; retroflex coronal fricatives do not block it. In fact, Whitney, elaborating on his description of Nati states this quite explicitly, as I indicate by the underlined portion of his discussion shown below (to maintain the coherence of Whitney’s discussion I repeat the part quoted earlier).

We may thus figure to ourselves the rationale of the process: in the marked proclivity of the language toward lingual [AG: retroflex] utterance, especially of the nasal, the tip of the tongue, when once reverted into the loose lingual position by the utterance of a non-contact lingual element, tends to hang there and make its next contact in that position; and does so, unless the proclivity is satisfied by the utterance of a lingual mute [AG: retroflex stop], or the organ is thrown out of adjustment by the utterance of an element which causes it to assume a different posture. This is not the case with the gutturals [AG: velars], or labials, which do not move the front part of the tongue ... and the y is too weakly palatal to interfere with the alteration. (Whitney 1887: §189a)

Indeed, from the class of retroflexes, it could only be the stop retroflexes that block the rule. To see this, consider (32) below, which shows two possible configurations where a retroflex intervenes between a trigger, ś or r, and the intended target of Nati, n. In (32a), the intervening retroflexes are confined to the stops {t th d dh n}. Retroflexion of the intended nasal target is blocked. In (32b), between the trigger and the potential target stands any sound from the set {ś r r’}. These latter sounds being triggers of the harmony themselves initiate their own spreading of retroflexion, and thus retroflexion of n takes place.
32. a. Nati is blocked
   Retroflex trigger  Intervening retroflex  Nasal target
   \{s r t ō\}  \ldots  \{t ūh d ūh n\}  \ldots  n

   b. Nati applies
   Retroflex trigger  Intervening retroflex  Nasal target
   \{s r t ō\}  \ldots  \{s r ō\}  \ldots  n

Hence, the statement that retroflexes block Nati is more accurately rephrased as ‘retroflex stops block the spreading of retroflexion’. And, again, this need not be stated as an independent property of the phenomenon, because it reduces to another property of Nati, namely, the fact that retroflex stops do not trigger Nati.

Finally, consider the blocking of retroflexion by the palatals. Based again on the descriptions of the ancient grammarians, the Sanskrit palatal sounds were articulated with an arched tongue dorsum raised below the medio-palate. This leads us to the reason why palatals block the spreading of retroflexion. As pointed out in section 3 of chapter 4, the articulatory configuration of palatals, a raised dorsum against the palate, is incompatible with the demands of retroflexion, namely, the rolling back of the tip-blade of the tongue. This articulatory incompatibility is ultimately due to biokinematic factors. To allow for the characteristic curling back of the tip to reach the postalveolar or prepalatal zone, the dorsum must be depressed downwards. A raised tongue dorsum, however, is heavily arched and thus convex behind the tongue blade.

A final refinement of the statement that Nati is blocked by the palatals is necessary. From Whitney’s description of Nati above, we infer that the palatal semivowel y does not in fact block the rule. Hence, the correct description is that Nati is blocked by any intervening palatal fricative or stop, but not by the palatal semivowel y. The semivowel requires a less arched tongue body than a fricative or a stop palatal does. Essentially following Whitney, I assume that retroflexion is compatible with the degree of palatal stricture required for y, but incompatible with the degrees of stricture required in a palatal fricative or stop.

To sum up, in this section I have first argued that the long-distance character of Nati is only apparent. Following Whitney and Allen, whose descriptions of the phenomenon are based on the testimonies of the ancient grammarians, I have proposed, consistently with the demands of Articulatory Locality, that Nati involves strictly local spreading of
retroflexion. I have then discussed the blocking effects of Nati, arguing that palatal stops and fricatives block Nati because their articulatory configurations are incompatible with the posture of retroflexion. The blocking by retroflexes and dentals reduces to two other facts that need to be addressed by any account of the phenomenon. The first is the limitation of triggers to the retroflex fricatives and the second is the limitation of targets to the dental nasal. These two properties of the rule are discussed in section 9.

8. AUSTRALIAN LANGUAGES

This section completes the cross-linguistic review of consonant harmony by illustrating instances of the phenomenon as it appears in some aboriginal languages of Australia. Consonant harmony in these languages turns out to be another case of TT CO harmony.

A typical Australian coronal inventory is shown in (33) below. The first striking characteristic is the lack of coronal fricatives. Indeed, Australian languages in general exhibit rather impoverished coronal fricative inventories. Although /s/ is the most common fricative, according to the survey of Maddieson (1984), it has been documented only in two languages of Australia, Kaka Kawaw Ya and Anguthmiri. It seems that when fricatives are attested the most common ones are drawn from the labial and velar classes (Evans 1995).

33. lamino-
dental apico-
alveolar apico-
alveopalatal
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>t</td>
<td>t</td>
<td>t</td>
<td>t</td>
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<tr>
<td>d</td>
<td>d</td>
<td>d</td>
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<td>n</td>
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<td>n</td>
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</tr>
<tr>
<td>l</td>
<td>l</td>
<td>l</td>
<td>l</td>
</tr>
<tr>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
</tr>
</tbody>
</table>

According to Dixon (1980), there are two categories of coronals: apical and laminal. Within each of these two categories, further subdivisions are made on the basis of the place of articulation. The laminal sounds can be ‘dental’ or ‘alveopalatal’, while the apical sounds can be ‘alveolar’ or retroflex ‘postalveolar’, as shown in (33) above.

In more detail, the articulatory characterizations of these sounds are as follows. Apico-alveolar [t] involves contact of the tongue tip at some
front area of the alveolar ridge, behind and without making any contact with the upper teeth. It contrasts with the other apical sound, the retroflex \( [\d] \) (or IPA \( \dot{s} \)), for which the tip is curled backwards, making contact at the postalveolar-prepalatal zone (Catford 1977, Dixon 1980). Lamino-dentals are attested in two variants. According to Catford (1977), in a lamino-dental, the tip of the tongue is just below the rims of the lower teeth, and the blade is against the back of the upper teeth. Dixon (1980), in addition to this articulation, describes another one which he calls ‘lamino-interdental’. This latter articulation can be characterized, slightly exaggerating, as if producing a \([d]\) with the tongue tip inserted between the teeth (as in fact is the case with some Yolŋu speakers). In this articulation, the tongue blade contacts both the lower and the upper teeth. Finally, in lamino-palatals, also called lamino-alveopalatal or -alveolars, the tongue blade touches the hard-palate or the alveolar ridge or often both, with the tip usually touching the teeth (Dixon 1980). Hamilton (1993) cites evidence from an unpublished palatographic study by Butcher (1992), showing that the lamino-alveopalatal s have contact with the palate going as far forward as the alveolar ridge.

With this in mind, I turn to consonant harmony which is attested in some languages of the Australian north. There are excellent in depth discussions of consonant harmony and other aspects of the phonology of aboriginal Australian languages by Hamilton (1993) and Steriadé (1995b). Here I merely wish to illustrate the basic properties of the phenomenon, referring the reader to the above sources for a detailed discussion.

Two cases of consonant harmony are illustrated for Gooniyandi and Gaagudju below. Typically, in these languages, there is no contrast between the two apical series in word-initial position. In Gooniyandi, a word like \( /duwu/ \), in (34a), surfaces in either of the two forms \([\d\w]\) or \([\d\w]\), which are in free variation. In Gaagudju apical initials are reported as being always alveolar, as in (34a), \([\na\w]\).

34. Gooniyandi

<table>
<thead>
<tr>
<th>a. [\d\w] - [\d\w]</th>
<th>'cave'</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. [d\ir\ip\indi]</td>
<td>'he entered'</td>
</tr>
<tr>
<td>c. [l\ap\g\i\ya] - [l\ap\g\i\ya]</td>
<td>'midday'</td>
</tr>
</tbody>
</table>
Gaagudju

a. naawu  ‘3sing. masc. pron’
b. d`een`mi  ‘again, as well’
c. niipja  ‘just’

Harmony occurs when a word-initial apical is followed by another apical coronal, in which case the word-initial apical assimilates to the place of articulation of the following apical. This case is exemplified by the Gooniyandi form (34b) [diripindi], *[diripindi], and the Gaagudju (34b) form [deenmi], which also has no *[deenmi] variant. The harmony is restricted to the class of apical sounds in these two languages. When the word-initial apical is followed by a laminal, as in (34c) of Gooniyandi and Gaagudju, it can be an alveolar or a retroflex depending on the licensing conditions of the language.

I will assume that the contrast between the apico-alveolars and the apico-postalveolars is characterized in terms of TTCO. Like the Nati rule of Sanskrit, these Australian harmonies are expressed as spreading of the TTCO parameter. There are two trivial differences between Sanskrit and these languages. First, the direction of spreading is here right-to-left, instead of left-to-right in Sanskrit (see the discussion of the directionality parameter in the following section). Second, whereas Sanskrit fricatives play a role as triggers of the harmony, the Australian harmonies involve only coronal stops. This follows from the trivial fact that fricatives are lacking from the inventories of these languages. Finally, once again, the apparent long-distance character of the phenomenon is a consequence of the simple fact that retroflexion is not distinctive for the vowels in these languages.

9. COMPARATIVE ANALYSIS

I have so far discussed differences in the various instantiations of consonant harmony which either follow from the difference in the assimilating parameter or are due to language-particular properties of the phonological inventory. There are, however, other properties of consonant harmony which are less trivial. For example, Sanskrit harmony targets only one sound from the class of potential targets, whereas Tahltan harmony targets all sounds from the class of potential targets; and while certain palatal sounds are blockers of the harmony is Sanskrit, the same sounds are completely transparent to the harmony of the Athabaskan
languages. In this section, I discuss these further properties of consonant harmony by comparing different languages. During this discussion, I motivate a number of constraints that seem necessary in order to account for the cross-linguistic variation of the phenomenon.

First, consonant harmony is an instance of assimilation, and like any other assimilation phenomenon there must be some constraint(s) which require it to happen. Two general types of such constraints have been proposed by various researchers. The first type derive from the perceptual domain. For example, Cole & Kisseberth (1994) propose that spreading or temporal extension of a feature in vowel harmony is favored because it facilitates perception of that feature. The second type of constraints enforcing assimilation derive from the articulatory domain. Steriade (1995b), for example, interprets cases of harmony in aboriginal Australian languages to be a consequence of a principle of articulatory ‘effort avoidance’ (Lindblom 1983). Illustrating the basic idea with an example from Gooniyandi, a language discussed in the previous section, the underlying form /dir`ipindi/ ‘he entered’ surfaces as [dir`ipindi], where the word-initial apical alveolar has turned into a retroflex, assimilating in TTCO to the following rhotic retroflex. If the underlying form were to surface as [diripindi], with no assimilation, then a more abrupt transition of tip movement would have to occur from the anterior constriction location of the apico-alveolar [d] to the more posterior constriction location of the retroflex [r]. Harmony is employed to avoid the extra articulatory effort required in this fast transition.

For the purposes of our discussion of consonant harmony, I will simply assume that there is a constraint, call it Harmony for the moment, which enforces assimilation in terms of some gestural parameter. I have identified two gestural parameters involved in consonant harmony, TTCO and TTCA, giving rise to the two basic types of consonant harmony enforced by the constraints Harmony(TTCO) and Harmony(TTCA). In its most general form, this constraint also needs to encode the domain of the temporal extension of the spreading parameter, also called the harmonic domain, and the direction that this extension takes. In most cases of consonant harmony discussed in previous sections, the harmonic domain is delimited by the segment which hosts the spreading parameter and the right or left edge of a word. In some cases, however, the domain extends to compounds as well as across words, as noted by Whitney (1889) for Sanskrit. I will thus assume that any morphological or prosodic category (M-Cat or P-Cat) can potentially be a harmonic domain. Concerning the direction of assimilation, we saw that while spreading of
TTCO propagates towards the right edge of a word in Sanskrit, in Tahltan spreading of TTCA proceeds towards the left edge of the word. Following Kirchner (1993), Smolensky (1993), Cole & Kisseberth (1994), Padgett (1995) and others, I assume that HARMONY is formulated as a constraint of the Generalized Alignment theory of McCarthy & Prince (1993b), specifically as stated in (35) below:

35. ALIGN(Spreading parameter, Domain of extension, Direction)
where:

- Spreading parameter = \{TTCO, TTCA\}
- Domain of extension = \{M-Cat, P-Cat\}
- Direction = \{L, R\}

For example, the constraint ALIGN(TTCA, Word, L) requires that TTCA originating from its segmental bearer in the word must extend to the left in order to align with the left edge of the word. For convenience, in what follows I will continue to use the shorthand version of the alignment constraint, HARMONY(Spreading Parameter).

With this at hand, we can proceed with our comparative discussion of the different types of harmony. Consider first the properties of consonant harmony in our prototype language of TTCA harmony, Tahltan, as given in (36) below.

36. Tahltan

a. Gestural parameter subject to assimilation: TTCA

b. Trigger segments: CP[TTCA]

\[
\text{CP[TTCA]}:
\]

- Subset [wide]: \{θ tθ tθ' d d\}
- Subset [mid]: \{s ts tś ż dz\}
- Subset [narrow]: \{s ts ts' z dz\}

c. Target segments: CP[TTCA]

d. Opaque segments: None
The first important property, given in (36a), is of course that the gestural parameter subject to assimilation is TTCA. In describing the triggers of the harmony in (36b), let us first introduce some useful terminology. Assume that the gestural parameter (or feature) $F$ partitions the set of coronal sounds of a language into a number of disjoint subsets, each corresponding to a different contrastive value of the parameter. The union of these subsets will be referred to as the Contrast Partition of $F$, or $CP[F]$ for short. $CP[F]$ simply contains all the sounds for which $F$ is contrastive. In Tahltan, the set of triggers is $CP[TTCA]$, the set of sounds in the union of all three subsets shown in (36b). Note that for some of the coronal sounds, $F$ may not be distinctive, and thus $CP[F]$ is in general a subset of the coronal sounds of the language. For example, TTCA is not distinctive for the class of coronal stops and laterals in Tahltan, which are thus excluded from $CP[TTCA]$. As can be seen in (36c), the set of segments which trigger the harmony is the same set of segments targeted by the harmony, namely, $CP[TTCA]$. The fourth property in (36d) can be ignored for the moment.

In languages with TTCA consonant harmony, the preservation of underlying contrasts in terms of TTCA is sacrificed so that the harmony-inducing constraint can be satisfied. In Tahltan, for example, the constraint enforcing spreading of TTCA must outrank the faithfulness constraint to the underlying value of TTCA, that is, $\text{HARMONY}(TTCA) \gg \text{FAITH}(TTCA)$. The reverse ranking, $\text{FAITH}(TTCA) \gg \text{HARMONY}(TTCA)$, would be part of the constraint hierarchy of a language such as English, for example, where TTCA is distinctive but no TTCA harmony exists. This suffices to derive the minimal typological split between languages with consonant harmony and languages with no consonant harmony.

I turn now to the TTCA harmony of Sanskrit, which exhibits some interesting differences from Tahltan and necessitates some refinements to the basic harmony-inducing grammar given above. The properties of consonant harmony in Sanskrit are shown in (37) below. Here, TTCA is the gestural parameter which defines the contrast between dentals and retroflexes. As shown in (37a), it is only the value of TTCA corresponding to retroflexes, TTCA-2 or [retroflex], which is subject to assimilation. Recall that in Tahltan all values of TTCA assimilate. I assume that this difference between Tahltan and Sanskrit is encoded in the HARMONY constraint, by specifying the value of the gestural parameter subject to assimilation, that is, $\text{HARMONY}(TTCA=[\text{retroflex}])$. 
37. Sanskrit

a. Gestural parameters subject to assimilation: TTCO-2 (retroflex)

b. Trigger segments: \{š r\}

\[ CP[\text{TTCO}]: \]

Subset [TTCO-1]: \{t th d dh s n l\}

Subset [TTCO-2]: \{t th d š n r\}

c. Target segments: \{n\}

d. Opaque segments: Palatal stops and fricatives

There are three other important differences between Tahltnan and Sanskrit. The first is that the set of triggers in Sanskrit, \{š r\} as shown in (37b), is a subset of the potential triggers of the harmony, namely, the retroflex sounds. In contrast, in Tahltnan harmony, every bearer of the spreading parameter TTCA is also a trigger of the harmony. The second difference is that the harmony in Sanskrit affects only one sound from the class of potential targets: it is only the dental nasal which turns to a retroflex nasal, as shown in (37c) above, in contrast again to Tahltnan harmony which affects all sounds for which TTCA is contrastive (see 36c). The third difference between Tahltnan and Sanskrit is that whereas the palatal sounds are transparent in the Tahltnan harmony, as indicated in (36d), they are opaque in the Sanskrit harmony, as indicated in (37d). I address each of these differences in turn.

Consider first Sanskrit’s limitation of triggers to the subset \{š r\} of retroflex sounds, and assume for the moment that both š and r are [+continuant], following Schein & Steriade (1986) and many others in this respect. The distinction that Sanskrit seems to draw in this respect is one between stops and fricatives. In Tahltnan such a distinction is irrelevant, because TTCA pertains only to sounds with a fricative component, that is, the fricatives and affricates of the language. In terms of constraint ranking, the most direct way to capture the distinction of Sanskrit is by relativizing the constraint enforcing harmony, \text{HARMONY}(\text{TTCO}=[\text{retroflex}]), according to the stricture of the trigger, and positing the ranking: \text{HARMONY}(\text{TTCO}=[\text{retroflex}], \text{trigger}=[\text{Fricative}]) >> \text{FAITH}(\text{TTCO}) >> \text{HARMONY}(\text{TTCO}=[\text{retroflex}], \text{trigger}=[\text{Stop}]). In this formulation, I am assuming consistently with Schein & Steriade (1986) and many others that r has the same degree of stricture as š. However, Whitney’s
characterization of $r$ as a ‘semivowel’ implies perhaps that $r$ has a more open stricture than that of a fricative, which would in turn mean that the distinction should be more accurately drawn between stop segments and segments with any other degree of stricture. This would also be consistent with the fact that Whitney includes in the class of triggers the short and long syllabic versions of $r$, namely, $\hat{r}$ and $\tilde{r}$, which he characterizes as ‘vowels’, implying perhaps an even lesser degree of stricture than that of a semivowel.

A source of independent evidence for the particular distinction drawn above may be rooted in the idea that segments which carry more salient cues to retroflexion are also more potent harmony-inducing triggers. Most relevantly, Steriade (1995b) points out the following difference between stops and fricatives: whereas in stops the cues to retroflexion are located primarily on the transition from the preceding vowel, what Steriade calls the ‘transition’ cues to retroflexion, fricatives possess an additional ‘internal’ cue, namely, the characteristic spectrum of frequencies generated during the period of their frication. This difference in cue availability between stops and fricatives could provide a plausible basis for the distinction encoded in terms of constraint ranking above.

Consider next Sanskrit’s limitation of targets to the dental nasal versus Tahltan’s absence of such a limitation. In Tahltan, the spreading parameter TTC A is by definition only relevant to sounds with a fricative component, that is, the obstruent fricatives and affricates of the language. For other classes of sounds, like stops, laterals, and nasals, TTC A plays no distinctive role. In Sanskrit, however, the TTC parameter is the basis of the contrast between the dental obstruents and sonorants, on the one hand, and the retroflex obstruents and sonorants, on the other. In other words, in Sanskrit, TTCO cross-classifies different classes of sounds, like stops, fricatives, and sonorants.

Therefore, the difference between Tahltan and Sanskrit in this respect seems to be principled. Instead of being an arbitrary property of Sanskrit, the restriction of targets to the nasal appears to be based on the fact that TTCO cross-classifies obstruents and nasals. I propose to capture the greater susceptibility of nasals to retroflexion by ranking the faithfulness constraint to the TTCO value for nasals lower than the faithfulness constraint to the TTCO value for obstruents, that is, $\text{FAITH(TTCO, Obstruent)} \gg \text{FAITH(TTCO, Nasal)}$. The constraint enforcing harmony should also be ranked higher than $\text{FAITH(TTCO, Nasal)}$ (see below for the complete hierarchy).

The proposed distinction between nasals and obstruent with respect
to assimilation receives independent support from other assimilation phenomena. In consonant clusters, it is a known fact that nasals assimilate more often than obstruents to the place of articulation of a following consonant. Any theory of assimilation must address this distinction. Padgett (1995), for example, proposes to capture it by fixing the ranking of the faithfulness-to-place of articulation constraints as $\text{FAITH}(\text{Obst-Place}) \gg \text{FAITH}(\text{Nas-Place})$. He also points out that the distinction seems to have a basis on perceptual facts, the nasal cues to place of articulation being less salient than those of an obstruent, because nasals lack a burst (see also Steriade 1995b).

Hence, I have proposed that two constraint rankings are necessary to account for the complexities of the Sanskrit harmony. The first ranking draws a distinction in terms of degree of stricture by differentiating stops from fricatives in their potency in inducing harmony: $\text{HARMONY}([\text{retroflex}], \text{trigger} = \text{Fricative}) \gg \text{HARMONY}([\text{retroflex}], \text{trigger} = \text{Stop})$. The second ranking draws a distinction in terms of sonority, separating obstruents from nasals in their susceptibility to retroflexion: $\text{FAITH}([\text{TTCO, Obstruent}) \gg \text{FAITH}([\text{TTCO, Nasal}) \gg \text{HARMONY}([\text{retroflex}], \text{trigger} = \text{Stop})$. Intercalating the two proposed hierarchies as in (38) below gives the right result: obstruents are immune to harmony which is triggered by retroflex fricatives but not stops and targets nasals but not obstruents.

38. Sanskrit harmony

$\text{FAITH}([\text{TTCO, Obstruent}) \gg \text{HARMONY}([\text{retroflex}], \text{trigger} = \text{Fricative}) \gg \text{FAITH}([\text{TTCO, Nasal}) \gg \text{HARMONY}([\text{retroflex}], \text{trigger} = \text{Stop})$

In contrast to Sanskrit, consonant harmony in Australian languages targets both obstruents and nasals, which means that the relevant ranking should be $\text{HARMONY}([\text{retroflex}) \gg \text{FAITH}([\text{TTCO, Obstruent}), \text{FAITH}([\text{TTCO, Nasal})$. Australian languages do not draw a distinction between stop and fricative triggers because they lack fricatives. For a language with TTCO contrasts but no harmony, the $\text{HARMONY}$ constraint is ranked below the two faithfulness constraints.

Finally, Sanskrit and Tahltan also differ with respect to the behavior of palatal sounds in their consonant harmonies. Where as palatals stop and fricatives in Sanskrit block consonant harmony, the same sounds are transparent not only in Tahltan but also in all other Athabaskan languages with consonant harmony. Recall that Tahltan harmony involves spreading
of TTCA, and that Sanskrit retroflexion involves spreading of TTCO. The apparent contradiction in the behavior of palatals is resolved when we consider how the two spreading parameters, TTCA and TTCO, control two different articulatory dimensions: TTCA constrains the shape of the tip-blade articulator in the cross-sectional dimension, while TTCO constrains the shape of the tip-blade in the mid-sagittal dimension. Palatal fricatives place strict control over the mid-sagittal posture of the tongue dorsum. As discussed earlier, because the tip-blade and the dorsum are contiguous sections on the surface of the tongue, there are constraints which disallow these two articulators to assume antithetical configurations in terms of their individual mid-sagittal postures. Hence, TTCO spreading will be blocked by palatal stops and fricatives in Sanskrit, because palatals require an arched tongue dorsum, and thus cannot sustain retroflexion, which requires a depressed tongue dorsum.

To capture the blocking effect by palatals, then, our grammar must include a constraint reflecting the above incompatibility. The precise formulation of this constraint requires yet another distinction in terms of degree of stricture. As Whitney carefully points out, it is only the palatal stops and fricatives that block retroflexion; the palatal semivowel does not block it (1889: §189a). As I pointed out in the earlier discussion of Sanskrit, this fact implies that the blocking of retroflexion occurs only for those degrees of tongue dorsum stricture greater than that for a semivowel. The constraint then would be stated as *[Tip-Blade: TTCA=\{retroflex\}, Dorsum: CD=\{closed, critical\}]*, where closed and critical are the constriction degrees corresponding to stop and fricative gestures respectively. This constraint will be undominated in the constraint hierarchy of Sanskrit, giving rise to the observed blocking effect by the palatals.

Returning to our comparison with Tahltan, although the above constraint is part of the constraint hierarchy of Tahltan and the other Athabaskan languages as well, palatal sounds in these languages will be transparent to the spreading of TTCA, because an arched tongue dorsum is fully compatible with the independent cross-sectional posture of the tip-blade articulator.

To sum up, I have discussed a number of differences in the cross-linguistic instantiation of consonant harmony. These differences motivate a set of constraints that fully account for this variation.

10. PREVIOUS ANALYSES OF CONSONANT HARMONY
Since consonant harmony is an instance of assimilation, it is important to
have the correct characterization of the features subject to assimilation. In this regard, there have been two previous proposals: assimilation can be in terms of [anterior] or in terms of the Coronal node itself. In this section, I discuss the problems with these proposals, arguing that they miss the crucial generalizations about the phenomenon.\textsuperscript{14}

The feature [anterior] has been proposed as a spreading feature in consonant harmonies, and in particular in Chumash consonant harmony (Poser 1982, Steriade 1987b, Shaw 1991). The problem with this proposal is that it predicts unattested cases of consonant harmony. Consider a language with one series of alveolar fricatives/affricates (apical or laminal), and another series of palatal fricatives/affricates, as shown in (39) below. Sekani is an example of such a language. Following standard assumptions, [s] will be [+anterior], and \( \ddot{s} \) will be [−anterior].

<table>
<thead>
<tr>
<th>39. Coronal inventory</th>
<th>Alveolar</th>
<th>Palatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fricative</td>
<td>s</td>
<td>( \ddot{s} )</td>
</tr>
<tr>
<td>Affricate</td>
<td>c</td>
<td>ċ</td>
</tr>
</tbody>
</table>

If [anterior] can spread in consonant harmonies, the prediction is that there should be languages with inventories such as the above which also show consonant harmony. Exactly the same analysis as that given by Shaw (1991) for Chumash, with spreading of the feature [anterior], would apply for these languages as well. The transparency of the stops, the nasals, and the laterals would follow from assuming that these segments are underspecified either for [anterior] or for the Coronal node itself (following Shaw 1991).

I do not know, however, of any language with the consonant inventory above which also exhibits consonant harmony. I have argued that there is a principled reason for this gap. Palatal fricatives do not participate in consonant harmonies (e.g. Chilcotin, Tahltan, Sekani, Slave) because they are articulated with the dorsum instead of with the tip-blade of the tongue. Note that the problem cannot be solved by underspecifying \( \ddot{s} \). In Radical Under specification, following standard assumptions, it is the least marked value of the feature that would be left underspecified, which is in this case the [+anterior] of the alveolar s, which would in turn allow spreading of the [−anterior] to an underspecified s. In Contrastive Under specification, both values of [anterior] must be specified underlyingly.
Before closing the discussion of [anterior] as a spreading feature, I consider Kaun's (1993) proposal that the spreading feature in Tahltan consonant harmony is the feature [anterior] redefined as having three different contrastive values as shown in (40) below.

40.  

[1 anterior] = interdental  
[2 anterior] = alveolar  
[3 anterior] = alveopalatal

Tahltan harmony can now be expressed as a straightforward assimilation in terms of the redefined feature. In Kaun's account, the transparency of coronal stops and laterals would follow from the fact that these series of sounds are not contrastive for this new [anterior] feature in Tahltan. As Kaun notes “to make this analysis convincing, evidence for a three-way [anterior] feature in other languages must be found” (Kaun 1995: p. 104). However, to my knowledge, no such evidence exists, and I believe that there are reasons to exclude such a proposal from further consideration. First, the problem with [anterior] noted above would still exist under this proposal. Second and most important, place of articulation is subject to non-contrastive variation in the case of fricatives, as I have repeatedly pointed out in the previous chapter. This variation makes this parameter a highly suspect basis for contrasts.

Next, I turn to proposals for spreading of Coronal. Two languages, Tahltan and Sanskrit, have been claimed to exhibit consonant harmony involving this node (Sagey 1986; Schein & Steriade 1986; Shaw 1991, Cho 1991, Odden 1994 and many others). In Tahltan, the harmonizing sounds are the three fricatives θ-s-ś and their affricates. To see why previous analyses have assumed spreading of Coronal, consider the feature assignments made possible by the Coronal-dependent features [anterior], [distributed], and [strident] (of SPE). Note that the distinction between θ-s cannot involve the same feature as the distinction between s-ś. The θ-s distinction can be expressed either by [distributed] or by [strident], with θ being [+distributed, −strident] and s being [−distributed, +strident]. The s-ś distinction can be expressed either by [anterior] or by [distributed], with s being [−distributed, +anterior] and ś being [+distributed, −anterior]. The feature [distributed] by itself cannot capture the distinctions among all three fricatives because this feature expresses a binary opposition instead of a ternary one needed here. Tahltan consonant harmony, then, must involve spreading of more than one Coronal-dependent feature, and
hence the harmony must be expressed as spreading of the Coronal node.

A generalization is missed here, however. Tahlta n harmony targets only fricatives and their corresponding affricates, a property which in fact pervades the Athabaskan family, and which would be treated as an accident under the assumption that what spreads is the Coronal node. Previous analyses have attempted to deal with this problem indirectly by marshalling language-particular arguments for the underspecified status of those coronal segments which do not take part in the harmony (see Shaw 1991 for such an analysis of Chumash and Tahlta n). Being placeless these latter segments would not participate in the harmony, because they lack the anchors on which the spreading feature(s) would have to dock. But even by looking at just two languages, Chumash and Tahlta n, Shaw finds that although there is language-particular evidence for the underspecified status of the non-participating coronal segments in Tahlta n, no such evidence exists for Chumash.

In contrast, the account of Tahlta n presented in this chapter provides a direct answer to the question of why only fricatives and affricates participate in the assimilation: the assimilating feature is TTCA, a feature which selects in its contrastive function precisely the class of coronal fricatives and their corresponding affricates.

Turning to previous analyses of Sanskrit, let me first illustrate how they have come to assume that the harmony here also involves spreading of Coronal. Recall that the Nati rule changes the dental /n/ to the retroflex /n/, an alternation which according to all previous analyses of the rule involves the features [anterior] and [distributed], with the dental being [+anterior], [+distributed], and the retroflex being [−anterior], [−distributed]. Hence, Nati is expressed as spreading of Coronal, the node which dominates the features [anterior] and [distributed].

According to previous analyses, then, some cases of consonant harmony must involve spreading of the Coronal node. This leads to what Ni Chiosáin & Padgett have characterized as an odd coincidence (originally pointed out by McCarthy & Traub 1992): “CPlace harmonies always involve Coronal [either by spreading Coronal itself or some of its dependent features: AG], and only Coronal has dependent minor place features” (Ni Chiosáin & Padgett 1993: p. 47). In other words, why, if Coronal can spread, another major articulator node like Labial or Dorsal cannot? To complete the picture, we can add another oddity for previous accounts, which we may call the ‘closure property’ of consonant harmony for reasons that will become apparent just below. According to standard understanding of assimilation, spreading of the Place node of a consonant
in, say, an NC cluster is accompanied by delinking of the underlying CPlace specification of the target nasal, whatever that place happens to be (Labial, Coronal, Velar etc.). Why, then, does spreading of Coronal always target only coronal segments? Or, in other words, why do we not find Coronal spreading to a consonant with a Labial CPlace specification turning it to a coronal? These questions have remained puzzles for the theory which assumes that Coronal can spread.

Taking up the closure property first, consonant harmony involves only coronal segments as both triggers and targets because the features which spread are in fact limited in their contrastive function to coronal consonants only: TTCA and TTCO provide distinctions for consonants articulated with the tip-blade only.

Next consider the limitation of consonant harmony to coronal harmony, and to the exclusion of other harmonies, like labial or dorsal, for example. Take a hypothetical case of labial harmony. What kind of a feature could be involved in such a harmony? Labials, unlike coronals, do not have ‘dependent’ features like TTCA and TTCO, which would refine the ways in which a Labial articulation is executed. Of course degree of constriction can refine Labial articulations, but according to Articulatory Locality spreading of constriction would have to propagate through the vowel, with fatal repercussions for the vowel. In contrast, TTCO and TTCA possess two special characteristics, one articulatory and one perceptual, which allow them to spread through vowels. The articulatory characteristic is that either the mid-sagittal or the cross-sectional shape of the tongue tip-blade, as defined by TTCO and TTCA respectively, can be maintained during the production of the intervening vowel in a CVC sequence, because vowels are produced by the tongue dorsum, an independent articulator from the tip-blade. The perceptual characteristic is that TTCO and TTCA have no significant acoustic effects on the intervening vowel in a CVC. In terms of constraints, the substance of Universal Grammar in Optimality Theory, the logic of this point translates in the presence of constraints that enforce spreading of some coronal dependent feature, HARMONY(TTCO) and HARMONY(TTCA), versus the absence of comparable constraints that would be relevant to labial consonants. Thus follows the presence of coronal harmony versus the absence of labial harmony.

The fact that previous accounts of consonant harmonies do not employ the correct features has repercussions in other parts of the theory. For example, assuming that Tahkt consonant harmony involves the spreading of Coronal leads to unnecessary parametrizations of locality, as
was discussed in section 5 of chapter 2.

11. APPARENT CASES OF CONSONANT HARMONY
A sound theoretical analysis should not be made on the basis of empirical data which are not true instances of the phenomenon one has originally set to investigate. It is thus appropriate at this point to consider some other phenomena that have been grouped under the name of consonant harmony, which I argue should be distinguished from the cases I have called consonant harmony, because they do not involve assimilation. To the extent that the term harmony entails assimilation of some feature, as in vowel harmony, it should not be used for the phenomena in question. Hence, although these phenomena are interesting they will not be investigated further in this dissertation.

11.1 Sound Symbolism
The first case of a phenomenon that has sporadically been dubbed consonant harmony but does not meet the assimilation criterion for harmony is the phenomenon known as ‘sound symbolism’. In general terms, sound symbolism refers to the linguistic use of phonetic oppositions in vowels and consonants to symbolize various distinctions of the human senses such as large/small, light/heavy, quick/slow, near/far, white/yellow, red/white etc. For example, in Dakota, distinctions between colors are denoted by alternations in the consonants used in naming them, e.g. zi ‘it is yellow’, zi ‘it is tawny’, and yi ‘it is brown’; degrees of intensity are also denoted by similar alternations, e.g. the neutral suza ‘it is badly bruised’, the diminutive suza ‘it has a slight bruise’, and the augmentative xuza ‘it is fractured’ (Jakobson & Waugh 1979: p. 202). Phonetic oppositions in vowels are also used to verbally distinguish perceptions of the senses. Benjamin Lee Whorf, for example, noted that “the vowels a (as in ‘father’), o, u are associated in the laboratory tests with the dark-warm-soft series, and e (English a in ‘date’), i (English e in ‘be’) with the bright-cold-sharp set” (Jakobson & Waugh 1979: p. 192). This phenomenon which is widespread in the languages of the world had drawn significant attention and was subject to serious experimental and cross-linguistic study by great linguists like Franz Boas, Maurice Grammont, Otto Jespersen, Gladys Reichard, and Edward Sapir around the turn of the century and in the first half of the twentieth century. However, after the 1950s interest in this phenomenon has considerably diminished. Jakobson & Waugh (1979) provide an excellent discussion of its early literature, where one finds a wealth of results that have been achieved with rigorous
methods of investigation. A review of these interesting results would take me far afield from my goal here, which is merely to show that the instances of this phenomenon that have been termed as consonant harmony cannot be analysed as assimilations.

In particular, in a 1959 IJAL short article on the Northwest Californian language Wiyot, Karl Teeter uses the term consonant harmony to refer to a process by which the diminutive or augmentative form of a noun is expressed by a set of consonant alternations, such as those given in (41) below. In (41a), I give a list of the alternations observed when the diminutive suffix -aats is added to a noun stem. The data are drawn from Cole’s discussion of the phenomenon (Cole 1991). As Cole points out, there is a limited number of examples of this process.

41. a. Alternations
\[ t \rightarrow ts, d \rightarrow dz/ts, ts \rightarrow ts, dz \rightarrow dz/ts, s \rightarrow š, l \rightarrow ř \]

b. Examples
\[ šwat \rightarrow šwats-aats ‘small bow’ \]
\[ delol \rightarrow dzirur-aats ‘small storage basket’ \]
\[ hudzwodž \rightarrow hutswots-aats ‘small basket’ \]
\[ bas \rightarrow baš-aats ‘small plate’ \]

As can be seen above, coronal stops, affricates, fricatives, and laterals are all affected in various ways: the alternations \[ t \rightarrow ts, l \rightarrow ř \] involve addition of the feature [+continuant], \[ ts \rightarrow ts, dz \rightarrow dz/ts \] involve a change to [+anterior], and the changes \[ s \rightarrow š, l \rightarrow ř \] involve a change to [-anterior]. There seems to be no way to coherently characterize all these alternations as a case of assimilation of some feature(s). For example, attempting a formulation of the phenomenon as assimilation in terms of a place of articulation feature, the \[ ts \rightarrow ts \] alternation is expressed by a shift from [-anterior] to [+anterior], but the \[ s \rightarrow š \] alternation involves the inverse shift from [+anterior] to [-anterior]. Indeed, Cole (1991) who has attempted such an assimilation analysis of this phenomenon, encounters precisely this obstacle, and concludes that “the latter rule \[ s \rightarrow š, AG\]… is really an arbitrary addition to the more general Augmentative/Diminutive Harmony, but I see no principled treatment of this problem at this time.” (Cole 1991: p. 88). The more general harmony rule referred to in Cole’s statement is a rule which spreads the features [+anterior] and [+continuant] from the diminutive suffix -aats to the consonants of the stem. Beside the serious problem just noted, the harmony analysis has to make a number of other problematic assumptions. For example, it has to
stipulate the class of target segments as being \([-\text{continuant}]\); it has to assume spreading of the \([-\text{continuant}]\) feature which is generally thought not to exhibit auto-segmental behavior (McCarthy 1988); and it has to spread both \([\text{anterior}]\) and \([\text{continuant}]\) two features that are not daughters of any single non-terminal node according to standard assumptions about the feature geometry (Clements 1985, Sagey 1986, McCarthy 1988).

The situation becomes even more hopeless when one looks at other cases of this phenomenon, which is quite widespread among various Western North American languages (Nichols 1971, Pentland 1974). In other languages, not only coronals but also uvulars, velars, and labial consonants may be affected. Some examples of alternations include: /w/ becomes /b/ in Hupa, /s/ becomes /k/ in Coos, /z/ becomes /n/ in Karok, /l/ becomes /n/ in Yana, uvular stops change to velars in various native languages in the Washington state area, and palatals change to alveolar affricates. These alternations are not necessarily triggered by the presence of an affix that could contain the spreading features (and what would those be?), and they can be attested in various combinations that make the formulation of the phenomenon in terms of assimilation impossible. Also, some of the languages which have consonant harmony in the sense of assimilation, such as Chumash and Basque, also have completely distinct processes of consonant symbolism.

To conclude, some cases of consonant symbolism have been misinterpreted as examples of consonant harmony. However systematic or interesting these phenomena may be, they cannot be coherently analyzed as instances of assimilation.

11.2 Child Language

The second case in which the term consonant harmony has been used is found in the literature on child language. Various authors, such as Vihman (1978), Stemberger & Stoel-Gammon (1991), and many others, refer to apparent cases of long-distance assimilation between consonants, e.g. \textit{bad} \rightarrow \textit{bab}, in child languages as cases of ‘consonant harmony’. In the common analysis assumed by these authors, the first consonant in a CVC configuration spreads to the C slot of the final consonant, with concomitant delinking of the latter’s featural specifications. To effect this apparent spreading these authors assume V/C Planar Segregation, with consonants and vowels lying on different planes (the representation I have rejected in chapter 3).

Here I wish to briefly outline a gestural account of this phenomenon suggested to me by Louis Goldstein, which involves no assimilation and
thus no need for spreading. Assume that the intention of the child is to produce the utterance *bad*, and consider in particular the production of the final coronal stop /d/. Coronal stops involve the coordination of at least two different articulators: the tip-blade, which forms a constriction at some place in the denti-alveolar zone, and the jaw, whose raising can be employed to facilitate elevation of the tongue in order to form the required constriction. Assuming that during the production of /d/ the jaw raises to facilitate the elevation of the tongue tip-blade, then the lower lip will also be raised. If the lower lip is raised enough so that it contacts the upper lip, something which is quite possible given that the lips may not have returned to their neutral state after the release of the preceding labial stop, then a labial stop will be produced together with the coronal stop. A combination of a coronal closing gesture with a labial closing gesture is perceived as a labial stop. In other words, the coronal gesture will be ‘hidden’, and hence the utterance will be perceived as *bab*.

No spreading in the sense of assimilation is involved in this account. Instead, the phenomenon is a consequence of an underdeveloped motor system, where the different contributions of the various articulators, or what Browman & Goldstein call the ‘articulator weights’, have not yet been finely tuned. Absence of such phenomena in adult speech follows from the assumption that the articulator weights have reached their stable values by adulthood.

There is another cluster of phenomena in child speech that have also been dubbed consonant harmony (by the same authors cited earlier), and which in fact do seem to involve assimilation. For example, Levelt (1994) reports productions of *poes* ‘cat’ /pus/ as *[puf]* by a Dutch child. The traditional consonant harmony account of this phenomenon argues that the Labial node of the initial consonant spreads to the final consonant, with concomitant delinking of its Coronal node (or alternatively, by filling in the Place node of the coronal, under the assumption that coronals do not have a place specification). Recall that the vowel does not interfere with this spreading, because this account assumes a segregated representation. Levelt (1994), however, provides a detailed analysis of a Dutch database of such phenomena, where the main finding is that “the assimilating place features were spread from the vowel adjacent to the assimilated consonant, rather than from the non-adjacent consonant” (Levelt 1994: p. 73). In our example, /pus/ → *[puf]*, it is not the labial specification of the initial consonant that spreads, but rather the adjacent vowel’s place specification. Levelt also argues convincingly that previous analyses of such phenomena in terms of V/C planar segregation are problematic and cannot be
maintained.

To sum up, first, I have discussed a phenomenon in child language which has been dubbed consonant harmony but does not in fact involve assimilation, and thus lacks the crucial property of the phenomenon I have been investigating in this chapter. Second, I have discussed another process in child language, which is also thought to be a case of consonant harmony. Although this latter process is a case of assimilation, it is assimilation between a vowel and its adjacent consonant, not assimilation between two consonants. As it turns out, then, none of the above phenomena in child phonology involve spreading from consonant-to-consonant ‘jumping over’ the intervening vowel in a CVC configuration, confirming once more the prediction of Articulatory Locality, this time from another area of research.

11.3 Consonant Disharmony
Another set of phenomena that have been classified as instances of consonant harmony are the ‘morpheme structure constraints’ which some languages impose on the consonants of their stems or roots. A familiar case of this is the co-occurrence restrictions on the consonants of Semitic roots (Greenberg 1950, McCarthy 1988). The characteristics of these phenomena, however, appear to be entirely different from the coherent set of properties of consonant harmony as they have emerged from the cross-linguistic review in this chapter. First, morpheme structure constraints are not instances of assimilation but rather of dissimilation, and second, these co-occurrence restrictions apply not only to coronal consonants, but to also to consonants with all other major places of articulation.

This section has two goals. First, it illustrates the distinct character of these phenomena by reviewing the restrictions on the consonants of the Semitic roots. The co-occurrence restrictions of Semitic are usually discussed in connection with the Obligatory Contour Principle (or OCP), which was extended to non-tonal phonology by McCarthy (1979), as stated below (emphasis: AG).

42. OCP (McCarthy 1979: p. 238)
In a given autosegmental tier, adjacent identical segments are prohibited.

The second goal will be to reconsider some arguments for locality as tier-adjacency based on the OCP effects of Semitic, and eventually show that these arguments cannot be maintained.
The original role of the OCP was to capture the distribution of identical consonants in Semitic roots. Specifically, there are two important facts involving identical consonants in trilateral roots, initially noted in Greenberg (1950). First, there are no roots in which the first and second consonants are identical. In contrast to this, roots with identical second and third consonants seem to be well formed. McCarthy (1979: p. 263) ingeniously explains this skewed distribution by assuming two things. First, a universal OCP prohibits underlying forms with two adjacent identical consonants. Second, spreading of underlying melodic material in Arabic is left-to-right. Considering the by now familiar surface form samam ‘poisoned’, the OCP implies that the underlying form must be /sm/ and not /smm/. This underlying form is then extended via spreading to /smm/ and not /ssm/ because the direction of spreading is left-to-right and not right-to-left.

McCarthy (1988) notes that there are further generalizations in the co-occurrence restrictions of Arabic. In particular, triconsonantal roots cannot contain more than one consonant from any of the following five classes: labials, coronal sonorants, coronal obstruents, dorsals, and guttural approximants. Consider the case of two labial consonants (b, f, or m). The restriction applies even when the two labials occupy the first and third positions of a root. Intervening consonants appear to be ‘transparent’ to this restriction on the distribution of [labial]. This can now be seen as an argument for the notion of locality as tier-adjacency: If the OCP applies only locally, then only tier-adjacency would provide the needed locality condition. As can be seen in the representation below, the two [labial] specifications are adjacent on their own tier.

43. (... on another plane ...)

\[
\begin{array}{cccc}
\text{C} & \text{V} & \text{C} & \text{V} & \text{C} \\
\text{[labial]} & \text{|} & \text{[velar]} & \text{|} & \text{[labial]}
\end{array}
\]

However, Pierrehumbert (1992) shows that “it is impossible to describe the observed cooccurrence restrictions if the OCP refers to features which are immediately adjacent on a tier ... Cooccurrence restrictions do cross intervening specifications of the same feature.” Specifically, Pierrehumbert calculated the strength of OCP effects between any pair of consonants in trilateral roots of Arabic. OCP effects between
a pair of two consonants are quantified by the ratio of the number of the observed occurrences of that pair in the dictionary (O) to the number of expected occurrences in the absence of an OCP effect (E). The O/E ratio can range from a value of 0, indicating an absolute OCP effect, to a value of 1 or more, indicating the absence of an OCP effect. Because phoneme frequency is highly dependent on position the correct positional probabilities of phonemes were used in the calculation of the O/E ratio.

The basic problem with the OCP is indicated in the following table. For each class of consonants this table shows the O/E index for two conditions, string adjacency vs. non-adjacency (ignoring intervening vowels here). It is clear from this table that the OCP effect shows significant degradation in the non-adjacent condition. This is not expected given that, when identical place specifications are involved, tier segregation makes them adjacent irrespective of their positions in a triconsonantal form.

44. OCP effects: O/E for $C_1 C_2$ vs. $C_1 C_3$

<table>
<thead>
<tr>
<th>Class</th>
<th>$C_1 C_2$</th>
<th>$C_1 C_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labials</td>
<td>0.00</td>
<td>0.29</td>
</tr>
<tr>
<td>Coronal Sonorants</td>
<td>0.06</td>
<td>0.67</td>
</tr>
<tr>
<td>Coronal Obstruents</td>
<td>0.29</td>
<td>0.67</td>
</tr>
<tr>
<td>Dorsals</td>
<td>0.04</td>
<td>0.34</td>
</tr>
<tr>
<td>Guttural Approximants</td>
<td>0.06</td>
<td>0.36</td>
</tr>
</tbody>
</table>

The second finding of interest is that in non-adjacent positions, when the two consonants are identical, the OCP effect is much stronger compared to homorganic but not identical consonants. This is shown in the next table. The second column lists the O/E index for identical consonants and the third column lists the O/E index for homorganic (but non-identical) consonants. Again the standard OCP does not predict such an effect. OCP effects between identical and homorganic consonants are predicted to be equivalent because only the place specification, and not the whole featural composition of the two segments, matters as far as the OCP is concerned.
45. OCP effects between $C_1 C_3$: O/E for identical vs. nonidentical

<table>
<thead>
<tr>
<th>Class</th>
<th>Identical</th>
<th>Nonidentical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labials</td>
<td>0.05</td>
<td>0.41</td>
</tr>
<tr>
<td>Coronals Sonorants</td>
<td>0.08</td>
<td>0.95</td>
</tr>
<tr>
<td>Coronals Obstruents</td>
<td>0.46</td>
<td>0.70</td>
</tr>
<tr>
<td>Dorsals</td>
<td>0.24</td>
<td>0.36</td>
</tr>
<tr>
<td>Guttural Approximants</td>
<td>0.05</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Pierrehumbert’s findings therefore argue against a formulation of the OCP which is restricted to apply only to features immediately adjacent on a tier. As a result, arguments for the notion of locality as tier-adjacency based on the OCP are at best dubious.

The cooccurrence restrictions of Semitic are in fact of the same type as those found in Russian (Padgett 1991) and English (Berkley 1994), where intervening material affects the strength of the OCP. The implication of this is that OCP effects must be analyzed as being non-local, precisely as independently entailed by Articulatory Locality, which treats the two underlined consonants in $CVC$ (and of course $CVCVC$) as non-local because their gestures are not contiguous.

12. SUMMARY AND CONCLUSION

In this chapter, I have documented the existence of consonant harmony in several American Indian, African, Australian, and Indo-Aryan languages. The phenomenon appears in various forms. Especially in languages of the aboriginal North America and Alaska, only fricatives and affricates participate in the harmony. In indigenous Australian languages, only stops participate. Yet, in other languages like Sanskrit, harmony is more intricate, triggered by one class of fricative sounds, while targeting a different class of (nasal) stop sounds.

Underlying this surface complexity of the phenomenon, I have argued that there are only two species of consonant harmony, TTCo and TTCA harmony, as shown in (46) below. The first involves spreading of the mid-sagittal shape of the tip-blade articulator, and the second involves spreading of the cross-sectional shape of the tip-blade articulator.
46. Typology of Consonant Harmony

**Consonant Harmony**

<table>
<thead>
<tr>
<th>Prototypes</th>
<th>Sanskrit</th>
<th>Tahltan</th>
</tr>
</thead>
</table>

The rich surface variation of the phenomenon as observed in different languages follows from three independent factors. The first factor is the gestural parameter subject to assimilation. This accounts, for example, for the transparency of palatal sounds in the TTCO harmony of Sanskrit, versus the opacity of the same sounds in the TTCA harmony of Tahltan. The second factor is the contrastive properties of a language’s phonological inventory. For example, (some) dental stops in Sanskrit block TTCO harmony because they contrast with the retroflexes in terms of TTCA, but the same sounds are transparent to the TTCO harmony of Chumash, because they have no contrastive counterparts in terms of TTCO.

The third factor in the variation is language-particular reranking of independently needed constraints. For example, Sanskrit TTCO harmony draws a distinction between its nasal and obstruent dental targets of the harmony; the former undergo the change to retroflexes, but the latter resist it, blocking the harmony. This distinction is part of the more general susceptibility of nasals to assimilation, which motivates ranking the faithfulness to the TTCO value of a nasal below the faithfulness to the TTCO value of an obstruent. Sanskrit harmony, then, results from placing the harmony-inducing constraint in between the two faithfulness constraints. Australian TTCO harmony, where both nasals and obstruents turn to retroflexes, results from a top ranked harmony-inducing constraint, outranking the two faithfulness constraints; and finally, absence of TTCO harmony in languages with TTCO contrasts results from ranking the harmony inducing constraint lower than the two faithfulness constraints.

Returning to the main thesis of the dissertation, I emphasize again the main result of this chapter and its connection to Articulatory Locality. As described in chapter 2, we began with what appeared to be a counterexample to Articulatory Locality: in a CVC configuration, there are cases of direct consonant-to-consonant assimilation, which seem to skip over the intervening vowel. A cross-linguistic investigation of these cases revealed that harmony is restricted to consonants articulated with the
tongue tip-blade. Specifically, the assimilating gestural parameters, TTCO and TTCA, are such that their configurations can be sustained during the production of the intervening vowel for two reasons: (a) the tip-blade is articulatorily independent of the dorsum (modulo the interaction between a retroflex posture of the tip-blade and an arched posture of the dorsum, as discussed in section 9), and (b) the mid-sagittal or cross-sectional shape of the tip-blade has no significant effect on the acoustics of the vowel. In short, vowels can sustain the spreading of TTCO and TTCA with no significant effects on their acoustic quality. Despite the apparent action à distance, C-to-C assimilations in fact respect articulatory contiguity, because the assimilating parameters propagate through the intervening vowels. This conclusion provides one final piece of support for the notion of Articulatory Locality.

NOTES

1. See also Ní Chiosáin & Padgett (1997) for theoretical work and Wiltshire & Goldstein (to appear) for experimental work that builds on this chapter.

2. I adopt the spelling of this word recommended by the Alaska Native Language Center. The other frequently used variant is ‘Athapaskan’, adopted by the National Museum of Man, Ottawa, Canada.

3. The term ‘wake-turbulence’ is used to indicate that the main acoustic energy of the sound is generated by the airstream hitting an obstacle, which is the teeth in the case of š, as opposed to turbulence generated at the constriction itself, as for the case of labiodental [f] or the bilabial [φ].

4. I should point out that Chumash will not be the only example of TTCO harmony. The typological predictions of this chapter would still be valid even if Chumash turned out to be a case of TTCA harmony, because there are other
languages for which we can say with certainty that they exhibit TTCO harmony, e.g. Sanskrit. I chose to illustrate TTCO harmony with Chumash purely on the basis of expository convenience: the Sanskrit harmony, in contrast to Chumash, involves various complications which would require deviations from the main focus of this first part of the chapter, which is to clearly illustrate the gestural approach I am pursuing. A detailed discussion of Sanskrit can be found in sections 7 and 9.

5. Flemming (1995) also proposes a gestural account of Chumash consonant harmony similar in spirit to my account.

6. Essentially the same idea has been proposed by Steriade (1995a). Briefly commenting on the Chumash harmony and citing personal communication with Peter Ladefoged, Steriade suggests “that the feature involved in Chumash and Chumash-like sibilant harmonies is laminality, a feature that is typically subject to phonetic (i.e., trivial) underspecification in the nonsibilant stops of languages, like English, French or Chumash” (1995a: p. 155).

7. Bladon & Nolan (1977) apparently did not test for long-distance coarticulation effects of the laminal fricatives [s,z] on the apical [n, l].

8. I wish to thank Keren Rice for her assistance with various issues on Athabaskan sound structure, and for providing me with Margaret Hardwick’s manuscript on Tahltan phonology and morphology.

9. Note that it is the cross-sectional shape which is described here, despite the use of the term ‘mid-sagittal groove’, which means that there is a groove running mid-sagitally along the
length of the tongue and indicating a channel created by symmetric lateral raising of both sides of the tongue, as opposed to a parasagittal channel where only one of the sides raises.

10. The term ‘flat’ is used here in its acoustic sense of having a downward shifting of formant structure. It is not to be confused with the articulatory sense of ‘flat’, which means not grooved, as for the fricative [θ].

11. For the reader interested in checking these data, I note that the C of Hardwick corresponds to the y of Nater.

12. To avoid confusion, the reader should keep in mind that the symbol š is used variously by different authors in the literature on Athabaskan languages. Whereas in Chilcotin and Tahltan, š is articulated with the tip-blade, in Sekani, š is articulated with the tongue dorsum (a better symbol for the latter sound would be the IPA symbol for the voiceless fricative known as ‘cedilla c’ ç).

13. Hamilton (1993) characterizes the distinction between apical-alveolars and apico-postalveolars (retroflexes) in terms of a binary feature [±retroflex]. This is equivalent to my use of TTCO.

14. I will not attempt to judge previous accounts of consonant harmony on the basis of their use of underspecification. For a thorough critique of underspecification accounts of consonant harmony in Sanskrit and Tahltan see Kaun (1993).

15. Also, for Tahltan in particular, we have seen that 0 is not only interdental but also alveolar. Some argument is thus needed for choosing the interdental specification only.
16. See chapter 1 for a discussion of hidden gestures in casual speech phenomena.