Coronal features and retroflexion in Indo-Aryan languages

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Hamann (2003) identifies several articulatory properties of retroflexion, three of which correspond to distinctive features commonly employed in the literature: posteriority ([–anterior]), apicality ([–distributed]) and retraction ([+back]). I use phonological activity as a diagnostic to determine which of these features are phonologically distinctive for retroflex segments in Indo-Aryan languages. The evidence suggests that retroflex segments in these languages are distinctively apical ([–distributed]), and potentially retracted ([+back]) at a post-lexical level. There is no evidence for [–anterior] at any level of representation. In light of similar findings reported in Dravidian and Australian languages with larger coronal place inventories, I argue that this is not a case of contrastive (under) specification. Rather, I suggest that posteriority ([–anterior]) may be a universally redundant and non-essential property of retroflexion that is derived from the combination of apicality ([–distributed]) and retraction ([+back]). Some implications for models of coronal place features are briefly discussed.

1. Introduction

In the phonological literature, three phonological features are commonly used to account for retroflex segments and other coronal places of articulation: [±anterior], [±distributed] and [±back]. In this paper, I use phonological activity as a diagnostic to determine which of these three features are phonologically distinctive for retroflex segments in Indo-Aryan languages. I argue that the phonological behavior of retroflexes in these languages can be explained if they are distinctively [–distributed], and if they are [+back] at a post-lexical level. However, the feature [–anterior] is not required to account for the behavior of retroflexes at any level of representation, and in some cases it makes very undesirable predictions. In light of broader cross-linguistic evidence, I suggest that the absence of [–anterior] on retroflexes in these languages is not a simple case of contrastive (under) specification. Rather, a posterior place of articulation (i.e., [–anterior]) may be a universally redundant and non-essential property of retroflexion
that is derived from the combination of [–distributed] and [+back]. This hypothesis raises doubts about the long-standing assumption that the specific ‘place’ of articulation along the anterior-posterior dimension is a primary factor in distinguishing retroflexes and other coronal consonants. It also opens up new avenues for research into the relationship between coronal places of articulation and secondary articulations such as [+back].

The paper is organized as follows. Section 2 lays the empirical and theoretical foundations of the paper. It introduces the coronal places of articulation (2.1) and the standard coronal place features that are assumed in the literature (2.2), along with features that are unique to palato-alveolars (2.3) and retroflexes (2.4). The diagnostic of phonological activity is introduced (2.5) and applied to retroflex consonants in Indo-Aryan languages in sections 3 and 4. In section 3 I present three case studies from Indo-Aryan languages, including the allophonic variation of retroflexes (3.1), loanword adaptation (3.2), and palatalization and gemination in Dhivehi (3.3). On the basis of these studies I argue that the behavior of retroflex consonants can be attributed to the features [–distributed] and [+back], but not [–anterior]. In section 4 I examine three apparent counterexamples to this claim including coronal assimilation in Sanskrit (4.1), sibilant neutralization in Gujarati (4.2), and the ruki rule of Sanskrit (4.3). In each case I demonstrate that the phonological behavior of retroflexes and other coronals is fully consistent with the proposed analysis, and does not provide positive evidence for [±anterior]. The proposed analysis is examined in light of broader cross-linguistic evidence in section 5, and its implications for models of coronal place features are briefly discussed. Finally, a short summary is provided in section 6.
2. **Theoretical background**

2.1 **Coronal places of articulation**

Phonological inventories can distinguish as many as four coronal places of articulation.¹ Four-place coronal inventories are generally considered maximal, and typically include lamino-dental, apico-alveolar, retroflex and palato-alveolar articulations.² Such inventories are common among Australian aboriginal languages.

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¹ Some languages distinguish more than four coronal fricatives. However, the additional contrasts are typically achieved through secondary articulations such as labialization, and not by distinguishing additional coronal places (Hall 1997a: 94). One possible exception is the Dravidian language Toda that is reported to have a five-way place contrast among coronal fricatives (Shalev et. al. 1993, Hall 1997a: 92). In light of the fact that this is the only reported case of a five-way place contrast among coronal fricatives, and that some secondary tongue body articulations can affect place of articulation, the data from Toda needs to be re-examined to ensure that place of articulation is the relevant factor, and that we are not dealing with another instance involving some kind of secondary articulation. Cf., the discussion of coronal affricates in section 5.3.

² Throughout this paper I use the term palato-alveolar as a cover term for any laminal post-alveolar coronal. Within this class a distinction is sometimes made between palato-alveolar (closer to alveolar) and alveolo-palatal (closer to palatal) (Pullum & Ladusaw 1996: 33, 204). However, these distinctions are not phonologically relevant because no language is known to contrast more than one laminal articulation in this range (Hall 1997a: 67). In the literature, these coronals are often described loosely as ‘palatal’. However, they must be distinguished from true palatals, which I take to be dorsal (cf., Ladefoged & Maddieson 1996: 32–33, Hall 1997a). In Indo-Aryan and Dravidian languages, laminal post-alveolar stops are typically pronounced with an affricated release. This also appears to be the case in Australian languages, although the affrication may be slightly less noticeable (e.g., Ladefoged 2005: 158). For uniformity, I represent them throughout the paper as /ʃ/ and /ʒ/. Other common transcription conventions include /c, j/, /č, ʃ/ and occasionally /č, ʒ/.
A similar inventory has been posited for Proto-Dravidian (Steever 1998, Krishnamurti 2003) and is maintained in some South Dravidian languages including Malayalam (Asher & Kumari 1997), Irula (Diffloth 1975) and the Kanniyakumari dialect of Tamil (Christdas 1988). Some representative voiceless coronal stop inventories from these language families are listed in (1–2).

(1) Australian voiceless coronal stop inventories (Hamilton 1996: 236–319)

<table>
<thead>
<tr>
<th>Language</th>
<th>Dental</th>
<th>Alveolar</th>
<th>Retroflex</th>
<th>Palato-Alv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyirbal</td>
<td>t</td>
<td></td>
<td>t</td>
<td>f</td>
</tr>
<tr>
<td>Ngiyambaa</td>
<td>t</td>
<td>t</td>
<td></td>
<td>f</td>
</tr>
<tr>
<td>Warlpiri</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>f</td>
</tr>
<tr>
<td>Kayardild</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>f</td>
</tr>
</tbody>
</table>

(2) Dravidian voiceless coronal stop inventories (Krishnamurti 2003: 61–77)

<table>
<thead>
<tr>
<th>Language</th>
<th>Dental</th>
<th>Alveolar</th>
<th>Retroflex</th>
<th>Palato-Alv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kannada</td>
<td>t</td>
<td>t</td>
<td></td>
<td>f</td>
</tr>
<tr>
<td>Telugu</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>f</td>
</tr>
<tr>
<td>Irula</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>f</td>
</tr>
<tr>
<td>Malayalam</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>f</td>
</tr>
</tbody>
</table>

2.2 Standard coronal place features

In their seminal work on articulatory features, Chomsky & Halle (1968) introduced a total of six binary place-of-articulation features. Two of these were the primary stricture features, [±coronal] and [±anterior]. The former distinguished sounds produced with the tongue blade (including the tip) from all others, while the latter split the oral cavity in two, so that all places of articulation in front of (but not including) the palato-alveolar region were said to be [+anterior] while all others were [–anterior].
To these, Chomsky & Halle added three tongue body features, [±high], [±low] and [±back]. The tongue body features had several functions. They distinguished vowels, place-of-articulation among dorsal (i.e., [-coronal] [-anterior]) consonants, and secondary articulation among coronal and labial consonants. With the exception of palato-alveolars, which were redundantly palatalized by means of the feature [+high], all other coronal consonants were assumed to have redundant negative values for these tongue body features. Secondary articulations were achieved by substituting positive values: [+high] for palatalization, and both [+high] and [+back] for velarization.

Finally, Chomsky & Halle introduced the feature [±distributed] in order to account for finer place distinctions among coronals and labials. [+distributed] sounds were defined as those with a considerable length of constriction along the direction of airflow, while [−distributed] sounds were those with a shorter length of constriction. Among coronals, this corresponded roughly to the distinction between laminal (i.e., tongue blade) and apical (i.e., tongue tip) articulations. Thus, [+distributed] was applied to all laminals (i.e., dentals and palato-alveolars) while [−distributed] was applied to apicals (i.e., alveolars and retroflexes).

Chomsky & Halle’s place features are summarized in (3). Note that they did not discuss the redundant tongue body features for retroflexes, and did not apply the feature [±distributed] to anything that was both [−coronal] and [−anterior].

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3 Cross-linguistically, there tends to be a correlation between dental place and laminality on the one hand, and alveolar place and apicality on the other (e.g., Keating 1991: 42, Ladefoged & Maddieson 1996: 20–21, Hall 1997a: 42). I assume that the laminal/apical distinction is the relevant distinction, as implied by the feature [±distributed], and that the specific place of contact (dental vs. alveolar) may vary.
Subsequent work on feature theory recognized the importance of active articulators in phonological patterns, and reclassified each of Chomsky & Halle’s place features under one of three privative features representing active articulators: LABIAL, CORONAL and DORSAL (e.g., Sagey 1986). In this way, [±anterior] and [±distributed] came to be regarded as exclusive dependents of the privative feature CORONAL. Similarly, the tongue body features, [±high], [±low] and [±back] came to be regarded as exclusively DORSAL, applying primarily to vowels and dorsal consonants (4).

(4) Place features according to Sagey (1986)

4 Here and elsewhere I distinguish privative features from binary features by representing them with small capitol letters (e.g., CORONAL).
The combination of the two binary features, [±anterior] and [±distributed], successfully predicted the attested maximal four-way system of coronals, as shown in (5). As a result, they were adopted in the vast majority of feature theories (e.g., Sagey 1986, Lahiri & Evers 1991, Halle 1992, Clements & Hume 1995, Hall 1997a, and many others). They have come to represent the standard approach to coronal features, as evidenced by the fact that they are still introduced in most contemporary textbooks and handbooks (e.g., Gussenhoven & Jacobs 2005, Odden 2005, Hall 2007, among others).

(5) Standard coronal place features

<table>
<thead>
<tr>
<th></th>
<th>Dental</th>
<th>Alveolar</th>
<th>Retroflex</th>
<th>Palato-Alv</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORONAL</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>[anterior]</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[distributed]</td>
<td>+</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

2.3 Palato-alveolar features

Coronal consonants are known to interact with vowels in many languages. In particular, rules of palatalization like that in (6) are very common cross-linguistically (e.g., Bhat 1978, Hall 1997a: 66). In these alternations denti-alveolar consonants become palato-alveolar in the context of front vowels and glides.

(6) \( t \rightarrow tʃ / i, e \)

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5 Following Hall (2007) I use a check mark to indicate the application of privative features.
These alternations are generally assumed to be assimilatory in nature (e.g., Lahiri & Evers 1991). If this is so, then palato-alveolar consonants and front vowels/glides must share certain articulatory features and form a natural class. However, there is no consensus on the feature or features that define this class.

At least two solutions to this problem have been proposed in the literature. One approach is to attribute coronal place features to front vowels. In this approach, the two privative features CORONAL and DORSAL replace the binary feature [±back]. Front vowels are specified for the same features as palato-alveolar consonants, namely CORONAL, [–anterior] and [+distributed], while back vowels are DORSAL. Palatalization is achieved by spreading [–anterior] from a front vowel to a [+anterior] denti-alveolar consonant (e.g., Lahiri & Evers 1991, Clements & Hume 1995).

A second approach is to attribute tongue body features such as [–back] and/or [+high] to palato-alveolar consonants, as originally proposed by Chomsky & Halle (1968). In models of feature geometry where these features are exclusive dependents of the DORSAL articulator, this analysis entails that palato-alveolars are complex segments with two articulators, one CORONAL and the other DORSAL. In other words, they are coronals with a secondary dorsal articulation (cf., Sagey 1986, Keating 1988).

A variation on this theme is presented by Hall (1997a) who argues that: (i) palato-alveolars are inherently palatalized by means of a feature that they share with front vowels, (ii) this feature is [–back] (which represents a fronted tongue body position), and (iii) [–back] can be a CORONAL or DORSAL dependent. Hall’s account is significant for at least two reasons. First, palato-alveolars are unique in bearing a secondary articulation ‘inherently’. Applied to other consonants, the feature [–back] counts as a secondary articulation of the type $C^j$. Applied to coronals that are [–anterior] and [+distributed] it
counts as a place of articulation (1997a: 89). Secondly, in Hall’s account palato-alveolars are not necessarily complex in terms of feature geometry because [–back] can be a coronal feature. In both of these ways, Hall’s analysis is a (partial) return to Chomsky & Halle’s original (1968) proposal. Thus, Hall supplements the standard coronal place features with [–back], as shown in (7).

(7) Coronal place features according to Hall (1997a: 98)

<table>
<thead>
<tr>
<th>Place of Articulation</th>
<th>Dental</th>
<th>Alveolar</th>
<th>Retroflex</th>
<th>Palato-Alv</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORONAL</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>[anterior]</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>[distributed]</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>[back]</td>
<td></td>
<td></td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

2.4 Retroflex features

Hamann (2003: 32ff.) identifies four articulatory properties of retroflexion: apicality, posteriority, sublingual cavity, and retraction (8).

(8) Articulatory properties of retroflexion (according to Hamann 2003)

a. apicality: articulated with the tip or underside of the tongue
b. posteriority: articulated behind the alveolar ridge
c. sublingual cavity: a cavity beneath the tongue blade
d. retraction: displacement of the tongue back towards the pharynx or velum
Three of these properties correspond to articulatory features commonly employed in the literature. Apicality and posteriority correspond to [–distributed] and [–anterior], respectively. The property of tongue retraction corresponds to the tongue body feature [+back] (Hamann 2003: 36). Various people have proposed [+back] for retroflexes because they pattern with back vowels in many languages (e.g., Lin 1989, Gnanadesikan 1994, Hamann 2002, 2003, Boersma & Hamann 2005). Parallel to patterns of palatalization like that in (6), we find patterns of retroflexion like that in (9), where a denti-alveolar becomes retroflex in the context of back vowels (see Hamann 2003: 90ff. for examples, and the discussion of retroflex variation in section 3.1 of this paper).

(9) \[ t \rightarrow \ddot{t} / u, o, a \]

If these alternations are assimilatory in nature, then they imply that retroflexes and back vowels share an articulatory feature such as [+back]. There are two views on the relationship between retroflexion and tongue retraction in the literature. One view suggests that retroflexes are only preferentially backed, for ease of articulation (e.g., Bhat 1974, Flemming 2003). A second view argues that retroflexes are inherently backed in much the same way that Hall (1997a) sees palato-alveolars as inherently fronted. For instance, Hamann (2002, 2003) and Boersma & Hamann (2005) argue that retraction is a necessary (but not sufficient) criterion of retroflexion, and that there is no such thing as a non-velarized or non-pharyngealized retroflex.
2.5 Distinctive and non-distinctive features

Summarizing the discussion of coronal features thus far, we find that the standard coronal features \([\pm \text{anterior}]\) and \([\pm \text{distributed}]\) are often supplemented by the tongue body feature \([\pm \text{back}]\) in order to account for the phonetic properties and phonological behavior of palato-alveolars and retroflexes. A more complete list of potential coronal features includes \([\pm \text{back}]\) (10).

(10) Summary of potential coronal place features

<table>
<thead>
<tr>
<th></th>
<th>Dental</th>
<th>Alveolar</th>
<th>Retroflex</th>
<th>Palato-Alv</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORONAL</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>[anterior]</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>[distributed]</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>[back]</td>
<td></td>
<td>+</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

Strictly speaking, however, no more than two coronal features (not counting CORONAL itself) are necessary to represent retroflexes, or any other coronal place of articulation. For instance, theories of underspecification suggest that languages might employ features only if they are contrastive, and they might only make use of marked feature values in establishing contrast. Thus, features might be redundant and underspecified if they are non-contrastive and/or unmarked (e.g., Dresher et. al. 1994). Assuming a contrastive approach to feature specification, it is doubtful that any language would ever require three binary features to distinguish among coronal places of articulation. This is because two binary features are sufficient to account for a maximal
four-way coronal contrast. The two features might be [±anterior] and [±distributed], as in the standard model in (5). Alternatively, they might be [±distributed] and [±back].

There is another reason why two features should be sufficient to represent retroflexes. Hamann (2003: 39) points out that the four articulatory properties of retroflexion are interrelated. Certain pairs of features automatically entail the remaining two. She identifies the implications in (11a-b). To these we could add (11c) because an apical gesture (in which the tip is turned up and tongue shape is concave) combined with a retracted tongue body is likely to yield a posterior contact and sublingual cavity.

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6 The combination of [±anterior] and [±back] might also be sufficient to yield a four-way contrast, but only if values of [±back] were extended to dentals and alveolars. Within the model I assume in (10), [±back] applies only to palato-alveolars and retroflexes (i.e., [–anterior] segments). Thus, the combination of [±anterior] and [±back] alone cannot account for the distinction between dentals and alveolars, and can only achieve a three-way contrast (i.e., denti-alveolar vs. retroflex vs. palato-alveolar).

7 According to Hamann (2003: 43) apicality and retraction yield only a velarized apico-alveolar without posteriority. However, she also argues that all retroflexes are necessarily velarized, but not necessarily posterior. This suggests that a velarized apico-alveolar and a (non-posterior) retroflex might be distinguished only by sub-lingual cavity. Given the entailments between articulatory features (p. 39) it is not clear to me how sub-lingual cavity could be manipulated independently (i.e., without some concomitant difference in apicality, retraction, or posteriority). This raises the question as to whether there is any phonological difference between a velarized apico-alveolar and a retroflex, or whether these are merely different phonetic implementations of the same phonological reality. This question deserves further exploration, but cannot be pursued here. I maintain that apicality and retraction can yield posteriority (at least potentially, if not necessarily). This is supported by the evidence from retroflex variation in Indo-Aryan languages discussed in section 3.1.
(11) a. apicality & posteriority $\rightarrow$ retraction, sublingual cavity  
b. posteriority & retraction $\rightarrow$ apicality, sublingual cavity  
c. apicality & retraction $\rightarrow$ posteriority, sublingual cavity

These entailments suggest that the phonological use of any two of the coronal features in (10) should be sufficient to account for the full range of phonetic properties associated with retroflex consonants. Thus, it is possible that some features are phonologically relevant while others are derived and redundant. The question is, which of the features associated with retroflexion are phonologically relevant?

Within models of contrastive specification, phonological activity is often taken as a diagnostic for the status of phonological features. According to the Contrastivist Hypothesis, only contrastive features are active in the lexical phonology, while non-contrastive features are phonologically inert (e.g., Dresher 2008). Borrowing this diagnostic, the question becomes: Which of the features associated with retroflexion are phonologically active? In other words, which features account for the phonological behavior of retroflexes? Throughout the rest of this paper I apply the diagnostic of phonological activity to Indo-Aryan languages. I argue that the phonological behavior of retroflexes in this language family can be attributed to the features [±distributed] and/or [±back], but not [±anterior].

3. **Phonologically active features in Indo-Aryan**

The Indo-Aryan family consists of as many as 219 languages (Gordon 2005) spoken throughout the region of South Asia, which includes India, Pakistan, Bangladesh, Nepal, Bhutan, Sri Lanka, and the Maldivian islands. With only a few exceptions, the
vast majority of Indo-Aryan languages have three-way coronal place systems consisting of denti-alveolar, retroflex, and palato-alveolar consonants. A representative sample of voiceless coronal stop inventories is listed in (12).

(12) Indo-Aryan voiceless coronal stop inventories (Cardona & Jain 2003)\(^8\)

<table>
<thead>
<tr>
<th>Language (Dardic)</th>
<th>Dental / Alveolar</th>
<th>Retroflex</th>
<th>Palato-Alveolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asamiya</td>
<td>( \grave{t} )</td>
<td>( \grave{t} )</td>
<td>( \grave{\emptyset} )</td>
</tr>
<tr>
<td>Bangla</td>
<td>( \grave{t} )</td>
<td>( \grave{t} )</td>
<td>( \grave{\emptyset} )</td>
</tr>
<tr>
<td>Bhojpuri</td>
<td>( \grave{t} )</td>
<td>( \grave{t} )</td>
<td>( \grave{\emptyset} )</td>
</tr>
<tr>
<td>Dhivehi</td>
<td>( \grave{t} )</td>
<td>( \grave{t} )</td>
<td>( \grave{\emptyset} )</td>
</tr>
<tr>
<td>Gujarati</td>
<td>( \grave{t} )</td>
<td>( \grave{t} )</td>
<td>( \grave{\emptyset} )</td>
</tr>
<tr>
<td>Hindi</td>
<td>( \grave{t} )</td>
<td>( \grave{t} )</td>
<td>( \grave{\emptyset} )</td>
</tr>
<tr>
<td>Magahi</td>
<td>( \grave{t} )</td>
<td>( \grave{t} )</td>
<td>( \grave{\emptyset} )</td>
</tr>
<tr>
<td>Maithili</td>
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<td>( \grave{t} )</td>
<td>( \grave{\emptyset} )</td>
</tr>
<tr>
<td>Nepali</td>
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<td>Sinhala</td>
<td>( \grave{t} )</td>
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</tr>
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<td>Urdu</td>
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<td>( \grave{t} )</td>
<td>( \grave{\emptyset} )</td>
</tr>
<tr>
<td>Kashmiri (Dardic)</td>
<td>( \grave{t} )</td>
<td>ts</td>
<td>( \grave{t} )</td>
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<td>Konkani</td>
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<td>( \grave{t} )</td>
</tr>
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<td>ts</td>
<td>( \grave{t} )</td>
</tr>
<tr>
<td>Gawarbatı (Dardic)</td>
<td>( \grave{t} )</td>
<td>ts</td>
<td>( \grave{t} )</td>
</tr>
<tr>
<td>Indus Kohistani (Dardic)</td>
<td>( \grave{t} )</td>
<td>ts</td>
<td>( \grave{t} )</td>
</tr>
<tr>
<td>Kalasha (Dardic)</td>
<td>( \grave{t} )</td>
<td>ts</td>
<td>( \grave{t} )</td>
</tr>
<tr>
<td>Shina (Dardic)</td>
<td>( \grave{t} )</td>
<td>ts</td>
<td>( \grave{t} )</td>
</tr>
</tbody>
</table>

\(^8\) All of the inventories in (12) are based on the various papers in Cardona & Jain (2003), with the exception of Dhivehi, which is taken from Cain & Gair (2000). The six Dardic languages listed in (12) have been selected to represent the six major Dardic sub-groups identified by Bashir (2000: 824–25).
For the sake of completeness, the list in (12) includes a sample of Dardic languages, which are spoken in northwest India, Pakistan and Afghanistan. There is no consensus on the sub-classification of Indo-Aryan languages, and the place of Dardic within the Indo-Aryan family has been controversial (Masica 1991: 446–63). Nevertheless, the Dardic languages are now generally recognized as a sub-group of Indo-Aryan, one that is transitional with the languages of central Asia (Bashir 2003).

The three-way coronal system consisting of dentity-alveolar, retroflex and palato-alveolar stops is the “statistically predominant pattern” of Indo-Aryan and other South Asian languages (Ramanujan and Masica 1969: 564). The most notable exception is Asamiya in northeast India, which has a single alveolar series (Goswami & Tamuli 2003). In addition, some Indo-Aryan languages distinguish dentity-alveolar and retroflex affricates (i.e., /ts/ and /tʃ/) from plosives (i.e., /t/ and /tʃ/). The proliferation of coronal affricates (and fricatives) is most characteristic of the Dardic sub-group (Bashir 2003). However, most accounts treat the extra affricates as distinct manners of articulation, not distinct places. The focus of the current study is the statistically predominant three-way system that does not include dentity-alveolar and retroflex affricates. I briefly discuss the systems with these affricates in section 5.3.

While most descriptions treat /t/ and /ts/ as a single place of articulation, some classify the former as dental and the latter as alveolar. Nevertheless, it is doubtful that the dental/alveolar distinction is phonologically relevant given that /ts/ patterns phonologically with laminals, not apicals (most notably with palato-alveolar /ʃ/, cf., section 5.3) and that descriptions of some languages clearly state that its place of articulation can vary anywhere in the dentity-alveolar range (e.g., descriptions of Kashmiri /ts/ in Bhat (1987: 24) and Wali & Koul (1997: 296)). Cf., footnotes 3 and 12.
There is some variation in how the coronal inventories of Indo-Aryan languages are described in the literature. Consider the comparison of four different accounts of Hindi in (13). Phonemes in parentheses are those identified by the respective authors as marginal, either because they are restricted to loanwords, certain dialects or registers, or because they are in near (if not complete) complementary distribution with another segment in native vocabulary.\(^{10}\)

(13) Coronal contrasts in Hindi

<table>
<thead>
<tr>
<th></th>
<th>Dental and Alveolar</th>
<th>Retroflex</th>
<th>Palato-alveolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Ohala (1983)</td>
<td>t tʰ</td>
<td>t tʰ</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d dʰ</td>
<td>d dʰ</td>
<td></td>
</tr>
<tr>
<td></td>
<td>s (z)</td>
<td>(f) (3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>(ŋ)</td>
<td>(n)</td>
</tr>
<tr>
<td></td>
<td>r</td>
<td>t  t̊</td>
<td></td>
</tr>
<tr>
<td>b. Ohala (1994)</td>
<td>t tʰ</td>
<td>t tʰ</td>
<td>t̊ t̊ʰ</td>
</tr>
<tr>
<td></td>
<td>d dʰ</td>
<td>d dʰ</td>
<td>d̊ d̊ʰ</td>
</tr>
<tr>
<td></td>
<td>s (z)</td>
<td>(f)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>l</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>r</td>
<td>t  t̊</td>
<td></td>
</tr>
</tbody>
</table>

\(^{10}\) In Hindi, the segments /z/, /ʃ/, and /ʒ/ are generally restricted to loanwords from languages such as English, Sanskrit, and Perso-Arabic. Similarly, /s/ is restricted to Sanskrit loanwords and is pronounced only in highly Sanskritized registers. The nasals /ŋ/ and /p/ have limited distributions and occur mainly (or even exclusively for some) before homorganic stops. The retroflex flaps /t/ and /ʈ/ are in complementary distribution with the stops /d/ and /ɖ/ in native vocabulary. Contrast has been introduced only through the introduction of loanwords containing retroflex stops in the environment normally reserved for the flaps.
The descriptions in (13) serve to illustrate several points. First, the maximum number of coronal place distinctions is always maintained among the stops (cf., Ramanujan and Masica 1969: 562, Rice and Avery 1993). Secondly, some Indo-Aryan languages extend one or more coronal place contrasts to other manners of articulation, including sibilants, nasals and (occasionally) liquids. However, the phonemic status of these contrasts is often marginal outside of the stops, as in the case of Hindi (13). Thirdly, wherever a given manner of articulation lacks coronal place contrasts, it tends to have a single denti-alveolar series. Fourthly, (13) demonstrates that descriptions of the same language can refer to the laminal postalveolar series variously as palatal, alveopalatal, palato-alveolar or postalveolar. For uniformity, I adopt the term palato-alveolar throughout the paper.¹¹

---

¹¹ Nothing critical rests on the choice of the term palato-alveolar over the other options because no language contrasts more than one laminal post-alveolar coronal series (cf., footnote 2). Moreover, Hall (1997a: 10ff.) argues that all so-called palatal stops and nasals are best re-classified as alveolo-palatal cross-linguistically, and that alveolo-palataials are phonologically non-distinct from palato-alveolars.
Some comments on the denti-alveolar series are in order. Within the South Asian tradition this series is typically described as dental. Most descriptions agree that the plosives are phonetically lamino-dental, but some suggest that other manners in this series may be alveolar. This is evident in (13), where Hindi stops are consistently classified as dental (or at least as denti-alveolar in (13a)), but other manners of articulation are classified variously as dental or alveolar. Nevertheless, it is clear that no Indo-Aryan language contrasts lamino-dentals and apico-alveolars (i.e., in addition to retroflexes and palato-alveolars within the same manner series) in the way that some Australian and South Dravidian languages do (e.g., compare the inventories in (1) and (2) with the complementary pattern of dentals and alveolars in (13b, c)). For this reason, they are generally treated as a single place of articulation from a phonological point of view, and it is safe to assume that the variation exhibited by certain manners of articulation within the series is a purely phonetic phenomenon. In keeping with the South Asian tradition, I continue to refer to this series as dental with the understanding that some manners of articulation may vary from this norm, but that any variation within the denti-alveolar range is not phonologically significant. Throughout the paper I use the dental

\[ **CORONAL,** \]

As I will demonstrate in due course (see especially sections 4.1 and 4.2), dentals pattern as the unmarked coronals in Indo-Aryan. If this is so, then they may be phonologically specified only as **CORONAL**, and underspecified for coronal sub-features. In this case, their precise articulation within the denti-alveolar range may be a matter of phonetic implementation that is influenced by non-phonological factors. For instance, phonetic studies of denti-alveolar stops in various languages have noted that voiced denti-alveolars tend to have a more alveolar contact, a more apical tongue shape (i.e., a more concave shape in which the tongue tip is turned up and the tongue middle is lowered), a lower jaw position, and a shorter duration of closure relative to their voiceless counterparts (e.g., Hamann & Fuchs 2008). All of these factors facilitate the aerodynamic requirement of voicing by producing a weaker constriction and possibly
diacritic on Indo-Aryan plosives (i.e., /t/, /d/) because they are rarely (if ever) alveolar (with the exception of Asamiya), and because it will be necessary to distinguish them from apico-alveolars at certain points in the discussion. For other manners of articulation I follow the more standard practice in the South Asian literature of representing the dentals without a diacritic (i.e., /s/, /n/, /l/, etc.). This reflects the fact that they are more subject to variation and that their precise status as dental or alveolar is generally irrelevant to the discussion.

In the following sub-sections, I use phonological activity as a diagnostic to determine the phonologically relevant features of retroflex consonants in three case studies. These studies look at the behavior of retroflexes with respect to allophonic variation (3.1), loanword adaptation (3.2) and palatalization and gemination in Dhivehi (3.3). The discussion focuses primarily (but not exclusively) on the behavior of stops, since the maximum number or coronal place distinctions is maintained most clearly and consistently in that manner of articulation.

3.1 Allophonic variation of retroflexes

Retroflex consonants are typically described as post-alveolar. Nevertheless, palatographic studies of Indo-Aryan languages have revealed that there is significant intra-speaker variation in their place of articulation. This variation is conditioned by an expanded cavity behind the oral closure. If this is so, then the trend observed among denti-alveolar stops might be a broader trend related to sonority. In other words, since the more sonorant manners of articulation also need to facilitate voicing, they may favour a slightly more apico-alveolar articulation relative to the less sonorant manners. It is also worth noting that a more alveolar place of contact does not necessarily imply an apical (as opposed to laminal) tongue gesture (cf., footnote 3, Hall 1997a: 42).
vocalic context. For example, a study by Khatiwada (2007) revealed that the retroflex stops of Nepali are apical alveolar in the context of front vowels, and post-alveolar (and apical or sub-apical) only in the context of back vowels (14).

(14) Variation of retroflex /t/ in Nepali

\[
\begin{align*}
\text{mi[t]i} & \quad \text{(nonsense word)}^{13} \\
\text{mu[t]u} & \quad \text{‘heart’} \\
\text{ba[t]a} & \quad \text{‘vessel’}
\end{align*}
\]

Similar patterns of variation have been reported in other Indo-Aryan languages, suggesting that the pattern may be a widespread family trait. For instance, Dixit & Flege (1991) found that the retroflex stops of Hindi range from post-alveolar to dental, and that the degree of retroflexion decreases systematically from the context of /a/ to /u/ to /i/. Hindi dental stops, by comparison, show little or no variation based on vocalic context (Dixit 1990). The same pattern of variation has been reported in Sinhala. Gair & Paolillo (1997: 11) report that the retroflex consonants of Sinhala are “pronounced as retroflex when preceded or followed by back vowels, and as alveolar in most other environments” (cf., Karunatillake 1992: x).

It is reasonable to expect that a phonologically distinctive feature (i.e., one that is critical to the identification of a segment within a language) should be subject to less variation than one that is non-distinctive. The studies cited above reveal that the retroflex consonants of Indo-Aryan languages vary from apical to sub-apical in terms of lingual

\[\text{13} \quad \text{Although the phonological sequence /miṭṭi/ does not occur as an independent word in Nepali, it does occur as part of the colloquial word /džiṭṭi ‘all belongings’ (Khatiwada, personal communication).}\]
contact, and from dental to post-alveolar in terms of place. Both apical and sub-apical articulations fall within Hamann’s (2003) definition of apicality (see (8a)). Thus, the variation of lingual contact falls within a range that can be identified as consistently apical and [–distributed]. Retroflexes are never laminal and [+distributed]. However, when it comes to the place of contact, the range of variation is not consistent with definitions of [–anterior]. It spans the area covered by both [–anterior] and [+anterior]. This suggests that Indo-Aryan retroflexes are distinctively apical (i.e., [–distributed]), but not distinctively posterior (i.e., [–anterior]). If retroflexes were distinctively [–anterior] then we would not expect them to be articulated so regularly in the [+anterior] region. However, if they are distinctively [–distributed], then some variation in their place of articulation might be expected and phonologically irrelevant.

The allophonic variation of retroflexes also suggests that they may be [+back] at a post-lexical level. From a phonetic point of view, the retroflex phonemes are maximally retroflex and posterior only in the context of back vowels. The pattern can be explained in one of two ways. First, retroflexes might be simple apical (i.e., [–distributed]) phonemes that assimilate [+back] in the context of back vowels to yield retroflexion, but remain apical alveolar elsewhere (15). This option is noted by Gair & Paolillo (1997: 11) who suggest “the retroflex series of Sinhala might equally be considered alveolar”. Alternatively, retroflex phonemes might become [+back] by means of post-lexical phonetic enhancement. If this enhancement is blocked/inhibited in the context of [–back] vowels, then they might emerge as apical alveolars in that context. In either analysis they are distinctively [–distributed], but not [–anterior], and they take on the feature [+back] post-lexically.
It is important to note that the allophonic variation of retroflexes cannot be attributed to [±anterior]. A shift from retroflex to alveolar would require a change from [–anterior] to [+anterior] in the context of front vowels. If front vowels are [–anterior] then there is no reason why they should induce a shift toward the [+anterior] region. Alternatively, a shift from alveolar to retroflex would require a change from [+anterior] to [–anterior] in the context of back vowels. However, by most accounts, coronal features such as [±anterior] apply only to front vowels, while back vowels are DORSAL. Thus, it is not clear why back vowels would have any affect on the feature [±anterior] at all.

In summary, the evidence from allophonic variation suggests that retroflex segments in Indo-Aryan languages are distinctively apical (i.e., [–distributed]) and potentially retracted (i.e., [+back]) at a post-lexical level. It also suggests that the combination of apicality and retraction may produce posteriority (i.e., [–anterior]). However, there is nothing to suggest that the feature [–anterior] is phonologically active at any level of representation.

3.2 Loanword adaptation

Another source of evidence that bears on the phonological representation of retroflexes comes from the domain of loanword adaptation. All Indo-Aryan languages that maintain a contrast between dental and retroflex stops exhibit a consistent pattern in
their adaptation of English loanwords: the apical alveolar stops of English are always adapted as retroflex, not as dental. This is illustrated in (16) with representative examples from Hindi (e.g., Koshal 1978, Ohala 1978).

(16) | English | Hindi |
    | t → t | taxi /tæksi/ |
    | hotel | /hoṭɛl/ |
    | coat | /koṭ/ |
    | d → d̚ | doctor /dakṭər/ |
    | soda | /sodə/ |
    | pad | /pəd̚/ |

It is often argued that segmental adaptations like these are determined to a large extent by the phonological system of the borrowing language, and in particular by the contrastive features of that language (e.g., Herd 2005, Rose & Demuth 2006, Dresher 2008). If this is so, then the treatment of English alveolars provides a useful diagnostic for determining the contrastive features of Indo-Aryan coronals. Apico-alveolars have exactly one feature in common with both dentals and retroflexes. They share [+anterior] with dentals, and [–distributed] with retroflexes (see (10)). If the distinction between dentals and retroflexes were established by [±anterior] then we would expect alveolars to be adapted as dental, since both dentals and alveolars are [+anterior] (17).

(17) t ← t t | [+ant] [+ant] [–ant]
The fact that alveolars are adapted as retroflex suggests that \([±\text{distributed}]\) is the relevant feature at work. If retroflex consonants in Indo-Aryan languages are distinctively apical and \([-\text{distributed}]\), then we can expect the speakers of these languages to perceive this property in English alveolars and relate it to their own retroflex series (18).

\[
(18) \quad \begin{array}{ccc}
& & \\
\text{[+dist]} & \text{[–dist]} & \text{[–dist]}
\end{array} \quad \begin{array}{c}
\text{t} \\
\to \\
\text{t}
\end{array}
\]

The evidence from loanword adaptation is fully consistent with the evidence from allophonic variation in section 3.1. Both suggest that retroflexes are distinctively apical and \([-\text{distributed}]\), but not distinctively \([-\text{anterior}]\). The loanword pattern is also consistent with the conclusion that retroflexes are \([+\text{back}]\) only at a post-lexical level. The absence of \([+\text{back}]\) on English alveolars does not disqualify them from being interpreted as retroflex because \([+\text{back}]\) is not lexically contrastive for retroflex segments in Indo-Aryan.

3.3 Palatalization and gemination in Dhivehi

The third case study comes from Dhivehi, a lesser-known Indo-Aryan language spoken in the Maldivian islands southwest of India. Unlike most other Indo-Aryan languages (but like its closest relative, Sinhala) it lacks contrastive aspiration and has phonemic pre-nasalized stops. Even so, Dhivehi maintains the characteristic three-way coronal system that includes dental, retroflex and palato-alveolar consonants. The inventory of Dhivehi consonant phonemes is listed in (19). Note that Cain & Gair (2000) classify the rhotic /r/ as retroflex.
Cain & Gair (2000) document a phonological pattern involving palatalization and gemination in Dhivehi. When noun stems ending in /i/ are followed by a vowel-initial suffix, two interdependent phonological alternations are triggered. First, the final /i/ is retracted into the stem where it causes palatalization of a preceding segment. Secondly, the final consonant of the stem geminates. The palatalization of the stem is realized in more than one way, depending on the nature of the final consonant. Labial and velar consonants (i.e., non-coronals) are transparent to palatalization. When /i/ is retracted into the stem, it passes through labials and velars to the nucleus of the preceding syllable where it forms a diphthong with the existing vowel. This is illustrated by the examples in (20). Note that the geminate counterpart of a pre-nasalized stop is a full homorganic nasal-stop sequence ($^NC \rightarrow NC$), and the geminate counterpart of /i/ is [pp].
(20) Diphthongization with gemination (VCi+V → VjjCC+V)

<table>
<thead>
<tr>
<th>Noun</th>
<th>Noun-INDEF</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Labial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>loobi</td>
<td>looijbb-ek</td>
<td>‘love’</td>
</tr>
<tr>
<td>a&quot;mbi</td>
<td>ajmb-ek</td>
<td>‘wife’</td>
</tr>
<tr>
<td>nijami</td>
<td>nijajmm-ek</td>
<td>‘navigator’</td>
</tr>
<tr>
<td>kurafi</td>
<td>kurajpp-ek</td>
<td>‘roach’</td>
</tr>
<tr>
<td>avi</td>
<td>ajvv-ek</td>
<td>‘sunlight’</td>
</tr>
<tr>
<td>Velar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>boki</td>
<td>bojkk-ek</td>
<td>‘bulb’</td>
</tr>
<tr>
<td>buraki</td>
<td>burajkk-ek</td>
<td>‘perch (fish)’</td>
</tr>
<tr>
<td>vaagi</td>
<td>vaajgg-ek</td>
<td>‘strength’</td>
</tr>
<tr>
<td>fulja'gi</td>
<td>fulaja'ng-ek</td>
<td>‘flying fish’</td>
</tr>
</tbody>
</table>

Coronals are not transparent to palatalization. When /i/ is retracted into the stem it causes palatalization of a preceding dental consonant, as illustrated in (21).

(21) Palatalization of dentals with gemination (ti+V → tʃʃ+V) \(^{14}\)

<table>
<thead>
<tr>
<th>Noun</th>
<th>Noun-INDEF</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eṭi</td>
<td>ettʃ-ek</td>
<td>‘thing’</td>
</tr>
<tr>
<td>roḍi</td>
<td>roddʃ-ek</td>
<td>‘thread’</td>
</tr>
<tr>
<td>ḍoodi</td>
<td>ḍooddʃ-ek</td>
<td>‘ray’</td>
</tr>
<tr>
<td>ha’ḍi</td>
<td>hapdʃ-ek</td>
<td>‘bluefin trevally’</td>
</tr>
</tbody>
</table>

\(^{14}\) In the transcription I employ here, tʃʃ and dʃ represent geminate palato-alveolars, not sequences of dental + palato-alveolar.
Coronal Features and Retroflexion in Indo-Aryan Languages

\[\begin{array}{lll}
\text{fani} & \text{faŋŋ-ek} & \text{‘worm’} \\
\text{duni} & \text{dʊŋŋ-ek} & \text{‘bow’} \\
\text{ðuuni} & \text{ðuŋŋ-ek} & \text{‘bird’} \\
\text{fali} & \text{fajj-ek} & \text{‘oar’}
\end{array}\]

Palatalization and gemination are interdependent. If one is blocked, then both fail to apply. For example, when the final consonant of the stem is already geminate, and therefore incapable of further gemination, then both gemination and palatalization are blocked, as illustrated in (22). Under these conditions, the final /i/ of the stem is retained and an epenthetic /j/ glide is formed to resolve the vowel hiatus.

\[(22) \quad \text{No palatalization or gemination after geminate consonants}\]

\[
\begin{array}{cccc}
\text{Noun} & \text{Noun-INDEF} \\
\text{Labial} & nappi & nappi-j-ek & *najpp-ek & \text{‘bad food’} \\
& \text{bimbi} & \text{bimbi-j-ek} & *bijmb-ek & \text{‘millet’} \\
\text{Dental} & \text{bat} & \text{bat}i-j-ek & *batʃ-ek & \text{‘light’} \\
& \text{bud} & \text{bud}i-j-ek & *budʤ-ek & \text{‘mind’} \\
& \text{bon} & \text{bon}ti-j-ek & *bonʧ-ek & \text{‘unopened frond’} \\
& \text{dʃinni} & \text{dʃinni-j-ek} & *dʃiŋŋ-ek & \text{‘genie’} \\
& \text{kulli} & \text{kulli-j-ek} & *kujj-ek & \text{‘emergency’} \\
\text{Velar} & \text{fani} & \text{fani}j-ek & *faŋŋ-ek & \text{‘frond’}
\end{array}\]

Significantly, palatalization and gemination are also blocked when the final consonant of the stem is retroflex (23). As coronals, the retroflexes are not transparent to
palatalization; they do not allow /i/ to pass through them to the nucleus of the preceding syllable.\textsuperscript{15} However, unlike dentals, the retroflexes are incapable of being palatalized. As a result, they block palatalization and, with it, gemination.\textsuperscript{16} Once again, the final /i/ of the stem is retained and an epenthetic /j/ glide is formed to resolve the vowel hiatus.\textsuperscript{17}

(23) No palatalization or gemination after retroflex consonants

<table>
<thead>
<tr>
<th>Noun</th>
<th>Noun-INDEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retroflex</td>
<td></td>
</tr>
<tr>
<td>baḍi</td>
<td>baḍi-j-ek</td>
</tr>
<tr>
<td>faḷi</td>
<td>faḷi-j-ek</td>
</tr>
<tr>
<td>buri</td>
<td>buri-j-ek</td>
</tr>
</tbody>
</table>

\textsuperscript{15} Dhivehi has no noun stems ending in /i/ (Bruce Cain, personal communication). As a result, there are no examples of palatalization and gemination involving underlying palato-alveolar stops in the stem. Even so, I assume (along with Cain 2000) that /i/ interacts with the coronal class as a whole. This analysis predicts that if noun stems ending in /i/ were introduced they would behave like dentals (i.e., they would host the features of /i/ and would not block gemination) with the exception that they might not show any significant change in palatalization since they are already inherently palatalized.

\textsuperscript{16} Cain (2000) notes a few exceptions to the patterns in (22) and (23). One is a case of palatalization applying to an underlying ‘geminate’ NC cluster (i.e., saanṭi + ek → saanṭ-ek ‘mat-INDEF’). The other is a case of gemination without palatalization (i.e., kaṣi + ek → kaṭ-ek ‘thorn-INDEF’). However, even these exceptions conform to the most critical generalization, which is that dentals are susceptible to palatalization while retroflexes are not.

\textsuperscript{17} The behavior of retroflexes with respect to palatalization and gemination cannot be attributed to a general ban on geminate retroflexes. Dhivehi has geminate retroflexes in monomorphemic words (e.g., /vetṭun/ ‘falling’, /uḍḍun/ ‘open side up’, /selli/ ‘flea’, /sirru/ ‘secret’) and in derived contexts (e.g., [avatṭeri] < /avas + ṭeri/ ‘neighbor’, [aḍḍiha] < /aṣ + ḍiha/ ‘eighty’) (Cain & Gair 2000: 12).
Cain (2000) argues that gemination in Dhivehi can be seen as a case of compensatory lengthening that is crucially linked to the loss of stem final /i/. The stem final /i/ is deleted only if it can preserve a trace of itself via feature spreading (i.e., diphthongization or palatalization). For example, in the case of roḍi + ek ‘a thread’, the stem final /i/ is able to leave a trace of itself via palatalization of the preceding dental stop. As a result, it is freely deleted and the palatalized dental undergoes compensatory lengthening (i.e., gemination). This is sketched in (24), where the palatalized dental takes over the mora vacated by /i/ in addition to forming the onset of the following syllable.

If a trace of the vowel cannot be preserved via feature spreading, then it is retained and compensatory lengthening of the preceding consonant does not occur. This is seen in examples like baḍi-j-ek ‘a gun’ where the consonant preceding /i/ is retroflex. The retroflex blocks diphthongization and palatalization so that /i/ is not able to spread its features. As a result, the vowel is preserved and the retroflex cannot geminate. Instead, glide formation applies to form an onset with the following syllable (25).
What features are required to account for the phonological behavior of retroflexes in Dhivehi? In the remainder of this section I argue that the behavior of retroflexes can be attributed to either [±distributed] and/or [±back], but not [±anterior].

In the pattern of palatalization and gemination, labials and velars are transparent with respect to /i/, but coronals are not. Cain (2000) observes that this asymmetry can be explained if front vowels are coronal. He adopts the model of Lahiri & Evers (1991) in which front vowels are defined as CORONAL, [–anterior] and [+distributed]. In this view, labials and velars fail to host or inhibit the features of /i/ because they are non-coronal. Any features spread from /i/ pass through them to the preceding syllable where they induce diphthongization (20). Dentals and retroflexes are not transparent to /i/ because they are CORONAL. They must either host the features of /i/ or repel them.

Following Lahiri & Evers (1991), Cain suggests that the palatalization of dentals is accomplished by spreading [–anterior] from /i/ to the dental, with concomitant delinking of [+anterior]. He argues that retroflexes block palatalization because they are already [–anterior] and, therefore, incapable of hosting a second [–anterior] from the vowel. However, while Lahiri & Evers’ (1991) model makes desirable predictions about the interaction of /i/ with coronals, the feature [±anterior] is problematic. I argue that this feature predicts very different results than those suggested by Cain. The positive and negative values of binary features represent mutually exclusive and antagonistic articulatory gestures. For this reason it is often assumed that a given segment cannot be

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18 Cain (2000) rejects the possibility that [–anterior] might spread to the retroflex with vacuous effects. If features of the vowel were preserved via spreading, then we would expect vowel deletion with compensatory lengthening of the retroflex. Thus, it is crucial that the features of the vowel are repelled by the retroflex and not simply merged with it.
specified for both values of the same feature (e.g., Chomsky & Halle 1968), or if it is (as in the case of contour segments, e.g., Sagey 1986), that the two values must be implemented sequentially, not simultaneously. If this is so, then we can expect opposing values of a feature to repel one another, and identical values to be compatible. Thus, if dentals are specified as [+anterior] then we should expect them to repel the spread of [–anterior], as shown in (26a). Similarly, if retroflexes are [–anterior] then we should expect them to be fully compatible with palatalization. In other words, there is no reason why they should not absorb the feature [–anterior] from the vowel (i.e., via merger with their own [–anterior]). This would satisfy the condition of feature spreading, allowing /i/ to delete and the retroflex to geminate, as shown in (26b).

(26) a.\[\begin{array}{cc}
t & i \\
\text{COR} & \text{COR} \\
{\text{[+ant]} & {\text{[–ant]}}}
\end{array}\] \[\begin{array}{cc}
*\text{t} & i \\
\text{COR} & \text{COR} \\
{\text{[+ant]} & \text{[–ant]}}
\end{array}\]

b.\[\begin{array}{cc}
t & i \\
\text{COR} & \text{COR} \\
{\text{[–ant]} & \text{[–ant]}}
\end{array}\] \[\begin{array}{cc}
*\text{t} & \text{i} \\
\text{COR} \\
{[\text{–ant}]} \\
{[\text{–ant}]}
\end{array}\]

The feature [–anterior] is problematic for Dhivehi because it predicts (erroneously) that retroflexes should form a natural class with palato-alveolars and front vowels. The feature [±distributed] makes much better predictions about the behavior of retroflexes in this language because it predicts a natural class that includes dentals, palato-alveolars and front vowels (all of which are [+distributed]), but excludes retroflexes (which are [–distributed]). The feature [+distributed] can spread from a front vowel to a dental because dentals are either (i) specified for the same feature, or (ii)
unmarked and underspecified for [+distributed] (27a).\textsuperscript{19} Retroflexes repel [+distributed] because they are distinctively [–distributed] (27b). Notice, however, that the spreading of [+distributed] alone is not sufficient to account for the palatalization of dentals because dentals are already [+distributed] (either distinctively or redundantly). Thus, in this analysis, palatalization must involve the spreading of [+distributed] along with some other feature(s). I tentatively represent this with [P] (for ‘palatalization’) in (27), and return to this issue again below.

\begin{align*}
(27) \quad &a. \quad \begin{array}{c|c|c}
\text{COR} & \text{i} & \text{COR} \\
\text{COR} & \text{COR} & \text{COR} \\
\text{[+dist]} & \text{[+dist]} & \text{[+dist]} \\
\text{[P]} & \text{[P]} &
\end{array} \\
\text{b.} \quad \begin{array}{c|c|c}
\text{COR} & \text{i} & \text{COR} \\
\text{COR} & \text{COR} & \text{COR} \\
\text{[–dist]} & \text{[+dist]} & \text{[–dist]} \quad \text{[+dist]} \\
\text{[P]} & \text{[P]} &
\end{array}
\end{align*}

\textsuperscript{19} The feature [+distributed] makes the right predictions with respect to palatalization in Dhivehi regardless of whether it is specified or underspecified on dentals. However, later I present evidence that [+distributed] might be unmarked in relation to [–distributed], and underspecified on dentals in Indo-Aryan languages. Evidence for this comes from patterns of coronal assimilation in which dentals are always the targets of assimilation, never the triggers (see the discussion of Sanskrit coronal assimilation in section 4.1). This kind of asymmetry is often attributed to unmarked features and/or underspecification (Rice 2007). This pattern is also evident in Dhivehi, where dentals are not only subject to palatalization, but also assimilate to retroflexes (e.g., /avəʃ + əri/ → [avəʃəɾi] ‘neighbor’, /aʃ + d̪iha/ → [aʤd̪iha] ‘eighty’) (Cain & Gair 2000: 12).
The feature [±back] is also capable of explaining the behavior of retroflexes because it predicts a natural class that includes palato-alveolars and front vowels (both [–back]) but not retroflexes (i.e., [+back]). If (i) [–back] is the palatalization feature (e.g., Hall 1997a), and (ii) retroflexes are [+back] (e.g., Lin 1989, Hamann 2003, etc.), and (iii) these features can be CORONAL or DORSAL dependents (e.g., Gnanadesikan 1994, Hall 1997a), then the vowel /i/ might attempt to spread [–back] to other coronals. In this analysis, dentals are susceptible to palatalization because they have no inherent tongue body features. The addition of [–back] to a dental yields a palato-alveolar (28a). Retroflexes repel [–back] because they are [+back] (28b).

(28) a. \[
\begin{array}{c}
t \\
COR \hspace{1cm} COR \hspace{1cm} COR
\end{array} \\
\begin{array}{c}
i \\
\hspace{1cm} \text{[–back]} \hspace{1cm} \text{[–back]}
\end{array}
\]

b. \[
\begin{array}{c}	t \\
COR \hspace{1cm} COR \hspace{1cm} COR
\end{array} \\
\begin{array}{c}
\text{\textbackslash} \hspace{1cm} \text{\textbackslash} \\
\text{[+back]} \hspace{1cm} \text{[–back]} \hspace{1cm} \text{[+back]} \hspace{1cm} \text{[–back]}
\end{array}
\]

In summary, the phonological behavior of retroflexes in Dhivehi might be attributed to the feature [±distributed] and/or [±back], but not [±anterior]. Minimally, this means that [–anterior] is not a distinctive feature of retroflexes in this language. Since the behavior of retroflexes is consistent with either [–distributed] and/or [+back], it is difficult to determine on the basis of internal evidence alone whether one or both of these features are active in the language. In light of the evidence from allophonic variation and loanword adaptation in other Indo-Aryan languages (sections 3.1 and 3.2), I argue that it is best to attribute the behavior of retroflexes in Dhivehi to the feature [±distributed].
Thus, palatalization involves the spreading of [+distributed], and retroflexes block palatalization because they are distinctively [–distributed], as sketched in (27).

As noted earlier, the feature [+distributed] alone is not sufficient to distinguish palato-alveolars from dentals. Thus, palatalization must involve the spreading of [+distributed] along with some other feature. Stated differently, palato-alveolars and front vowels must share some ‘palatalization’ feature not shared by dentals. This was tentatively represented with [P] in (27). The precise nature of this feature is underdetermined by the Dhivehi data, and might be [–anterior] or [–back]. If we accept [–anterior] as the palatalization feature, then at the very least we must assume that this feature is subordinate to [±distributed] and plays no role in the phonological behavior of retroflexes in Dhivehi. I suggest that [–back] is a better candidate for the palatalization feature because there is positive evidence from allophonic variation (section 3.1) that [±back] is active in the post-lexical phonology of Indo-Aryan languages, but there is nothing that requires [±anterior] at any level of representation.

Drawing on the combined evidence from allophonic variation (section 3.1), loanword adaptation (section 3.2) and palatalization in Dhivehi (section 3.3), I propose the features in (29) for Indo-Aryan retroflexes and other coronals. Features in parentheses might be unmarked and/or non-contrastive.
CORONAL FEATURES AND RETROFLEXION IN INDO-ARYAN LANGUAGES

(29) Proposed coronal place features for Indo-Aryan languages

<table>
<thead>
<tr>
<th></th>
<th>Dental</th>
<th>Retroflex</th>
<th>Palato-Alveolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORONAL</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>[distributed]</td>
<td>(+)</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>[back]</td>
<td>(+)</td>
<td>−</td>
<td>(35)</td>
</tr>
</tbody>
</table>

In the following section I examine some additional case studies from Indo-Aryan languages that appear to support the feature [–anterior] on retroflexes, or raise doubts about the features [–distributed] and [+back]. In each case I demonstrate that there is no positive evidence for [–anterior], and that the phonological behavior of retroflexes and other coronals is fully consistent with the representations in (29).

4. Apparent counterexamples

The evidence surveyed thus far indicates that retroflexes in Indo-Aryan languages are distinctively [–distributed], and potentially [+back] in the post-lexical phonology. The behavior of retroflexes does not support the feature [–anterior] at any level of representation. However, Hall (1997a: 45–46) has argued that at least two Indo-Aryan languages, Sanskrit and Gujarati, provide evidence for the feature [–anterior] and the natural class it predicts. In these examples, retroflexes and palato-alveolars appear to pattern as a class of posterior (i.e., [–anterior]) coronals. In the following sections I re-examine these cases and argue that the parallel behavior of palato-alveolars and retroflexes is a product of their relative markedness within the coronal class, and not the product of a shared articulatory feature such as [–anterior].
4.1 Coronal assimilation in Sanskrit

The first potential counterexample to the claim that Indo-Aryan retroflexes are not phonologically [-anterior] comes from Sanskrit, an Old Indo-Aryan language with the consonant system in (30).

(30) Sanskrit consonant phonemes (Cardona 2003)

<table>
<thead>
<tr>
<th>LABIAL</th>
<th>DENTAL</th>
<th>RETROFLEX</th>
<th>PALATO-ALV</th>
<th>VELAR</th>
<th>GLOTTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>pʰ</td>
<td>tʰ</td>
<td>tʰ</td>
<td>tʃʰ</td>
<td>k kʰ</td>
</tr>
<tr>
<td>b</td>
<td>bʱ</td>
<td>dʱ</td>
<td>dʱ</td>
<td>dʃʱ</td>
<td>g gʱ</td>
</tr>
<tr>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>h̥</td>
</tr>
<tr>
<td>m</td>
<td>n</td>
<td>n̥</td>
<td>n̥</td>
<td>n̥</td>
<td>j̥</td>
</tr>
<tr>
<td>r</td>
<td>l</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sanskrit has a process of coronal assimilation in which dentals assimilate to retroflexes and palato-alveolars (31–32) (e.g., Whitney 1967 [1889]: 66-68, Hall 1997a: 80-81).

(31) \( \text{t, n, s } \rightarrow \text{t, n, s} / \_ \_ \) retroflex

\( \rightarrow \text{tʃ, n, s} / \_ \_ \) palato-alveolar

\( 20 \) Once again, in (32) the transcription /tʃ/ represents a geminate palato-alveolar, not a sequence of dental + palato-alveolar. Note that voicing assimilation also applies between adjacent stops.
CORONAL FEATURES AND RETROFLEXION IN INDO-ARYAN LANGUAGES

There are two points to note about this process. First, dentals assimilate to other coronals, but not to non-coronals, as illustrated by the examples in (33).

(33)  
\[
\begin{align*}
\text{mañ} + b^6\text{ ağ} & \rightarrow \text{mañ}b^6\text{ ağ } & \text{‘illustrious’} \\
\text{mañ} + \text{kavih} & \rightarrow \text{mañkavih} & \text{‘great poet’}
\end{align*}
\]

Secondly, although the process is restricted to coronals, it does not target all coronals equally. Dentals are always the target of assimilation, and never the trigger, while retroflexes and palato-alveolars are always the trigger, but never the target. Thus, the rule is both regressive and progressive, so that dentals are targeted regardless of whether they precede or follow retroflexes and palato-alveolars (at least word-internally). Some examples of progressive assimilation involving retroflexes are shown in (34). Examples involving palato-alveolars are rare but do occur in words such as \textit{raḍṇaru}, the instrumental singular form of \textit{raḍṇan}- ‘king’ (cf., \textit{naṃna}, instrumental singular of \textit{naṃn}- ‘name’) (Whitney 1967 [1889]: 68, Stenzler 1997: 12).
CORONAL FEATURES AND RETROFLEXION IN INDO-ARYAN LANGUAGES

(34) \[i:\text{	exttt{d}} + \text{	exttt{te}} \rightarrow i:\text{	exttt{t}}\text{	exttt{e}}\] ‘he worships’

\[i:\text{	exttt{s}} + \text{	exttt{\texttt{a}}-} \rightarrow i:\text{	exttt{\texttt{s}}\texttt{a}-}\] ‘desired’

According to Hall (1997a) Sanskrit coronal assimilation involves the spreading of
[–anterior] from retroflexes and palato-alveolars to dentals. He sketches the rule in (35).

(35) Coronal assimilation according to Hall (1997a: 81)

\[
\begin{array}{c|c}
\text{PLACE} & \text{PLACE} \\
\hline
\text{COR} & \text{COR} \\
\hline
\text{[–ant]} \\
\end{array}
\]

In this analysis, coronal assimilation is accomplished by spreading the coronal
node, not the place node. This accounts for the fact that the assimilation takes place
among coronals, but not between coronals and non-coronals. Hall accounts for the
asymmetry between dentals and other coronals by suggesting that the rule is triggered by
the presence of [–anterior]. Dentals fail to trigger the rule because they are [+anterior].

On the surface of things, Sanskrit coronal assimilation appears to make crucial
reference to the feature [–anterior]. However, a closer examination reveals that the
feature [–anterior] is not required to account for either (i) the derivation of palato-
alveolars and retroflexes from dentals, or (ii) the asymmetry between dentals and other
coronals. First, it is important to notice that the spreading of [–anterior] alone, or any
individual coronal feature, is not sufficient to derive both palato-alveolars and retroflexes
from dentals. Thus, as Hall suggests, the rule must spread the entire coronal node along
with all of its dependent features. As a result it does not provide positive evidence for the
phonological activity of any feature apart from CORONAL. As long as CORONAL spreads, taking all of its dependents with it, then any set of coronal sub-features will suffice to derive retroflexes and palato-alveolars from dentals, including [±distributed] and [±back], a set that does not include [±anterior] (e.g., see (37) below).

Secondly, the feature [–anterior] is not required to explain the asymmetry between dentals and other coronals. Asymmetries like these find a more natural explanation in theories of markedness. If phonologically marked segments are characterized by the presence of feature structure, while unmarked segments are characterized by the absence of some feature structure (e.g., Avery & Rice 1989), then asymmetries like that in Sanskrit follow quite naturally. Marked segments are expected to serve as triggers of assimilation because they have feature structure to spread. Unmarked segments are expected to serve as targets of assimilation because they lack feature structure. They can receive features via spreading, but they have no features to give (e.g., Rice 2007).

Taking the target/trigger asymmetry as a diagnostic for markedness, the evidence suggests that Sanskrit dentals are unmarked in relation to other coronals. If this is so, then they might be specified only as CORONAL and underspecified for all other coronal features. If retroflexes and palato-alveolars are marked in relation to dentals, then we can expect them to be contrastively specified for at least some coronal sub-features. In this way, we can predict the pattern of assimilation without stipulating a particular feature or value as the trigger. No matter what set of coronal features we assume, dentals will assimilate to retroflexes and palato-alveolars because segments with coronal sub-features will always spread them to segments without. Thus, the rule of coronal assimilation in Sanskrit can be formulated as in (36), where [±F] represents any coronal sub-feature.
Coronal assimilation without $[\pm \text{anterior}]$²¹

\[
\begin{array}{c}
\text{PLACE} \quad \text{PLACE} \\
\uparrow \\
\text{COR} \quad \text{COR} \\
\downarrow \\
[\pm F]
\end{array}
\]

The rule in (36) indicates that when two coronal segments are adjacent, then the one with dependents (i.e., the marked segment) will spread its entire coronal node to the one without. This rule relies only on general principles of structural markedness and does not require the stipulation of a specific triggering feature or feature value. Thus, it is consistent with any set of coronal features. This point can be illustrated by assuming the representations proposed in (29), where dentals are underspecified for coronal sub-features, retroflexes are distinctively $[-\text{distributed}]$, and palato-alveolars are both $[+\text{distributed}]$ and $[-\text{back}]$. The derivations in (37) demonstrate that this analysis predicts the right results without reference to $[\pm \text{anterior}]$.

²¹ This formulation of the rule is modeled after that of Hall (1997a: 81), which was presented in (35). Alternatively, the rule might be formulated as in (i).

\[
\begin{array}{c}
\text{COR} \quad \text{COR} \\
\downarrow \\
[\pm F]
\end{array}
\]

In (i) the coronal sub-features spread, but not the CORONAL node itself. Either formulation of the rule is consistent with the claims of the current analysis. I prefer (36) only because it serves to further distinguish coronal assimilation from the rule of Merger in Gujarati, which is presented in (45). The Gujarati rule involves the merging of coronal sub-features. By analogy, the rule of coronal assimilation in (36) can be seen as the merging of CORONAL nodes.
In summary, the evidence from Sanskrit coronal assimilation does not provide positive evidence for the phonological activity of any coronal feature apart from \textit{CORONAL}. Since the rule requires complete assimilation of all coronal features (and not just one particular feature), it is consistent with just about any set of coronal features. Moreover, the asymmetry between dentals and other coronals indicates that dentals are the unmarked (or least marked) coronal. The parallel behavior of retroflexes and palato-alveolars is a product of their relative markedness in relation to dentals, and not the result of a shared articulatory feature such as [–anterior]. Thus, there is nothing that requires the feature [±anterior] to be phonologically active in the representation of retroflexes or any other coronal. The pattern of coronal assimilation is fully compatible with the representations based on [±distributed] and [±back] that were motivated by evidence from other Indo-Aryan languages.

It is worth noting that the pattern of coronal assimilation exhibited in Sanskrit has also been reported in other Indo-Aryan languages such as Panjabi (e.g., Malik 1995: 127–
128) and in languages as genetically diverse as Polish (a Slavic language, e.g., Jarmasz 2008) and Telugu (a Dravidian language, e.g., Gilbert 1991). In all of these cases, dentals are the targets of coronal assimilation, but not the triggers. This suggests that the status of dentals as the unmarked coronal may not be an isolated property of Sanskrit, but a broader cross-linguistic trend.

4.2 Sibilant neutralization in Gujarati

The diachronic development of sibilants in Gujarati presents another potential counterexample to the claim that [–anterior] is not phonologically relevant for retroflexes in Indo-Aryan languages. Old Indo-Aryan (OIA, represented by Sanskrit) distinguished three coronal sibilants: dental, retroflex, and palato-alveolar. This three-way contrast has been reduced to a two-way contrast in the standard dialect of modern Gujarati (38).

(38) Inventory of sibilants in Old Indo-Aryan and Gujarati

<table>
<thead>
<tr>
<th>Dental</th>
<th>Retroflex</th>
<th>Palato-alveolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanskrit (OIA)</td>
<td>s</td>
<td>§</td>
</tr>
<tr>
<td>Gujarati</td>
<td>s</td>
<td></td>
</tr>
</tbody>
</table>

Diachronically, the three-way contrast of OIA was completely neutralized to dental /s/ in most Middle Indo-Aryan (MIA) dialects (Masica 1991: 168). In Gujarati, however, complete neutralization only occurred before back vowels (39). Before front vowels and glides, retroflex sibilants became palato-alveolar (40), and palato-alveolars remained unaffected (41). Dentals remained dental in all environments (i.e., before back and front vowels) (42). This last point is significant because it suggests that the palato-
alveolars of Gujarati derive directly from OIA palato-alveolars and retroflexes and not via neutralization to dentals with subsequent palatalization (Pandit 1954, Hall 1996).²²

(39) $ʃ, ʂ \rightarrow s / ___ back vowels and the labial approximant /v/.

<table>
<thead>
<tr>
<th>Sanskrit</th>
<th>Gujarati</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ʃaṭaṭi</td>
<td>saṛvū</td>
<td>‘to rot’</td>
</tr>
<tr>
<td>ʃunḍaː</td>
<td>sūḍlo</td>
<td>‘basket’</td>
</tr>
<tr>
<td>aḍarʃaḥ</td>
<td>aṛso</td>
<td>‘mirror’</td>
</tr>
<tr>
<td>ʃvasaḥ</td>
<td>saːs</td>
<td>‘breath’</td>
</tr>
<tr>
<td>maṃsa</td>
<td>maːso</td>
<td>‘measure of weight’</td>
</tr>
</tbody>
</table>

²² For example, based on the data in (39) to (41), it could be argued that the OIA sibilants were completely neutralized to dental /s/ in all environments in MIA, and that the palato-alveolar sibilants of Gujarati developed at a later stage via a rule of palatalization, as sketched in (ii).

(ii) OIA MIA Gujarati
$ʃ, ʂ, ʃ \rightarrow s \rightarrow ʃ$ before front vowels and glides
$\rightarrow s$ elsewhere

However, the fact that OIA dentals remained dental in (42), and did not become palatalized, suggests that the Gujarati palato-alveolars were not derived from dentals. Rather, they derive directly from OIA palato-alveolars and retroflexes without an intermediate dental stage. Thus, neutralization did not occur in all environments, but only before back vowels, and the changes described in (ii) are inaccurate for Gujarati (Pandit 1954, Masica 1991: 200, Hall 1996).
(40)  § → ş / ___ front vowels and glides.

<table>
<thead>
<tr>
<th>Sanskrit</th>
<th>Gujarati</th>
</tr>
</thead>
<tbody>
<tr>
<td>दुष्का:</td>
<td>दुष्की:</td>
</tr>
<tr>
<td>‘astrologer’</td>
<td></td>
</tr>
<tr>
<td>दुष्ना</td>
<td>दुष्नी:</td>
</tr>
<tr>
<td>‘surname’</td>
<td></td>
</tr>
<tr>
<td>माशि:</td>
<td>मेश</td>
</tr>
<tr>
<td>‘lamp-black’</td>
<td></td>
</tr>
</tbody>
</table>

(41)  ş → š / ___ front vowels

<table>
<thead>
<tr>
<th>Sanskrit</th>
<th>Gujarati</th>
</tr>
</thead>
<tbody>
<tr>
<td>शुका:</td>
<td>शुक़ह</td>
</tr>
<tr>
<td>‘advice’</td>
<td></td>
</tr>
<tr>
<td>शिताका:लह</td>
<td>शिताक़ो</td>
</tr>
<tr>
<td>‘winter’</td>
<td></td>
</tr>
<tr>
<td>शिर्शम</td>
<td>शिरश</td>
</tr>
<tr>
<td>‘head’</td>
<td></td>
</tr>
<tr>
<td>श्रेष्ठी:</td>
<td>श्रेष्ठह</td>
</tr>
<tr>
<td>‘merchant’</td>
<td></td>
</tr>
</tbody>
</table>

(42)  s → s / all environments (i.e., before front or back vowels)

<table>
<thead>
<tr>
<th>Sanskrit</th>
<th>Gujarati</th>
</tr>
</thead>
<tbody>
<tr>
<td>सम्बराटे</td>
<td>सम्बरणी:</td>
</tr>
<tr>
<td>‘broom stick’</td>
<td></td>
</tr>
<tr>
<td>सिन्दुराम</td>
<td>सिन्दुर</td>
</tr>
<tr>
<td>‘red lead powder’</td>
<td></td>
</tr>
<tr>
<td>सेद्बाति</td>
<td>सिद्धारवु</td>
</tr>
<tr>
<td>‘to depart’</td>
<td></td>
</tr>
<tr>
<td>वासिता</td>
<td>वासि:</td>
</tr>
<tr>
<td>‘stale’</td>
<td></td>
</tr>
</tbody>
</table>

The sound changes affecting Gujarati sibilants are summarized by the two informal rules in (43) (from Hall 1996: 15).
Hall (1997a: 45–46) has argued that the phonological patterns in (43) provide evidence in favour of [−anterior] and the natural class it predicts. Admittedly, if there were evidence in support of [−anterior], then this would be it. The pattern of assimilation in (43a) appears to be confined to the class of [−anterior] segments (i.e., retroflexes and palato-alveolars), while the pattern of neutralization in (43b) appears to apply exclusively to this class. However, as in the case of Sanskrit coronal assimilation (section 4.1), these phonological patterns can be attributed to effects of markedness within the coronal class, and do not require reference to [±anterior]. The analysis that I propose below is modeled closely after the one proposed by Hall himself (in his 1996 paper) with the exception that I generalize his rules to apply to any or all coronal sub-features and I use the feature [±back] in place of [±anterior].

Neutralization is often taken as another diagnostic for markedness. According to this view, neutralization results from the loss of feature structure. The loss of features entails the loss of phonemic distinctions and the emergence of unmarked (or less marked) representations. Thus, marked segments are expected to be the targets of neutralization, while unmarked segments are expected to be the outputs of neutralization (e.g., Rice 2007). With this diagnostic in mind, observe that wherever complete neutralization occurs in Gujarati (i.e., everywhere except before front vowels and glides) the targets are retroflexes and palato-alveolars and the output is dental. By implication, therefore, retroflexes and palato-alveolars must be marked within the coronal class (i.e., they must be specified for at least some coronal sub-features), while dentals must be unmarked and
underspecified for coronal sub-features. This conclusion was independently motivated for Indo-Aryan languages by patterns of coronal assimilation (section 4.1). It is also corroborated by evidence from non-standard dialects of Gujarati. These dialects have carried sibilant neutralization even further so that they have a single dental sibilant that occurs in all environments (Mistry 1997: 657–58).23

Since the evidence from Gujarati indicates that dentals are the unmarked coronals, I assume the same feature representations adopted earlier, in which dentals are CORONAL but are not distinctively specified for any coronal sub-features. Retroflexes are distinctively [–distributed] and palato-alveolars are [+distributed]. I also adopt the analysis of palato-alveolars and front vowels that was proposed for Dhivehi (section 3.3). In addition to CORONAL and [+distributed] they both bear a palatalization feature, which I take to be [–back] (following Hall 1997a). Back vowels are DORSAL. These representations are summarized in (44) where features in parentheses are unmarked and/or non-contrastive and phonologically inert.

(44) Proposed coronal feature specifications

<table>
<thead>
<tr>
<th></th>
<th>s</th>
<th>s</th>
<th>j</th>
<th>i, e</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORONAL [distributed]</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>[back]</td>
<td>(+)</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>(+)</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
</tbody>
</table>

23 Some dialects of Gujarati reduce dental s even further to h (Mistry 1997: 658). This can also be attributed to neutralization and feature loss. In this case, the sibilant looses not only coronal sub-features but also CORONAL itself and possibly all oral place features.
The diachronic developments in Gujarati can be explained by two rules: Merger (45) and Neutralization (46).\(^{24}\)

(45)  Merger (cf., Hall 1996: 18)

\[
\begin{array}{c}
\text{COR} \\
\downarrow \\
[\pm F]
\end{array}
\quad
\begin{array}{c}
\text{COR} \\
\downarrow \\
[\pm F]
\end{array}
\]

(46)  Neutralization (cf., Hall 1996: 17)

\[
\begin{array}{c}
\text{COR} \\
\downarrow \\
[\pm F]
\end{array}
\]

According to the rule of Merger, a sequence of two adjacent coronals bearing any value of the same coronal sub-feature \([\pm F]\) will merge their sub-features. This is accomplished by spreading the triggering sub-feature from the second coronal to the first along with any other additional coronal dependents that it might have. Merger is triggered by retroflexes and palato-alveolars before front vowels because all of these segments are CORONAL and specified for some value of the feature \([\pm \text{distributed}]\). It does not apply to dental sibilants because these are unmarked for \([+\text{distributed}]\) (47a). Nor is it triggered by back vowels since they are DORSAL. The rule effectively converts retroflexes into palato-alveolars by spreading \([+\text{distributed}]\) from the vowel along with \([–\text{back}]\) (47b). It applies

\(^{24}\) The rules in (45) and (46) are simplified to show only the relevant place features. I assume, as Hall (1996) does, that a more complete formulation of the rules would include a manner feature, such as \([+\text{continuant}]\), in order to restrict the rules to sibilants.
to palato-alveolars with no visible effect since they are [+distributed] and [−back] to begin with (47c).

\[(47)\]

\[a. \quad \text{merger}\]

\[
\begin{array}{c}
\text{COR} \\
\text{COR} \\
\text{[+dist]} \\
\text{[−back]}
\end{array}
\]

\[b. \quad \text{merger}\]

\[
\begin{array}{c}
\text{COR} \\
\text{COR} \\
\text{[−dist]} \\
\text{[+dist]} \\
\text{[−back]}
\end{array}
\]

\[c. \quad \text{merger}\]

\[
\begin{array}{c}
\text{COR} \\
\text{COR} \\
\text{[+dist]} \\
\text{[+dist]} \\
\text{[−back]} \\
\text{[−back]}
\end{array}
\]

The rule of Neutralization in (46) predicts that coronal sibilants with sub-features will lose those sub-features whenever possible. Since retroflex and palato-alveolar sibilants are both distinctively specified for coronal sub-features, they are both affected by the rule. The loss of all coronal sub-features yields a sibilant that is specified only as CORONAL. Since this is the phonological representation of dentals, the output of neutralization is a dental sibilant.

Merger blocks Neutralization in the context of front vowels. Notice that the output of Merger is a structure in which two adjacent coronal nodes are linked to the same set of sub-features (47b–c). The rule of Neutralization does not apply to linked
structures such as these (Hall 1996). Since back vowels are DORSAL, not CORONAL, Merger does not apply before back vowels and no linked structure is created. This leaves Neutralization free to apply in these contexts. Thus, Merger blocks Neutralization before front vowels, effectively restricting it to back vowel contexts. The application of both rules is sketched in (48), where Merger takes precedence over Neutralization.

(48) a. § i \[\text{Neutralization}\] \\
\begin{array}{c}
\text{COR}\quad \text{COR}
\end{array}
\quad \rightarrow \quad \begin{array}{c}
\text{COR}\quad \text{COR}
\end{array}
\quad \downarrow
\begin{array}{c}
[-\text{dist}]\quad [+\text{dist}]
\end{array}
\quad \rightarrow
\begin{array}{c}
\text{COR}\quad \text{COR}
\end{array}
\quad \downarrow
\begin{array}{c}
[-\text{back}]
\end{array}

b. § i \[\text{Neutralization}\] \\
\begin{array}{c}
\text{COR}\quad \text{COR}
\end{array}
\quad \rightarrow \quad \begin{array}{c}
\text{COR}\quad \text{COR}
\end{array}
\quad \downarrow
\begin{array}{c}
[+\text{dist}]\quad [+\text{dist}]
\end{array}
\quad \rightarrow
\begin{array}{c}
\text{COR}\quad \text{COR}
\end{array}
\quad \downarrow
\begin{array}{c}
[-\text{back}]\quad [-\text{back}]
\end{array}

c. § a \[\text{Merger}\] \\
\begin{array}{c}
\text{COR}\quad \text{DOR}
\end{array}
\quad \rightarrow \quad \begin{array}{c}
\text{COR}\quad \text{DOR}
\end{array}
\quad \downarrow
\begin{array}{c}
[-\text{dist}]
\end{array}
\quad \rightarrow
\begin{array}{c}
\text{COR}\quad \text{DOR}
\end{array}
\quad \downarrow
\begin{array}{c}
[-\text{dist}]
\end{array}

d. § a \[\text{Merger}\] \\
\begin{array}{c}
\text{COR}\quad \text{DOR}
\end{array}
\quad \rightarrow \quad \begin{array}{c}
\text{COR}\quad \text{DOR}
\end{array}
\quad \downarrow
\begin{array}{c}
[+\text{dist}]
\end{array}
\quad \rightarrow
\begin{array}{c}
\text{COR}\quad \text{DOR}
\end{array}
\quad \downarrow
\begin{array}{c}
[+\text{dist}]
\end{array}

The analysis sketched here is essentially the same as the one proposed by Hall (1996) with the exception that it is generalized to apply to any coronal sub-feature, and
makes no reference to [±anterior]. This serves to highlight the point that Gujarati sibilant neutralization does not provide positive evidence for [±anterior], or any other coronal sub-feature for that matter. It also confirms Hall’s own observation that, “neither the choice of features, nor the nature of their hierarchical relationship” affects the analysis (1996: 18). As in the case of Sanskrit coronal assimilation (section 4.1), the patterning of retroflexes with palato-alveolars is not the result of an articulatory feature such as [–anterior], but a product of markedness within the coronal class. Both rules target coronals with dependent features. As a result, both apply to retroflexes and palato-alveolars but not to dentals.

In summary, neither coronal assimilation in Sanskrit (section 4.1) nor sibilant neutralization in Gujarati (section 4.2) provides positive evidence for the phonological activity of [±anterior] in Indo-Aryan. The behavior of retroflexes and other coronals in these examples is consistent with the phonological activity of [±distributed] and [±back], for which there is independent evidence in other Indo-Aryan languages. In the following sub-section, I consider one more apparent counterexample to this claim.

4.3 The ‘ruki’ rule in Sanskrit

The Sanskrit ruki rule presents a potential challenge for the claim that retroflexes are distinctively [–distributed], and [+back] post-lexically. The rule states that dental sibilants become retroflex when they occur after any of the segments r, u, k, or i (or any of their alternants, including syllabic r) (e.g., Whitney 1967 [1889]: 61–64, Zwicky 1970). For example, the locative plural suffix -su shows retroflexion in the ruki environment (50b) but not elsewhere (50a).
CORONAL FEATURES AND RETROFLEXION IN INDO-ARYAN LANGUAGES

(49) \( s \rightarrow \mathfrak{s} \) / r, u, k, i 

(50) a. \( \mathfrak{d} \mathfrak{a}:-\mathfrak{s} \mathfrak{u} \) ‘progeny’

mar\( \mathfrak{u}t\)\( -\mathfrak{s} \mathfrak{u} \) ‘wind’

ap\( -\mathfrak{s} \mathfrak{u} \) ‘water’

b. \( \mathfrak{v} \mathfrak{a}\mathfrak{r}t \)\( -\mathfrak{s} \mathfrak{u} \) ‘sister’

\( \mathfrak{f} \mathfrak{a}\mathfrak{t} \mathfrak{r} \)\( -\mathfrak{s} \mathfrak{u} \) ‘enemy’

\( \mathfrak{u} \mathfrak{a} \mathfrak{k} \)\( -\mathfrak{s} \mathfrak{u} \) ‘voice’

\( \mathfrak{a} \mathfrak{g} \mathfrak{n} \)\( -\mathfrak{s} \mathfrak{u} \) ‘fire’

The ruki rule presents a challenge to the proposed analysis because it induces retroflexion in both back and front vowel contexts. If retroflexes are \([-\text{distributed}]\) and \([+\text{back}]\), then they should not be conditioned by front vowels, which are \([+\text{distributed}]\) and \([-\text{back}]\). The rule, as stated in (49), is not only problematic for the proposed analysis, but for phonological feature theory in general. It is not clear that any feature, or reasonable set of features, could possibly unite the segments r, u, k and i in a natural class and at the same time link them to retroflexion (e.g., Zwicky 1970, Vennemann 1974). The apparent challenges of the ruki rule disappear once we recognize that it does not represent a single, homogenous phonological process in the synchronic grammar of classical Sanskrit. Rather, it stems from the conflation of more than one rule through a process of historical merger. This conclusion is supported by evidence from a variety of domains including comparative and historical linguistics, phonetic studies and cross-linguistic typological generalizations.
To begin with, evidence from historical and comparative linguistics has established that the *ruki* rule is not primarily a synchronic rule of classical Sanskrit. Rather, it is a diachronic rule that operated on Indo-European (IE) *s. The effects of the rule can be traced in several branches of Indo-European, including Balto-Slavic, Iranian (i.e., Avestan and Old Persian) and Old Indo-Aryan (i.e., Sanskrit). Significantly, Old Indo-Aryan is the only branch in which the *ruki* environment ultimately produced retroflexes from IE *s. In other languages, the same *ruki* environment produced very different results, ranging from palato-alveolar sibilants in Baltic and Iranian to velar fricatives in Slavic (e.g., Anderson 1968, Sussex & Cubberley 2006: 23–24, Hall 1997b).

These observations have led many to conclude that, collectively, the ruki class never produced a uniform output, but produced a range of different outputs that were subsequently merged in different ways within the various branches of Indo-European. In other words, it is not the case that *r, u, k* and *i* all induced retroflexion of IE *s. Rather, each of these segments likely induced a different allophonic variation of *s*, and these allophones were ultimately collapsed to form a single new phonemic category within each language family: velar /x/ in Slavic, palato-alveolar /ʃ/ in Baltic and Iranian, and retroflex /ʂ/ in Old Indo-Aryan. This hypothesis has been put forward, in one form or another, by Morgenstierne (1929), Allen (1951: 941, 1954), Vennemann (1974), Flemming (1997) and Hamann (2003). Each account differs in the details, but all agree that the *ruki* environment originally produced more than one distinct output. Some of the proposals are summarized in (51).
Most accounts also agree that the basis for the historical merger of the various outputs was not a shared articulatory feature (such as [–anterior]), but the perceptual similarity of postalveolar fricatives. In other words, the merger was not accomplished because postalveolar fricatives share some articulatory property. On the contrary, fricatives such as [ʃ] and [ʂ] are quite distinct in terms of articulatory properties. Palato-alveolars are laminal with a fronted and raised tongue body while retroflexes are apical with a retracted tongue body. In spite of these articulatory differences, postalveolar fricatives are acoustically and perceptually similar. They are all characterized by lower frequency noise relative to denti-alveolar sibilants, and this acoustic/perceptual similarity was the basis for merger (e.g., Vennemann 1974, Flemming 1997, Hamann 2003). The end result of merger in each family was probably determined by system-internal factors, such as previously established processes and categories (e.g., Allen 1954: 654–55). The acoustic/perceptual basis of the merger is supported by phonetic studies that demonstrate the perceptual similarity and confusability of postalveolar sibilants (e.g., Nowak 2006). This account also explains why the *ruki* rule applies only to fricatives, and not to stops, nasals, or liquids.
The proposed account of the Sanskrit *ruki* rule is also supported by cross-linguistic typological evidence. It is important to note that the *ruki* rule, as stated in (49), does not occur as a productive rule in the synchronic grammar of any living language. However, individual rules like those in (52) are well attested cross-linguistically.\(^{25}\)

\[
\begin{align*}
(52)\quad \text{a. } & \quad s \rightarrow \text{s} / r \\
\text{b. } & \quad s \rightarrow \text{s} / u \\
\text{c. } & \quad s \rightarrow \text{s} / i
\end{align*}
\]

Rhotics (52a) are perhaps the most common trigger of retroflexion, both diachronically and synchronically (e.g., Hamann 2003: 83–89, 2005). Historically, they have been a source of retroflexion in Indo-Aryan languages (i.e., independently of the *ruki* rule, Masica 1991: 176), Tibeto-Burman languages (DeLancey 1987: 804), Australian languages (Dixon 1980, 2002) and Germanic languages such as Norwegian (Kristoffersen 2000). Synchronically, many English speakers pronounce alveolar stops as retroflex in the context of /r/ (Rogers 2000: 48, cf. Jones 1967: 141, 144, 165, 167).

There is also abundant cross-linguistic evidence in support of (52b), demonstrating that retroflexes pattern with back vowels and resist front vowels. Historically, back vowels have been a source of retroflexion in Australian languages. They are still responsible for conditioning retroflexion synchronically in many cases (Dixon 1980, 2002). A similar pattern is evident in the synchronic variation of retroflexes

\(^{25}\) I omit the velar context in (52) because examples of this environment inducing an alternation in coronal sibilants are not well documented cross-linguistically. Thus, unlike the other environments in (52), there is insufficient evidence to establish a clear cross-linguistic trend.
in Indo-Aryan languages (section 3.1). The resistance of retroflexes to front vowels (and palatalization) is evident in the behavior of retroflexes in Dhivehi (section 3.3). Hamann (2003: 90ff.) catalogues many other phonological patterns demonstrating the affinity between retroflexion and back vowels (and possibly low vowels) and the aversion of retroflexes to front vowels. These are summarized in (53).

(53) Phonological patterns involving retroflexes and vowels (Hamman 2003)

a. /ut/ → [u̯] retroflexion in a back vowel context

b. /it/ → [i̯] de-retroflexion in a front vowel context

c. /it/ → [i̯] or [u̯t] vowel retraction in the context of a retroflex

d. /et/ → [æ̯t] vowel lowering in the context of a retroflex

e. /it/ → [i̯æ̯t] vowel diphthongization in the context of a retroflex

While retroflexes are dis-preferred in front vowel contexts, palato-alveolars are favoured. There is abundant cross-linguistic evidence to support patterns of palatalization like that in (52c) (e.g., Bhat 1978, Hall 1997a). This pattern is also evident in some of the case studies discussed above, including the palatalization of dentals in Dhivehi (section 3.3) and the diachronic development of palato-alveolar sibilants in Gujarati (section 4.2). Thus, cross-linguistic evidence supports the hypothesis, motivated by comparative historical evidence, that the ruki rule in (49) is not a homogenous phonological process.

The ruki rule is encoded in Pāṇini’s Aṣṭādhyāyī, which is the earliest Sanskrit grammar (circa 400 BC). This cannot be taken as evidence that the rule was a natural
homogeneous process at any time in the history of the language. It is likely that the merger of the allophones of IE *s into ś was accomplished before the early Indian grammarians encoded the rule. The persistence of the pattern in Sanskrit can be attributed to the fact that Pāṇini’s grammar, and the grammatical tradition that produced it, was essentially prescriptive in nature, not descriptive. The early Indian grammatical tradition grew out of the study and ritual recitation of early Vedic prayers and hymns. One of the primary goals of the early tradition was to preserve a normative standard of Sanskrit, without which the ritual recitation of Vedic texts was deemed ineffective (e.g., Subrahmanyan 1999: 2–4). Given the religious significance attached to the use of a normative standard, it is reasonable to assume that once the ruki rule was encoded and prescribed by the early grammarians, subsequent generations would have been careful to follow it whether it was natural from an articulatory point of view, or not.

In summary, the Sanskrit ruki rule does not constitute an exception to the analysis of retroflexion proposed in the preceding sections. Contrary to popular assumptions, the rule does not represent a single homogeneous phonological process, but the conflation of multiple processes with different outputs. All of the proposals concerning the development of IE *s in (51) agree that front vowels originally induced some form of palatalization (i.e., ç or ğ), not retroflexion. The ultimate merger of this palatal or palato-alveolar fricative with retroflex sibilants in Sanskrit was motivated by perceptual factors, not by shared articulatory properties. Thus, there is no need to posit a rule of retroflexion in the context of front vowels, and the evidence does not contradict the claim that the relevant articulatory features of retroflexion are [−distributed] and [+back].
5. Discussion

Evidence from the allophonic variation of retroflexes (section 3.1), loanword adaptation (section 3.2), and palatalization and gemination in Dhivehi (section 3.3) indicates that the features [–distributed] and [+back] are active in the phonological representation of retroflexes in Indo-Aryan languages. More specifically, the evidence suggests that retroflexes are contrastively [–distributed], and [+back] at a post-lexical level. Evidence from Sanskrit coronal assimilation (section 4.1) and Gujarati sibilant neutralization (section 4.2) indicates that retroflexes are marked in relation to dentals, and that dentals are the unmarked (or least marked) segments in the coronal class. Evidence from palatalization in Dhivehi (section 3.3) and Gujarati (section 4.2) also suggests that palato-alveolars and front vowels share a palatalization feature not shared by retroflexes. Following Hall (1997a) I have argued that the palatalization feature is best regarded as [–back], not [–anterior]. In light of these considerations I propose that Indo-Aryan retroflexes and other coronals are distinguished by the features in (54). Features in parentheses might be unmarked or non-contrastive.

(54) Proposed coronal place features for Indo-Aryan languages

<table>
<thead>
<tr>
<th></th>
<th>Dental</th>
<th>Retroflex</th>
<th>Palato-Alveolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORONAL</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>[distributed]</td>
<td>(+)</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>[back]</td>
<td>(+)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

In the remainder of this section I discuss some of the implications of this analysis for the phonological status of [±anterior] (5.1), natural classes (5.2), contrasts among
coronal affricates (5.3) and the relationship between coronal places of articulation and secondary articulations (5.4).

5.1 The status of [±anterior]

In the patterns of allophonic variation (section 3.1), loanword adaptation (section 3.2), and palatalization in Dhivhei (section 3.3), the phonological behavior of retroflex consonants is not compatible with the feature [–anterior]. Sanskrit coronal assimilation (section 4.1) and Gujarati sibilant neutralization (section 4.2) do not constitute counterexamples to this claim. The patterning of retroflexes with palato-alveolars in these examples is a product of their relative markedness with respect to dentals, and not the product of a shared articulatory feature. The ruki rule of Sanskrit (section 4.3) is also consistent with this claim because it too is not the product of shared articulatory features, but the result of historical merger motivated by perceptual factors.

On the basis of the Indo-Aryan languages examined in this study, we might assume that the absence of evidence for [–anterior] is a case of underspecification. There is no contrast between retroflexes and apico-alveolars in these languages, so the retroflexes could easily remain underspecified for [–anterior]. However, if this were the case, then we should expect [–anterior] to be a distinctive feature of retroflexes in languages with larger coronal inventories, where a contrast between apico-alveolar and retroflex segments is maintained. Recall that this contrast is found in some South Dravidian and Australian languages (e.g., (1) and (2)). Significantly, these languages also fail to show evidence for the feature [±anterior] and the natural classes it predicts. For example, Diffloth (1975) argues that the feature [±anterior] is “useless” for defining natural classes in the South Dravidian language, Irula. Hamilton (1993) makes the same
point with respect to Australian languages, and Gnanadesikan (1994) with respect to both Australian and Dravidian. These same authors demonstrate that the laminal and apical classes predicted by \[\pm\text{distributed}\] are highly relevant in these languages. Moreover, palato-alveolars often pattern with front vowels, and retroflex consonants with back vowels, much like they do in Indo-Aryan languages (e.g., Gnanadesikan 1994, Dixon 1980, 2002). Thus, while there is a conspicuous lack of evidence for \[\pm\text{anterior}\] in Dravidian and Australian languages, there is evidence that \[\pm\text{distributed}\] and \[\pm\text{back}\] are phonologically active.

In light of these broader cross-linguistic considerations, it is doubtful that the absence of \[\neg\text{anterior}\] on retroflexes in Indo-Aryan languages is the product of underspecification. The evidence suggests that it might not be a distinctive feature in any sense at all. I suggest that posteriority (i.e., \[\neg\text{anterior}\]) might be a universally redundant property of retroflexion that is derived via articulatory entailments from the combination of apicality (i.e., \[\neg\text{distributed}\]) and retraction (i.e., \[\text{+back}\]). Stated differently, retroflexes may tend to have a posterior contact because they are apical and retracted, but this property may not be phonologically significant or even required. This is consistent with Hamann’s observation that “a segment is still retroflex if it has all criteria except posteriority satisfied” (2003: 43).

This hypothesis opens up new avenues for research into the representation and phonological behavior of coronal consonants. For instance, we might explore the possibility that coronal places of articulation are distinguished solely by the features \[\pm\text{distributed}\] and \[\pm\text{back}\], as shown in (56). The standard model of coronal place features, which was presented in (5), is repeated here as (55) for ease of comparison. Within the alternative model in (56), we would have to assume that the feature \[\pm\text{back}\]
achieves a ternary contrast so that the absence of this feature on dentals and alveolars is
distinct from both [+back] and [–back]. In other words, dentals and alveolars are simple
laminal and apical coronals, while retroflexes and palato-alveolars are coronals with
inherent secondary articulations represented by [±back].

(55) Standard coronal place features

<table>
<thead>
<tr>
<th></th>
<th>Dental</th>
<th>Alveolar</th>
<th>Palato-Alv</th>
<th>Retroflex</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORONAL</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>[anterior]</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>[distributed]</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>–</td>
</tr>
</tbody>
</table>

(56) Coronal place features without [±anterior]

<table>
<thead>
<tr>
<th></th>
<th>Dental</th>
<th>Alveolar</th>
<th>Palato-Alv</th>
<th>Retroflex</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORONAL</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>[distributed]</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>[back]</td>
<td>–</td>
<td></td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

The hypothesis in (56) departs from a long-standing assumption in phonetics and
phonology that the specific ‘place’ of articulation is a primary factor in distinguishing
coronal consonants. In (56) the specific place of contact along the roof of the mouth (i.e.,
the anterior-posterior dimension associated with [±anterior]) is not a phonologically
relevant property of retroflexes or any other coronal consonant. Only properties of the
active articulators are phonologically relevant. These include the laminal or apical
gestures implemented by the tongue front (i.e., [±distributed]) and the position of the tongue body (i.e., [±back]).

5.2 Natural classes

The hypothesis in (56) makes very different predictions about natural classes than the standard model in (55). To begin with, (56) predicts that retroflex and palato-alveolar consonants do not form a natural class defined by an articulatory feature such as [–anterior]. Thus, phonological processes that target or spread a lingual articulatory gesture (e.g., palatalization, velarization, etc.) are not expected to affect them in a uniform way. Rather, the model predicts that palato-alveolars should form a class with segments that have a fronted tongue body (i.e., [–back]), such as front vowels and glides, whereas retroflexes should form a class with segments that have a retracted tongue body (i.e., [+back]), such as back vowels. These predictions do not follow from [–anterior] in the standard model. While [–anterior] predicts that palato-alveolars and front vowels form a natural class, it also predicts (erroneously) that retroflexes belong to this class. Moreover, the feature [±anterior] makes no predictions about the interaction of retroflexes with back vowels.

The elimination of [±anterior] in (56) also entails that lamino-dentals and apico-alveolars do not form a natural class defined by an articulatory property such as [+anterior]. This is a desirable prediction. Studies of Dravidian and Australian languages with maximal or near-maximal coronal inventories have indicated that lamino-dentals and apico-alveolars do not pattern as a natural class (e.g., Gnanadesikan 1994). In his cross-linguistic study of coronal phonology, Hall (1997a) acknowledges the lack of evidence for [+anterior] as a natural class, but suggests that this is “purely accidental” (p.
38) and “not a true cross-linguistic systematic gap” (p. 46). However, within a model like that in (56) this gap is not accidental. It is fully expected because lamino-dentals and apico-alveolars do not share an articulatory feature (apart from CORONAL).

In a model like (56), retroflexes and palato-alveolars might form a natural class opposed to dentals and alveolars in only two ways. First, they might form a natural class of marked coronals, while dentals and alveolars form a class of unmarked coronals. In (56) retroflexes and palato-alveolars are both inherently complex (i.e., marked) in relation to dentals and alveolars by virtue of having inherent secondary articulations. Phonological processes that target marked segments (e.g., neutralization in section 4.2) or unmarked segments (e.g., coronal assimilation in 4.1) will tend to treat retroflexes and palato-alveolars as a class opposed to dentals and alveolars.\(^\text{26}\)

Secondly, retroflex and palato-alveolar sibilants might form a natural class defined by shared acoustic/perceptual properties. As discussed in section 4.3, they are both characterized by lower frequency noise relative to dental and alveolar sibilants despite the fact that they are articulated in different ways. It might be possible to retain a feature like \([\pm \text{anterior}]\) if it were redefined, not in terms of place of articulation, but in terms of acoustic/perceptual properties, much like standard definitions of \([\pm \text{strident}]\) (e.g., Chomsky & Halle 1968: 329). If the feature were defined in terms of relative noise frequency, it would be applicable only to those manners of articulation that are characterized by noisy airflow, such as fricatives and (possibly) affricates.

\(^{26}\) As noted in section 3, some Indo-Aryan dentals vary in articulation within the denti-alveolar range. This cannot be taken as evidence for a natural class defined by \([+\text{anterior}]\). Rather, it is another effect of (un)markedness. Cf., footnote 12.
5.3  **Coronal affricates**

The hypothesis in (56) might be extended to account for other kinds of coronal systems, including those with distinctive coronal affricates. Recall that some Indo-Aryan languages have distinctive denti-alveolar and retroflex affricates (i.e., /ts/ and /tʃ/) in addition to plosives (i.e., /t/ and /tʃ/). These contrasts are most characteristic of the Dardic sub-group in northwest India, Pakistan and Afghanistan. Relevant examples from (12) are repeated here in (57).

(57) Indo-Aryan voiceless coronal stop inventories with distinctive retroflex and/or denti-alveolar affricates (Cardona & Jain 2003).

<table>
<thead>
<tr>
<th></th>
<th>Dental / Alveolar</th>
<th>Retroflex</th>
<th>Palato-Alveolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Konkani</td>
<td>Ɂ</td>
<td>tʃ</td>
<td></td>
</tr>
<tr>
<td>Marathi</td>
<td>Ɂ</td>
<td>ts</td>
<td>tʃ</td>
</tr>
<tr>
<td>Kashmiri (Dardic)</td>
<td>Ɂ</td>
<td>ts</td>
<td>tʃ</td>
</tr>
<tr>
<td>Gawarbati (Dardic)</td>
<td>Ɂ</td>
<td>ts</td>
<td>tʃ, ʃ</td>
</tr>
<tr>
<td>Indus Kohistani (Dardic)</td>
<td>Ɂ</td>
<td>ts</td>
<td>tʃ, ʃ</td>
</tr>
<tr>
<td>Kalasha (Dardic)</td>
<td>Ɂ</td>
<td>ts</td>
<td>tʃ, ʃ</td>
</tr>
<tr>
<td>Shina (Dardic)</td>
<td>Ɂ</td>
<td>ts</td>
<td>tʃ, ʃ</td>
</tr>
</tbody>
</table>

As noted earlier, the denti-alveolar and retroflex affricates are typically analyzed as contrasting with their plosive counterparts in terms of manner, not place. One popular view is that of Clements (1999), who argues that coronal affricates are [+strident] stops.

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27 Similar coronal contrasts are also characteristic of non-Indo-Aryan languages in the same region including: Iranian languages such as Pashto (Elfenbein 1997), Tibeto-Burman languages such as Ladakhi (Koshal 1979) and Lhasa Tibetan (Denwood 1999), and the isolate Burushaski (Anderson 1997). These coronal obstruent systems also bear a resemblance to those found in some Slavic languages such as Polish (Jarmasz 2008) and Serbian (Morén 2006).
Clements combines the standard coronal place features \([\pm \text{anterior}]\) and \([\pm \text{distributed}]\) with the manner feature \([\pm \text{strident}]\) in order to account for affricate-plosive contrasts among coronals, as shown in (58).

(58) Features of coronal plosives and affricates according to Clements (1999)

<table>
<thead>
<tr>
<th></th>
<th>Dental</th>
<th>Alveolar</th>
<th>Retroflex</th>
<th>Palato-Alv</th>
</tr>
</thead>
<tbody>
<tr>
<td>([\text{anterior}])</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>([\text{distributed}])</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>([\text{strident}])</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
</tbody>
</table>

Clements argues that the feature system in (58) does not overgenerate because all of the contrasts in (58) are attested. However, this claim is based on pair-wise contrasts across languages. In other words, one language contrasts lamino-dental plosives and affricates (i.e., /t/ vs. /ts/) while another contrasts lamino-dental and apico-alveolar stops (i.e., /t/ vs. /t/), and so on. In fact, Clements’ model does overgenerate in another important sense: no individual language has the full eight-way contrast among coronal plosives and affricates predicted by (58). Instead, when plosives and affricates are taken together, the maximal system appears to be the five-way system exhibited by some Dardic languages in (57).

As an alternative, it might be worth exploring the possibility that all coronal affricates are distinguished by tongue body features, much like the hypothesis concerning palato-alveolars in (56). Clements (1999) notes that patterns of assimilation like that in (59) are one of the most common sources of affrication cross-linguistically. In these
patterns, denti-alveolar plosives become affricates in the context of high vowels and glides, whether front or back (cf., Kim 2001).

\[(59) \quad t \rightarrow ts / i, u\]

These patterns of assimilation suggest that affricates are characterized by a high tongue body position. The combination of the tongue body feature \ [+high\] with \ [±back\] yields three possibilities. A segment may be simply \ [+high\] without any fronting or retracting of the tongue body (i.e., denti-alveolar /t$\$s/), or it may be \ [+high\] and \ [–back\] (i.e., palato-alveolar /t$\$f/), or \ [+high\] and \ [+back\] (i.e., retroflex /t$\$s/) as sketched in (60).

\[(60) \quad \text{Hypothesis concerning coronal affricates and tongue body features} \]

<table>
<thead>
<tr>
<th></th>
<th>Denti-Alveolar</th>
<th>Retroflex</th>
<th>Palato-Alv</th>
</tr>
</thead>
<tbody>
<tr>
<td>[distributed]</td>
<td>+</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>[high]</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>[back]</td>
<td>+</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

This hypothesis is consistent with the phonological behaviour of affricates in languages such as Japanese, where dental stops become alveolar affricates before [u] and palato-alveolar affricates before [i] (61). The assimilation of \ [+high\] from [u] yields [ts] and the assimilation of both \ [+high\] and \ [–back\] from [i] yields [t$\$f].
Alternations in the stem /tat/ ‘stand’ in Japanese (Clements 1999)

<table>
<thead>
<tr>
<th>Form</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ta[ts]-u</td>
<td>(present)</td>
</tr>
<tr>
<td>ta[tʃ]-i-mas-u</td>
<td>(polite present)</td>
</tr>
<tr>
<td>ta[t]-e</td>
<td>(imperative)</td>
</tr>
<tr>
<td>ta[t]-oo</td>
<td>(cohort)</td>
</tr>
<tr>
<td>ta[t]-a-nai</td>
<td>(negative)</td>
</tr>
</tbody>
</table>

This hypothesis is also consistent with evidence from Indo-Aryan languages. In some Indo-Aryan languages there is a tendency to pronounce the palato-alveolar phoneme /tʃ/ as denti-alveolar [ts]. In languages with this tendency, a palato-alveolar pronunciation is often retained in the context of front vowels and glides (Masica 1991: 94). This has led to a pattern of complementary distribution with [tʃ] occurring before front vowels and glides and [ts] occurring elsewhere. Through dialect mixture and the introduction of loanwords this complementary distribution has developed into a marginal phonemic split in languages such as Konkani and Marathi (Emeneau 1956: 7, Masica 1991: 94). Nevertheless, even in these languages the pattern of complementary distribution is still evident in productive alternations where [tʃ] functions as the palatalized counterpart of [ts] in the context of front vowels (e.g., Marathi: /sudʰaː + ts + iː/ → [sudʰaː-tʃ-iː] ‘Sudha-poss-3sf’, Pandharipande 1997: 563, cf., Pandharipande 2003: 718, Miranda 2003: 731, 738). This is consistent with the hypothesis in (60), where [ts] and [tʃ] are both [+distributed] and [+high], but palato-alveolar [tʃ] is distinguished by the palatalization feature [−back].

The tongue body hypothesis in (60) has the potential to provide a more restrictive model than that of Clements (1999), provided that the combination of tongue body
features with [±distributed] is constrained by articulatory factors. For instance, an apical tongue gesture requires the tip to be turned up and the middle of the tongue to be lowered so that the tongue has a somewhat concave shape. This is facilitated if the tongue body is in a neutral, low or retracted position because these positions allow more room for the apical gesture in the front of the mouth. An apical gesture is difficult to implement if the tongue body is raised and/or fronted, as evidenced by the fact that retroflexes and other apicals are generally resistant to palatalization (Hall 2000, Hamann 2003). Thus, we do not expect to find a segment that is apical (i.e., [–distributed]) with a raised and fronted tongue body (i.e., [+high] and [–back]). The combination of [–distributed] and [+high] might be possible only in conjunction with [+back], because the raising and retraction of the back of the tongue still leaves the tip sufficient room and freedom to achieve an apical gesture. By comparison, a laminal (i.e., [+distributed]) gesture requires a more convex tongue shape in which the tip is down. Thus, [+distributed] is more compatible with a raised and/or fronted tongue body, and can be combined with both [+high] and [–back].

In summary, the hypothesis concerning coronal affricates and tongue body features in (60) has the potential to account for the phonological behaviour of coronal affricates and to provide a more restrictive model of coronal contrasts. Like the hypothesis concerning coronal places of articulation in (56), it entails that the place of articulation along the passive articulator is derived from the behaviour of the active articulators, and is not phonologically relevant. At present the hypothesis concerning affricates is somewhat speculative, but it warrants further investigation.28

28 It is also worth exploring the possibility that the five-way coronal system of plosives and affricates in Dardic languages is related to the five-way contrast among coronal fricatives that has been
5.4 Secondary articulations

The proposed analysis of Indo-Aryan coronals in (54) and the hypothesis in (56) also raise new questions about the relationship between coronal places of articulation and secondary articulations. For instance, if retroflex and palato-alveolar consonants have inherent secondary articulations, then we predict that languages should not be able to contrast velarized and non-velarized retroflexes (/tʰ/ vs. /t/), or palatalized and non-palatalized palato-alveolars (/ʃ/ vs. /ʃ/). A cursory glance at the data suggests that this is the case. I know of no languages (Indo-Aryan or otherwise) with a contrast between velarized and non-velarized retroflexes, and Indo-Aryan languages with distinctive secondary palatalization systematically fail to palatalize the palato-alveolar series (e.g., Konkani: Miranda 2003, Kashmiri: Bhat 1987).

However, some languages have contrasts such as /t/ vs. /ʃ/ and /s/ vs. /ʃ/ (e.g., Konkani: Miranda 2003, Kashmiri: Bhat 1987). From a phonetic point of view, the distinction between palatalized denti-alveolars such as [t] and palato-alveolars such as [ʃ] lies more in the relative timing of articulatory gestures than in the nature of the gestures themselves. In the case of [t], the palatal gesture is delayed relative to the primary coronal closure, whereas in the case of [ʃ] it is implemented more or less reported for the Dravidian language, Toda (Shalev et. al. 1993, Hall 1997a: 92). An account of one might be extended to the other. Cf., footnote 1.

Some Slavic languages, such as Russian, are said to have a contrast between palatalized and non-palatalized palato-alveolar fricatives (ʃ vs. ʃ). However, phonetic studies reveal that the latter phoneme is apical. Thus, the distinction is more accurately described as palato-alveolar vs. retroflex (ʃ vs. s) (e.g., Hamann 2003: 40–47, 2004, cf., Keating 1991: 35–36, Hall 1997a: 63). As a result, these cases do not constitute exceptions to the generalization made here. See also Hall 1997a: 71ff.
simultaneously with the closure. Thus, it is possible that the distinction between the two does not lie in articulatory features, which represent articulatory gestures, but in some other aspect of phonological representation that is responsible for the implementation and timing of those gestures. They may be distinguished by differences in segmental structure (e.g., simple vs. complex or contour segments, as in Sagey 1986), prosodic structure, or some combination of these (cf., unary vs. cluster analyses of nasal-obstruent sequences in Riehl 2008). These possibilities deserve consideration, but cannot be explored here.

6. Conclusion

The phonological behavior of retroflex consonants in Indo-Aryan languages suggests that they are distinctively [–distributed], and that they may also be [+back], at least at a post-lexical level. However, there is nothing to indicate that the feature [–anterior] is relevant for retroflexes at any level of representation. South Dravidian and Australian languages with more than one apical ([–distributed]) series also lack evidence for the feature [±anterior] and the natural classes it predicts. In light of these cross-linguistic considerations, I argue that the absence of [–anterior] on Indo-Aryan retroflexes is not the result of contrastive (under) specification. Rather, I suggest that posteriority (i.e., [–anterior]) may be a universally redundant and non-essential property of retroflexion that is derived from the combination of apicality (i.e., [–distributed]) and retraction (i.e., [+back]). This hypothesis raises doubts about the long-standing assumption that the specific ‘place’ of articulation along the anterior-posterior dimension is a primary factor in distinguishing retroflexes and other coronal consonants. It also raises new questions about the relationship between coronal places of articulation and secondary articulations. These issues are the subjects of ongoing research.
References


