2 Articulatory variation and common properties of retroflexes

Retroflexion is traditionally described as an articulation involving the bending backwards of the tongue tip, see for instance the definition by Trask (1996: 308). An illustration of such a retroflex is given in figure 2.1, based on a sagittal x-ray tracing of a Tamil retroflex stop from Ladefoged & Maddieson (1996: 27).

Figure 2.1 Tracing of a sagittal x-ray of a retroflex stop in Tamil, based on Ladefoged & Maddieson (1996: 27). This articulation is a retroflex in the traditional sense with the tongue tip bent backwards and having contact on the post-alveolar area.

The Latin-based term 'retroflex' (Dixit 1990), bending backwards, refers to a tongue gesture as depicted in figure 2.1.

In the present chapter it will be shown that the class of retroflexes displays large articulatory variation, and that the actual gesture of bending the tongue tip backwards is not a defining property of this class because it is not true for all sounds traditionally described as retroflex. This chapter investigates the articulatory variation of retroflexes and the factors responsible for variation, and proposes a different articulatory definition of retroflexion, namely by the four properties of *apicality*, *posteriority*, *sublingual cavity*, and *retraction.* Bending backwards of the tongue tip is not included in these four properties. It will be shown that most of the segments traditionally described as retroflex satisfy all four properties. One noticable exception to this is the retroflex fricative in Mandarin, that lacks the property of posteriority. Furthermore, the four properties introduced here will be shown to imply that secondary palatalization of retroflexion causes a change from retroflex to non-retroflex, as the palatalized segment satisfies only two retroflex properties.

This chapter proceeds as follows. In section 2.1, the phonetic terminology to be used is defined. Section 2.2 is concerned with both the phonetic and phonological factors responsible for the large articulatory variation in retroflexion. This includes descriptions of the manners of articulation that retroflexion can occur with. Abstracting away from the described variation, section 2.3 describes in detail the

four properties that characterize retroflexion; apicality, posteriority, sublingual cavity, and retraction. In section 2.4, these properties are applied to post-alveolar fricatives of Slavic languages which are treated in the traditional literature as laminal but which are argued here to be retroflex. The subsection illustrates that these Slavic segments can be considered as non-prototypical retroflex fricatives since they satisfy three of the four properties postulated in 2.3. Section 2.4 concludes that the property of posteriority is the only one that can be missing for such non-prototypical retroflex fricatives. Section 2.5 is concerned with the secondary palatalization of retroflexes. There it is argued that secondary palatalization causes a change from retroflex to palato-alveolar. The last section 2.6 summarizes.

2.1 Phonetic terminology

In this dissertation, several articulatory terms are used. To avoid confusion, short definitions of these terms are provided here. First of all, a distinction between active and passive articulator is made. The active articulator is either the lower lips or some part of the tongue. This active articulator (sometimes just referred to as 'articulator' in the phonetic literature) moves towards the immobile, passive articulator, which is the area on the upper side of the vocal tract from the upper lips to the pharynx. The passive articulator is also referred to as 'place of articulation' in most phonetic studies.

For the present study, two specific regions of the active and the passive articulator are of importance. In the case of the active articulator this is the front part of the tongue, which is usually divided into tongue tip and tongue blade. This area is often referred to as 'coronal' in the phonetic and phonological literature. Sounds produced with the tongue tip are called apical, those with the tongue blade laminal. There are two differing views on where the borderline between tip and blade is located. According to the traditional view, as represented e.g. by Catford (1988, 1994) and Ladefoged & Maddieson (1996), the tip is the part of the tongue that is roughly vertical at rest, and the tongue blade starts just a few millimetres after this vertical part, see figure 2.2 below. A different view is represented by e.g. Ohde & Sharf (1992), who count both tip and blade as defined above under the term 'tongue tip' and use 'blade' for the front area of what is traditionally referred to as the tongue dorsum. The present study follows the traditional definition of tongue tip and blade.
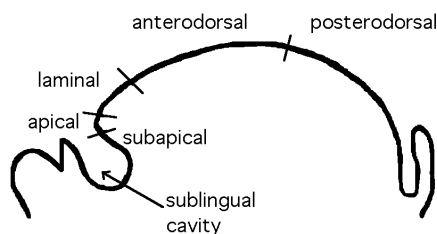

Figure 2.2   Representation of the sublingual cavity and of the parts of the tongue (based on Catford 1988).

The underside of the tongue, i.e. the area below the tongue tip, can be referred to as subapical (e.g. Catford 1977 and Laver 1994), or sublaminal (e.g. Ladefoged & Maddieson 1996 and Dixit 1990). In the present study, the term 'subapical' will be used. The space between the tongue tip and the lower teeth that comes into existence when the tongue tip or blade is raised towards the post-alveolar region or further back is called the 'sublingual cavity'.

Behind the laminal area, which extends 1 to 1.5 cm behind the apex, the tongue dorsum starts. The tongue dorsum is sometimes referred to as tongue body and can be further distinguished into pre-dorsum and post-dorsum, or anterodorsum and posterodorsum (e.g. by Catford 1988), the latter often called the tongue back. According to Catford (1988: 79) this distinction of the dorsum is not necessary, since the anterodorsum practically always articulates against the roof of the mouth in the palatal area, and the posterodorsum articulates in the velar area. In the present study I will refer to these two parts of the dorsum as tongue middle and tongue back, respectively.

For the passive articulator, the focus of the present study will be on the area on or behind the alveolar ridge. The alveolar ridge is the protuberance immediately behind the upper teeth, after which a concave slope of the palate starts (cf. for instance to the definition by Catford 1977). The alveolar ridge can be seen in figure 2.3 in the alveolar area:
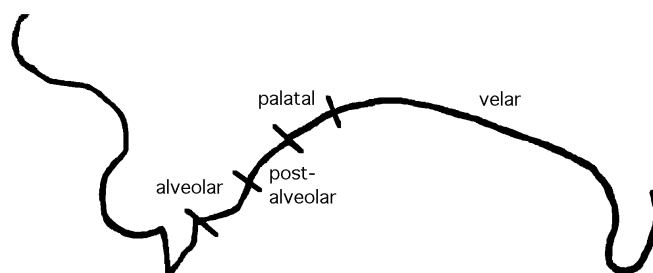

Figure 2.3   Representation of the alveolar, post-alveolar, alveolo-palatal, palatal, and velar regions (based on figures by Heike 1982: 26 and Laver 1994).

Articulations on the alveolar ridge are called 'alveolar'; those right behind the ridge are 'post-alveolar'. Behind the short stretch of the post-alveolar region, the palatal area is located. The remainder of the palate is the 'velar' area.

Besides these distinctions of active and passive articulators, some terms for specific sound classes have to be defined explicitly since they will be used throughout the dissertation. First of all, I will use the term 'apical alveolar' for all front apical articulations, including apical dentals. The anterior apical is realized language-dependently, but the realization of an apical alveolar is cross-linguistically more common (Ladefoged & Maddieson 1996: 23), therefore this term is used here. Apical alveolars are transcribed with the IPA symbols [t, d, n, l, s, z, r] without further diacritics. Laminal dentals or alveolars are transcribed with a dental diacritic,

for instance [t̪], since they are dental in most languages. Laminal post-alveolars are transcribed as [t̠] etc.

Laminal fricatives articulated in the post-alveolar region, transcribed with the IPA symbols [ʃ, ʒ], will be termed 'palato-alveolar' (following e.g. Trask 1996: 255). Together with the retroflexes they make up the class of 'post-alveolar' fricatives. Laminal fricatives articulated with a narrow constriction at the post-alveolar and the palatal area, i.e. [ɕ, ʑ], are referred to as 'alveolo-palatal' fricatives (e.g., by Trask 1996).

Regarding the tongue shape, the terms 'domed' and 'flat' will be used in the present dissertation. 'Domed' describes a raised tongue middle as can be found in articulations of the palato-alveolar [ʃ, ʒ], or in any kind of secondarily palatalized coronals. 'Flat' can be used in two different meanings, one indicating the non-raising of the tongue middle towards the palate, i. e. flatness in the sagittal dimension: in the present study the term will be used in this meaning. The second meaning is applied e.g. by Laver (1994: 252) who uses 'flat' to refer to a fricative that lacks a groove in the tongue middle, i.e. flatness refers here to the cross-sectional dimension of the tongue.

2.2   Parameters of articulatory variation

In contrast to other articulatory classes (such as e.g. dentals) that have a fixed place of articulation and active articulator and therefore allow little variation, retroflexes have a wide range of articulatory possibilities, which will be examined in this section. The indeterminacy of the retroflex class is reflected by the fact that the IPA symbol chart lists 'retroflex' along with terms referring to places of articulation such as 'dental', 'alveolar' etc., although I argue below that 'retroflex' describes an articulatory shape or gesture, rather than a place of articulation. Ladefoged (1975) nevertheless uses 'retroflex' in his phonetic feature systems as a value of the feature 'articulatory place'. A similar use of this term can be found in Maddieson (1984). Catford (1977), Ohala (1983), and Laver (1994), on the other hand, apply the term 'retroflex' exclusively to the articulatory gesture.

Besides the cover term 'retroflex', one can find several more accurate descriptions of retroflex segments in the phonetic literature; terms used for the active articulator are e.g. 'apical', 'subapical' or 'sublaminal'; terms for the passive articulator are 'alveolar', 'post-alveolar', 'prepalatal' or 'palatal'. Nevertheless, 'retroflex' behaves parallel to true places of articulation because it has the same manner of articulation classes, i.e. plosives, fricatives, nasals, and so on.

The difficulty in describing the articulation of retroflexes is due to several parameters of variation, some of which are purely phonetic, such as speaker dependency, dependency on the manner of articulation, or the segmental context of the retroflex. Others are phonological, such as the inventory size of a language or common characteristics of the language family.

In this section, the main parameters of variation are described, starting with the phonetically motivated intra-speaker variation in 2.2.1. Three further phonetic

sources for variation are subsequently introduced, namely the vowel context of the segments (2.2.2), speech rate (2.2.3), and manner of articulation (2.2.4). In sections 2.2.5 and 2.2.6, two phonological parameters, namely language family and inventory size, are described respectively. Mutual influence of the factors on each other occurs, as will be illustrated when appropriate.

2.2.1 Speaker dependency

The shape of the tongue and the exact placement of the tongue tip depend very much on the speaker's vocal tract. There is large variation between speakers in their vocal tract anatomy and in their flexibility of the articulators. Concerning the place of articulation for retroflexes, Catford (1970: 310) points out that "some people can curl up their tongue retroflexively so that the tongue-point touches the uvula: others can barely reach the centre of the hard palate". An apical uvular (i.e. a retroflex in the uvular region) is therefore theoretically possible for some speakers, but no language seems to employ this sound.

The active articulator for retroflexes is also subject to speaker variability; it can vary from the tongue tip or blade to the extreme underside of the blade.

Phonetic investigations of the realization of retroflex segments within one language confirm intra-speaker variation. Ladefoged & Bhaskararao (1983) made x-ray tracings of Hindi voiceless retroflex stops for five native speakers. Whereas four of the speakers have an alveolar place of articulation (varying between apical and subapical articulator), the fifth shows a subapical post-alveolar articulation. An electropalatographic (henceforth: EPG) and electromagnetographic study of Norwegian retroflex stops by Simonsen et al. (2000) for two native speakers showed similar variation between the speakers; one articulates the retroflex with a bent tongue tip and a post-alveolar contact, the other without bending and with an alveolar contact. That variation depending on the speaker is consistent across different manners can be seen in Dart & Nihalani's (1999) experiment for Malayalam. Their palatographic and linguographic data of nine speakers show that eight speakers produce post-alveolar retroflex stops, and one an alveolar one. The same speaker also shows an alveolar place of the retroflex nasal, whereas all others have a post-alveolar nasal. The consistency of the single speaker's articulation across different manners was also observable for the active articulator.

The degree of variation open to the speaker can be limited by the inventory size of the language, as will be shown in section 2.2.5. But even for Australian languages that employ a four-way place distinction in the coronal area (such as for instance Eastern Arrernte, Miriwung, and Wembawemba), and where one therefore would expect nearly no variation, Hamilton (1996: 37) observes that the articulation of retroflexes is less uniform than that of the alveolars, and furthermore that the area of contact for retroflex segments is much broader.

Variation due to a speaker's gender should also be mentioned in the context of speaker-specific differences in articulation. The vocal folds are usually longer for men than for women, and vocal fold vibration is therefore lower for men (Beck 1997). Furthermore, the vocal tract is generally larger for men, which results in

lower formant values. However, this is a general phenomenon not restricted to retroflex segments and has therefore not been the topic of any articulatory study on retroflexion.

2.2.2 Vowel context

Vowel context seems to be one of the major causes for variability in retroflexion. Several studies such as Švarný & Zvelebil (1955), Ladefoged & Bhaskararao (1983), Dixit (1990), Dixit & Flege (1991), and Krull, Lindblom, Shia & Fruchter (1995) illustrate the change of the active articulator and the place of articulation of retroflex segments according to the adjacent vowel. Dixit (1990) and Dixit & Flege (1991) for instance made EPG measurements of the retroflex stops [ʈ] in Hindi preceded and followed by the vowels [a u i]. The results of both studies show that the place of retroflex constriction changes according to the vowels. In /i/ context, i.e. preceded and followed by an /i/, the retroflexes were articulated in the dental area, in /a/ context in the alveolar region, and in /u/ context in the post-alveolar area. Similar results were obtained by Simonsen et al.'s (2000) EPG experiments with two native speakers of Norwegian, where the retroflex in the /a/ vowel context was articulated far more back than in the /i/ context. Variance in retroflexion according to vowel context is obviously a coarticulatory effect and can be explained physiologically. For the front vowel /i/ the tongue blade is fronted and the tongue middle raised, and the tongue tip is usually tucked under the lower front teeth. This tongue shape is inherently less compatible with that of retroflexion than e.g. a neutral tongue position, and therefore the combination of both front vowel and retroflex gesture results in the reduction of either the degree of retroflexion or the frontness of the vowel. For both processes see the phonological rules of de-retroflexion in high front vowel context, high vowel lowering, and front vowel retraction, all described in section 4.3. The articulatory gesture for the low vowel /a/ has neither a fronted tongue blade nor a raised tongue middle, thus it allows a posterior retroflex articulation. The high back vowel /u/ is articulated with a raised and retracted tongue back, a position very similar to that of the retroflex. The tip is not constrained in this type of articulation and can move easily to or from the retroflex gesture.

The position of the vowel with respect to the retroflex has a considerable influence on the variation of retroflexes. The quality of the preceding vowel has a different effect on retroflexion than that of the following one. In Simonsen et al.'s (2000) study on Norwegian retroflex stops, the contact on the palate was further back in post-vocalic position than in prevocalic position, both for /i/ and /a/ context. Krull et al. (1995) have similar results in their study of Swedish, Hindi, and Tamil retroflexes. The difference between post-vocalic and pre-vocalic position is that during the preceding vowel the tongue tip advances into the post-alveolar region. The retroflex consonant itself involves a movement of the tongue tip from this post-alveolar displacement to its natural resting position or to the position necessary for the following vowel. This is sometimes referred to as 'flapping out', see e.g. Ladefoged (1964) on West African rhotic retroflexes or Hamilton (1996: 37) on Australian retroflex segments. The movement from the retroflex gesture towards

neutral tongue position or tongue position of the following segment during the production of the consonant is very pronounced for retroflex stops and nasals (illustrated e.g. in Butcher's 1992 palatography of retroflex stops in Australian languages). Retroflex fricatives differ slightly, as they usually hold the posterior tongue position during almost all of the frication and only show a very late flapping out.[1] But in judging these differences one has to take into account that fricatives usually show less bending backwards of the tongue tip than stops, see section 2.2.4.3 below. The articulatory influence of the vowel preceding a retroflex segment is thus far greater than that of the following vowel, and more vowel-dependent variation can be observed in post-vocalic retroflexes than in pre-vocalic ones. This dependency on position of the vowel is again unique to retroflexion. Dentals do not show any variation across post- and pre-vocalic position, as illustrated by Krull et al.'s (1995) study on Swedish and Hindi, and Simonsen et al.'s (2000) study on Norwegian.

2.2.3 Speech rate

Speech rate is another factor influencing the articulation of retroflex segments. Bhat (1974b: 236) states in his cross-linguistic study that the bending backwards of the tongue tip decreases with the speed of the utterance. This is in accordance with Ladefoged & Maddieson's (1996: 222) finding that some speakers of Malayalam have a contrast between alveolar and retroflex trill in careful speech only. Dixit & Flege (1991) tested in an EPG experiment the influence of speech rate on retroflex articulations of the Hindi stop [ʈ]. Their results show that in fast speech the constriction for the retroflex is more posterior. No information was provided about the reduction of the tongue tip gesture. The retraction of the place of articulation seems to go counter expectations, because one would suppose a reduction of the retroflex gesture to result in a position closer to the neutral position of the tongue tip. Dixit & Flege (1991) explain their findings in the following way:

> [T]he place of tongue-palate contact receded in fast speech probably because the general shape of the tongue was more like its bunched shape in the surrounding vowel. Therefore the tongue tip or blade did not reach the same articulatory place in fast speech as it did in normal or loud speech. (Dixit & Flege, 1991: 223)

Dixit & Flege hence propose that the bunched tongue body shape of the vowel influences the tongue shape of the retroflex in fast speech, which results in a more posterior place of articulation for the retroflex stop. Alternatively, the retraction of the tongue body might be interpreted as a compensatory gesture: the fast speech rate does not allow a raising and retraction of the tongue tip, thus the speaker retracts the whole tongue body (which can be done during the vowel artiuclation already) and then only has to raise the tongue tip.

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[1]   The difference between retroflex fricatives and stops with respect to the occurrence of the 'flapping out' is not the subject of any articulatory study to my knowledge. It can also be inferred from the transitions in the acoustic signals, see chapter 3.

Lindblad & Lundqvist (1997) looked at Swedish coronal fricatives in isolated vs. phrasal production (which I assume to be equivalent to slow vs. fast speech). Their results show a more fronted articulation of the retroflex fricative in phrasal, fast speech; i.e. a change from a post-alveolar/palatal place of articulation in isolated speech to an alveolar place in fast speech. Both studies only looked at a change in the place of articulation, not at the tongue tip. Whether the tongue tip gesture is reduced in fast speech has to be further tested. Furthermore, it cannot be established whether the differing results for Hindi and Swedish are language-specific (Hindi has retroflex retraction in fast speech whereas Swedish has fronting) or manner-specific (fricatives are fronted whereas stops are retracted). Further studies have to be conducted to clarify this point.

2.2.4 Manner dependency

The third and most important phonetic parameter for variation of retroflex sounds is the manner of articulation. As we will see in the following, there are some systematic differences between retroflex manners. This difference is not restricted to retroflexes but is a general articulatory necessity. Lindblad & Lundqvist (1999: 417) observe in their study on front coronal sounds that "the hypothesis that sounds that share roughly the same articulatory gesture nevertheless tend to differ in gestural details, caused by general production conditions for each specific articulatory manner, is certainly valid also for all other sounds, not least posterior coronals such as retroflex sounds." To exemplify this in detail, the following sections will examine the retroflex articulations of plosives, fricatives, affricates, laterals, and rhotics respectively. Manners articulated with ingressive airstream, such as implosives and clicks, and with glottalic egressive airstream (ejectives) are not discussed.

Before describing the manners of articulation for retroflexes, it has to be pointed out that retroflexes also occur as geminates, as in Bengali, Marathi, and Tamil. As geminates can occur with all of the manners described below, they are treated briefly here. Balasubramanian (1982) investigated the articulatory difference between singleton and geminate nasal and lateral retroflex in Tamil and his study shows that retroflex geminates, which occur intervocalically only, are articulated with a firmer contact than the non-geminated counterparts. The nasal retroflex geminates are also articulated further back than the singleton nasals, namely in the palatal region. Thus, the realization as singleton or geminate can account already for some articulatory variation of retroflexes.

2.2.4.1 Plosives

In the phonetic and phonological literature one often finds the distinction between two kinds of retroflex stops. Keating (1991: 34f.) and Hall (1997: 46) for example describe an apical and a subapical post-alveolar retroflex segment, where the second involves a more retroflex gesture than the first.[2] Figure 2.4 exemplifies these two

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[2] Keating (1991) and Hall (1997) do not refer to stops specifically, but their articulatory illustrations for both types of retroflex articulations are taken from stops only.

stop types, with a retroflex stop from Hindi on the left, and one from Tamil on the right.

Figure 2.4   Hindi retroflex stop [ɖ] (left) and a Tamil retroflex stop [ɖ] (right), both based on sagittal x-ray tracings from Ladefoged & Maddieson (1996: 27).

The Hindi retroflex stop is articulated with the tongue tip against the post-alveolar region, whereas the Tamil retroflex stop involves a placement of the underside of the tongue tip against the palatal region. Whereas Hall (1997) assumes that there are only these two retroflex articulations, Ladefoged & Bhaskararao (1983) point out that the two types like the ones illustrated here can be assumed to be extremes on a continuum of possible retroflex plosives.[3] Taking into account all the other parameters of variation described up to now and the changes in articulation they incur, the view of retroflex articulation as a continuum seems appropriate. But in order to avoid mentioning all possible articulations of retroflex stops, the following will be mainly concerned with the description of the two extreme types.

In order to distinguish phonetically between these two extreme articulations of retroflex stops, Ladefoged & Maddieson (1996: 15) introduce two different symbols. The type found in Hindi, involving just the tongue tip (see figure 2.4 left), is transcribed with a subscript dot beneath the symbol for the alveolar sound [t] whereas the articulation with the underside of the tongue (see figure 2.4 right) as in Tamil and other Dravidian languages is transcribed with the traditional IPA symbol for retroflex stop [ʈ]. Švarný & Zvelebil (1955) also distinguish the two types, and introduce a different term for each. In their terminology, 'retroflex' stops involve the use of the underside of the tongue, whereas 'cacuminal' stops use the tongue tip only.[4] Ball & Rahilly (1999: 56) propose the use of the IPA diacritics for 'advanced' and 'retracted' to differentiate between the two retroflex places of articulation. Sections 2.2.5 and 2.2.6 below look at the correlation between the two retroflex types in figure 2.4 with the language families they occur in, and their co-occurrence with other coronal segments within one language, respectively.

Usually, the voiced and voiceless retroflex segments in one language are articulated at the same place. However, Ladefoged (1964) observed that some West

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[3]   Ladefoged & Maddieson (1996: 26) assume that the retroflex voiced stop in Ewe (a West-African language) is even less retroflexed than the Hindi one, being articulated actually at the alveolar ridge, and therefore should be one endpoint of the continuum. Their palatographic data, however, show that the tongue moved from the post-alveolar to the alveolar area during articulation, which makes its place of articulation very similar if not identical to that of the Hindi stop.

[4]   Dixit (1990: 190) points out that 'cacuminal' is a term referring to the place of articulation rather than to the tongue gesture, though Švarný & Zvelebil use both 'retroflex' and 'cacuminal' for describing the active articulator.

African languages (Ghanaian languages such as Gã, Effutu, Late and Anum) have a difference in place of articulation between the voiceless and the voiced coronals. Whereas the voiceless stop is laminal denti-alveolar, the voiced one is apical alveolar or post-alveolar, i.e. retroflex. No possible reasons for this difference are given. The only further evidence for a difference between the voiced and voiceless series could be found in Dixit's (1990) measurements of Hindi, which showed that the voiced retroflex (and dental) have narrower constrictions than the voiceless counterparts. But no change in place of articulation resulted from that.

Retroflex stops have in common that they involve a flapping out of the tongue tip in their articulation. This gestural release takes place at the release of the stop.[5] In Ladefoged's (1964) investigations of Ewe stops, the tongue tip movement during the release is observable from a large area of contact at the roof of the mouth, though the active articulator was actually quite small. Further unifying properties for both retroflex stop types and also of the following manners will be discussed in 2.3.

2.2.4.2 Nasals

Coronal nasals are often produced at the same place of articulation and with the same articulator as the corresponding stops in the respective languages. Maddieson (1986) observes that the presence of a nasal usually implies the presence of a plosive or obstruent at the same place of articulation. This is attested in Dart's study (1991) on the articulatory similarity between coronal stops and coronal nasals in French and in English.[6]

For retroflexes, Laver (1994: 217) shows with sagittal cross-sections that the retroflex stops and nasals in Tamil have identical active and passive articulators and the same gesture of articulation.

Further evidence for a similar treatment of retroflex nasals and stops can be drawn from the fact that languages which employ a retroflex nasal also have a retroflex stop. The only counterexample in Maddieson's database is the Finno-Ugric language Ostyak, which has a retroflex affricate and a retroflex lateral as the only other retroflex segments besides the retroflex nasal.

Butcher (1992: 25) claims that in Australian languages stops appear to be more likely to have sublaminal articulation than nasals, thus implies a difference in active articulator between retroflex nasals and stops. However, Butcher does not give any phonetic evidence for his claim.

Only a few articulatory studies, such as Balasubramanian (1982) and Dart & Nihalani (1999), are concerned with nasal retroflexes. Dart & Nihalani (1999) investigated the coronal nasals and stops of Malayalam. For all nine speakers of their study the nasal retroflex was articulated at the same place and with the same articulator as the stop, namely subapical for six speakers, apical for three, with a post-alveolar place for all except one, who had an alveolar place. Balasubramanian

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[5] This observation holds only for released retroflexes. Unreleased retroflex segments such as e.g. [ʈ˺] do not show any flapping out. Unreleased [ʈ˺] occur for example before other coronal consonants, before retroflexes with a different manner of articulation, or phrase-finally in some languages.

[6] See e.g. Boersma (1998: 162f.) on how specific articulatory gestures are used for more than one manner class and how this can account for symmetries within segment inventories.

(1982b) looked at retroflex nasal singletons and geminates in Tamil of one speaker, who produced a subapical post-alveolar for the singleton and a subapical palatal for the geminate. As these studies were concerned with retroflex nasals in Dravidian languages, they give descriptions of subapical post-alveolar articulations only. But assuming that the nasal is articulated in the same way as the corresponding stop in the respective languages, there should be a more apical retroflex nasal e.g. in Indo-Aryan languages. As we do not have any further data to refute the claim, we thus assume that nasals can vary articulatorily in the same way as retroflex stops do.

2.2.4.3 Fricatives

The articulatory requirements for fricatives are different from those for stops and nasals. The front coronal fricative [s], for example, seems to be cross-linguistically more laminal than the corresponding stop [t] (see for instance Dart 1991 on French and English, Lindblad & Lundqvist 1999 on Swedish, and Wängler 1958 on German). This is due to the fact that strident coronal fricatives require a grooving of the tongue blade and an air-jet that strikes the front incisors (Lindblad & Lundqvist 1999), which can be easier achieved with a longer place of constriction. Thus one would expect retroflex fricatives to differ inherently from the articulatory configuration found in retroflex stops or nasals, as the contact area of retroflex stops is rather small. Furthermore, one can speculate that retroflex fricatives require the retroflexion gesture to be held throughout the whole segment in order to maintain the air turbulence, whereas stops allow an early flapping out (recall the description in 2.2.4.1). Keating (1991: 35) confirms these expectations of a different articulatory position for fricatives by pointing out that retroflex fricatives of India do not seem to involve the same kind of curling of the tongue as the plosives in these languages, but are articulated at the same place as the plosives.

Let us look at some realizations of retroflex fricatives in order to test the assumptions made up to now. The left hand side of figure 2.5 on the next page is a sagittal x-ray tracing of the Tamil retroflex fricative (Ladefoged & Maddieson 1996: 156). In this picture, the tongue tip is not distinguishable from the tongue body; therefore no raising or bending backwards of it is discernible. Compared to the retroflex stop in the same language (refer back to figure 2.4), the fricative differs very much in its articulation and shows a longer, narrower channel of articulation.[7] Thus, the retroflex fricative type found in Tamil is in accordance with the assumptions made above.

According to the detailed phonetic descriptions of Sridhar (1990), a similar difference between the retroflex plosive and the retroflex fricative can be found in Kannada, another Dravidian language. Toda, though from the same language family (Dravidian) as Tamil and Kannada, and having the same type of retroflex stop, shows a different articulation of the retroflex fricative, depicted in figure 2.5 on the right (based on Ladefoged & Maddieson 1996: 160).

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[7]   The x-ray tracing of the Tamil fricative in figure 2.5 shows no discernible tongue tip, which seems to be retracted into the tongue.

Figure 2.5   Tamil retroflex fricative [ʂ] (left) and a Toda retroflex fricative [ʂ] (right).

The Toda retroflex fricative involves a raising of the tongue tip towards the palatal region, and its position of the tongue blade against the post-alveolar region resembles the articulation of the retroflex stop in Indo-Aryan languages. The articulation of the Toda fricative, which is further backwards than that of the Tamil fricative, still does not involve the extreme curling backwards of the tongue tip found in Dravidian retroflex stops. Ladefoged & Maddieson (1996: 156) introduce again two different symbols for the two retroflex fricative articulations. Whereas the Tamil-type of fricative is transcribed with an alveolar symbol with a subscript dot [s̠] and is called a 'flat retroflex' (defined as not being domed like palato-alveolars), the fricative found in Toda is transcribed with the traditional IPA symbol for retroflex fricatives, namely [ʂ].

A retroflex fricative with an extreme curling backwards of the tongue tip, comparable to the Tamil stop in figure 4.1 on the right, could not be found in any articulatory study. Laver (1994: 252) mentions a subapical palato-alveolar fricative as a possible retroflex articulation but does not refer to any language that employs a segment like this. From this we can conclude that retroflex fricatives do not involve the same backwards bending of the tongue tip as retroflex stops, which probably has to do with the different articulatory requirements on fricatives elaborated above.

Besides the generally accepted two types of retroflex articulation exemplified up to now, another type of retroflex fricative exists. This type does not necessarily involve the tongue tip in its articulation and thus shows no kind of bending backwards of the tip at all. Its place of constriction is the post-alveolar region (recall the definition in section 2.1), but it differs from the traditional laminal post-alveolar [ʃ] and from the retroflex fricative in figure 2.5 left in the shape of its tongue body, which is flatter. Fricatives like these can be found in Mandarin Chinese, see figure 2.6 (based on Ladefoged & Wu 1984: 269).

Figure 2.6   X-ray tracing of the Mandarin voiceless retroflex fricative (based on Ladefoged & Wu 1984: 269).

In the traditional phonetic literature, the Mandarin sounds of voiced and voiceless post-alveolars are referred to as 'retroflex' (e.g. Chao 1948, 1968). Phonological descriptions agree with this terminology, cf. Chao (1986), Pulleyblank (1989), and Lin (1989). Laver (1994: 252), however, describes 'Standard Chinese' as having a laminal 'flat' post-alveolar fricative, 'flat' as this sound does not show any grooving of the tongue blade otherwise typical for coronal (including retroflex) sibilants, and he introduces the symbol [ʃ₊] for this segment. Ladefoged & Wu (1984: 277) point out that the Mandarin retroflex is very different from the same segment class in Tamil. The study by Lee (1999) with palatograms and linguograms shows that these sounds are apical post-alveolars for the two speakers tested. These findings lead Lee to refrain from referring to this segmental class as 'retroflex', since it shows no bending backwards of the tongue tip. The present study follows traditional phonetic literature and Ladefoged & Maddieson (1996) in classifying these sounds as retroflex.

Some Slavic languages, such as Polish and Russian, are said to have similar fricatives, though in the traditional Slavic literature they are never described as 'retroflex' (e.g. Wierzchowska 1980 and Rubach 1984). Articulatory arguments for why these sounds are classified as retroflex in the present study are discussed in detail in 2.4, phonological reasons are given in chapter 4.

2.2.4.4 Affricates

In the following discussion of retroflex affricates, four types of affricates are distinguished: first, a segment that is traditionally described as affricate, i.e. a stop that is released into a homorganic fricative, second, a stop that is released into a rhotic, thirdly, a laterally released stop, and lastly, a nasally released retroflex stop.

The retroflex affricate [tʂ][8] can be found e.g. in Burushaski (Edelman 1983), Gujarati (Pandit 1954), Karok (Bright 1957), and Mandarin (Ladefoged & Wu 1984), which all also have a retroflex fricative.[9] As can be seen in many articulatory descriptions of specific languages (e.g. Ladefoged 1994 on Toda and Ohala 1994 on Hindi), affricates differ in place of articulation from the corresponding stops, in as far as they are usually more retracted, and are close to the series of corresponding fricatives.[10] The retroflex affricates in Polish and other languages are therefore assumed to be identical in place and degree of articulation to the retroflex fricatives described in 2.2.4.3 and to show similar variation.

The second type of affricate to be treated here are the rhotically released stops, which can be represented with the symbols [tɽ] or [dɽ]. They occur in Athapaskan

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[8] This segmental class is also transcribed as [tʂ]. The exact place of articulation of the plosive part is not further investigated in any study of my knowledge, therefore no decision on the correct transcription can be made here. In the present dissertation, the stop is assumed to be homorganic with the fricative part.

[9] From the seven languages with a retroflex affricate listed in Maddieson (1986), Ostyak and Jaqaru do not have a retroflex fricative in their inventory. Furthermore, the Micronesian language Ponapean has an affricate and a flap as its only retroflex segments (Rehg 1973). From this follows that a retroflex affricate does not imply the presence of a retroflex fricative in the same language.

[10] Kehrein (2002: 7) observes that strident affricates (as opposed to laterally or nasally released affricates) form phonologically a class with the corresponding fricatives.

languages such as Minto-Nenana (Tuttle 1998) and Upper Kuskokwim (Krauss 1973: 906), and in the Australian language Anguthimri (Crowley 1981: 152). Rhotically-released stops are usually not included in phonetic descriptions of possible affricate articulations. In traditional Athapaskan literature (e.g. Kraus 1979), these segments are however referred to as affricates because they show the same three-way phonation contrast of plain, aspirated and glottalized phonemes as other Athapaskan affricates such as e.g. [ts]. This classification seems worth following.

According to Crowley (1981: 152), the Anguthimri affricates, which he symbolizes as [tʳ, dʳ], are post-alveolar stops articulated slightly behind the alveolar ridge and followed by a trill. Phonotactically, they behave like one segment. Crowley notes that these sounds are not the same as corresponding retroflexes in other Australian languages. As this is the only study known to me that describes the realization of rhotically-released retroflex stops, the exact articulation and possible variation of this class cannot be further discussed here.

The third type of affricate is the laterally released stop. The inclusion of this type seems necessary since Ball & Rahilly (1999: 67f.) mention that laterally released retroflex stops [ʈɭ, ɖɭ] are possible to produce. Unfortunately, they do not provide example languages. Since the lateral is phonetically presumably more affricated than a lateral occurring in vowel context (due to the larger constriction in place of articulation), I claim that the laterally released stops described by Ball & Rahilly are actually lateral affricates such as the alveolar [tɬ] or [dɮ] found e.g. in the Na-Dené languages Navajo and Tlingit (Maddieson 1984). Evidence for the non-distinctiveness of laterally released stops and lateral affricates is taken from the fact that no phonetic description makes this distinction,[11] and furthermore no language seems to employ the two types distinctively. Masica (1991: 105) mentions that in the northwest West Pahari dialects Bhadrawahi and Bhalesi (Indo-Aryan languages) a 'peculiar set of laterally-released apical stops' exists, but transcribes these sounds as lateral fricatives, which is further evidence for the claim made here that there is no difference between laterally released stops and lateral affricates. The segments that occur in these dialects are [ʈɭ, ʈʰɭ, ɖɮ, ɖʰɮ].[12] According to O'Grady, Voeglin, & Voeglin (1966) the Pama-Nyungan language Adynyamathanha (also known as Wailpi), spoken in South Australia, also has lateral retroflex fricatives.

Lastly, the class of affricates sometimes includes stops with a nasal release (as in Kehrein's 2002 classification). However, I could not find any language described as having a retroflex nasal affricate.

2.2.4.5 Laterals

As Ladefoged & Maddieson (1996: 183) point out, the place of articulation for laterals is usually the same as the place for the corresponding stop in the same

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[11] Even Ball & Rahilly (1999), who introduce the class of laterally released stops, do not explicitly distinguish it from lateral affricates and fail to point out the differences between them.

[12] I transcribed the segments with the corresponding IPA symbols according to Masica's (1991) descriptions. Kehrein (2002: 6) employs the symbols [tˡ] and [dˡ] with a raising sign underneath the retroflex laterals for these speech sounds.

language, though the tongue shapes behind the constriction might differ. This suggests that retroflex laterals show the same articulatory characteristics and variation as the stops. Švarný & Zvelebil's (1955) x-ray study for Tamil and Telugu confirms this hypothesis, as it shows that both stop and lateral retroflex are subapical post-alveolar in these languages. Dixon (1980: 143) gives further evidence from Australian languages. According to him, the Australian retroflex lateral is a subapical post-alveolar just like the retroflex stop. Therefore, retroflex laterals are expected to show the same kind of variation as retroflex stops.

In Indo-Aryan languages we would expect to find an apical post-alveolar lateral. No articulatory study on Indo-Aryan laterals could be found to confirm this.

2.2.4.6 Rhotics

Post-alveolar rhotics articulated with a retroflex tongue shape are possible with three manners. These are the post-alveolar flap (in the IPA symbol chart described as a flap or tap), the post-alveolar central approximant, and the post-alveolar trill.

The retroflex flap [ɽ] could have been included in the class of stops, as it is often described as a flapped stop (e.g. by Laver 1994: 221) because the active articulator hits the passive one in passing. Phonologically, there is evidence for sharing a class with both stops and rhotics: Masica (1991: 97) describes that in many Indo-Aryan languages such as Panjabi, Hindi, and Sindhi the retroflex flap [ɽ] is in complementary distribution with the voiced retroflex stop [ɖ]. In Australian Warlpiri and Maung or African Gbaya and Shona, these segments pattern with rhotics. The retroflex flap is not articulated further back than alveolar. This is due to the tongue movement taking place during its articulation; the tongue tip is curled inwards and approaching the post-alveolar region but flaps out before the actual contact takes place. See figure 2.7 of two production stages of the flap based on Laver (1994: 223).

Figure 2.7   Two stages in the production of a retroflex flap: the retroflex onset (left), and the sliding from post-alveolar to alveolar during closure and release (right) both based on Laver (1994: 223).

Due to this large movement towards the alveolar ridge during the articulation, the flap [ɽ] is inherently less retroflex than e.g. a retroflex stop.

The retroflex trill is articulated with the tongue underside vibrating against the post-alveolar region. The IPA chart does not provide any symbol for this sound; Laver (1994: 220) represents it with an underlined apical trill [r̲], whereas traditional Dravidianists such as Emeneau (1984) use the symbol for an apical trill with a

subscript dot [ṛ]. Spajić et al. (1996) explain that the first contact for a retroflex trill takes place further back than the subsequent contacts, i.e. there is a flapping out gesture observable during the articulation of the trill.

Some speakers of Malayalam have a retroflex trill (recall its dependence on the speech rate illustrated in 2.2.2). Ladefoged, Cochran & Disner (1977) describe this sound as 'almost retroflex', and one can conclude from this that the place of articulation for this segment is not as far back as for other retroflexes and that it is rather the tongue tip than the tongue underside that is involved in the articulation. The Toda retroflex trill investigated in Spajić et al. (1996), however, is a subapical post-alveolar. This indicates language-specific variation within the class of retroflex trills, comparable to the one observed for stops in 2.2.4.1.

The third type of retroflex rhotic is the approximant [ɻ]. This segment occurs e.g. in Australian languages where, according to Dixon (1980), it is articulated almost as far back as the retroflex stop. McDonough & Johnson (1997) demonstrate that the Tamil retroflex approximant shows a constriction at the hard palate. Contrary to the other two types of retroflex rhotics, the approximant does not show any evidence of a forward motion during the consonant closure.

Australian languages usually employ four coronal stops, nasals, and laterals, but only two rhotics which are both apical. Dixon (1980: 144) describes these rhotics as apical trill and subapical post-alveolar continuant. The latter can also be realized as a post-alveolar trill, typically at the end of a stressed syllable. The distinction between rhotics in Australian languages therefore seems to be not in the manner but in the place of articulation, namely apical alveolar versus retroflex. The same variation in manner but consistency in place can be observed in Hausa rhotics, which are apical trill versus retroflex flap or approximant (Newman 1980).

In sum, retroflex rhotics seem to be prone to a large degree of variation, not only in the place of articulation and active articulator, but also in the actual manner of articulation.

2.2.4.7 Retroflex vowels

Vowels can show some kind of secondary articulation as 'apico-post-alveolarized, advanced velar approximants' (Catford 1977: 150), a variant that is often referred to as 'retroflex vowels'. Catford (1977: 192) points out that these vowels involve a raising and sometimes drawing backwards of the tongue tip, which results in apico-post-alveolarized or sublamino-prepalatalized articulations. American English is reported to have retroflexed vowels such as [ɔ�] in *board*. Further instances can be found in the Uto-Aztecan language Serrano and the Mesoamerican Tarascan (Bhat 1973: 38). Vowel retroflexion typically occurs pre-rhotically as e.g. in British and American English (Wakelin 1972), see section 4.4 below. These vowels are also called 'r-coloured' or 'rhotacized' (e.g. by Wells 1982: 139 and Laver 1994: 270). An illustration of such an articulation is given in figure 2.8.

The tongue configuration for a retroflex vowel is nearly identical to the first stage of the retroflex flap, see the left side of figure 2.7, which is also based on Laver.

Figure 2.8 Retroflex vowel, based on an x-ray tracing by Laver (1994: 271).

Catford (1988: 161f.) distinguishes between *retroflexed* and *rhotacized* vowels, the former affecting only open vowels, and the latter referring to the sound [ɚ] as in the American English word *bird*. Rhotacized vowels are, according to Catford, articulated with a redrawn tongue tip or with a bunched, retracted tongue body. The latter do not show any retroflex articulation and are therefore not topic of the present dissertation. Trask (1996: 310) unites both articulations, referring to both as retroflexed or 'r-coloured', and defines them as having the distinct acoustic quality of a lowered third formant.

The present dissertation is primarily concerned with retroflex consonants. Where retroflex vowels are discussed, they are assumed to be articulated as in figure 2.8.

2.2.5 Language family

The association of degree of how far the tongue tip is bent backwards with a specific language family has been made repeatedly in phonetic and phonological literature. Catford (1977: 153) e.g. distinguishes two types of tongue tip bending (retroflexion) and correlates them with the two language families found on the Indian subcontinent, namely Indo-Aryan and Dravidian. He states that the retroflex stops in Indo-Aryan languages are articulated with the underside of the tongue (subapical area) against the back of the alveolar ridge, an articulation he terms 'sublamino-post-alveolar'. Retroflex segments in Tamil and other Dravidian languages however are articulated with the underside against the prepalatal area, according to Catford, and termed by him 'sublamino-prepalatal'. He calls this type of gesture 'the most retroflex of retroflex articulation'. The distinction between moderately retroflexed segments in Indo-Aryan languages and extremely retroflexed segments in Dravidian language is supported by phonetic studies by e.g. Švarný & Zvelebil (1955), Balasubramanian (1972), and Ladefoged & Bhaskararao (1983). Švarný & Zvelebil compare X-rays of retroflex stops of Tamil, Telugu (both Dravidian) and Hindi (Indo-Aryan). They used one speaker of each language, and the results show that the Tamil speaker has the most retroflexed stop with an apical-prepalatal articulation. Ladefoged & Bhaskararao (1983) evaluate the articulation of retroflex stops of several Hindi and Telugu speakers via x-rays and found a systematic difference. The Telugu stops are all considerably retroflexed, with a subapical articulator and prepalatal place of articulation, whereas the Hindi stops are mostly apical and post-

alveolar. Thus, the difference in the degree of tongue tip bending in languages spoken on the Indian subcontinent can be correlated with the distinction of the two language families.

Ladefoged (1964) examines sounds of the West-African language Ewe and the neighbouring Central Togo languages Logba, Siwu, and Gẽ palatographically. He notes that the retroflex voiced stops occurring in these languages are less retroflexed than those of many Indian languages such as Hindi. The exact articulatory description, however, shows that the retroflex in Ewe has "the tip of the tongue against the alveolar ridge (usually the posterior part)" (Ladefoged 1964: 20). Ladefoged's generalization seems to indicate that West-African languages show a common characteristic of apical post-alveolar articulation in the retroflex voiced stops.

The two North-Germanic languages Norwegian and Swedish that employ retroflexion both show apical articulation and a place of constriction that is rarely further back than the post-alveolar region (see Simonsen et al. 2000 on Norwegian, and Lindblad & Lundqvist 1994, 1997 on Swedish). This could be interpreted as a trait of North Germanic.[13]

Retroflex segments in Australian languages do not show one homogenous articulation. According to Butcher (1992: 14), some languages such as Western Arrernte (belonging to the Arandic branch of Pama-Nyungan), Yindjibarndi (south-western branch of the Pama-Nyungan subfamily) and Tiwi (Tiwian subfamily) have retroflex sounds that are articulated with the tongue tip just behind the alveolar ridge, whereas others such as Adynyamathanha (south-western branch of Pama-Nyungan) and Gupapuyngu (Yuulngu branch of Pama-Nyungan) have subapical retroflex segments. Hence, no common retroflex characteristic for all Australian languages can be stated. Further investigations into the numerous Australian sub-families might result in some traits that are shared within subfamilies.

In general, languages belonging to the same language family tend to employ a similar type of retroflex segment, though this does not seem to hold for all language families, as exemplified by the Australian languages.

2.2.6 Inventory size

The degree of articulatory variation is often influenced by the inventory size of the respective languages. Inventory size is partly interrelated with the factor language family described in 2.2.5, as related languages often show similar segment inventories.

Both English and French have only one anterior coronal for any manner (apart from the fricatives) and therefore allow a considerable amount of articulatory

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[13] Optional retroflex articulation of rhotics is reported for various Germanic languages such as English (Ball & Rahily 2000), German (Wiese 2001) (for the area North-East of Dresden) or Dutch (Verstraeten & Van de Velde 2001) (as a variant in the North of the Netherlands). This variation is ignored here as it concerns only one manner class (which might affect other manners via spreading as is the case e.g. in some of the rhotic variants of English) and mostly only regional variants of these languages.

variation, see for instance Dart's (1991) study on alveolars in French and English. The situation is different for languages with large coronal inventories such as Australian languages, where the existence of other, articulatorily close classes prohibits large variation of e.g. the retroflex class. Butcher (1992) investigated several Australian languages and found that the only apical coronal in the Kalaw Kawaw Ya dialect of the Western Torres Strait language is often articulated as retroflex and displays far more variation than either one of the apical segments in Australian languages with a two-way apical contrast. To examine how far the inventory size can influence the degree of tongue tip bending, let us look closely at two different retroflex manners, namely stops and fricatives, and the correlation between their articulation and the size of the inventory.

Stops. To account for the articulatory difference between Hindi and Tamil retroflex stops exemplified in figure 2.4 above in terms of language system, there should be a difference in their coronal inventories. Since it shows less tongue tip bending in its stop, Hindi is expected to have a smaller coronal inventory than Tamil. And indeed, Hindi has two coronal plosive series,[14] a dental and a retroflex (Ohala 1994), see (1a), whereas Tamil has four: a dental, an alveolar, a retroflex, and a palato-alveolar (Christdas 1988), see (1b).

(1)   (a)   Hindi   [t̪, ʈ]   (or: [t̪, t̠])
      (b)   Tamil   [t̪, t, ʈ , t̠]
      (c)   Toda   [t̪, t, ʈ]
      (d)   Kannada   [t̪, t, ʈ]

Thus the pressure of many segments in the coronal region seems to cause a more retracted articulation of the retroflex plosive for Tamil. Toda supports this hypothesis. Like Tamil, it has a subapical post-alveolar retroflex stop (Shalev, Ladefoged & Bhaskararao 1993) and two additional coronal stops, a laminal dental and an apical alveolar, see (1c). The existence of one further apical element in a language, not necessarily a four-way coronal contrast, seems therefore to cause a subapical articulation of retroflex stops. Kannada (another Dravidian language) also has a subapical retroflex stop and the same three-way coronal distinction as Toda, see (1d), and hence supports this point.

     As all the languages characterized by a subapical stop and a large inventory mentioned up to now are Dravidian, one could argue that these two characteristics are specific to this language family (see 2.2.5 above) or are areal features that spread together, but are not correlated. In order to refute this argument, languages from families other than Dravidian have to be found that behave similarly. Australian languages with a four-way coronal contrast of apical alveolar, laminal dental, retroflex, and laminal post-alveolar stops (but also nasals and laterals) seem to be ideal for this purpose. Eastern Arrernte (Butcher 1995) e.g. has such a four-way

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[14]   'Series' is used to denote a voiced and/or voiceless segment in one place of articulation such as dental, alveolar etc. The segments [c, ɟ, ç, ʑ, ɲ] are assumed to be alveolo-palatal, not palatal (following e.g. Keating 1991, Hume 1992, Hall 1997a) and thus belong to the coronal sounds.

contrast and a retroflex that is apical palatal, see (2), thus providing evidence for the systemic pressure of a large inventory on subapical retroflex articulation.

(2)   Eastern Arrernte   [ʈ, t, ʈ , t̪]

Other Australian languages, however, do not support this inventory theory. Butcher's (1992) palatographic studies of the retroflex stops in five of these languages with the same two-way apical contrast as Eastern Arrernte (Warlpiri, Kunwinjku, Murrinh-Patha, Nyangumarta and Western Desert) indicate that the retroflex stops vary from apical post-alveolar in Nyangumarta to subapical palatal in Murrinh-Patha, with the remaining three languages somewhere in-between. The apical alveolars, however, are articulated in exactly the same way in all five languages. Thus the larger inventory incurs a noticeable restriction on the variation allowed within the alveolar class, but not within the class of retroflexes.

One can conclude from this that a large coronal inventory does not necessarily impose a subapical post-alveolar articulation on the retroflex stop, though there is a general tendency towards more retracted retroflexes in larger inventories. Small inventories with a retroflex stop, on the other hand, seem to have retroflex segments articulated further front and with the tongue tip. Support for this comes from the West-African language Ewe, which has two coronal (voiced) stops, one laminal denti-alveolar and an apical post-alveolar retroflex, see (3).

(3)   Ewe   [d̪, ɖ]   (or: [d̪, ɖ])

Here the relatively small coronal inventory allows a segment that shows almost no bending backwards of the tongue tip. Similar observations can be made for Norwegian, which has a laminal dental and an apical (post)alveolar retroflex as the only coronals (Simonsen et al. 2000), see (4).

(4)   Norwegian [t̪, ʈ]   (or: [t̪, t̪])

Fricatives. The correlation of inventory size with degree of tongue tip bending seems also to work for fricative inventories. The difference in retroflex fricative between the Tamil laminal post-alveolar and the apical post-alveolar in Toda as illustrated above in figure 2.5 can be explained by differences in the inventory. Though both languages are Dravidian, Tamil has three coronal fricatives, see (5a), whereas Toda is the only language of this family with four coronal fricatives, namely a laminal alveolar, an apical post-alveolar, a laminal post-alveolar, and a subapical palatal, see (5b). Hence the subapical palatal in Toda might be due to the large fricative inventory.

(5)   (a)   Tamil   [ð, s, ʂ]   (or [ð, s, ʂ])
       (b)   Toda   [ʂ, s̠, ʃ, ʂ]   (or [ʂ, s̠, ʃ, ʂ])

The coronal fricative system of Toda is of further interest for the present study, as its apical post-alveolar is very similar in place of articulation and active articulator to the retroflex fricative in Tamil (depicted in figure 2.5 on the left). Based on this similarity, one could postulate that Toda has two types of retroflex fricatives, a

subapical palatal (like the retroflex stop in Dravidian languages) and an apical post-alveolar (like the Tamil fricative), as Ladefoged & Maddieson (1986) did. In later work, Ladefoged (1994), Ladefoged & Maddieson (1996), and Shalev et al. (1993) disprove this claim, arguing that there are "no two degrees of retroflexion" in Toda (Ladefoged 1994: 20). As elaborated in the present chapter, degree of tongue tip bending is variable, and some retroflex sounds do not even show a bending of the tongue tip at all, recall the Ewe stop. Especially fricatives typically have a lesser degree of tongue tip bending than plosives or nasals, recall 2.2.4.3. Thus, Ladefoged et al.'s argumentation that Toda does not have two retroflexes because there are no two 'degrees of retroflexion' is not convincing as no definition of retroflexion is given by them. According to the phonetic descriptions of retroflex segments made above, the articulation of retroflexes can range from apical to subapical and from alveolar to palatal place of articulation. Both the Toda apical post-alveolar [s̱] and the subapical palatal [ʂ] fall into this range and thus can be classified articulatorily as retroflex. Chapter three will show that both Toda fricatives also comply with the acoustic criteria for retroflex. It remains to be discussed whether it is phonologically necessary or useful to distinguish two retroflex categories, and how they could be represented. This question will be dealt with in chapters 4 and 5.

As in the retroflex stop systems, the existence of four coronal fricatives in a language is not the decisive factor for the degree of tongue tip bending. The Bzyb dialect of Abkhaz, a Northwest Caucasian language, has according to Ladefoged & Maddieson (1996: 161f.) four coronals, three of them laminal (an alveolar, a post-alveolar, and an alveolo-palatal) and one apical, see (6).[15]

(6)　Abkhaz　　　[ṣ, ʃ, ʂ, ɕ]　　　　(or: [ʂ, ʃ, ṣ, ɕ])

The apical [ʂ] is a post-alveolar with slight tongue tip bending only. This might be due to the fact that there is no second apical and therefore no need for maximizing an articulatory difference between apical alveolar and subapical post-alveolar.

To complete this section on retroflex fricatives and their correlation with inventory size, a discussion of the post-alveolar fricatives in the Slavic languages Polish and Russian has to be included. As indicated already in 2.2.4.3, the Polish and Russian sounds are articulated with a flat, non-domed tongue middle and with a raised tongue tip (see also section 2.4 about the extent to which Polish fricatives conform to retroflex characteristics). With such a variant of retroflex, we would expect the coronal fricative inventory to be small.

(7)　(a)　Russian　　　[s̪, ʂ, ʃː]
　　　(b)　Polish　　　　[s̪, ʂ, ɕ]

Both Russian and Polish, however, have a fricative inventory with three segments, a dental [s̪], a retroflex [ʂ], and a further post-alveolar fricative. In Russian, the additional fricative is a laminal post-alveolar, see (7a). This segment is usually

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[15]　Ladefoged & Maddieson use a different symbol for the laminal post-alveolar in Abkhaz because this sound differs from e.g. English [ʃ] in that it is articulated with the tongue tip behind the lower teeth, and does not have a sublingual cavity.

transcribed as [ʃʲː] but referred to as [ʃː] in this study, because it does not consist of a post-alveolar plus an additional short glide, i.e., it is not a real secondarily palatalized post-alveolar.[16] Polish has the additional alveolo-palatal [ɕ], see (7b). Russian and Polish thus have two laminal coronal fricatives besides the apical retroflex. The absence of a second apical coronal can explain why these two languages employ a retroflex that shows no backwards bending of the tongue tip, because there is no need for a maximal distinction between two apicals.

In sum, it has been shown that the articulatory variation of retroflex stops, fricatives, and also of other manners, if the findings can be transferred to them, can be partly accounted for by referring to the inventory system in which the retroflex segment occurs. Whereas small inventories with only one apical, namely the retroflex, allow considerable variation of the retroflex and also a place of constriction further front than the post-alveolar region, large inventories (i.e., those with two apicals and one or more laminals) generally show less variation and an articulation with a bent backwards tongue tip. It has to be pointed out that this is only a tendency and no universal regularity, as illustrated by the counterexamples above.

2.3 Common articulatory properties of retroflexion

As was shown in the previous section, the exact place of contact and the exact articulator of retroflex segments are subject to a large amount of variation, depending on several parameters. Furthermore, it was shown that the traditional property of retroflexes as a bending backwards of the tongue tip is not universally valid. Variation in the class of retroflexes seems to be larger than in any other articulatory class, which makes it difficult to find common properties that hold for all retroflexes.

The present section is concerned with defining more or less invariant characteristics that can be used as articulatory defining criteria for a retroflex articulation. Four such properties are proposed here, namely apicality, sublingual cavity, posteriority, and retraction. Not all of them occur in the same degree in all instances of retroflex segments, but they can be viewed as defining characteristics of a prototype retroflex; the more of these properties a segment has, the more retroflex it is.[17] Interrelations between these properties proposed here are developed in the following sections and summarized in 2.3.5. Seeming counterexamples of languages such as Polish, Russian, and Mandarin, which have retroflexes that do not have all four properties, are discussed in 2.4.

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[16] The Russian laminal post-alveolar is not an alveolo-palatal [ɕ], either, see figure 2.13 below.

[17] Shalev et al. (1993: 106) point out that retroflex stops have a lower jaw position than the other coronals. This property is not further developed here.

2.3.1 Apicality

As could be seen in the phonetic descriptions above, retroflexes mainly involve the tongue tip in their articulation, either its upper side (apical articulation) or its lower side (subapical articulation). Even in cases where no judgement on the involvement of the tongue tip can be made from the articulatory data, as is the case for some fricatives (e.g. the Tamil fricative in figure 2.5 left or the Mandarin fricative in figure 2.6), the tongue tip is not in resting position, i.e. behind the lower teeth, but raised. Usually, however, the tip of the tongue forms the actual constriction for retroflexes.

In the present study, the term 'apicality' is defined to refer to this involvement of the tongue tip. Apicality is meant here in a strict phonetic descriptive way. It is not used as a phonological feature such as e.g. 'apicality' in Williamson's (1977) feature system or [–distributed] in traditional featural theories (e.g. Chomsky & Halle 1968 and Sagey 1986), since these feature values do not allow the inclusion of cases as the Tamil retroflex which does not show an active articulation with the tongue tip.

Retroflex segments share the characteristic of apicality with front apicals in the dental/alveolar region. All apical segments have in common that they consist of an extremely rapid gesture, as the tongue tip is the most flexible and quickest active articulator. In fast speech, this quick gesture is often reduced or lost, which explains the decrease of tongue tip bending with increased speed of speech described in 2.2.2. Retroflexes differ from front apicals in the place of constriction, which is defined as the second characteristic criterion, 'posteriority'.

2.3.2 Posteriority

Retroflexion in the traditional sense refers to an articulation behind the alveolar region, usually described as 'post-alveolar' or sometimes 'palatal' (e.g. Catford 1977). This is termed 'posteriority' below, and is employed as one of the articulatory characteristics of retroflexion. Besides retroflexes, the segmental classes of palato-alveolars and alveolo-palatals are also posterior. Posteriority thus corresponds to [CORONAL, –anterior] in Feature Geometric notation (Sagey 1986), i.e., only segments articulated with the tongue tip or blade can be posterior. In order to distinguish the three posterior classes retroflex, palato-alveolar, and alveolo-palatal, further characteristics have to be used.

The two non-retroflex posterior segment classes, palato-alveolars and alveolo-palatals, are both laminal, thus differ from retroflexes in the characteristic apicality. Furthermore, they occur only with a fricative manner, whereas retroflexes can occur with all possible manners of articulation (see description in 2.2.4). A third point distinguishing these two classes from retroflexes is the shape of the tongue middle during their articulation: palato-alveolars and alveolo-palatals have a domed, i.e. raised, tongue middle; retroflexes a flat one (which is defined as belonging to the fourth property, 'retraction', see section 2.3.4).

Section 2.4 will discuss some retroflex sounds that lack the characteristic of posteriority, e.g. the Polish fricative. These exceptions only involve fricative manners of articulation.

Retroflexes typically involve a movement of the tongue tip from a posterior to a more anterior position during their articulation, a feature referred to above as "flapping out". This flapping out could be treated as another, separate property of retroflexion. The present study does not adopt this view because flapping out, in contrast to the other characteristics introduced here, does not occur in the same way for all manners of retroflex articulation. Fricatives, for example, allow flapping out only at the onset of a following segment but not during the fricative constriction. Introducing this gesture as a separate property would thus imply that specific manners like fricatives are inherently less retroflex than e.g. stops or flaps, an implication avoided here. The flapping out gesture occurs almost exclusively with an apical articulation on a posterior place, and hence is assumed a possible concomitant of the properties 'posteriority' and 'apicality'.

2.3.3 Sublingual cavity

A unifying criterion for retroflex segments seems to be their sublingual cavity, visible in all the x-ray tracings of the retroflexes given above. All sounds articulated with the tongue tip or blade on or behind the alveolar ridge evince a cavity beneath the tongue, due to the backwards displacement of the tongue front (Sundberg & Lindblom 1990: 1316). Keating (1991: 43) points out that this cavity increases in volume from palatal, alveolo-palatal ("hissing-hushing" in her terms), palato-alveolar, apical retroflex, to the sublaminal retroflex. The property of sublingual cavity is thus not unique to retroflex segments, but judging from Keating's description it is largest for any kind of retroflex articulation. All segment classes with a sublingual cavity share also the property of 'posteriority', according to Keating's definition above. They differ, however, in the criterion apicality, which is unique to retroflexes.

'Sublingual cavity' differs from traditionally employed articulatory descriptions of segment classes, which are usually restricted to the place of articulation and the active articulator.

Vowel context seems to affect the size of the front cavity systematically. As Sundberg & Lindblom (1990: 1315) point out, "everything else being equal, that cavity tends to be larger for [retroflex] tokens surrounded by /u/, intermediate for /a/, and smallest for samples with /i/." The dependence of the sublingual cavity on context proves the aforementioned impossibility to find a property that is invariant for all retroflexes in all contexts.

2.3.4 Retraction

The property 'retraction' to be discussed in this section is not as obvious a characteristic of retroflexion as those proposed up to now and is the most controversial of all. Bhat (1974a) writes that retroflexion cannot be equated with

retraction (defined by him as backing of the tongue body), because retraction does not occur exclusively with retroflexion. Furthermore, some retroflexes are said to occur without retraction, namely Lardil retroflex consonants and Badaga retroflex vowels.[18] It is argued here that all retroflexes - but also other sounds - show retraction.

In the phonetic literature, retraction is usually defined by the place in the vocal tract where the tongue retracts to, and distinguished into pharyngealization or velarization. The term pharyngealization is mostly used for a secondary vowel articulation (e.g. by Ladefoged & Maddieson 1996: 365) where the root of the tongue is drawn back towards the back wall of the pharynx. Velarization is understood as a secondary articulation where the tongue dorsum is raised towards the velum (e.g. definition by Trask 1996: 374). Brosnahan & Malmberg (1970: 67) define velarization as 'the elevation of the back of the tongue toward the soft palate or rear wall of the pharynx', which actually covers both velarization and pharyngealization as defined previously. Ladefoged (1971) points out that there is little difference between velarized and pharyngealized sounds[19] and says that no language distinguishes between these two. He goes on to say that

> [I]t is interesting to note that there is some similarity in quality between retroflex stops and velarized or pharyngealized stops. This is due to the fact that in all these sounds the front of the tongue is somewhat hollowed (Ladefoged 1971: 208)

The property 'retraction' introduced here is thus defined as a displacement of the tongue back towards the pharynx or velum. A schema of these possible displacements is given in figure 2.9, based on x-ray tracings of velarized and pharyngealized segments in Laver (1994: 326ff.) and Ladefoged & Maddieson (1996: 365).

Figure 2.9   Retraction, i. e. velarization (upper movement) and pharyngealization (lower movement) in comparison to neutral tongue position

These displacements of the tongue towards the velum or the pharynx are sometimes referred to as 'tongue backing', as by Bhat (1974a) and Stevens (1998).

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[18]   For a detailed discussion of Bhat's claims the reader is referred to Hamann (2002a).

[19]   An interesting language-specific case of the similarity between pharyngealization and velarization is Russian. Whereas Russian consonants are traditionally described in terms of the opposition palatalized vs. velarized, Bolla (1981: 70) describes the latter as 'pharyngealized' because he 'found the movement of the root of the tongue and the postdorsum towards the pharyngeal wall to be more important than that towards the soft palate'.

It is difficult to see retraction in x-ray tracings of retroflex segments clearly, as most of these pictures do not even show the pharyngeal area and the tongue position therein. Furthermore, often no comparison to the normal, non-retracted tongue position can be made, as x-ray studies usually do not include a figure of the articulators at rest.

The legitimacy of combining the distinct secondary articulations of pharyngealization and velarization as a single property is further confirmed by the fact that they are described as resulting in the same acoustic effects, see section 3.2.4.

The property 'retraction' is not identical to the feature 'retracted tongue root', henceforth RTR (opposed to 'advanced tongue root', see Halle & Stevens 1969), because this articulatory setting involves a pharyngeal constriction at a lower level than for pharyngealization, according to Laver (1994: 411). Furthermore, RTR is usually only used for vowel articulations (see Ladefoged's 1964 description of Igbo vowels). Retraction as defined here is also different from McCawley's (1966) feature 'retracted articulation' by which he distinguishes dentals from alveolars and retroflexes from palatals (amongst others), the second item in each pair being [+retracted] (and thus ascribing retroflex a non-retracted status). The property 'retraction' is best captured by the traditional phonological feature [+back] (e.g. Clements 1991, Hall 1997a, Lin 1989, Rubach 1984).

Cooccurrence of retroflexion with retraction can be articulatorily explained. The tongue, in order to be able to move its tip upwards and into a displaced position in the post-alveolar region, stretches and pulls backwards (Spencer 1984: 30), which results in a lowered tongue middle and retracted tongue back. Tongue lowering is thus a concomitant of the property 'retraction', or the reverse.

'Lowering' describes the flat tongue middle that is found with retroflex articulation. In many phonetic descriptions the lowering of the tongue middle in retroflexes is described as a concaving of the dorsum (Brosnahan & Malmberg 1970: 46) or a less convex shape of the tongue than in lamino-post-alveolar articulations (Catford 1977: 157). The shape of the tongue middle is actually one of the main differences between retroflexes and palato-alveolars or alveolo-palatals: the latter two have a raised tongue middle, sometimes called "domed" (e.g. Ladefoged & Maddieson 1996: 148), in contrast to the lowered one of retroflex segments.

The retraction of the tongue back and the lowering of the tongue middle that occurs with retroflex articulation is given schematically in figure 2.10, where the grey underlying figure indicates the tongue position at rest.

Bhat (1974a) argues that retraction is not restricted to retroflexes but mostly occurs with apicals in general. Stevens, Keyser & Kawasaki (1986: 436), however, claim that a fronted tongue body provides a more favourable posture for an apico-alveolar articulation, i.e. that a non-retroflex apical usually occurs with fronted tongue body.
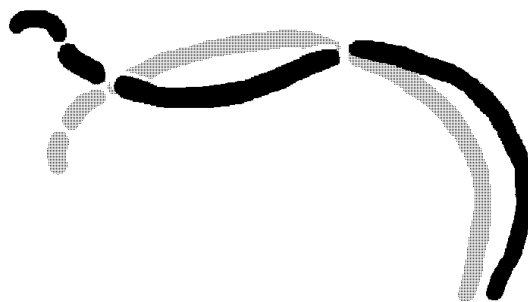
Figure 2.10 A schematic illustration of tongue gestures co-occurring with tongue tip retraction. Underlyingly grey are the tongue parts at rest, from left to right: tip, blade, middle (or pre-dorsum), and back (or post-dorsum) as defined in section 2.1.

From comparing the realization of apico-alveolars in different languages we know that this class can be non-retracted. For example, British English, Dutch, and Catalan have a non-velarized lateral in the onset and a velarized lateral in coda position.[20] Thus retraction cannot be assumed to occur exclusively with retroflexes. Nevertheless, as retraction is not used as the single defining criterion for retroflexion but along with the other three properties developed above this does not cause any definition problems.

Further evidence in the phonetic literature for the correlation of retroflexion and retraction besides Bhat (1974a) is Catford (1977: 157) who writes that the tongue body for retroflex segments shows some velarization. Language-specific descriptions of a correlation between retroflexion and retraction are, for example, Hamilton (1980: 21), who uses the terms velarization and retroflexion interchangeably for the post-alveolar fricative in Polish, and Wood (1996), who writes that the Bulgarian retroflexed /r/ involves a pharyngeal tongue body gesture. In Ponapean, a Micronesian language spoken on the Pohnpei Island, the velarized counterpart of the dental t is a retroflex affricate (Rehg 1973), giving further evidence for the inherent retraction of retroflexes (see section 4.4.1 below).

Using 'retraction' as a defining characteristic of retroflexion poses problems with languages that are said to have a distinctively non-retracted (i.e. non-velarized or non-pharyngealized) retroflex segment. The Australian language Lardil is the only language known to me which is supposed to have a phonetically and phonologically non-velarized retroflex fricative (Hall 1997a, 2000a, and Wilkinson 1988, both based on Stevens et al. 1986). The phonetic evidence for this claim comes from Hall (1997a: 49) who gives midsagittal tongue tracings of non-velarized and velarized retroflexes from the languages Lardil and Polish, respectively, to

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[20] Retraction of the tongue body (towards the velum) also seems to occur distinctively in the articulation of velar consonants, though for velars this is the primary constriction in the vocal tract, not an additional secondary one.

illustrate the difference. The source for the figure of the non-velarized retroflexes in Lardil is given as Stevens et al. (1986). Stevens et al., however, do not provide any graphic illustrations of the Lardil coronal. The only figure that might have served as the basis of Hall's figure is a schematized retroflex stop in figure 20.4 on page 433, based on Ladefoged & Bhaskararao (1983) and Wierzchowska (1965). These sources, though, investigated retroflexes in Hindi, Tamil, and Polish. The schematic retroflex sound in Stevens et al. shows a distinct backing of the tongue body and is explicitly described as 'more backed' than an apical dental or a laminal post-alveolar in the text. In their phonetic description of Lardil sounds at a later point, Stevens et al. (p. 444f.) observe that [+distributed, −anterior] segments, i.e. laminal post-alveolars, are [−back] in this language. Hall (1997a) presumably misapplied this correlation to [−distributed, −anterior], i.e. retroflex, segments and concluded that Lardil is a language with [−back], i.e. non-velarized, retroflexes. A discussion of the phonological inadequacy of the distinction between velarized and non-velarized retroflexes in Lardil can be found in Hamann (2002a: 17ff.).

Though the primary concern of the present study is retroflex consonants, let us shortly look at the vowel system of the Dravidian language Badaga (spoken in the Indian state of Tamil Nadu), which is another apparent counterexample to the claim that velarization always co-occurs with retraction. According to Bhat (1974a: 234), Badaga contrasts plain, retroflex, and retracted vowels. Using retraction and retroflexion contrastively implies that they do not co-occur together in this language. Bhat bases his description of Badaga vowels on Emeneau (1939), who, however, describes the three-way contrast as one of 'non-retroflexed, half-retroflexed, and fully-retroflexed vowels'. Bhat does not motivate his reanalysis of these vowels, so we follow Emeneau's description, which poses no counterevidence for the assumption that the characteristic 'retraction' holds for retroflex vowels, too. Summing up, no language seems to exist with a non-retracted retroflex.

Besides the claim that non-velarized or non-pharyngealized retroflexes do not occur, the retroflex property 'retraction' introduced here has a further implication. If retroflex segments are inherently retracted, they should not be compatible with secondary palatalization, because a simultaneous articulation of palatalization and velarization or pharyngealization is articulatory impossible. The palatalization of segments involves a raising of the middle of the dorsum and a lowering of the tongue back, whereas retraction has the opposite articulatory consequences of flattening the middle of the dorsum and raising the back. Both gestures cannot co-occur, as the non-existence of a segment with secondary palatalization and velarization or pharyngealization in the languages of the world attests. Nevertheless, one finds references in the literature to palatalized retroflexes in languages such as Toda (Shalev et al. 1993; Spajić, Ladefoged & Bhaskararao 1996) and Kashmiri (Bhat 1987). I will argue that these segments are not retroflex (namely that palatalization of retroflexes triggers a change from a retroflex to a palato-alveolar articulation). This point will be developed in detail in section 2.5 below.

2.3.5 Summary of characteristic properties

In sections 2.3.1 to 2.3.4 above, four articulatory characteristics for retroflex segments were described, namely apicality, posteriority, sublingual cavity, and retraction. Looking at them separately, none of them is totally new for defining retroflexion, as they have been mentioned in connection with retroflexion in the phonetic and phonological literature before, though not necessarily with these terms and with a narrower definition in the case of retraction and apicality. Using the four of them together as defining criteria for retroflexion, however, is a novel approach.

The bending backwards of the tongue tip and the flapping out of the retroflex articulation have not been introduced as separate properties for the following reasons. As has been shown in 2.2, the tongue tip often fails to bend backwards in a retroflex, and hence this property would be violated by a large number of segments traditionally considered retroflex. Furthermore, if the two properties apicality and posteriority are met, this includes a possible bending backwards of the tongue tip, as the property apicality includes subapical, but it does not necessarily require it. Thus, the bending backwards of the tongue tip does not have to be stated as a separate property. Concerning the flapping out, it has been shown in 2.2 that not all retroflex manners include this gesture.

As has been indicated in their definitions, the proposed four properties are interrelated, i.e. some of them imply the presence of others. Posteriority implies the presence of a sublingual cavity, which means that a posterior articulation always co-occurs with a sublingual cavity. This entailment is given in (8a). Furthermore, the combination of some pairs of properties automatically entails the presence of the remaining two: apicality and posteriority imply a retracted articulation with sublingual cavity, see (8b), and posteriority and retraction imply apicality and a sublingual cavity, see (8c). Finally, two properties imply the presence of a third, thus a sublingual cavity plus retraction implies an apical articulation, see (8d), and apicality plus sublingual cavity implies retraction, see (8e).

(8) (a) posteriority   →   sublingual cavity
     (b) apicality & posteriority   →   retraction, sublingual cavity
     (c) posteriority & retraction   →   apicality, sublingual cavity
     (d) subling. cavity & retraction   →   apicality
     (e) apicality & sublingual cavity   →   retraction

The criterion 'retraction' makes some implications on the articulatory restrictions for retroflex segments that have not been proposed before. It predicts the absence of non-retracted (i.e., non-velarized or non-pharyngealized) retroflexes in languages of the world, which could be attested by showing that Lardil, the only known counterexample, does not have such a segment, either. A second implication is that secondary palatalization of retroflexion is impossible, because the result would have to be apical and laminal at the same time. This point will be further developed in 2.5 below.

2.4 Retroflex fricatives in Slavic languages

Having established four properties for retroflexion, this section applies these properties to two languages of a single family, namely Slavic, as a contribution to the analysis of retroflex consonants in this group. The post-alveolar fricatives[21] in the two Slavic languages Polish and Russian will be shown to be retroflex. Though traditionally described as palato-alveolar [ʃ], it has been argued by e.g. Keating (1991) and Hall (1997a) that the Polish fricative should be considered phonetically and phonologically to be retroflex. Keating (1991) argues similarly in favour of the retroflex quality of the Russian segment, though only on acoustic grounds, without giving a proper definition of retroflex. Whether these fricatives in Polish and Russian behave as retroflex phonologically as well, will be dealt with in chapter 4. The difference between retroflex and non-retroflex post-alveolar fricatives in Slavic languages was discussed in Hamann (2002b), where I show that Bulgarian, in contrast to Polish and Russian, has a non-retroflex laminal post-alveolar fricative. Hamann (2002b) also deals with Czech, but found no coherent phonetic results. Furthermore, there was no phonological evidence but also no counterevidence for concluding that the Czech post-alveolar is retroflex.

2.4.1 Polish

Polish has a fricative articulated in the post-alveolar region, as exemplified by the data in (9).[22]

(9) *Word-initial*   *word-medial*   *word-final*
     szal [ʃal] 'scarf'   kasza [ˈkaʃa] 'groats'   lekarz [lɛkaʃ] 'physician'

Traditionally, this sound is described as apical palato-alveolar, e.g. by Rubach (1984) and Wierzchowska (1980), and referred to with the IPA symbol [ʃ], e.g. by Dogil (1990). Ladefoged & Maddieson (1996: 155) compare this segment to the post-alveolar fricative in Mandarin, see figure 2.6, but argue that both sounds do not belong to the class of retroflexes, as they are laminal flat post-alveolars. At a later point (p. 154) Ladefoged & Maddieson refer to these sounds as 'flat post-alveolar (retroflex)' and use the alveolar symbol with a subscript dot for them, which is a traditional way of transcribing retroflex sounds used in studies of the languages of the Indian subcontinent. Thus Ladefoged & Maddieson's classification of the Polish (and Mandarin) sound with respect to retroflexion is unclear, and even less so are the criteria for their classification. Keating (1991) argues that the Polish sound gives an acoustic impression similar to that of other retroflexes, hence can be included into the class of retroflex sounds. But she does not give any articulatory criterion either.

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[21] The discussion in this section is restricted primarily to the voiceless post-alveolar fricative in the respective languages, but the argumentation can be extended to the voiced counterpart and to the affricate series as well (recall section 2.2.4.4 on the articulatory similarity of retroflex fricatives and affricates).

[22] The IPA symbol [ʃ] is used for the Polish and Russian examples in order to avoid any implications on their status before looking at their exact articulation.

Let us apply the four properties of retroflexion discussed in 2.3 to the Polish sounds, starting with apicality. The literature differs on the description of the active articulator of the Polish fricative. Biedrzycki (1974: 20ff.), Catford (1988: 90f), Dogil (1990), and Spencer (1986) all describe it as apical, Ladefoged & Maddieson (1996: 154) call it laminal. Ladefoged (2001: 151) describes it as a sound produced with a raised tongue tip, and Keating (1991) says it is variable. An x-ray tracing of the Polish post-alveolar voiceless fricative, given in figure 2.11 (based on Wierzchowska 1980: 64), shows that the tongue tip is not in resting position for this sound, thus 'apicality' (as defined in 2.3.1) is satisfied. Tracings from other sources (e.g. Ladefoged & Maddieson 1996: 154) show a similar articulation.

Figure 2.11　Polish post-alveolar with apical alveolar articulation (based on Wierzchowska 1980: 64)

Concerning 'posteriority', the Polish sound is generally described as post-alveolar. The x-ray tracing in figure 2.11, however, indicates a place of articulation that is at the alveolar ridge, and thus further front than defined for 'posteriority'. The property of posteriority thus seems not to be fully fulfilled by the Polish sound.

The sublingual cavity of the Polish segment is clearly discernible from figure 2.11, and the literature (such as Keating 1991) agrees on its existence, thus the criterion of 'sublingual cavity' is fulfilled. In cases where the shape of the tongue is described (e.g. in Keating 1991 and Ladefoged & Maddieson 1996), there is agreement on its lowered, backed nature, which fulfils the definition of 'retraction'.

Though not fulfilling all four parameters of retroflexion, the Polish sound can be classified as retroflex on the grounds of its apicality, its retraction, and the existence of a sublingual cavity in its articulation.

2.4.2 Russian

The Russian post-alveolar fricative, exemplified by the data in (10), is also traditionally described simply as a post-alveolar fricative.

(10) *Word-initial*　　　　*word-medial*　　　　*word-final*
　　šag　[ʃak] 'step'　　pošel　[pʌˈʃol] 'went'　　naš　[naʃ] 'our'

The notion of retroflexion is never mentioned in the literature, with the only exception of Keating (1991). The sound in question is illustrated in figure 2.12 (based on Bolla 1981: plate 60).

Figure 2.12 Russian post-alveolar fricative, based on an x-ray tracing by Bolla (1981: plate 60).

Bolla (1981: 71) describes this sound as a mediodorsal alveolo-palatal,[23] but the x-ray tracings from the same source show that this sound-class is articulated with a raised tongue tip. Keating (1991: 35) even states that some x-ray tracings of the post-alveolar fricatives in Russian made by Oliverius (1974) show a bending backwards of the tongue tip. Hence the criterion of apicality is fulfilled.

Though described as post-alveolar, the place of articulation in figure 2.12 seems to be the alveolar region (according to the definition and illustration given in 2.1), so the Russian fricative is not for certain posterior. Its sublingual cavity is visible in the x-ray tracing of figure 2.12.

Regarding retraction, phonetic descriptions on the Russian sounds explicitly mention a velarized and flat tongue shape, e.g. Bolla (1981: 90), and Jones & Ward (1969: 134). Maddieson (1984: 226) even uses special diacritics to indicate velarization for these sounds: [ʃ] and [ʒˠ]. Catford (1977: 192) says that the Russian apico-post-alveolars have "the part of the tongue immediately behind the apex and the blade slightly hollowed, and the back slightly raised, giving a somewhat velarized effect." In addition, the x-ray tracing in figure 2.12 shows a flat tongue shape and a distinct retraction of the tongue body, so there is no doubt about the retraction of this sound.

Like the Polish post-alveolar, the Russian fricative definitely fulfils three properties of retroflexion, although the property of posteriority could not be clearly determined.

2.4.3 Slavic post-alveolar fricatives as non-prototypical retroflexes

Summing up the results of the comparison in this section, all three Slavic fricatives fulfil the criteria of apicality, sublingual cavity, and retraction. Posteriority, however, is a property that is not consistently present in the Slavic sounds. Whether the post-alveolars segments in Polish and Russian behave phonologically like post-alveolars, i.e. [-anterior], is a point that will be discussed in chapter 4. The present discussion looks at the phonetic criteria only. Since three criteria are fulfilled, the Slavic post-alveolar fricatives can be classified as retroflex, though they do not

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[23] This description by Bolla refers to both [ʃ] and [ʃː], which differ strongly in their articulation, cf. section 2.5 below, where I argue that the first one is retroflex and the second one laminal post-alveolar.

conform to the most prototypical retroflex fricative such as the fricative in e.g. Toda, which satisfies all four criteria but which is crosslinguistically extremely rare.

Altogether, a segment is still retroflex if it has all criteria except posteriority satisfied. The question has to be posed here whether any three criteria are sufficient, or whether it is only posteriority that can be lacking for a retroflex class. To answer this question, all other combinations of three of the four properties have to be examined. These possibilities are given in (11).

(11) (a)   posteriority & subl. cavity & retraction   violates (8c), (8d)
     (b)   apicality & posteriority & retraction   violates (8a), (8b), (8c)
     (c)   apicality & posteriority & subl. cavity   violates (8b), (8e)

A sound with all retroflex properties present except for apicality, see (11a), would be a laminal post-alveolar with a sublingual cavity and retraction. Posteriority with a sublingual cavity is possible in a laminal post-alveolar, but this cannot be combined with retraction, since a laminal articulation always involves a raised tongue middle, i.e. a bunched tongue (see e.g. x-ray tracings of laminal consonants in general in Laver 1994, or language-specific for Toda in Shalev et al. 1993), which cannot be combined with a flat tongue middle and a retracted tongue back. This means that a segment with the criteria posteriority, sublingual cavity, and retraction but without apicality is articulatorily impossible. See also the implications (8c) and (8d) which require the presence of the property apicality in this combination.

The second property that could be missing is the sublingual cavity, see (11b). As a posterior articulation always entails a sublingual cavity (recall the entailment in (8a)), such a segment is articulatorily impossible. Finally, retraction of the tongue body could be missing, see (11c), but apicality and posteriority is only possible with a retracted tongue back, see (8b), hence also the third possibility of one missing property cannot be articulatorily realized. Thus, only 'posteriority' can be lacking from a retroflex, as all other combinations of one missing criterion are articulatorily impossible.

What happens now if two characteristic properties are not present in a segment; can this still be a retroflex? Combining two properties of the set of four gives us six possibilities, all listed in (12).

(12) (a)   apicality   & posteriority   violates (8a) and (8b)
     (b)   apicality   & subl. cavity   violates (8e)
     (c)   apicality   & retraction   realized as velarized alveolar apical
     (d)   posteriority & subl. cavity   realized as laminal post-alveolar
     (e)   posteriority & retraction   violates (8a) and (8c)
     (f)   subl. cavity & retraction   violates (8d)

Four of them, (12a), (12b), (12e), and (12f), are articulatorily impossible because of the entailments stated in (8), e.g. the combination of posteriority and retraction in (12e) to the exclusion of apicality and sublingual cavity is impossible, as apicality is entailed by the implication (8c) and sublingual cavity by (8a) and (8c).

The remaining two possibilities (12c) and (12d) are non-retroflex. Apicality and retraction alone (12c) yield a dental or alveolar apical with secondary velarization or pharyngealization. And a segment that fulfils the properties of posteriority and sublingual cavity exclusively, see (12d), is a laminal post-alveolar with a non-retracted tongue back. Toda contrasts such a fricative with a retroflex fricative that meets the requirements of all properties, and hence these two criteria are also not sufficient for defining retroflexion. The overall conclusion is that a segment satisfying two properties only of the four defined here for retroflexion either is unpronouncable or does not fall into the category retroflex.

2.5 Secondary palatalization of retroflexes

In this section it is argued that palatalized retroflex segments do not exist *phonetically*, as the two articulatory gestures of palatalization and retraction cannot be produced at the same time. It is shown that instead, the process of palatalization triggers a change in the retroflex segment from apical to laminal (as proposed already in Hall 2000), from flat, low tongue middle to bunched, raised tongue middle, and from retracted tongue back to fronted tongue back; i.e. from a retroflex which satisfies all four properties of retroflexion defined in 2.3 to a segment which satisfies only two of them (namely posteriority and sublingual cavity) and thus is non-retroflex. The analysis of secondary palatalization in section 6.3.3 will show that in some cases secondary palatalization of retroflexes is phonologically possible, though it still remains phonetically impossible.

Evidence for the claim that palatalized retroflexes are non-existent is found in Maddieson's (1984) typological study, which lists no language with a phonemic palatalized retroflex segment. Only two counterexamples could be found in the phonetic and phonological literature, namely Toda (Emeneau 1984; Spajić et al. 1996) and Kashmiri (Bhat 1987), which are both said to have palatalized retroflexes.

This section proceeds as follows. First, traditional definitions of palatalization as mere additional articulations are shown to be inadequate for coronal sounds. Then, to illustrate the change from retroflex to non-retroflex occurring with palatalization, the Russian retroflex fricative and its palatalized counterpart are discussed. In subsection 2.5.2, the alleged palatalized retroflex segments in Toda and Kashmiri are discussed and the status of these segments is analysed. Alternative descriptions for these supposedly palatalized retroflexes are proposed and it will be hypothesized that there are no counterexamples to the claim that secondary palatalization of retroflexion does not occur phonetically.

2.5.1 Palatalization as change in primary articulation

Palatalization in traditional articulatory terms is defined as the superimposition of an [i]-like gesture upon a labial, dental, alveolar, or post-alveolar consonant (cf. Ladefoged & Maddieson 1996). This superimposition of a gesture is undoubtedly the case for labials with a secondary palatalization, where the tongue dorsum gesture can take place independently and at the same time as the labial closing gesture. But

for primary gestures with the tongue (either coronal or dorsal), the primary and secondary gestures are not independent of each other and therefore are expected to influence each other, which results in a change of the primary place of articulation. Support for this assumed change can be found in Ladefoged (1971: 207) who points out that "the terms palatalization and palatalized may also be used in a slightly different way from a secondary articulation, namely as describing a process in which the primary articulation is changed so that it becomes more palatal." Ladefoged & Maddieson (1996: 365) further specify this by stating that for all *coronal consonants*, secondary palatalization always involves a displacement of the surface of the tongue. This displacement is said to produce a slightly different primary constriction location (ibid.). We conclude from this that the traditional description of a secondary palatalization is inaccurate in the case of coronal segments, as this process always involves a change in the primary articulation for coronal sounds.

Articulatory evidence for a change of place in palatalized *apical dentals* is given in Scatton (1975) for Bulgarian, and Ćavar & Hamann (2002) for Polish. Hall (2000) argues that apical stops in general either turn into laminal stops when palatalized (in a synchronic or diachronic process) or resist palatalization.

For *retroflex segments*, it is proposed here that the addition of a palatalization gesture involves not only a change in primary articulation from apical to laminal but also in the articulatory class from retroflex to non-retroflex, since retroflexes not satisfying the criterion of apicality do not exist, see section 2.4.3. Support for this proposal can be found in Ladefoged (1971: 208), who mentions that the secondary articulations of palatalization, velarization, and pharyngealization involve different shapes of the tongue that cannot occur simultaneously. As velarization and pharyngealization were defined as realizations of the retroflex criterion 'retraction' in 2.3.4, Ladefoged's remark can be interpreted as an articulatory incompatibility of retroflexion and palatalization.

The incompatibility of gestures and the change in primary place is exemplified with the Russian fricatives in the post-alveolar region. Figure 2.13 is based on x-ray tracings of the Russian retroflex fricative (solid line) and its palatalized counterpart (dashed line) (both based on Bolla 1981: 159). As discussed before (see 2.4.2), the Russian retroflex fricative satisfies at least three of the four properties for retroflexion, namely apicality, sublingual cavity, and retraction, and is therefore assumed to be retroflex in this study (see also Hamann 2002b for a more detailed discussion of the Russian sound and its palatalized counterpart).
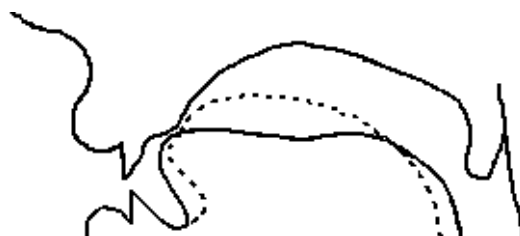

Figure 2.13 Russian retroflex fricative (solid line) and palatalized post-alveolar fricative (dashed line).

Comparing now the palatalized variant to the retroflex one, some major differences can be observed. First of all, the place of articulation changes for the palatalized segment; it moves further backwards to the post-alveolar region, which gives evidence for the assumed change in primary place of articulation for palatalized retroflex segments. Furthermore, the articulator is now the tongue blade, and the shape of the tongue middle changes to bunched and raised. The changes occurring for the palatalization of a retroflex are depicted in figure 2.14 with the four tongue parts as assumed already for a retroflex articulation in figure 2.10.
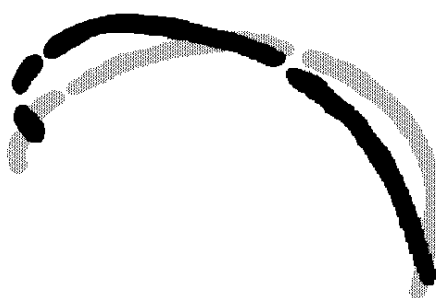

Figure 2.14 Palatalized 'retroflex', schematic movements of the tip, blade, middle, and back, underlyingly grey are the tongue parts at rest.

In terms of retroflex properties this means that the palatalized segment does not satisfy the properties of apicality and retraction, but only those of posteriority and sublingual cavity. As defined above in 2.3.5 und 2.4.3, a segment that has fewer than three retroflex properties does not belong to the category of retroflexes, thus the palatalized version of the retroflex fricative is claimed to be non-retroflex.

As palatalization in general involves the addition of or change towards an [i]-like gesture, and [i] and other front, high vowels are always articulated with a bunched tongue middle, this implies that secondary palatalization of retroflexes always results in a change in the property retraction from retracted to non-retracted articulation. But as apicality and posteriority without retraction is not possible (see implication in (8b)), a further change from apical to non-apical is necessary. The resulting segment satisfies the two properties of posteriority and sublingual cavity, and is according to (12d) not retroflex but a laminal post-alveolar. For the fricative [ʂ] the process of secondary palatalization thus results in the palato-alveolar fricative [ʃ], see (13a). The secondary palatalization of a retroflex stop and nasal is assumed to trigger similar changes, see (13b) and (13c), respectively.

(13) (a) [ʂʲ] = [ʃ]

   (b) [ʈʲ] = [t̠] or [c]

   (c) [ɳʲ] = [n̠] or [ɲ]

Hume's (1994) observations on the palatalization of the post-alveolar fricative in Polish can be interpreted to support the claim made here. Hume follows the

traditional descriptions of the Polish post-alveolar fricative and refers to it as post-alveolar [ʃ] instead of retroflex. Furthermore, she claims that the segment resulting from the palatalization process, i.e. [ʃʲ], is articulatorily identical to the laminal alveolo-palatal [ɕ].[24] Thus Hume describes the post-alveolar palatalization in Polish as in (14), which differs from the proposal made here in (13a).

(14)   [ʃʲ] = [ɕ]

Though she does not explicitly mention a change in articulatory class, Hume's description of the segments indicates such a change. She refers to the palatalized sound with the features [–anterior, +distributed], which describe a laminal post-alveolar, and to the non-palatalized sound as [–anterior, –distributed], which is a retroflex segment in traditional featural accounts. Therefore Hume's description implies that the process of palatalization in Polish actually changes a retroflex fricative into a laminal post-alveolar, as stated in (13).

Besides the categorical change described above, another possible outcome of the secondary palatalization of retroflexes is to resist palatalization altogether, as pointed out by Hall (2000a). He gives an example from Scots Gaelic, where nouns usually undergo palatalization in the genitive singular: [kʰatʰ] 'cat' (nom. sg.) surfaces as [kʰatʰʲ] (gen. sg.). Nouns with retroflex consonants, however, remain unpalatalized, e.g. [paːʈ] 'a poet' (both nom. and gen. sg.) (Borgstrøm 1940: 76). A resistance to palatalization is otherwise only reported for apical alveolars or dentals (e.g. Hall 2000a), which are also inherently retracted in some languages (recall 2.3.4). The property retraction can thus be made responsible for the blocking of palatalization, for the same articulatory reason that causes this property to change into non-retraction in secondarily palatalized retroflexes, namely articulatory incompatibility. It has to be tested whether the apical alveolars that show a resistance to palatalization are retracted and thus provide further evidence for the claim of articulatory incompatibility.

In sum, it was shown that retraction is incompatible with palatalization, which results in two possible outputs for retroflex palatalization, either a corresponding palatalized laminal, or a plain retroflex without palatalization.

2.5.2 Counterexamples: Toda and Kashmiri

According to Emeneau (1984), and Spajić et al. (1996) the Dravidian language Toda has palatalized counterparts of all its three rhotics, including the retroflex flap /ɽ/. Toda has minimal pairs such as [oɽ] 'to cook' vs. [oɽʲ] 'foot', or [toɽ] 'thigh' vs. [toɽʲ] 'pole used at funeral'. Interestingly, Spajić et al. could elicit retroflex rhotics and their palatalized counterparts only from some of their subjects; the three speakers of the Kas *mund* (a tribal location). The three speakers of the Melgas *mund* did not produce any of these forms. Sakthivel (1976, 1977) transcribes the palatalized retroflex rhotics, like all palatalized segments, with a sequence of rhotic

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[24]   The only difference between the palatalized retroflex and the alveolo-palatal is, according to Hume, a secondary labialization of the palatalized sound, which the alveolo-palatal does not share.

(or other segment) plus palatal glide, indicating that the sounds in question consist of a sequence of two different articulations.

Though presenting a detailed phonetic study of the rhotics in question, Spajić et al. unfortunately do not include any palatographic or linguographic measurements of the palatalized flap /ɽʲ/ from which the exact articulation and the correlation of the gesture of retroflexion and that of palatalization can be judged.

Palatalized retroflex segments are also said to occur in the Indo-Aryan language Kashmiri (Bhat 1987: 43ff.). Kashmiri has the phonemes /ʈʲ, ʈʰʲ, ɖʲ/. In Maddieson's phoneme inventory of Kashmiri (based on Kelkar & Trisal 1964), these segments are not included, the only retroflexes given there are the plain plosives /ʈ, ʈʰ, ɖ/. Morgenstierne (1941) proceeds similarly and does not mention palatalized retroflexes. The reason for this discrepancy in the description of the Kashmiri phoneme inventory is probably the class of the so-called *mātrā* vowels in Kashmiri. *Mātrā* vowels are extremely short (Maddieson 1986: 271 terms them 'overshort') or 'whispered' vowels (Masica 1991: 121). One of them is the *ⁱ-mātrā* which is said to leave a palatalizing effect on the preceding consonant. The assumption of this short /i/ vowel makes the statement of separate palatalized consonants redundant. Thus, in some descriptions of Kashmiri (e.g. Grierson 1911 and Morgenstierne 1941), the use of a retroflex segment with a following *ⁱ-mātrā* stands for what is described as palatalized retroflex in e.g. Bhat (1987). But this poses the question whether it is really a secondary palatalization of retroflexes that occurs in Kashmiri. These doubts are supported by Bailey (1937) who uses a retroflex plus a vowel /i/ in his transcriptions of Kashmiri in the place where the other researchers used either the *ⁱ-mātrā* or the palatalized consonant. In (15), a comparison of Grierson's and Bailey's transcriptions is given with the masculine singular forms of the adjective 'big'.

		Grierson	*Bailey*
(15)	NOM	boɖᵘ	boɖ
	DAT	baɖis	bɜɖis
	AG	baɖⁱ	bɜɖi
	ABL	baɖi	baɖi

As in the case of Toda, no articulatory data could be found for Kashmiri to illustrate the simultaneous combination of the retroflex and the palatalization gesture.

As the present study assumes that a simultaneous articulation of retroflexion and palatalization is impossible, the segments in these two languages have to be accounted for in another way. I propose that these segments are actually not retroflexes with a superimposed palatalized gesture, but sequences of a retroflex articulation followed by a short glide /j/. This proposal does not imply that the palatalized segment, which consists of two successive gestures, should be phonologically interpreted as two phonemes instead of one. I propose that Toda and Kashmiri are languages that chose to interpret the two gestures as belonging to one category. Only articulatorily do they make up two gestures.

Support for these separate gestures can be seen in the diachronic development of the alleged palatalized retroflexes in Kashmiri. Diachronically, the *mātrā* vowels in Kashmiri stem from vowels which have been shortened word-finally (Morgenstierne 1941: 89). Kashmiri hence had two separate gestures that were assigned to different phonemes, a consonantal and a vocalic one. These gestures were categorized at a later stage as belonging to one category (not consistently by every author, though, as we saw above). Furthermore, whereas the $^{-u}$- and $^{-ü}$-*mātrā*s (both causing velarization of the preceding consonant) are said to be inaudible nowadays (Morgenstierne 1941: 87), the $^{-i}$-*mātrā* still sounds like a very short [i], indicating a separate, additional i-gesture (ibid.).

Further evidence for the claim that there are two gestures instead of one may be found in the acoustic signal of the Toda trills. Spajić et al.'s (1996: 19) data of one speaker shows a difference between palatalized and non-palatalized retroflex trill: the duration of /ʈʲ/ is 190 ms and that of /ʈ/ only 100 ms. The palatalized version is thus nearly twice as long. There is no articulatory explanation why a palatalized segment should take longer to articulate than a non-palatalized one if one assumes that the two gestures co-occur. Assuming, however, that two gestures are produced successively, the nearly double length of the palatalized segment compared to the non-palatalized is explained.

In order to judge the values for palatalized and non-palatalized segment lengths, we will compare them to duration measurements (in ms) of the palatalized and non-palatalized segment pairs in Russian from Bolla (1981), see the tables 2.1, 2.2, and 2.3 below, giving the labial, velar and coronal (the latter tongue dependent) articulations, respectively.

Table 2.1 Duration measurements (in ms) of the plain and palatalized labials in Russian from Bolla (1981).

	p	b	f	v	m	ratio
plain	116	120	128	115	97	1
palatalized	170	140	130	125	97	1.14

Table 2.2 Duration measurements (in ms) of the plain and palatalized velars in Russian from Bolla (1981).

	k	g	x	ratio
plain	169	150	110	1
palatalized	184	160	120	1.08

Table 2.3 Duration measurements (in ms) of the plain and palatalized coronals in Russian from Bolla (1981).

	t	d	n	s	z	ratio
plain	134	102	105	195	96	1
palatalized	190	120	98	177	160	1.17

The average ratio between plain and palatalized segments in Russian is 1 : 1.12. The Toda retroflex rhotics have a ratio of 1 : 1.9 for plain vs. palatalized signal length, which is far higher than the Russian ratio. This difference sustains the claim made before that there might be two successive gestures involved in the articulation of the palatalized retroflex in Toda.

Unfortunately, we do not have any further measurements for palatalized rhotics, so the present data merely hint at the correctness of the hypothesis made here. Further research has to be conducted on the exact articulation and gestural timing of palatalized rhotics in general and palatalized retroflex in particular. This may shed light on the articulatory timing of the gestures and further properties of their articulation.

A formal account on how an articulatory sequence of retroflexion and palatalization can be phonologically interpreted as one segment will be given in section 6.3.3.5.

2.6 Summary and outlook

In this chapter, it has been shown that the class of retroflex consonants is one with enormous articulatory variation. This variation can be systematically accounted for by such parameters as speaker-dependence, context, manner of segment, language family, and inventory size.

Despite this large variation, there are some characteristics that can be found in nearly every instance of a retroflex. These properties have been defined as apicality, posteriority, sublingual cavity, and retraction. In order to belong to the retroflex class, a segment does not have to meet all four of these criteria: posteriority can be lacking. This is the case with the post-alveolar fricatives in Mandarin, which have traditionally been described as retroflex. It becomes obvious from this exception that a more restricted definition of retroflexion, one that requires all four articulatory properties to be present in a retroflex segment, would not include all segments traditionally described as retroflex. Because of this new definition, the non-posterior Polish and Russian fricatives had to be included into the retroflex class as well. We will see in chapter 4 that there is phonological evidence for such a wide definition, since all of the segments included here share some phonological behaviour. Furthermore, the broad definition of retroflex as applied here results in two retroflex fricative classes for Toda (see section 2.2.6). How this causes problems for traditional featural representations but can be dealt with in the featural approach I follow is a topic of chapter 5.

Apart from posteriority, it was shown that all other criteria have to be present in a segment to belong to the retroflex class. This was shown by the process of palatalization which causes a change towards non-apical and non-retracted articulation and thus from a retroflex to a non-retroflex segment.

Several sections of this chapter indicated topics that have to be further investigated. With respect to the variation of the retroflex class, the different

reduction mechanisms of retroflex gestures applied in specific languages for instance could be studied; we saw in section 2.2.3 that Swedish retroflexes show fronting of the retroflex category in fast speech, whereas Hindi retroflexes show retraction in fast speech. On what factors do these reduction strategies depend, and do related languages show similar strategies? Another topic of retroflex variation mentioned in section 2.2.5 was the language-specific realizations of retroflex classes. Especially the sub-families of the Australian languages are worth investigating since traits might be found that are not shared by the large group of Australian families.

More important for the present study are additional studies on the allegedly palatalized retroflexes in Kashmiri and Toda, and evidence for their actual non-retroflex status in order to sustain the claim of non-existing palatalized retroflexes made here. In addition, other possible non-posterior retroflex fricatives should be tested, as for instance the Serbian post-alveolar fricatives as indicated by Keating (1991), to further attest that segments which lack the criterion of posteriority still behave phonetically and phonologically as retroflex. These issues I leave open for future research.