4 Retroflex processes and their phonetic grounding

In this chapter, cross-linguistically very common phonological processes involving retroflex segments are discussed. These processes are: retroflexion in a rhotic context and in a back vowel context, de-retroflexion in a front vowel context (and in secondary palatalization) or retraction of the front vowel, retroflexion of velarized or labialized segments, retroflexion of vowels before retroflex segments, non-occurrence of retroflexes word-initially and post-consonantally, and (local and non-local) assimilation of non-retroflex coronals. They are represented in this order in (1), where *t* is a cover symbol for a [+anterior] coronal, and *ʈ* for a retroflex segment. *C* is any kind of consonant, *V* any kind of vowel, and *(ω* indicates the left boundary of a prosodic category higher than the syllable (phonological word, phrase boundary). The first column gives the inputs, the second the outputs, and the third gives these processes terms that I will continue to use in this and following chapters.

(1)		*input*	*output*	*process*
	(a)	/rt/	[ʈ]	retroflexion in rhotic context
	(b)	/ut/	[uʈ]	retroflexion in back vowel context
	(c)	/iʈ/	[it] or [ɨʈ]	deretroflexion or vowel retraction
		/ʈʲ/	[tʲ] or [ʈ]	deretroflexion or depalatalization
	(d)	/Vʈ/	[Vᵀʈ]	retroflexion of adjacent vowel
	(e)	/ʈ/	(ω[t], C[t]	phonotactic restrictions on retroflexes
	(f)	/ʈt/	[ʈʈ]	local assimilation of retroflexes
		/ʈVt/	[ʈVʈ]	non-local assimilation of retroflexes

Bhat (1973) already described some of the processes in (1), namely the retroflexion of dentals or alveolars by a preceding /r/ (1a), by a preceding back vowel (1b), and a preceding retroflex consonant (1f). Retroflexion caused by implosion, another process elaborated by Bhat (p. 43), will not be treated here, as I want to restrict my investigations to normal egressive airflow. Two further processes of retroflexion that I found when collecting and analysing the data are not included in the descriptions below and the analysis in chapter 6: these are retroflexion via secondary velarization and via secondary rounding, see (2a) and (2b), respectively.

(2)				
	(a)	/tˠ/	[ʈ]	retroflexion of velarized segments
	(b)	/tʷ/	[ʈ]	retroflexion of labialized segments

These processes are phonetically motivated, since retroflexion via velarization is a type of articulatory assimilation if one assumes retroflexes to be inherently retracted, and retroflexion via rounding has obvious perceptual similarities between input and output, cf. section 4.3.2.4 on the rounding of vowels before retroflexes. Nevertheless, the two processes are not included here, because of the lack of clear

supporting examples. Ponapean is the only language I found that might have introduced retroflexes via velarized alveolars, though the literature (Rehg 1973, Harrison 1995) is not very explicit on this point. Retroflexion via secondary rounding seems to have been a diachronic process in Athapaskan; the affricate [ʈʶ] in Minto-Nenana originates from a rounded segment, though the actual realization of it is a topic of unclarity. Krauss (1973) describes the respective Proto-Athapaskan segment as */kʷ/, Tharp (1972) refers to it as */tʷ/, and Rice as (1989) */tʃʷ/. I leave the clarification of these data and the collection of further examples of both processes open for future research.

Bhat (1973) found that rules of retroflexion are typically caused by a preceding non-retroflex sound or by the retroflexion spreading leftward, i.e. the expected order in the input is a non-retroflex followed by a retroflex segment. This will be shown to be a general tendency for the examples given in this chapter, but even so most of the phonological changes in (1) will be shown to occur also in reverse segmental order of input (and also output), namely the retroflexion in rhotic context (1a) and in back vowel context (1b), avoidance of front vowel context (1c), and assimilation processes (1f). Examples in the subsections below will illustrate this point. Not all of the processes have retroflex segments as outputs (as (1a), (1b), and (1f)); some of them have retroflexes as input (for instance, the process of de-retroflexion in (1c) and (1e)), others are only triggered by retroflexes (for instance, the vowel changes in (1c)).

For each change in (1), evidence from several language families is given in order to show the universal validity of the process. This universality is argued to be based on the phonetic grounding of these processes, explained by the articulatory and acoustic characteristics of retroflexion as elaborated in chapters 2 and 3, respectively. The present chapter gives no phonological account of the processes involving retroflexes. The data collected here show general, recurring patterns that will be represented in the phonological formalizations of retroflexes in general in chapter 5 and of these processes specifically in chapter 6.

The present chapter is structured as follows. Section 4.1 deals with retroflexion induced by rhotic segments (1a). In section 4.2, the retroflexion of coronals in back vowel context is discussed (1b), whereas section 4.3 deals with the opposite process, non-retroflexion in front vowel context (1c). Vowel retroflexion (1d) is the topic of section 4.4. In section 4.5, the phonotactic restrictions of retroflexes (1e) are discussed. Lastly, section 4.6 deals with local and non-local assimilations of retroflexes (1f). All of these sections are subdivided into two subsections, where the first presents the examples and the second gives the phonetic grounding of the process under discussion. Section 4.7 concludes.

Before starting with the detailed discussion, a note on the transcription is necessary. In the examples throughout the chapter, the retroflexes are represented by their respective IPA symbols, which sometimes depart from their description in the original sources. I also transferred non-retroflex segments into respective IPA symbols if the sources used other transcriptional systems.

4.1 Retroflexion in rhotic context

The first process to be discussed here is the change of an anterior coronal into a retroflex caused by a rhotic, as illustrated in (1a). This process can be found in North-Germanic languages, in Australian languages and Indo-Aryan languages. It is also diachronically attested in some of these languages, and is responsible for the introduction of retroflex phonemes into a number of languages, as illustrated below in 4.1.1. Section 4.1.2 will provide a possible explanation based on the acoustic characteristics of the segments involved in this process.

4.1.1 Examples

Before examples of this process are given, one problem in its description has to be pointed out. Due to the lack of appropriate graphemes for retroflex sounds in Latin-based writing systems, different methods for representing these sounds are employed in languages with retroflex phonemes. One of them is to write a sequence of *r* plus *t, d, s, n, l,* or *r*. This is often found in the literature on Australian languages, see for example McKay (2000) on Ndjébbana.[1] Such a transcription convention should not be confused with an underlying sequence of two phonemes, namely a rhotic and an alveolar or dental, which can be realized with one phoneme via a phonological contraction rule, as demonstrated below. The difference of these two representations is of particular importance for the North-Germanic languages Swedish and Norwegian, which are assumed to have a retroflex phoneme and a sandhi-process of retroflexion, both represented graphemically in the same way.

In Norwegian,[2] the so-called 'retroflex rule' merges clusters of apical alveolar /r/[3] or retroflex flap /ɽ/ plus all laminal dentals /t, d, s, n, l/ into corresponding retroflexes across morpheme and word boundaries. Examples from Kristoffersen (2000: 96f.) are given in (3) (in Kristoffersen's transcription).

(3)

	input	*output of RR*		*gloss*
Inflection	/sʉr-t/	[sʉːʈ]	*surt*	'sour'AGR
	/bar-n/	[baːɳ]	*baren*	'bar' DEF-SG
Derivation	/ʋor-li/	[ʋoː.ɭi]	*vårlig*	'spring-like'
Clitics	/brur-s/	[bɾuːʂ]	*brors*	'brother' POSS
	/bær-n/	[bæːɳ]	*bær han*	'carry him!'
Compounds	/ʋor-tejn/	[ʋoː.ʈæjn]	*vårtegn*	'spring sign'
	/ʋor-dag/	[ʋoː.ɖaːg]	*vårdag*	'spring day'

[1] Other systems employed to represent retroflexes in the literature on Australian languages are the usual grapheme for coronals (d, n, l, r) with a subscript dot or an underlining. A further option is to transcribe retroflexes with capital coronals, as used for example in the Dravidian language Kannada (Schiffman 1983, Sridhar 1990).

[2] The term "Norwegian" is used here and below to cover the variety that is defined as urban East Norwegian speech, a notion explicated for example by Vanvik (1972, 1973), Endresen (1974), and Kristoffersen (2000).

[3] The underlying apical alveolar /r/ is realized as a tap [ɾ] in Norwegian (Kristoffersen 2000: 24).

The geographical domain of the retroflex rule does not hold for the whole of Norway, but extends only over the eastern part of South Norway all the way up north to the Russian border (Kristoffersen 2000: 88). This area coincides with that of the spread of the apical rhotic, which led some scholars, such as Torp (2001), to propose that retroflexion can only occur with coronal /r/, whereas the uvular /ʀ/, which is used in the remaining part of the country, blocks retroflexion.

Swedish has a similar rule of retroflexion, which is sometimes called post-alveolarization or supradentalization (Eliasson 1986: 278). Examples of this process are given in (4) (in Eliasson's transcription).

(4)		*input*	*output*		*gloss*
	Inflection	/før–t/	[fœ̝ːʈ]	*fört*	'brought' SUP
		/før–s/	[fœ̝ːʂ]	*förs*	'is brought' PASS
	Derivation	/før–tal/	[fœ̝ˈʈɑːl]	*förtal*	'slander'
		/før–sorj/	[fœ̝ˈʂɔrj]	*försorg*	'taking care'
	Compounds	/før–tɯr/	[ˈfœ̝ːˌʈɯːr]	*förtur*	'priority'
		/før–sal/	[ˈfœ̝ːˌʂɑːl]	*försal*	'entrance hall'
	Across words	/før tɯnː/	[fœ̝ˈʈənː]	*för tunn*	'too thin'
		/før sen/	[fœ̝ˈʂeːn]	*för sen*	'too late'

According to Eliasson (1986: 282), the sandhi rule of retroflexion in Swedish is sensitive to the type of boundary between the /r/ and the dental. The higher up in the prosodic hierarchy the two categories are, the less likely retroflexion occurs across their boundary.

Both Norwegian and Swedish also have retroflexes which cannot be the result of the merger in (4) because no morpheme boundary occurs between /r/ and the dental, e.g. *kart/karta* [kʰaʈ(a)][4] 'map', or *kors* [kʰɔʂ] 'cross'. In most cases these retroflexes derive historically from the same retroflexion rule as those described above. Due to this common origin, Endresen (1974) among others proposes that there are no underlying retroflex phonemes and that all retroflexes are derived via the same rule. Since the rule is not triggered by a morpheme boundary in examples like /kʰɔrs/, Endresen assumes that it applies across the board. This assumption is problematic for the following reasons. First of all, not all word-internal retroflexes in Norwegian can be derived from rhotic plus dentals: the retroflex fricative in words like *skje* [ʂeː] 'spoon', and the retroflex flap in words like *sol* [suːʈ] 'sun' (Kristoffersen 2000: 23 and 24, respectively) have a different historical origin. To account for these forms with a context-free retroflexion rule, one has to assume the underlying forms /rseː/ and /suːrr/, respectively, which would violate the sonority sequency generalization.

Furthermore, the graphemic sequence *rd* is often not retroflexed, and some words exist that show variation between retroflexion and non-retroflexion (Kristoffersen 2000: 89). *Bård*, for instance, a male Christian name, can be pronounced as [boːɖ] or [boːr], whereas other words can only be pronounced with the retroflex voiced stop, e.g. [fɔ.ˈɖiː] *fordi* 'because' or [gɑ.ˈɖiːn] *gardin* 'curtain'.

[4] The form with the /a/ is the Swedish, that without /a/ is the Norwegian.

In addition, the retroflexion of *rd* is stress-dependent: after stressed vowels one finds almost only [ɾd], after unstressed vowel only [ɖ], see for example the alternations: *garde* 'guard' [ˈgɑɾ.də] and derived *gardist* 'guardsman' [gɑ.ˈɖist], where the stress is moved to the suffix. /rd/ after long vowels can be pronounced as so-called 'thick l' [ɽ], e.g. *ard* 'plough' [ɑːɽ] (Popperwell 1963: 83).

For these reasons, the present study follows Kristoffersen (2000) among others in assuming an underlying retroflex phoneme and a sandhi rule of retroflexion that applies across morpheme and word boundaries in both languages.

Retroflexion does not necessarily have to be induced by an *apical* rhotic, as the following description of a Swedish dialect suggests. Svantesson (2001) describes the phoneme inventory of his own southern Standard Swedish idiolect. Instead of the apical trill or fricative, this variety has a uvular fricative [ʁ], like all Southern Swedish dialects. Svantesson's idiolect shows deletion of the rhotic when occurring in coda position as the first member of a cluster. A following dental consonant is retracted, and becomes 'alveolar' in Svantesson's terms (p. 157), which he represents as /t̲, d̲, s̲, n̲, l̲/. His study unfortunately does not contain any articulatory data to infer the exact articulation of these retracted segments, and no other study on the articulation of Southern Swedish dentals and alveolars could be found to serve this purpose. However, the description of these segments allows the interpretation that they are non-posterior retroflexes (see the definition in section 2.3.5): the segments in question cause preceding vowels to lower and rhotacize, and therefore behave phonologically like retroflexes, cf. sections 4.3.2.2 and 4.4 below. The retraction of dentals in Svantesson's data suggests that the retraction of coronals in r-context is not caused by coronal rhotics only, but can be triggered by uvular rhotics as well. It remains open for future articulatory studies to determine whether the resulting segments are indeed retroflexes (i.e., apical post-alveolars). If that were the case, it would show that retroflexion can be induced by non-coronal rhotics, too. Furthermore, it would provide evidence against claims that retroflexion does not occur in regions with a uvular rhotic, as proposed by Torp (2001) and others.

Australian languages are another language-family that shows retroflexion in a rhotic context. Bhat (1973: 35) points out that in these languages the morphophonemic sequences of /r/ + /t/ are generally realized as retroflexes. An example of this is Ndjébbana (McKay 2000: 175), spoken in Central Anrhem Land. Ndjébbana has a contraction process for the 'realis prefix' *rra* [ra] followed by a root with an initial apical alveolar /n/: this may show vowel deletion to /rn/ and subsequent realization as a retroflex nasal [ɳ], see the example in (5).

(5) ba-**ra**-**n**maramaɭo-ŋa (> ba-**rn**maramaɭo-ŋa) > ba**ɳ**maramaɭoŋa
3rd PS-AUGS-RE-swim-REM 'they swam'

Another example of morphophonemic retroflexion is Watjarri (Douglas 1981), spoken in South-Western Australia, which has the ergative and locative affixes *–tu* and *–ta*, respectively, which change their initial apical alveolar /t/ into a retroflex when the preceding stem ends in an alveolar /r/. An example for this process is the sequence /maju maɳku**r**/ 'the three children', which changes into [maju maɳku**ʈ**a]

'on the three children' when locative *-ta* is added (Douglas 1981: 208). Note that the rhotic does not have to be retroflex.

Diachronically, old Indo-Aryan (i.e. Sanskrit) developed a retroflex fricative partly by a rhotic /r/ which changed a following /s/ into a retroflex. For discussion see section 4.3.4 on the *ruki* rule below. Another sub-branch of the Indo-Iranian language family, namely Iranian, shows a similar retroflexion process. Several Modern Iranian languages developed retroflexes via rhotics.[5] In the Iranian language Yidgha, spoken in Pakistan, the retroflex [ɳ] developed from the sequence /rn/, and the phoneme [ʂ] from /rʃ/ (Bhat 1973: 34, Skjærvø 1989c: 411). Interestingly, /rt/ developed into [ʈ], not into a retroflex stop.[6] Yidgha also introduced the phoneme [ʂ] via the sequences /str/ and /sr/ (Skjærvø 1989c: 413), an instance of regressive influence of a rhotic. This development is rather common in Modern East Iranian languages. Pashto, for example, shows exactly the same process causing the retroflex fricative to become a phoneme, as corresponding words in the predecessing language Avestan indicate: Pashto [ʂa] 'good' and [ʂna] 'hip bone' correspond to Avestan [srao] and [sraoni], respectively (Morgenstierne 1927). Further examples for such a development can be found in Wakhī, Sanglīčī, and Iškašmī (Payne 1989), and in Munǰī (Skjærvø 1989a). The Indo-Aryan language Sindhi developed retroflexes from dentals preceding *r*, but here the rhotic remained: Old-Indo-Aryan *traya-* 'three' or *draka* 'grape' changed to Sindhi [ʈreː] and [ɖraːkʰa] (Masica 1991: 210).

A rhotic causing a segment to the right to change into a retroflex as in the Iranian Pashto and the Indo-Aryan Sindhi is a process that occurs cross-linguistically less often than a rhotic causing a change of the segment to its left (as in Norwegian, Swedish, Ndjébbana, and Watjarri). A further instance for this latter assimilatory direction is Cham, spoken in Vietnam (Bhat 1973: 36), in which retroflexes were diachronically introduced via an anterior coronal plus following /r/. The changes that occurred here were: tr > ʈ, tr' > ʈ', and sr > ʂ. A similar process can be observed in some Southern dialects of the Dravidian language Tamil, which realize literary Tamil /nr/ as [ɳɖ], e.g. *anru* 'that day' is [aɳɖu] in Ceylon Tamil, or /muːnru/ 'three' [muːɳɖu] (Zvelebil 1970: 173).

In some central African languages, which sometimes have retroflexion of the voiced coronal stop, this retroflexion is triggered partly by a following /r/ as for example in the Nilo-Saharan Lugbara, where the stops in *tr* and *dr* can be retroflexed without deletion of the rhotic (Bhat 1973: 40).

The diachronic development of a retroflex from a following rhotic can be observed in the Sino-Tibetan language Tibetan and its closely related neighbouring languages. Bhat (1973: 34) gives examples of this development, which took place in syllable-initial consonant clusters, see (6).

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[5] In some of the Iranian languages, the introduction of a retroflex via a sequence of rhotic plus dental was accompanied by a change in manner. Sanglīčī, for example, spoken in Tadžikistan, introduced a retroflex lateral ɭ from the sequence *rt (Payne 1989: 424).

[6] The retroflex stops /ʈ, ɖ/ occur in Yidgha in loanwords only (Skjærvø 1989c: 411).

(6)	*Class. Tibetan*	*gloss*	*Modern languages*	
	/grod-pa/	'belly'	Central Tibetan	/ɖʰø-pa/
	/drung-du/	'before'	Central Tibetan	/ʈung-du/
	/pʰru-gu/	'child'	Central Tibetan	/ʈʰu-gu/
	/krad-pa/	'leather'	Spiti	/ʈad-pa/
	/kʰron-pa/	'a spring'	Spiti	/ʈʰon-pa/
	/skra/	'hair'	Jad	/ʈa/
	/gru/	'ship'	Jad	/ʈu/
	/bran/	'slave'	Jad	/ʈan/

It is interesting to note that in these examples not only coronals plus rhotic changed into a retroflex, but also velars and labials plus rhotic.

The examples described in this section show several characteristics of retroflexion in a rhotic context. First of all, the segment to be changed in the rhotic environment does not have to be an apical coronal; it can be laminal, as in Norwegian and Swedish, or even non-coronal, as the developments in the Tibetan languages suggest. Secondly, there is some evidence that the rhotic causing the change can be non-coronal, as Svantesson's dialect of Southern Swedish show. Thirdly, the direction of influence is not restricted, either; the rhotic might precede or follow the target segment, though retroflexion via preceding rhotics seems to prevail.

4.1.2 Phonetic grounding

Two possible phonetic explanations are proposed here for the change of non-retroflex to retroflex caused by a rhotic, both exemplified in (7) (again, *t* stands for an apical dental/alveolar, and *ʈ* for a retroflex).

(7)	(a)	rt > ɽt > ʈt > ʈ	or	tr > tɽ > ʈɽ > ʈ		articulatory explanation
	(b)	rt > ʈ	or	tr > ʈ		perceptual explanation

In (7a), which exemplifies a development in several stages, the first stage is a variation in the place of articulation of a rhotic from dental/alveolar to retroflex. Evidence for such a variation can be found in the fact that quite a number of languages allow a retroflex variant along with their more widespread other rhotic articulation(s). This variant can be either areally restricted, as in British English, where a retroflex [ɻ] is spoken in the South-Western counties of Cornwall, Devon, Somerset, Wiltshire, and Hampshire (Wakelin 1972: 98),[7] or positionally restricted, as in Dutch, where a retroflex variant of the usually apical rhotic can occur in word-final position, according to Goeman & Van de Velde (1999: 99). An example of such a non-restricted change is the Sanskrit retroflex *r* which originates from Indo-European (presumably) alveolar /r/.

Hall (1997a: 215 footnote 21) suggests that an alveolar approximant [ɹ] can easily change to a retroflex approximant [ɻ] because the tongue tip is not inhibited in

[7] Wakelin transcribes the British English retroflex rhotic as the flap [ɽ], whereas Ball & Rahilly (1999: 125) refer to this sound as the retroflex approximant [ɻ].

any way during the articulation of the approximant and therefore can retract or even curl backwards. This can result in a retroflex variant. It seems more likely, however, that a change from alveolar to retroflex trill occurs to enhance the perceptual cue of a lowered F3 for the rhotic (see section 3.6 on cue enhancement). Both Hall's and my explanation can account for the context free change of an alveolar /r/ to a retroflex one in American English and, furthermore, for the fact that approximants are the only retroflexes in a number of languages (Bhat 1973).

In some languages, the development of a retroflex variant is followed by assimilation of a non-retroflex adjacent to the retroflex rhotic, see the second stage in (7a), with subsequent drop of the rhotic gesture. Such a development is likely to have occurred in languages where the rhotic is apical and thus can be easily retroflexed. Furthermore, it could have taken place in the diachronic development of retroflexion, where several stages of development are possible. Thus, (7a) can be assumed for the diachronic development of retroflexes in Indo-Aryan and Indo-Iranian, and for the retroflex phonemes in Norwegian and Swedish. Furthermore, the articulatory explanation can account for the above-mentioned development from /rt/ into [ʈ] in Yidgha, where instead of rhotic deletion as assumed in (7a), the stop was deleted. Languages which developed a retroflex in a rhotic context without subsequent deletion of the rhotic, such as Sindhi and Lugbara described above, are further evidence for the staged development as proposed in (7a), since these languages can be assumed not to have undergone the last stage of the development, the rhotic deletion.

The second explanation, given in (7b), is not based on articulation as in (7a). Instead, it refers to the acoustic similarity of rhotic plus non-retroflex and retroflex. Both rhotic and retroflexes share a low third formant (Lindau 1985, Stevens 1998),[8] which could be re-analysed or misparsed by the language learner as belonging to the adjacent coronal segment (specified as [+1F2]), a process Ohala (1993: 89f.) calls "false association parsing error". A schema illustrating this misparsing is given in figure 4.1.

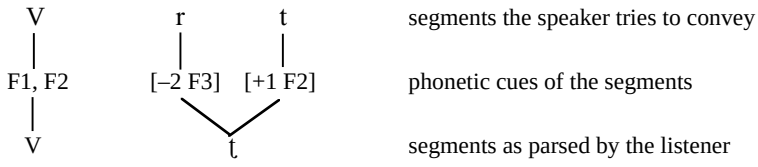

Figure 4.1 Reanalysis of the sequence vowel–rhotic–anterior coronal as vowel plus retroflex (the phonetic cues being, of course, not complete).

[8] Not all rhotics show a lowered F3, though. This is usually a characteristic of coronal rhotics, whereas uvular rhotics show a high F3 (Ladefoged & Maddieson 1996: 244). Ladefoged and Maddieson (ibid.) even mention two cases where retroflex approximant rhotics have a high F3, namely Arrernte and Hausa.

The auditory re-analysis of the rhotic cue makes it possible to economize on the gesture of the rhotic, as it is an additional gesture without perceivable acoustic consequences. This explains the drop of the rhotic after causing the retroflexion, as observable in Scandinavian or Indo-Iranian. Evidence for such a reanalysis of rhotic plus dental/alveolar as a retroflex is the fact that sequences of vowel-rhotic-dental/alveolar are often misperceived as vowel-retroflex sequences (Sharpe 1982: 17).

This second explanation of acoustically similar cues can account for the synchronic processes described in section 4.1.1, as they show a segmental change without any intermediate stages. Furthermore, it can be assumed to account for the retroflexion in Svantesson's (2001) southern Standard Swedish, which is triggered by a uvular rhotic and thus excludes an articulatory assimilation. Both explanations of retroflexion in a rhotic context are formalized in an OT framework in section 6.3.1. It was observed that retroflexion after rhotics is more common than retroflexion before rhotics. This might be explained by the asymmetrical spread of retroflex transitional cues, which have slightly stronger VC cues than CV cues (as described in section 3.5), and are thus more influenced by preceding segments and their cues.

Special attention should be given to the examples in (6) above on the developments from Classical Tibetan, where retroflexion of non-coronals took place. The occurring change of place of articulation from labial or velar to post-alveolar cannot be accounted for by the explanations proposed so far. For this special development, two explanations can be offered. The first one is based again on perception. The acoustic similarity between velars, labials, and retroflexes (see section 3.3.2 and 5.1.1 on Jakobson, Fant & Halle's 1952 feature 'flat') might have caused a reanalysis of velar or labial (plus rhotic) as a retroflex. A second explanation is to assume that there was an intermediate development in Classical Tibetan where the velar or labial changed to an anterior coronal, and only in a subsequent process this anterior coronal followed by a rhotic changed to a retroflex, as in the processes explained above in (7). Such a development would look like /gr/ > /dr/ > /ɖ/. This assumption still cannot explain why a change of labial or velar to anterior coronal should take place. Hence, the explanation based on perceptual similarity between retroflex and velar/labial is preferred here.

Bhat (p. 44) points out that the change from Classical Tibetan was paralleled by the reduction of other initial consonant clusters, where a two- or three-segmental onset was reduced to the last segment of the cluster. This indicates that it might have been the rhotic that changed into a retroflex after the velar, with a subsequent drop of the velar, i.e. a development as described in (7a). Further studies on the diachronic development of initial retroflexes in Tibetan languages are necessary to answer the question of how the retroflex segments emerged in Tibetan. This process will not be further dealt with in chapter 6.

4.2 Patterning with back vowels

In this section the connection between retroflexes and back vowels as given under (1b) is illustrated, where the category of "back vowels" sometimes includes the low vowel /a/, but is often restricted to /u/. Retroflexion in a back vowel context was already the topic of previous studies, among which Bhat (1973), and the data and phonetic grounding of this process given below is largely in line with these studies. Contrary to these former descriptions, it is claimed here that the articulation of retroflexes is closer to that of the mid back vowel [o] than to that of [u], and the fact that [u] is more often the trigger of retroflexion can be accounted for by the larger perceptual similarity between a retroflex and the vowel [u].

The examples in 4.2.1 are mainly from Australian languages, while some instances of Indo-Aryan and American Indian languages are also included. A phonetic explanation for this affinity between back vowels and retroflexes based on articulation is given in section 4.2.2.

4.2.1 Examples

In his description of Australian languages, Dixon (1980) points out that the languages with only one apical (alveolar) of Eastern Australia often have a retroflex allophone after a back vowel. Evidence for the change of alveolars into retroflexes in back vowel contexts comes from the diachronic development of Australian languages. Dixon (1980: 155) reconstructs a single alveolar series of stops, nasals, and laterals for proto-Australian. Cognate sets in languages with one apical (dental or alveolar) and two apicals (dental/alveolar and retroflex) suggest that this single alveolar series in proto-Australian had retroflex allophones after /u/ and alveolar allophones elsewhere. Several West-Australian languages developed contrastive sequences such as [ɑɖ], [iɖ] and [ud], which led to a phonological distinction between apical alveolar and retroflex. This contrast spread to cover almost all languages in the west and the centre. Eastern Australian languages retained one apical, with several of them showing an allophonic distribution as illustrated above.[9] Nyawaygi, spoken on the coast of Queensland between Ingham and Townsville, underwent a diachronic change of apical alveolar to retroflex in back vowel context (Dixon 1983: 449f.). Intervocalically the plosive /d/ became the retroflex flap [ɽ] before *u* and the apical [r] before other vowels.[10] The initial *d* changed to [r], but as this process does not involve a retroflex, it will not be further discussed here. The developments of retroflex and apical flaps can be seen when comparing the language Nyawaygi to its neighbour Wargamay, which retained the original contrasts, see (8).

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[9] Dixon (1980: 156) finds evidence for his hypothesis of one alveolar series in proto-Australian in the statistical distribution of phonemes in modern Australian languages. The dictionary of Pitjantjatjara for example shows that after /u/ 53 percent of the apicals are retroflex, whereas after /a/ or /i/ only 39 percent are retroflex.

[10] Nyawaygi still has a voiced apical stop in the consonant cluster [nd], but this can be treated as an allophone of the retroflex flap, see Dixon (1980: 148).

(8)		*Wargamay*	*Nyawaygi*	*gloss*
	(a)	wudu	wuɽu	‘nose’
		gidul	giɽul	‘cold’
	(b)	gadala	garala	‘dry’
		baːdi	baːri	‘to cry’
	(c)	dubi	rubi	‘worm’

In (8a) the Wargamay stop /d/ before the back vowel corresponds to the retroflex flap /ɽ/ in Nyawaygi. (8b) shows that before non-back vowels Nyawaygi has an alveolar. The example in (8c) illustrates that word-initially no retroflex occurs (but a change towards a rhotic).

Even Australian languages that do have apical alveolar and retroflex phonemes sometimes allow a retroflex allophone of the apical alveolar in the /u/ context. The two closely related languages Margany and Gunya spoken in Queensland show a retraction of the alveolar nasal following /u/, so that /guni/, ‘to hit’ sounds like [guɳi], according to Breen (1981: 288).

The Yadhaykenu dialect of Uradhi, a Northern-Paman Australian language spoken in Queensland, has an apical alveolar lateral which is realized as retroflex flap [ɖ] when following the long back vowels [aː] or [uː], see example in (9a) (from Crowley 1983: 317). When following a short back vowel, lateral and flap are in free variation, see (9b).

(9)				
	(a)	/anaːlu/	[anaːɖuŋ]	‘come’-PRES
	(b)	/ipula/	[ipulaŋ] ~ [ipuɖaŋ]	2non-SG-NOM

In the Angkamuthi dialect of Uradhi, the retroflex plosive shows additional frication noise in the form of a rhotic (described by Crowley 1983: 316 as rhotic release). This phenomenon is restricted to contexts where a back vowel follows, see (10).[11]

(10)		
/antu/	[anʈ^{r}uŋ]	‘canoe’
/wuntu/	[wunʈ^{r}u]	‘crooked’

Besides Australian, several Indo-European languages display a general pattern of retroflexion in a back vowel context. Sinhala, an Indo-Aryan language spoken in Sri Lanka, has a retroflex-dental distinction among apical consonants. Phonetically, the retroflex series varies in place of articulation from retroflex to alveolar (Gair & Paolillo 1997: 11). This variation is phonologically conditioned, so that retroflex consonants are pronounced as retroflex when preceded or followed by back vowels, and as alveolar in most other environments (Karunatillake 1992).[12] In Sri Lankan Portuguese Creole, the dental alveolar nasal and lateral have retroflex allophones

[11] A rhotic or retroflex release also occurs in other Australian languages, as in the Daly language Marrithiyel, where /maṣi/ ‘belly’ can be pronounced either as [mazi̯] or [mazʲi] (Evans 1995: 739). Evans, though transcribing it with an additional rhotic, describes this phenomenon as r-colouring of the vowel, which could also be interpreted as retroflexion of the vowel, cf. section 4.5.

[12] The question arises why this series is described as ‘retroflex’ with alveolar allophones, and not the other way round, as the occurrence of the retroflex allophone is far more restricted than that of the alveolar allophone. A reason is probably that this series corresponds etymologically to the retroflex consonants of other Indo-Aryan languages.

after the non-high back vowels [o, ə, a], for instance [aɳima[] ‘animal’ (Hume & Tserdanelis 2002). Interestingly, the remaining dental-alveolars [t d s z r] do not have such allophones, and the back high vowel [u] is not included in the context.

Some American Indian languages also show an affinity between retroflex sounds and back vowels. In the Molinos dialect of Mixtec, an Oto-Manguean language spoken in Molinos in the Tlaxiaco District of Mexico, the post-alveolar fricatives /ʃ, ʒ/ have retroflex varieties when preceding /a, o, u/, for example *žoʔo* [ʂoʔo] ‘rope’ or *žạạ* [ʂoãː] ‘very’ (Hunter & Pike 1969: 29). When a front vowel follows, the palato-alveolar is realized as such, e.g. *žįį* [ʃĩː] ‘side’.[13] Further Southern American languages having a fricative or an affricate which is changed into a retroflexed one while occurring before back vowels are Acoma, Mazatec, and O’odam (Bhat 1974a: 234). Certain Alaskan languages of the Athapaskan family are described to show a similar behaviour (in the same source).

In the Indonesian language Tolitoli (from the Austronesian language family) an alveolar lateral approximant [l] is in complementary distribution with a retroflex lateral flap [[] (Himmelmann 1991). The data indicate that the retroflex lateral occurs after the back vowels, [o, u, a], see (11a).

(11)	(a)	mo[[]ogo	‘wash hands’
		u[[]ag	‘snake’
		to[[]ito[[]i	‘Tolitoli’
		lelemba[[]an	‘to carry’
	(b)	membembe[l]an	‘to tremble’
		[l]abia	‘sago’
		kiki[l]o	‘firefly’

The alveolar lateral seems to occur elsewhere, see (11b).

4.2.2 Phonetic grounding

The phonetic motivation of the affinity between retroflexion and back vowels is both articulatory and acoustic. Back vowels, as their name indicates, are articulated with a backed, i.e. retracted, tongue body, just as retroflexes are, recall the description of retraction as a feature of retroflexes in section 2.3.4. Thus, the cooccurrence of retroflexes in a back vowel context can be seen as a coarticulation process of the dental/alveolar towards the tongue body shape of the back vowels. Bhat (1974a) proposed a similar explanation for the affinity of back vowels and retroflexes.

Since the vowel [o] is articulated with a slightly less raised tongue back and with more retraction (see figure 4.2), it seems as if the back mid vowel is articulatorily closer to the retroflex than [u].[14]

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[13] It coul be argued that the underlying fricative phoneme in Molinos Mixtec is actually retroflex with a palato-alveolar variant in a front vowel context. One indication for this is the writing convention according to which the fricative plus /i/ followed by another vowel is realized as [ʃ], e.g. *žįạʔụ* [ʃãʔũ] ‘fifteen’ (Hunter & Pike 1969: 31).

[14] The exact locations of [o] and [u] differ according to the language under investigation. The x-ray tracings of the two vowels in the Akyem dialect of Akan (a Niger-Congo language spoken in Ghana) in Ladefoged & Maddieson (1996: 301) are similar to the cardinal vowels in figure 4.2 on the left. The

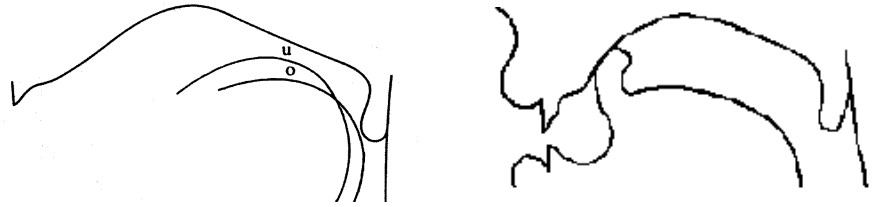

Figure 4.2 Comparison of the tongue back positions for the vowels [o] and [u] (based on x-ray tracings of the cardinal vowels by Catford 1988: 128) on the left with that of a retroflex stop (based on x-ray tracings of a Tamil stop by Ladefoged & Maddieson 1996: 27).

However, only one language could be found that has retroflexion in an [o] context to the exclusion of [u], namely Sri Lankan Portuguese Creole, as illustrated in 4.2.1 above. This strongly suggests that this process is not purely articulatorily motivated.

A further, non-articulatory explanation might be that both retroflexion and back vowels have a lowered F3.[15] The development of retroflexion next to back vowels could be caused by a reassociation of the acoustic cues of backness from vowel to consonant, similar to that of the reassociation of rhotic cues illustrated in section 4.1.2. This explanation is expected to hold especially for back, rounded vowel context, as rounded back vowels show a particularly low F3. Some languages such as Molinos Mixtec or the Yadhaykenu dialect of Uradhi show retroflexion of consonants with a following back vowel, which indicates that the CV transitional cues for retroflexes are important and distinctive enough to allow such a re-association, recall the discussion of asymmetricality of retroflex cues in section 3.5.

Looking at the manner of articulation of those segments that change into a retroflex in the languages discussed here, it is mainly nasal, lateral, and rhotic dentals/alveolars that are influenced as the single segments in languages by the back vowel context. In the Australian languages, this restriction holds for Nyawaygi, Margany, and Gunya; furthermore, it can be observed in Sri Lankan Portuguese Creole and in the Indonesian Tolitoli. In some languages, the whole dental/alveolar series is retroflexed, as in Sinhala and the Angkamuthi dialect of Uradhi. An account for this can be given by the different inherent cues of the manner classes involved. Sonorants like nasals, laterals, and rhotics have continuous formants just like the adjacent vowels. Instead of a clearcut borderline between the vowel formants and those of the sonorants, a smooth transition is given in these segment sequences. It is therefore more likely that a hearer misaligns a low F3 in the context of liquids than

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tracings of these vowels in Even (Ladefoged & Maddieson 1996: 307), a Tungus language of North-Central Siberia, however, show that both vowels have the same degree of backing and differ only in the degree of lowering. This interaction of retroflexes with the two back vowels is a topic that has to be left open for future research.

[15] The acoustic cues shared by retroflexion and back vowels certainly cannot be treated as independent of the articulatory similarity: retraction of the tongue body causes a lowering of F3, as described in section 3.2.4.

in that of for instance a stop, where only short vowel transitions are available followed by the silence of the stop closure. For a formal account of this difference see section 6.3.2.

One systematic exception to this observation are American Indian languages such as Molinos Mixtec and Mazatec (Oto-Manguan languages), Acoma (Keresan language), and O'odam (Uto-Aztecan) in which a fricative or affricate are the only segments to be retroflexed in a back vowel context. This is in line with the general tendency of American Indian languages to show retroflexion of fricatives and affricates only.

Further instances of the interaction of retroflex segments with back vowels are given in subsection 4.3.2.1 below where front vowels are changed into back ones in a retroflex environment due to a dislike of the gestures of retroflexion and front vowels.

4.3 Non-occurrence of retroflexes in front vowel context

As was already indicated in section 4.2.2, the front vowel context is avoided by retroflex segments. This avoidance can be observed in a large number of languages, but it is not a universal principle as there are languages where retroflexes do occur in a front vowel context. The dispreference of retroflexes for the front vowel context is realized in a number of avoidance strategies, recall the description in (1c) which gave two outputs, namely [it] or [ɨʈ]. These two illustrate the two main strategies that languages employ to avoid the dispreferred sequence, namely a change of the retroflex into an anterior coronal (i.e. the front high vowel gesture dominates), repeated here in (12), and to change the front vowel (i.e. the retroflex gesture dominates). The change of the front vowel can take on several forms: (13a) vowel retraction, (13b) vowel lowering, (13c) vowel diphthongization, or (13d) vowel rounding.

		input	*output*	*process*
(12)		/iʈ/	[it]	de-retroflexion
(13)	(a)	/iʈ/	[ɨʈ] or [ɯʈ]	retraction
	(b)	/ɛʈ/	[æʈ]	lowering
	(c)	/iʈ/	[iəʈ]	diphthongization (schwa insertion)
	(d)	/iʈ/	[yʈ]	rounding
(14)	(a)	/ʈʲ/	[t̠ʲ]	de-retroflexion
	(b)	/ʈʲ/	[ʈ]	de-palatalization
	(c)	/ʈʲ/	[ʈj]	separate palatal realization

Due to the articulatory similarity between high front vowels and the front glide /j/, the present illustration includes a short discussion on the incompatibility of retroflexes with secondary palatalization, recall the development of this assumption in section 2.5. In (14) the avoidance strategies for secondary palatalization are given: a change into a non-retroflex coronal with secondary palatalization (14a), into a non-palatalized retroflex (14b), or realization as a separate palatal glide (14c).

The examples given below are subdivided accordingly: section 4.3.1 deals with processes such as (12), section 4.3.2 with processes like (13), and section 4.3.2.5 with those in (14). Mandarin, Polish and Russian are shown to apply one of these strategies, and thus provide phonological evidence for the retroflex status of their fricatives (recall discussion in 2.4): Mandarin retroflexes occur only in a non-front vowel context, see 4.3.1 below, and Polish and Russian centralize a following /i/, cf. section 4.3.2.1. The phonetic grounding of the avoidance strategies is discussed in section 4.3.3. Section 4.3.4 deals with a counterexample for front vowel avoidance, namely the *ruki* rule, where retroflexion occurs precisely in front vowel context.

4.3.1 De-retroflexion in front vowel context

In section 4.2 it was shown mainly for Australian languages that retroflexes are often in complementary distribution with other coronal segments (apical alveolars for example), where the retroflex consonants occur in a back vowel context, and the other coronal series in a front vowel context. Several other languages also show this pattern. In Karok, for example, a Northern Hokan language spoken in Northwestern California (around the Klamath river), the retroflex segments [ʂ, ʈʂ] are in (near) complementary distribution with the palato-alveolars [ʃ, ʧ].[16] The retroflex fricative and affricate do not occur after the front vowel [i] even if other consonants intervene, while in this same environment palato-alveolars do occur, see the examples in (15) with retroflexes in the first column and palato-alveolars in the second (from Bright 1957).[17]

(15)	[ʂara]	‘bread’	[pikʃip]	‘shadow’
	[ʔaʂʂak]	‘on a rock’	[tuɻʃip]	‘mountain’
	[ʔaːʂ]	‘water’	[ʧiːʃ]	‘younger sister’

As a result of this complementary distribution, morphological processes cause a change from retroflex to palato-alveolar after a sequence of front vowel and /p/, see (16a), and from palato-alveolar to retroflex after a mid or back vowel, see (16b).

(16)	(a)	/ʔarip+ʂuru/	[ʔaripʃuru]	‘to cut a strip off’
		/pəhip+ʂuruk/	[pəhipʃuruk]	‘under the pepperwood’
	(b)	/mu+iʃpuka/	[muʂpuka]	‘his money’
		/ʔu+iʃkak/	[ʔuʂkak]	‘he jumps’

Acoma, a Keres language spoken in New Mexico, shows a similar complementary distribution, here the retroflexes change to alveolar or palato-alveolar before front vowels (Miller 1965). The same process occurs in Molinos

[16] Exceptions to this allophonic distribution are some loanwords which allow a front vowel-retroflex sequence, e.g. [ʂikspiʈʂ] ‘six bits’, and reduplicated forms such as e.g. [taʂinʂir] ‘to brush repeatedly’ from /taʂir/ (Bright 1957: 44). Bright further reports that nouns plus a possessive prefix allow some idiolectal variation, thus /nani-ʂara/ ‘my bread’ can be realized either as [naniʃʃara] or [naniʂʂara].

[17] The restriction for retroflexes seems also to hold before non-high front vowels, as no words containing a sequence retroflex-front vowel could be found in the data.

Mixtec (Hunter & Pike 1969). Another Amerindian example is the Pano-Tacanan language Chácobo spoken in Bolivia, in which the retroflex [ʂ] does not surface in words when preceded or followed by the front vowel [i]. In this case, the palato-alveolar [ʃ] occurs (Prost 1967: 62).

Further evidence for the cross-linguistic validity of retroflexes dispreferring the front vowel context comes from the Sino-Tibetan language group. Khonoma Angami, a Tibeto-Burman language spoken in the Naja Hills in the North-Eastern parts of India, has a retroflex approximant [ɻ] and a voiceless counterpart of this. According to Blankenship, Ladefoged, Bhaskararao, & Chase (1993: 132), the retroflex approximant is laminal before high vowels and subapical otherwise. The laminality indicates that this allophone is not retroflex, recall the retroflex criterion of apicality as introduced in section 2.3.1.[18]

In several Chinese dialects the retroflex fricative and affricate series (and also the dentals and velars) do not occur before a high front vowel, whereas the alveolo-palatals occur only in these positions (Yip 1996). Table 4.1 illustrates these phonotactic restrictions.

Table 4.1 Cooccurrence restrictions in Mandarin and other Chinese dialects (Yip 1996).

	_aj	_u	_i	_y
ʈʂ, ʂ	√	√	*	*
tɕ, ɕ	*	*	√	√

This evidence for the incompatibility of Chinese post-alveolar fricatives and affricates supports the claim made in chapter 2 that these sounds are retroflex on articulatory grounds.

Diachronic evidence for the avoidance of retroflexes in a front vowel context can be found in the Indo-Aryan language Gujarati, where [ʂ] became alveolo-palatal [ɕ] before front vowels, but stayed retroflex elsewhere (Pandit 1954).

4.3.2 Change of front vowels in retroflex context

This section discusses and exemplifies several processes of how a front vowel is changed in a retroflex context. The processes found in natural languages are retraction, lowering, diphthongization, and rounding of front vowels, see (17a) – (d).

(17)	*input*	*output*	*process*
(a)	/iʈ/	[ɨʈ] or [ɯʈ]	retraction
(b)	/ɛʈ/	[æʈ]	lowering
(c)	/iʈ/	[iəʈ]	diphthongization (schwa insertion)
(d)	/iʈ/	[yʈ]	rounding

[18] As coronal rhotics are almost always apical (see Hall 2000a), the segment occurring before high front vowels is expected to show a manner change towards a non-rhotic, as well. No indication for this could be found in Blankenship et al.

Vowel retraction, lowering, diphthongization, and rounding will be illustrated in sections 4.3.2.1, to 4.3.2.4, respectively. Often more than one of these processes occurs simultaneously in one language.

4.3.2.1 Retraction of front vowels

The first avoidance strategy modifying the vowel, namely retraction of front vowels (17a), is observable in the Dravidian vowel system. Zvelebil (1970: 38) notes that Iruḷa shows retraction of the front vowel /i/ to the central [ɯ] before a retroflex consonant. Likewise, the front vowel /e/ is retracted to [ɤ] in this environment. As a consequence the high and mid back unrounded vowels (graphically represented as *ï* and *ë*) were added as phonemes to the general Dravidian five-vowel system *i, e, a, o, u*. The backing of front vowels can also be found in the South-Dravidian language Koḍagu (also called Kodava) spoken in the Coarg district (Zvelebil 1970, Emeneau 1970, Ebert 1996). Here the vowels /i/ and /e/ are backed before the retroflex consonants /ʈ , ɖ , ɳ , ɭ/. The phonetic representations of the outcome of this change differ: Gnanadesikan (1994) uses the symbols [ɨ] and [ɘ], whereas Ebert represents them as [ɯ] and [ʌ], implying a more extreme retraction.[19]

Gnanadesikan (1994: 132) compares Koḍagu with other Dravidian languages to exemplify the change, given here with additional examples (based on Zvelebil 1970) in (18), where (a) involves backing in non-labial context, and (b) backing and rounding after labials.

(18)		*Koḍagu*	*Other Dravidian languages*		
	(a)	ɨɭi	iɭi	(Tamil, Malayalam, Kannada)	‘to descend’
		ɘɳɳ-	eɳɳu	(Tamil)	‘to say’ in Koḍagu ‘to count’ in Tamil
		kɘːɭ	keːɭ	(Tamil)	‘to hear’
	(b)	puɖi	piʈi	(Tamil, Malayalam)	‘to catch hold’
		puɳɖ	piɳɖu	(Kannada)	‘to squeeze’
		poɳɳɨ	peɳ	(Tamil, Malayalam, Kannada)	‘wife, female’

The backing of vowels after labials and before retroflexes can also be observed in Colloquial Tamil, e.g. /viːɖɯ/ can be pronounced as [vɘːɖɯ] (Zvelebil p. 47f., Bright 1975: 15).[20] Toda, a Dravidian language spoken in the Nilgiri Hills in Southern India, is a further example for a language that has a process of vowel retraction in a retroflex context (Zvelebil 1970: 46). Here, Proto-Dravidian *i changed to [ɯ], e.g. ‘mountain’ is [tɯʈ] in Toda but [tiʈːu] in Tamil, and Toda [kɯɾ] ‘small’ is Tamil [kiɾu].

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[19] Zvelebil (1970) uses only the diacritic [˙] above *i* and *e* to symbolize their retraction, but gives no indication for the amount of backing. Bright (1975: 16) explains that the retracted *i* is similar to the underlying back [ɯ].

[20] Bright explicitly points out the difference between the two vowels in this example, the first one being central, the second back.

Several members of the Australian language family show vowel retraction. For instance, Bunuba (Rumsey 2000), spoken in Western Australia, realizes the phoneme /i/ as high central vowel [ɨ] before retroflexes, see (19).[21]

(19) /biɖi/ [bɨɖi] ‘upper leg, thigh’
/giɭiɭi/ [gɨɭɨɭi] ‘shoulder blade’
/dʒiʈʌli/ [dʒɨʈʌli] ‘before, long ago’

Wembawemba, an Australian language spoken in Victoria (Hercus 1986: 17; Flemming 2002: 91), shows retraction of front vowels: The mid front vowel /e/ is retracted if preceding a retroflex, see the examples in (20).

(20) /peɳeʈ/ [pɜɳɜʈ] ‘teal duck’
/meʈmeʈil/ [mɜʈmɜʈil] ‘large black cormorant’
/weʈpuk/ [wɜʈpuk] ‘tree trunk’

This vowel retraction is accompanied by vowel lowering as described in section 4.3.2.2 below. The high front vowel /i/ in Wembawemba undergoes rounding and lowering before retroflexes, cf. section 4.3.2.4.

Vowel backing occurs also in the Micronesian language Ponapean (Rehg 1973, Gnanadesikan 1994: 133), where the front vowels /i/ and /e/ surface as backed after retroflexes (and other consonants referred to as ‘back’ in Rehg), see (21a) below. Back vowels remain unchanged in this environment, see (21b).

(21) (a) ʈɨʈ ‘secret’ (b) ʈʂop^{w} ‘lush’
ʈʂəŋ ‘tight’ ʈɔŋ ‘burned’

The Chinese language Pingding (Lin 1989) has a process whereby the retroflex lateral [ɭ] is inserted after the initial consonant of the stem to denote familiar usage (originally this infix had diminutive meaning). The process triggers a change in the following front vowel towards a back vowel, see (22a), or a loss of the front high vowel, see (22b) (Lin 1989: 187).[22]

(22) (a) /tɕ^{h}yæ̃/ [ts^{h}ɭua] ‘circle’
/ʂəu tçyæ/ [ʂəu tsɭua] ‘handkerchief’
(b) /tçiəŋ/ [tsɭəŋ] ‘now’

Polish post-alveolar fricatives and affricates show a retraction of vowels similar to that illustrated up to now, and thus give support to their articulatory analysis as retroflexes in chapter 2. The process in Polish whereby /i/ surfaces as the central high vowel [ɨ] after hard (i.e. velarized) dentals and retroflexes is called ‘retraction rule’ (Booij & Rubach 1987:16ff.; Rubach 1995: 858ff., Hall 1997: 44). Examples of this rule are given in (23) with the verbalizing suffix /i/.

[21] Interestingly, the retraction of front vowels is also triggered by velars in Bunuba, see e.g. /miŋʌli/ ‘hand’ is realized as [miŋʌli] (Rumsey 2000: 44).

[22] The cooccurring change from alveolo-palatal to alveolar affricate is due to the allophonic restriction of alveolo-palatals to appear in front vowel contexts only, cf. 4.3.1 above.

(23)	towarzy**sz**+**y**+ć	[tovazʲɻʂɨtɕ]	‘to accompany’
	stra**sz**+**y**+ć	[straʂɨtɕ]	‘to frighten’
	miaż**dż**+**y**+ć	[mʲazʲɻdzʲɻtɕ]	‘to squash’

The same behaviour of vowel retraction can be observed for the Russian post-alveolar fricatives. Like the Polish segments they do not occur in front vowel context. Only the central vowel /ɨ/ is allowed after these sounds (Hamilton 1980), see the occurring pronunciations in the first row of (24) with the impossible ones in the second row.

(24)	[ʂɨɬ]	*[ʂiɬ]	*šil*	‘he sewed’
	[zʲɻɬ]	*[zʲɻɬ]	*žil*	‘he lived’

Based on these data I assume a cooccurrence restriction for Russian that disallows sequences of retroflex fricatives and front high vowels, phonologically supporting the fricatives’ retroflex status.

4.3.2.2 Lowering of front vowels

Norwegian has a rule of *e*-lowering before retroflexes. Examples of this process are given in (25), where the first column contains words with /ɛ/ or /eː/ followed by a dental, and the second column contains an /ɛ/ followed by a retroflex, where the vowel is realized as [æ] (based on Kristoffersen 2000:14, 105f.).[23]

(25)	[ʋɛt]	*vett*	‘intelligence’	[ʋæʈ]	*vert*	‘host’
	[hɛlg]	*helg*	‘weekend’	[hæʈj]	*helg*	less formal register
	[heːl]	*hæl*	‘heel’	[hæːʈ]	*hæl*	less formal register

With respect to [ʂ], Norwegian shows variation, cf. [hæʂ.ʂə] *herse* ‘to bully’ vs. [hɛʂ.ʂə] *hesje* ‘haydrying rack’, but in most cases [æ] is found (ibid.).

In Svantesson’s (2001) Southern Swedish dialect, vowel lowering of [ø, ʉ, o, ɛ] (and the long counterparts) occurs before ‘retracted’ coronals, which is an indication of the retroflex nature of these consonants (recall discussion in 4.1 above). Examples of this process are given in the first column of (26), compared to unaffected vowels in non-retroflex environment, see the second column.

(26) (a)	[hœːʂ]	*hörs*	‘is heard’	[høːs]	*hös*	‘hay’s’
	[bɒːʂ]	*burs*	‘cage’s’	[bʉːs]	*bus*	‘mischief’
	[læːʂ]	*lärs*	‘is learned’	[lɛːs]	*läs*	‘read’
(b)	[bœəʂ]	*börs*	‘purse’	[løs]	*löss*	‘lice’
	[kɔəʈ]	*kårt*	‘short’	[skot]	*skott*	‘shot’
	[væʈ]	*värt*	‘worth’	[vɛt]	*vätt*	‘wett’
(c)	[lɐːʂ]	*Lars*	(name)	[laːs]	*las*	‘was laid’

In (26a) the lowering of high and middle long vowels is illustrated. In (26b) the respective short vowels are lowered. All the short vowels apart from [ɛ] show

[23] The apical tap [ɾ] also triggers vowel lowering, e.g. [tʋæɾ] *tverr* ‘cross’ (adj.), which is unexpected, since it is not retroflex.

additional schwa insertion. (26c) shows that the long [a] is raised in a retroflex context whereas the short [a] remains unchanged, cf. *kart* [kaʈ] ‘unripe fruit’.

In the Australian language Kayardild (Evans 1995: 58f.), a following retroflex causes lowering and retroflexion of the high vowels [i] and [u]: *birdiy* [bɛᵗɖej] ‘bad’ and *kuru* [koᵗʈɯ] ‘egg’. The two Pama-Nyungan languages Margany and Gunya (Breen 1981: 289) also show lowering of both high vowels (plus retraction in the case of the front vowel) before all retroflexes, see the examples in (27), where (a) illustrates the change for the high front vowel, and (b) for the high back vowel.[24]

(27)	(a)	/badbiɖa/	[bɐrbɨɖɐ] ~ [bɐrbəɖɐ]	‘porcupine’
		/nikiɭ/	[nikəɭ]	‘hot coal’
	(b)	/juɖi/	[joɖi]	‘meat’

Lowering of vowels when adjacent to retroflexes also seems to occur in the Dravidian languages Tamil, Malayalam, and Kannada. Here, standard forms with /o/ alternate with more substandard forms such as /u/, e.g. [koʈu] ~ [kuʈu]. Zvelebil (1970: 63) mentions that there is some evidence that the forms with /u/ are older than those with /o/, and thus vowel lowering before retroflexes took place in the standard languages.

4.3.2.3 Diphthongization of front vowels

Diphthongization is a further strategy applied to avoid the sequence high front vowel – retroflex. Schwa-insertion resulting in a diphthong occurs for example in the Beijing dialect of Chinese. A high front vowel – retroflex sequence might occur in Beijing by the morphological process of [ɻ] suffixation (Lin 1989), which has the same meaning of indicating familiar usage as the retroflex infix in Pingding illustrated earlier in (22). If the stem ends in a front high vowel, then a schwa is inserted between stem and suffix, see the examples in (28a) compared to those in (28b) where no insertion takes place (from Lin p. 188).

(28)	(a)	/pʰi + ɻ/	[pʰiəɻ]	‘skin’
		/y + ɻ/	[yəɻ]	‘fish’
	(b)	/xua + ɻ/	[xuaɻ]	‘flower’

In the Australian language Gugada spoken in Queensland, the transitions of vowels into the retroflex are lengthened, and the vowel quality is changed into a lower, backer vowel (Platt 1972). This results in a schwa-like segment before the retroflex. Platt transcribes the result as [ɪə].

In Svantesson’s (2001) Southern Swedish dialect, vowel diphthongization of the high vowels [i, y, u] (long and short) and the mid vowels [eː, ø, o] occurs before all retroflexes.[25] These diphthongized vowels are realized with the same quality as their non-diphthongized equivalents, but with a schwa-like offglide of the vowel. Examples of this are in (29) (Svantesson 2001: 157), with non-diphthongized equivalents in the second column.

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[24] The second example, /nikiɭ/, exists only in Margany, the other two in both languages.

[25] Recall the discussion in section 4.1 whether the segments causing this process are retroflexes or not.

(29)						
	[hiəʂ]	*hirs*	‘millet’	[his]	*hiss*	‘lift’
	[piːəʂ]	*pirs*	‘pier’s’	[biːs]	*bis*	‘bee’s’
	[syəʂa]	*syrsa*	‘cricket’	[systə]	*syster*	‘sister’
	[bœəʂ]	*börs*	‘purse’	[løs]	*löss*	‘lice’
	[kɔəʈ]	*kårt*	‘short’	[skot]	*skått*	‘shot’
	[kuəʈ]	*kort*	‘card’	[skut]	*skott*	‘shoed’
	[kuːəʂ]	*kors*	‘cows’’	[kɪuːs]	*kos*	‘cow’s’
	[eːəʂ]	*ers*	‘your’	[eːs]	*es*	‘e’s’

Not all of the Southern Swedish vowels as described by Svantesson undergo diphthongization before retroflexes; the long non-high vowels and [ɛ] show lowering (recall section 4.3.2.2). The short vowels /ø/ and /o/ are both lowered and diphthongized, resulting in /œə/ and /ɔə/, respectively.

4.3.2.4 Rounding of front vowels

Wembawemba, which was illustrated to have backing of vowels in (20) above, also has a process whereby the vowel /i/ is rounded if it precedes retroflex consonants (Hercus 1986, Flemming 2002: 89ff.), see (30).

(30)			
	/ʈʲiɳʈʲiɳ/	[ʈʲyɳʈʲyɳ]	‘poker’
	/tiʈənaiuk/	[tyʈənaiuk]	‘new, fresh’
	/miʈkuk/	[myʈkuk]	‘egg’

Rounding in Wembawemba does not occur in the absence of a retroflex, see for example the word for ‘tomahawk’, /tir/, which is realized as [tir]. A similar process of vowel rounding can be found in Wergaia (Hercus 1986, Flemming 2002: 90), a language that is closely related to Wembawemba, see examples in (31).

(31)			
	/giʈəm/	[gyʈəm]	‘spear shield’
	/ɖʲiʈuk/	[ɖʲyʈuk]	‘end’

Retroflexes also condition the rounding of vowels in South-Dravidian languages. Iruḷa, for example, shows a diachronic development from /a/ to [ø] and from /e/ towards [ɯ] or [ø], triggered by a retroflex that was partly lost, as comparisons with Tamil words show, see (32) (based on Zvelebil 1970: 44, 59, 64).[26]

(32)	*Iruḷa*	*Tamil*	*gloss*
	[køtːu] ~ [køtu]	[kaɭutːu]	‘neck, throat’
	[kɯʈːa]	[keʈːa]	‘bad’
	[øːɭdu]	[eɭutu]	‘to write’

Bright (1975: 23) describes these vowels as retracted only; no mentioning is made of rounding. Considering Bright’s very precise descriptions of Dravidian vowels (recall

[26] The Iruḷa vowels also show raising, which probably occurred independently of the retroflex context, as no other language to my knowledge shows vowel raising in retroflex context. The raising is not phonetically motivated and is therefore not further discussed in this dissertation.

footnotes 19 and 20), it does not seem accidental that he does not mention any rounding of the Iruḷa retracted vowels. Further support for this non-rounded description of the retracted vowels in Iruḷa is Diffloth (1975: 55), who describes these segments as "centralized (or retroflexed) vowels". Following Bright and Diffloth, I assume that the vowels in Iruḷa are not rounded and will therefore not further treat the Iruḷa data in this dissertation.

In Koḍagu, another South-Dravidian language, the process of vowel backing is accompanied by vowel rounding when the preceding vowel is a labial, as illustrated already in (18). This process can be further illustrated when compared to other Dravidian languages: Proto-Dravidian */e:/ is changed to an /o:/ in Koḍagu, cf. [boːʈe] 'hunting' compared to Tamil [veːṭːai] 'id.', or Koḍagu [poːʈ] 'to transport by pack-animal' vs. Kannada [peːɽu] 'to load' (Zvelebil 1970: 61).

4.3.2.5 Retroflexion and secondary palatalization

Secondary palatalization of retroflexion, as discussed already in section 2.5, shows three avoidance strategies, namely change of the retroflex into a laminal palatalized coronal, non-palatalization of the retroflex, or sequential realization of retroflex and palatal glide. All three processes are illustrated here in (33).

(33)	*input*	*output*	*process*
(a)	/ʂʲ/	[ʃʲ]	de-retroflexion
(b)	/ʈʲ/	[t̪]	de-palatalization
(c)	/ʈʲ/	[ʈj]	separate palatal realization

In section 2.5 de-retroflexion as in (33a) was assumed to take place in Polish and Russian, where /ʂʲ/ surfaces as an inherently palatalized laminal palato-alveolar [ʃ].

Resistance towards secondary palatalization as exemplified in (33b) can be found in Scots Gaelic, where nouns usually undergo palatalization in the genitive singular, recall the example [kʰatʰ] 'cat' (nom. sg.) versus [kʰat̠ʰʲ] 'cat' (gen. sg.) from section 2.5.1. Nouns with retroflex consonants remain unpalatalized, e.g. [paːʈ] 'a poet' (both nom. and gen. sg.) (Borgstrøm 1940: 76).

As described in section 2.5.2, Toda has palatalized retroflex rhotics such as [oɽʲ] 'foot', or [toɽʲ] 'pole used at funeral' (Spajić et al. 1996). In the same section acoustic evidence was given for the claim that these allegedly palatalized retroflexes are realized as retroflexes with a following front glide.

4.3.3 Phonetic grounding

The previous sections contained several processes illustrating that retroflexes disprefer front vowel context and secondary palatalization. The processes applied to avoid these segments or segment sequences are repeated here in (34), (35), and (36).

		input	*output*	*process*
(34)		/iʈ/	[it]	de-retroflexion
(35)	(a)	/iʈ/	[ɨʈ] or [ɯʈ]	retraction
	(b)	/ɛʈ/	[æʈ]	lowering
	(c)	/iʈ/	[iəʈ]	diphthongization (schwa insertion)
	(d)	/iʈ/	[yʈ]	rounding
(36)	(a)	/ʈʲ/	[t̠ʲ]	de-retroflexion
	(b)	/ʈʲ/	[ʈ]	de-palatalization
	(c)	/ʈʲ/	[ʈj]	separate palatal realization

Whereas sequences of front vowels and retroflexes actually occur in natural languages, it was claimed in section 2.5 that retroflexion with a secondary palatalization is articulatorily impossible and therefore does not occur in any language. Despite this difference, both the dislike of retroflex and front vowels and the absolute incompatibility of retroflexion and secondary palatalization have the same articulatory grounding: a flat tongue middle and retracted tongue back configuration for retroflexion cannot be combined with the high tongue middle and fronted tongue back necessary for both front vowels and palatalization. A simultaneous production of both gestures as in secondary palatalization is impossible, and a sequential order such as retroflex and high front vowel or high glide is dispreferred, because it involves a major movement of the tongue from one extreme position (namely a high fronted position) to the other (the backed, velarized position).[27]

The articulatory distance between the two positions can be reduced by a number of mechanisms. First of all, the retroflex gesture can be reduced, resulting in a non-retroflex coronal, as in (34) and (36a). Secondly, the gesture of the vowel or the glide can be reduced. For the glide, only a total deletion can be observed in the languages of the world (see 36b), probably because a partial reduction is not recognizable as secondary palatalization anymore.[28] For the front high vowel, several articulatory reductions are possible which facilitate the transition to a retroflex gesture: the vowel can be retracted (35a), or lowered (35b), or both; or diphthongization of the vowel can occur (35c).

Vowel retraction or lowering involves a departure from the underlyingly specified vowel quality. The vowel realized instead has a tongue position that is closer to that of the adjacent retroflex, and thus diminishes the distance between vowel and consonant gestures. Only high vowels are target of lowering, and front vowels target of retraction.

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[27] The articulatory argumentation of a dislike for high front vowels and a backed, velarized position is not restricted to retroflexion. It can also explain why velars always have a fronted allophone when adjacent to front high vowels.

[28] Only one case of front vowel deletion in retroflex context could be found, namely Pingding Chinese, recall the examples in (22b).

Diphthongization involves the movement from the high front vowel to some kind of neutral position (or a position as in a retracted or lowered vowel) before the tongue position for the retroflex is assumed. Only high or mid front vowels are a target of this process. The vowel and the retroflexion gestures show a gestural delay, as illustrated in figure 4.3.

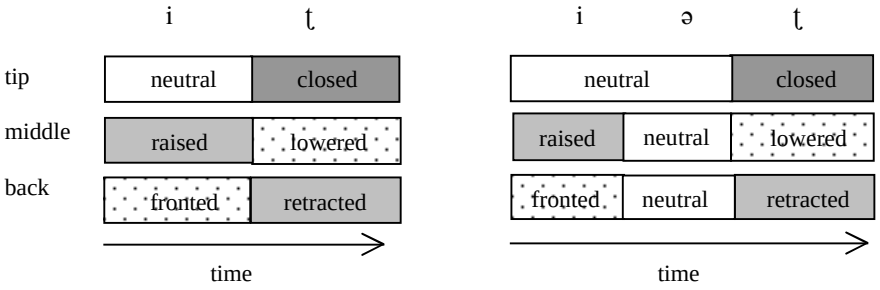

Figure 4.3 Gestural timing of vowel – retroflex sequences, without delay on the left, and with delay and resulting vowel diphthongization on the right. The three tiers indicate the three tongue parts tip, middle, and back. The tongue blade is not included, since it is not relevant for the depiction of this process. Neutral position of the tongue parts is depicted with white boxes, a positive degree of constriction i.e. raising of the articulator with a grey box (dark grey standing for full closure), and negative constriction i.e. lowering of the articulator with a dotted box.

Rounding of a vowel, see (35d), is obviously not a process that facilitates the articulation of front high vowel – retroflex sequences, since both retroflexion and rounding are produced with independent articulators, namely the tongue and the lips, respectively, and therefore do not affect each other. This process can be motivated by two different explanations. In Koḍagu vowel rounding seems to be caused by the adjacent labial consonant, and not by the retroflex. The articulation of a rounding gesture is rather slow; according to Stevens (1998: 44) the minimal time from a rounded to an unrounded configuration of the lips is 50 to 100 ms. This slowness can account for the fact that the lips are still not in neutral position at the beginning of the vowel, which can subsequently lead to a rule of full vowel rounding after labial consonants, a process that is cross-linguistically quite common.

Vowel rounding in Wembawemba and Wergaia, however, cannot be articulatorily motivated since it is not caused by adjacent labials. Flemming (1995 [2002], 2001) proposes that the rounding in a retroflex context in these languages is the result of a reduction of the retroflex gesture (process (34)) with concomitant rounding of the vowel in order to preserve the perception of a low F3 typical for a retroflex (section 5.3.2 below gives a summary of Flemming's analysis). This perceptual preservation seems plausible: the listener can interpret the lowered F3 of the rounded vowel as belonging to the coronal consonant as illustrated in Figure 4.4.

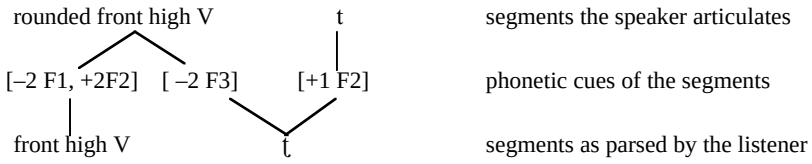

Figure 4.4 Listener's interpretation of the sequence rounded front vowel – alveolar as (rounded) front vowel–retroflex (illustration of Flemming's proposal).

Flemming, though, fails to explain why the rounding is realized on the vowel and not on the consonant, since it is the retroflexion of the consonant that is supposed to be enhanced by rounding. The shift in target segment can be explained by the fact that rounding on consonants is perceptually not as salient as rounding on vowels. Especially stop articulations yield only transitional perceptual cues for rounding, since no continuous formant cues during the consonant are available. In addition, the slowness of the labial gesture probably causes distinct labialization cues only halfway of the consonant. If, on the other hand, in a vowel-consonant sequence as in Wembawemba or Wergaia the rounding configuration is assumed for the vowel, perceptual cues of rounding are available throughout the vowel. Therefore rounding is more effective if realized on the preceding vowel instead on the retroflex itself.[29] Both the articulatory and the perceptual motivation for the rounding processes will be formalized in section 6.3.3.4.

Whereas for diphthongization the vowel and consonant gestures show delay, in vowel retraction and lowering there occurs some overlap in gestures; the tongue position is changed already during the vowel. This gestural overlap provides the listener with additional cues for retroflex articulation, though at the cost of the vowel cues.

It is assumed here that languages requiring very precise vowel cues, such as languages with large vowel inventories, do not allow articulatory assimilations of retroflex and front vowels with resulting changes in the perceptual cues of the vowels, because it would reduce the perceptual difference between the single vowels and thus risk perceptual confusion. Evidence for this assumption can be found in the fact that mainly languages with very small inventories, such as the Australian Margany, Gunya, and Bunuba with the vowels [i, a, u] (short and long) allow the processes in (35). An assimilation mechanism acceptable for large vowel inventories is diphthongization, see (35c), because it preserves at least part of the cues of the original vowel. The large vowel inventory of Swedish, for example, mainly undergoes diphthongization before retroflexes (see (26) and (29)).

Having established the phonetic motivation of the processes involving high vowel and retroflex sequences, we can now inspect the contextual position of the

[29] The present argumentation does not exclude the possibility that rounding occurs on both the vowel and the consonant.

segments undergoing the changes, and the manner of the retroflexes involved. The list in (37) – (41) gives a summary of this information from the examples given above, where *R* stands for the class of retroflexes and *L* for labials:

	vowel	retroflex	language
(37)	*de-retroflexion (section 4.3.1)*		
	i_	ʂ, ʈʂ	Karok, Acoma, Molinos Mixtec
	_i_	ʂ, ʈʂ	Chácobo
	_i	ʂ, ʈʂ	Khonoma Angami, Chinese, Gujarati
(38)	*retraction (section 4.3.2.1)*		
	i e	_R	Iruḷa, Koḍagu, colloqu. Tamil, Toda
	i e	ɽ, ʈʂ _	Ponapean
	i	_R	Bunuba
	e	_R	Wembawemba
	i	ʂ _	Russian, Polish
	y	ɭ _	Pingding Chinese
(39)	*lowering (section 4.3.2.2)*		
	e	_R	Norwegian
	ɛ ɛː oː øː ʉː	_R	Swedish
	i u	_R	Kayardild, Margany, Gunya
	u	_R	Tamil, Malayalam, Kannada
(40)	*diphthongization (section 4.3.2.3)*		
	i	_ɻ	Beijing Chinese
	i	_R	Gugada
	high Vs + eː ø o	_R	Swedish
(41)	*rounding (section 4.3.2.4)*		
	i	_R	Wembawemba, Wergaia
	e	L_R	Koḍagu (plus retraction)

The process of palatalization is not included here, because it differs from the vowel – retroflex sequences in that it always involves a palatalization context, i.e., a high front vowel, which usually follows the consonant.

In general, it can be observed that the retroflexes involved in the processes are almost always the whole retroflex class of the specific language. In some cases I specified the retroflex class of specific languages, as for Russian, Polish and Ponapean, to show the restricted set of retroflexes in these languages. The only exceptions to this are the Beijing Chinese rhotic and the Pinging Chinese lateral, which are not the only retroflexes in these languages, but the only segments involved in the processes. This is due to the morphological conditioning of the processes: diphthongization in Beijing occurs only after the suffixation of the retroflex rhotic, and backing in Pingding occurs only after infixation of the lateral retroflex.

The direction of influence is often from retroflex to preceding vowel. Vowel lowering and rounding occurs only before retroflexes in our examples. This behaviour is in accordance with the stronger cues of retroflexion leading into the segment (VC cues) than those leading out of it (CV cues), as illustrated in section 3.5. Furthermore, some studies (e.g. Krakow 1999) prove that there is a difference in the synchronization of CV gestures, which are well synchronized, and that of VC gestures, which are less synchronized. Therefore retroflexes and preceding vowels show more gestural overlap than retroflexes and following vowels.

In the cases where retroflexes influence following vowels or where vowels influence preceding retroflexes (namely in de-retroflexion) this is restricted to retroflex fricatives, affricates, and liquids (see the examples from Gujarati, Chinese, Ponapean and Russian). These segment classes have strong internal cues as described in section 3.1. Furthermore, they have stable articulations without a flapping out gesture as observable in retroflex stops (see discussion in 2.2.4.1), which leads to less reduced CV cues than for stops. These factors can explain why retroflex fricatives, affricates, and liquids but not stops or flaps show perceptual influence on following vowels.

Considering the targets of vowel changing processes, it is mainly the high front vowel or the class of front vowels that is changed, in line with the articulatory incompatibility of these vowels with retroflexes. Lowering in (35b) is the only process illustrated above that occurs also with high back vowels, as discussed above (e.g. in Kayardild, Margany, Gunya, and Tamil). In section 6.3.3 below I will propose formal accounts for the processes avoiding retroflex – front vowel sequences with one example of each process.

4.3.4 Exception: The *ruki*-rule in Sanskrit

The morphophonemic process of retroflexing /s/ after the vowels /u/ and /i/ and after the consonants /k/ and /r/ in Sanskrit (Whitney 1889: 61f.), spelled out in rule-format in (42), is a recurrent topic in phonological descriptions.

(42) $s \rightarrow ʂ$ / r, u, k, i _

This process is often referred to as the *ruki*-rule and it involves four contexts which seems to make up an unnatural class as they include both back and front vowels, contradicting the rule for deretroflexion in a front vowel context given in (1c). Via the *ruki*-rule the retroflex fricative [ʂ] was introduced into Sanskrit from the proto-Indo-European alveolar fricative /s/.[30] Other retroflex segments in Sanskrit subsequently emerged from assimilation, see section 4.6 below. Examples of the *ruki* rule are given in (43a) with the locative plural suffix /-su/ (Whitney 1889, Flemming 1997). In other environments, this suffix occurs with an alveolar fricative, see (43b).

[30] The retroflex fricative entered Sanskrit also via a change from Indo-European *k before a /t̠/. This separate development will be ignored here since it is a process that does not occur cross-linguistically and seems to lack a phonetic grounding. For a detailed discussion of this change see Hall (1997b: 213f.).

(43)	(a)	[svasɻʂu]	‘sister’	(b)	[ɟaːsu]	‘progeny’
		[ɕaʈ̪ɽuʂu]	‘enemy’		[apsu]	‘water’
		[vaːkʂu]	‘voice’			
		[agn̪iʂu]	‘fire’			

According to Whitney (1889: 61f.), a following [ɽ][31] prevents the retroflexion of /s/. Thus forms like [usɽa] or [t̪isɽas] do not surface as [uʂɽa] and [t̪iʂɽas], as though they satisfy the conditions of the *ruki*-rule.[32] A dissimilation process like this occurs in other languages, too, cf. section 4.6 below.

The [i] context seems unusual as trigger of the *ruki*-rule since retroflexes are expected to avoid front vowels, recall section 4.3 and the articulatory explanation for it in section 2.5. The other three segments triggering the *ruki*-rule are phonetically motivated, however, as discussed below. Several explanations have been put forward for the unusual set of contexts in which the change from an alveolar to a retroflex fricative occurs. Whitney (1889: 61f.) himself proposes an articulatory explanation for its four contexts: retroflexion after a retroflex rhotic is clearly an assimilatory process, and the contexts /k/, /i/ and /u/ share a retracted tongue position which causes the tip of the tongue “to reach the roof of the mouth more easily at a point further back than the dental one” (ibid.). But as Vennemann (1974: 93) points out, it does not follow from the retracting influence of /i/, /u/, and /k/ that the outcome should be retroflex instead of for instance palato-alveolar.

A widespread assumption concerning the development of the *ruki*-rule is that it occurred historically in two stages, with the retroflex as final outcome and a different segment as intermediate output. Misra (1967: 28ff.), Mayrhofer (1989) and Hall (1997b) propose that Proto-Indo-European *s developed to a palato-alveolar fricative [ʃ] in Indo-Iranian in the *ruki* context, and then, via a general rule, to the retroflex in Sanskrit. The two stages of this diachronic process are given in (44).

(44)	(a)	*s (Indo-European)	→	ʃ / ɽ̥, u, k, i _	(Indo-Iranian)
	(b)	*ʃ (Indo-Iranian)	→	ʂ	(Sanskrit)

Hall proposes that evidence for such an intermediate stage can be found in the fact that the same change (44a) occurred in Avestan, Old Persian and Baltic, where the alveolar remains palato-alveolar, and in Slavonic, where it further changed into a velar [x] (Allen 1951, 1954, Andersen 1968). The change in (44b) is context free, and motivated by Hall as a change towards an unmarked sibilant inventory. The output of (43a), /ʃ/, became phonemic, which caused the two-way sibilant place contrast /s, ɕ/ in Indo-European to change to /s, ɕ, ʃ/. Hall shows that this three-way place contrast does not occur in any other language of the world because of the large similarity between /ɕ, ʃ/, and therefore a further change (43b) was triggered, see the representation of the development in (45).

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[31] This transcription is mine, based on descriptions in Whitney.

[32] Another exception, though not systematic, is the occurrence of a retroflex fricative somewhere after the alveolar fricative, e.g. [si**s**akʂi] (Whitney 1889: 62). In such cases, the *ruki*-rule sometimes does not apply.

(45) *stage 1* *stage 2* *stage 3*
/s, ɕ/ → /s, ɕ, ʃ/ → /s, ɕ, ʂ/

Hall's proposal is based on the assumption that the Sanskrit sound represented as 'ś' and described as 'post-alveolar laminal fricative' is the alveolo-palatal [ɕ]. Usually, however, it is interpreted as the palato-alveolar [ʃ], as by Whitney (1889) and Allen (1953). If the palato-alveolar is taken as the Sanskrit post-alveolar fricative, then the outcome of the *ruki*-rule would collapse with this already existing class:

(46) *stage 1* *stage 2* *stage 3*
/s, ʃ / → /s, ʃ/ → ? /s, ɕ, ʂ/

From the second stage in this development there is no obvious way to derive the inventory assumed for stage 3. This supports the assumption made by Hall that the Sanskrit laminal post-alveolar is the alveolo-palatal [ɕ], which will be followed here. Hall's proposal, however, does not provide an answer to the question why all four contexts of the *ruki* rule caused exactly the same output, namely a palato-alveolar [ʃ].

Another proposal, going back to Morgenstierne (1929) and applied by Allen (1951: 941), Vennemann (1974), Gnanadesikan (1993: 47), and Flemming (1997), suggests that /s/ assimilated to the four contexts, resulting in different assimilation outputs at an intermediate stage, or several intermediate stages, as Morgenstierne (1929: 2000) proposes. These outputs collapsed at a later stage to the retroflex category, see the development depicted in (47).[33]

(47) *stage 1* *stage 2* *stage 3*
/s/ → [s, ʳs, ᵘs, ᵏs, ⁱs] → /s, ʂ/

The symbols *ʳs, ᵘs, ᵏs,* and *ⁱs* are used here to indicate the four allophones of the *ruki* assimilation (in line with Vennemann's transcription), and *s* as the allophone occurring in other environments. Allen (1951: 941, 1954: 564) assumes that the outputs of the second stage could have looked like [ʂ, x^w, x, ç], respectively. Gnanadesikan (1993: 47, footnote 22) proposes only three different outputs. According to her, /ɽ/ could have triggered a retroflex fricative, /u/ and /k/ a velar one, and /i/ an alveolo-palatal one. Flemming (1997) suggests also three differing outputs at stage 2, though they differ slightly from Gnanadesikan's. Flemming's outputs are [ʂ, s^w, ʃ, ʃ], respectively. The three proposals are summarized in table 4.2 on the next page.

The exact output of the distinct assimilation processes is obviously not clearly predictable because of lack of supporting evidence. The preceding retroflex can be assumed to have a retroflexing influence on the fricative; cross-linguistic evidence plus a phonetic motivation for this kind of process were presented in section 4.1.

[33] This representation neglects the additional posterior fricatives that occur in Indo-European and Sanskrit given in (45) and (46), as they are irrelevant for the line of reasoning.

Table 4.2 Comparison of different proposals for the output of /s/-assimilation in proto-Indo-European.

	Allen (1951, 1954)	Gnanadesikan (1993)	Flemming (1997)
ɽ _	ʂ	ʂ	ʂ
u _	x^w	x	s^w
k _	x	x	ʃ
i _	ç	ɕ	ʃ

The second context, the back vowel /u/, can also cause retroflexion, recall section 4.2 above, though Flemming's assumption of an intermediate stage of a rounded alveolar seems also likely, as it would involve only a change in secondary articulation with a similar acoustic result. Rounding in a back vowel context is also predicted by Allen. For the *k* and *i* context, however, a retroflex output is very unlikely. Retraction of *s* in the context of *k* rather leads to a palato-alveolar [ʃ], or, if place-assimilation takes place, to a velar [x]. The alveolo-palatal [ɕ] is not a possible output of this process, since it is already present in the Sanskrit sibilant inventory. The high front vowel /i/ causes palatalization of a front coronal sibilant which can result in a more posterior place of articulation as in the palato-alveolar [ʃ], see a similar development of palatalization in Basque (Iverson & Oñderra 1985). A summary of these predictions is given in table 4.3.

Table 4.3 Alternative proposal for the output of /s/-assimilation in proto-Indo-European.

input	output
ɽ _	ʂ
u _	ʂ/s^w
k _	ʃ/x
i _	ʃ

Based on these assumptions, minimally two (for instance [ʂ, ʃ]) to maximally four ([ʂ, s^w, x, ʃ]) different outputs of *ruki*-assimilation can be postulated.

All assimilatory outputs (those by Allen, Gnanadesikan, Flemming, and my own) have in common that they are acoustically very similar to each other: they all have lowered high frequencies, as pointed out already by Vennemann (1974: 93),[34] though they are acoustically very distinct from /s/. The perceptual similarity of these outputs led to a collapse of all two to four allophones into one category which contrasts with the original category of the alveolar fricative. A merger of acoustically similar allophones is a common diachronic process. In Norwegian, for example, the palato-alveolar [ʃ], an assimilation product from historical /sj/ and

[34] For a discussion on the acoustic similarity of retroflex, rounded fricatives, and palato-alveolar see e.g. Hamann (2002b). Note also that the outputs of the *ruki*-rule assumed by Flemming are particularly designed to be acoustically as close as possible.

/skV/ (Kristoffersen 2000: 23), merged with the output of the retroflexion rule, [ʂ], to one category [ʂ], so *skje* 'spoon' is realized nowadays as [ʂeː].[35]

The merger of the four allophones in Sanskrit, however, does not explain why the resulting category is retroflex rather than palato-alveolar, velar or alveolo-palatal. The retroflex category seems arbitrary, as the same process of assimilation in *ruki* context and merger of outputs lead to a different category in other Indo-Iranian languages: in Avestan, Old Persian, and Baltic it resulted in a palato-alveolar fricative, and in Slavic in a velar one. Allen (1954: 564) proposes that the different resulting categories in these languages might be due to already existing processes and categories: in Sanskrit, retroflexion was an established process in connection with liquids, thus the retroflex was a likely category to emerge. Avestan had no retroflex segments or allophones, thus a retroflex is not expected to be the endresult of this development. Allen proposes that the existing palatalization and labiovelarization processes would favour either [ç] or [x^w]. For Slavonic, the already existing opposition of palatalized and velarized articulations promoted the emergence of [ç]/[x] (Allen 1954: 565).

Another instance of fricative merger, which also seems to be motivated by already existing categories occurred in Old High German, according to Vennemann (1974: 94). Here, the allophones of /s/ after /r/ (which might have been a retroflex allophone, analogous to the processes described in section 4.1), and before /w, b, p, m/, i.e. both [^{r}s, s^w], merged with the existing class [ʃ], for instance in the words *bars* 'bass', *swert* 'sword', *spil* 'game', and *smal* 'small' (Penzl 1969: 80).

The *ruki*-rule was included in this chapter on phonetically-grounded processes involving retroflexes despite the fact that at first glance this process seems to have an unnatural context with retroflexion occuring after both back and front vowels. At closer investigation it became clear that this diachronic process took place in several stages, each of which with a natural context and a phonetic motivation.

4.4 Retroflexion of vowels

This section deals with the rule of vowel retroflexion illustrated in (1d). Ball & Rahilly (1999: 125) point out that in many languages post-vocalic rhotics can be realized by pronouncing part or all of the vowels with a tongue tip raising or backwards bending instead of a rhotic gesture. The resulting vowels are called r-coloured, retroflexed, or rhotacized, recall the description of retroflex vowels in section 2.2.4.7. Vowel retroflexion is not only caused by rhotics but can also occur before a non-rhotic retroflex consonant, often in combination with a drop of the retroflex. Section 4.4.1 will present examples of vowel retroflexion in retroflex contexts, and section 4.4.2 gives a phonetic explanation for this process.

[35] A further merger can be observed in present day Norwegian, where the phoneme classes [ɕ] and [ʂ] collapse in favour of the retroflex, cf. Papazian (1994) and Dommelen (2001).

4.4.1 Examples

Several Dravidian languages show retroflexion and backing of vowels in pre-retroflex position (Zvelebil 1970: 38). Badaga (Emeneau 1939: 44) even has two types of retroflex vowels, half and fully retroflexed. Examples of this are given in (48) using Emeneau's transcription.

(48)	*Plain vowel*		*half retroflexed*		*fully retroflexed*	
	kae	'unripe fruit'	áé	'tiger's den'	käë	'weeds'
	kombu	'horn'	kómbile	'I did not have (her) as wife'	köë	'carcass'
	be·	'mouth	bé·	'bangle'	bë·	'crops'

Zvelebil gives an example of Badaga vowel retroflexion, which was caused by a retroflex rhotic that was later lost, as comparisons with other Dravidian languages illustrate. Thus 'ass' is [kaˡte] in Badaga, where it contrasts with [kate], 'I learned', whereas in Kota 'ass' is realized as [kaɻt]. The retroflexion of vowels in Badaga seems to show some incompatibility with fronted tongue articulations, a process typical of retroflexes as we saw already in section 4.3. Phonetically the half and fully retroflexed /i/ and /e/ are backed. Emeneau (1939) mentions that in the fully-retroflexed phonemes "the elevation of the tongue to mid and high position [is] as far back in the oral cavity as possible, in the half-retroflexed phonemes [it is] advanced almost to the mixed position" (p. 44). The fully retroflexed short /i/ does not occur in Emeneau's data, which he took to be an accidental gap. This gap, however, might be an indication that a fully retroflex short /i/ does not exist in Badaga, due to the large articulatory distance between the retroflex and the front vowel gesture as described above. The existence of a fully retroflexed long high front vowel, e.g. *kï·e* 'down', is no counterevidence to this claim, as the long vowel allows a transition from a front high tongue position to a backed one. Further work on the Badaga vowel system has to be conducted to confirm or falsify this hypothesis.

Koḍagu is another South-Dravidian language in which vowels are retroflexed by a following rhotic, which then gets deleted: the future base /tir-p-/ 'I shall finish' is realized as [tɯrˡp], again with retraction of the vowel (Zvelebil 1970: 38). In Tamil, all retroflex consonants trigger retroflexion of the vowels that precede them (Christdas 1988: 181).

The dialects of British English spoken in West Somerset and North-east Devon have an interesting process involving the retroflex rhotic, a segment typical for this area, followed by a high front vowel [i] or [ɛ]. Besides lowering and centralizing of the vowels to [ə], the rhotic is realized as retroflexion of the vowel. The word *red*, for example, is pronounced as [əˡːɖ] in these dialects, and pretty as [pəˡːɖɪ] (Wakelin 1972: 99).

Australian languages show many processes of vowel retroflexion before retroflex consonants. In Bunuba, according to Rumsey (2000), all vowels followed by /r/ "take on an r-coloration" (p. 44). In some Bunuba words with *g* or *b* followed by /ir/, the /i/ merges completely with the following /r/, e.g. *biray* 'come out'

surfaces as [bɽe]. The result sounds like a consonant cluster, according to Rumsey. This process of high front vowel deletion can be taken as further evidence for the dislike of retroflexes and high front vowels, recall section 4.3.[36]

Morphy (1983: 20) observes that in the Djapu dialect of Yolngu, another Australian language spoken in Arnhem Land, all vowels have a slight degree of retroflexion before retroflex consonants. The vowels in the Australian language Yukulta show the same process, according to Keen (1983). In Margany and Gunya, only the low vowel /a/ is retroflexed before a retroflex consonant (Breen 1981), see /ŋanʲbaɖ/ [ŋanʲbaˈɖ] 'sweat'.[37]

While it is usually the preceding vowel so affected, in languages such as Marrithiyel the following vowel is retroflexed. Pitta-Pitta (Australian) is a case where vowels are retroflexed both when preceding and following a retroflex consonant. The retroflexion is apparently weaker in the following vowels (Blake & Breen 1971). And in Bengali, /i/ is said to be somewhat retroflex after /ʈ/, /ɖ/, /lɖ/, and /lʈ/ (Ferguson 1960).

4.4.2 Phonetic grounding

Vowel retroflexion can easily be accounted for as a gestural overlap of the vowel gesture and the retroflexion of the tongue tip: the tongue tip is curled in already when the vowel is still articulated. This overlap of gestures is possible since vowels do not involve the tongue tip in their articulation. If the retroflex apical gesture is not synchronized with the beginning or end of the vowel gesture, it influences the vowel next to it. Especially retroflex approximants, which have no closure and thus no definite point which the retroflex tongue tip gesture can be synchronized with, make retroflexion of a neighbouring vowel very likely. The examples in 4.5.1 show that high front vowels undergo lowering and/or retraction before they are retroflexed. This is due to the dislike of the high tongue middle plus fronted tongue back with the lowered tongue middle and the retracted tongue back of retroflexes.

The gestural overlap occurring in retroflexed vowels is depicted in figure 4.5 on the next page, where the left graphic illustrates non-overlap, and the right total overlap (retroflexion of the vowel).

Vowel retroflexion adds a cue to facilitate the perception of the retroflex consonant, without diminishing the vowel cues as the processes of vowel lowering or retraction. The gestural overlap that occurs in vowel retroflexion can result in a lengthening of the vowel gesture as observed in the Australian language Kayardild (Hamilton 1996: 45, Evans 1985: 504), in order to prolong the cues for the vowel.

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[36] The Bunuban example illustrates the difficulty to distinguish between a retroflexed vowel and a retroflex approximant in vowel context. A similar problem is observable in Mayali, a Gunwinggun language spoken in Arnhem Land and Croker Island. According to Evans (1995: 740), Mayali has a process of "syllable-retroflexion" manifested in different ways: the word for 'death adder', for example, can be pronounced as [beɻk], [bɹɐk], [beɹɐk], or [bek]. These realizations might be instances of approximant insertion and/or vowel retroflexion, a point to be clarified in future studies.

[37] Breen (1981: 289) uses a subscript dot under the /a/ to indicate the retroflexion of this vowel, just as he uses the alveolar with subscript dot for the retroflex series.

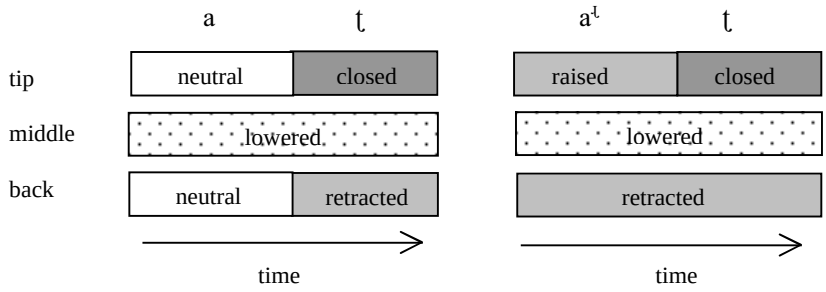

Figure 4.5 Low vowel – retroflex sequences with synchronized gestures (left) and with gestural overlap (right). The three tiers indicate the three tongue parts tip, middle, and back. The tongue blade is not included, since it is not relevant for the depiction of this process. Neutral position of the tongue parts is depicted with white boxes, a positive degree of constriction i.e. raising of the articulator with a grey box (dark grey standing for full closure), and negative constriction i.e. lowering of the articulator with a dotted box.

Retroflexion of a vowel sometimes leads to a deletion of the retroflex consonant triggering it, as in the case of Badaga or the South-Western dialects of Britain, which can be explained by a total overlap of vowel and retroflexion gesture. This process occurs only for retroflex approximants, since approximants do not require a full closure and thus the retroflexion gesture can totally blend with the vowel gesture.

The descriptions above showed that vowel retroflexion often co-occurs with vowel retraction (as described in 4.3.2.1), a further indication of the retroflex gesture being articulated already during the vowel, as a lower tongue position facilitates the retroflexion of the tongue tip.

The more frequent retroflexion of vowels in a position preceding retroflex segments compared to those following retroflexes has also an articulatory explanation: the tongue tip can curl inwards already during the articulation of the vowel (anticipatory gesture), since vowel and retroflex are articulated with different parts of the tongue. Thus an overlap of both gestures is possible. Gestural overlap is also possible in the other direction, and results in retroflexion of a following vowel (as was shown for Marrithiyel, Pitta-Pitta, and Bengali). But instead of an anticipatory gesture which saves articulatory time, the retroflex gesture is held longer than necessary in this case and thus influences the vowel. Retroflexion of following vowels is probably perceptually motivated by an enhancement of the retroflex cues only, whereas retroflexion of the preceding vowel is perceptually and articulatorily motivated.

4.5 Phonotactics of retroflex segments

This section is concerned with restrictions on the phonotactics of retroflexes. The occurrence of retroflexes within a syllable and a prosodic word is cross-

linguistically asymmetrical: word-finally and post-vocalically they occur more often than in word-initial position and post-consonantally, see (1e). This asymmetry was the topic of an extensive study by Steriade (1995, 2001a), whose phonetic explanation will be largely followed here. Steriade's analysis is described in detail in section 5.3.3.

The following subsection 4.5.1 gives some examples of this asymmetrical behaviour. Possible phonetic accounts are discussed in subsection 4.5.2.

4.5.1 Examples

This section discusses two language families: the Australian languages, which mostly have two apicals and two laminals and show a number of interesting restrictions on the occurrence of retroflexes, and the Indo-Aryan languages, with smaller coronal inventories.

Most Australian languages have no retroflex segment word-initially, which leads to a neutralization of the contrast between apical alveolar[38] and retroflex in word-initial position as described by researchers such as Evans (1995: 727), Hamilton (1993: 134), and Gnanadesikan (1993: 35). Bunuba (Rumsey 2000) is such a language. Word-medially, Bunuba contrasts both apicals, see (49a) (the sounds in question are boldfaced), whereas word-initially only apical alveolars occur, see (49b). If a subsequent syllable contains [ɖ, ɳ, ɭ], the word-initial apical is realized as retroflex, see (49c), which is an instance of long-distance retroflexion, to be discussed in section 4.6.2.[39]

(49)	(a)	bi**ɖ**i	'thigh'	wi**d**igi	'stick insect'
		ga**ɭ**u	'penis'	ga**l**u	'road'
		dʒi**ɽ**igi	'bird' (gen.)	dʒi**r**ingin	'owlet nightjar'
	(b)	**l**aɲi	'freshwater eel'		
		dumuru	'chest'		
	(c)	**ɳ**aɖʌ	'short'		
		ɖuɭu	'heart'		

Further Australian languages with the same restrictions on retroflexes word-initally and word-finally are Andiljaugwa (Dixon 1970), Kalkatungu (Hamilton 1996), Kitja (Dixon 1980), Ndjébbana (McKay 2000)[40], Ngiyambaa (Donaldson 1980), Thargan (Dixon 1980), Watjarri (Douglas 1981), and the closely-related Margany and Gunya (Breen 1981). Only 3 of the 22 languages Dixon (1980) investigates show an apical contrast in word-initial position.

A number of Australian languages is reported to have a retroflex but no apical alveolar in word-initial position. That is, the apical contrast is neutralized in favour

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[38] As defined in chapter 1, 'apical alveolar' is used in this dissertation to denote any kind of front apical articulation, i.e. it includes both alveolar and dental place of articulation.

[39] The rhotic /ɽ/ is the only retroflex segment that does not trigger the retroflexion of word-initial apicals. Recall from the data in (19) that the high front vowels in these examples are retracted before a retroflex.

[40] The retroflex rhotic in Ndjébbana, however, does occur in word-initial position, where it contrasts with the apical alveolar rhotic (McKay 2000: 177).

of the retroflex place of articulation. Hamilton's (1996) database of Australian languages lists Bularnu, Djambarrpuyngu, Gaalpu, Kayardild, Mangarrayi, Marra, Ngalakan, Ngandi, Pintupi, Pitta-Pitta, Ritharrngu, Wardaman, Wambaya, and Walmatjari[41] as such languages. Lardil is a further example of an Australian language with a retroflex as the only apical in word-initial position (Dixon 1970, Gnanadesikan 1994: 128). Sharpe (1972) describes that Alawa, a Maran Australian language spoken in Arnhem land, has a retroflex in word-initial position following a vowel and within a phonological phrase. In the same position following a phrase boundary, the segment is alveolar. This indicates a dependency of the type of articulation on the phrasal position.

For some Australian languages free variation between both apicals is reported. According to Hamilton (1996: 133), Gooniyandi is such a language, where the two word-initial apical series vary freely between alveolar and retroflex articulation when not conditioned by a following apical (50a) (data based on McGregor 1990: 70f.). When the following consonant is apical, the initial apical segment harmonizes to this place of articulation, see (50b). Laminal consonants that follow the retroflex do not cause assimilation of the initial segment to a laminal articulation, see (50c).

(50)	(a)	/duwu/	[duwu ~ ɖuwu]	'cave'
	(b)	/diɽipindi/	[ɖiɽipindi]	'he entered'
		/dili/	[dili]	'flame; light'
	(c)	/laŋgija/	[laŋgija ~ ļaŋgija]	'midday'

Neutralization occurs also post-consonantally in Gooniyandi, whereas post-vocalically, a contrast between retroflex and apical alveolar is given, see (51).

(51)	/iliŋi/	[ili**ɳ**i]	'grass'
	/waɖguluna/	[waɖgulu**n**a]	'I bring them'

McKay (2000: 177) mentions that the Ndjébbana neutralized initial apical sometimes appears to be retroflex, thus providing another example of variation. Butcher's (1992) phonetic study shows that free variation occurs in the neutralized position of several Australian languages.

Besides in word-initial position, retroflexes also have the tendency not to occur post-consonantally, see Gooniyandi. A language showing neutralization after consonants but not in initial position is Nunggubuyu (Steriade 1995: 18).

Languages that have an apical contrast only intervocalically and in V_C position are numerous on the Australian continent. The Djapu dialect of Dhuwala-

[41] Walmatjari has been subject of several studies with differing interpretations. According to Gnanadesikan (1993: 49) this language has retroflexes only utterance-initially, but alveolars morpheme-initially and word-initially. Gnanadesikan (1994: 128f.) states that there is free variation between alveolars and retroflexes in syllable-initial positions in Walmatjari, except after /u/, /a/ and other retroflex consonants, where they are solely retroflex. This interpretation is based on Hudson & Richards (1969) who claim that the alveolar/retroflex contrast is "neutralized", and who use the symbols ţ, ḍ, etc. for their transcription.
Gnanadesikan further proposes that one might interpret the Walmatjari initial apicals as being articulated midway between an alveolar and a retroflex, see discussion in section 4.5.2 below.

Dhuwal (Morphy 1983, Hamilton 1993: 131), for example, has both apicals and laminals post-vocalically in coda position with a following non-coronal. Homorganic coronal clusters are also allowed, for instance [miːn̪.d̪uŋ] 'snail'. These tendencies in Australian phonotactics lead Dixon (1980: 155) to posit restrictions on the occurrence of segments in words of the general shape $C_1VC_2C_3VC_4$: the apical contrast only occurs at C_2 and C_4, i.e. those slots that follow a vowel. Apical contrasts do not generally occur in C_3-position in a heterorganic cluster.

A number of Dravidian and Indo-Aryan languages also disallow retroflexion word-initially. Proto-Dravidian has neither retroflex nor alveolar consonants in word-initial position, i.e. no word begins with [t, l, r, ʈ, ɳ, ɭ, ɽ] (Zvelebil 1970: 77). This behaviour holds for many modern Dravidian languages, such as Iruḷa (Diffloth 1975).[42] Tamil (Christdas 1988), Koḍagu (Ebert 1996), and Toda (Shalev, Ladefoged & Bhaskararao 1993: 101). In the Indo-Aryan language Punjabi, all phonemes are allowed in word-initial position apart from the retroflex liquids [ɭ, ɽ] and the nasal [ɳ]. Punjabi, however, allows [ɭ] and [ɽ] as final members in word-internal three-consonantal clusters such as [lombɽiː] 'fox' and word-final clusters such as [kʈ, nɖ, lʈ, rɖ] (Bhatia 1993: 340).

Interestingly, some Indo-Aryan languages with a twofold apical series but no retroflexes in word-initial position allow both apicals word-initially in loanwords. In Koḍagu (Ebert 1996), for example, retroflex consonants do not occur initially in native words. In loanwords, however, word-initial retroflex consonants are quite frequent: English /t/, for instance, is rendered in Koḍagu as [ʈ]: *teacher* is [ʈiːtʃerɯ] (Ebert 1996: 6).[43] Punjabi (Bhatia 1993) also only allows retroflexes in loanwords, e.g. [ʈraːm] 'tram'. The Dravidian Tamil allows the retroflex fricative [ʂ] initially exceptionally in some proper nouns, all of them recent borrowings from Hindi or Sanskrit.

4.5.2 Phonetic grounding

As we saw in section 4.5.1 above, several Australian languages suspend the contrast between the two apicals in word-initial position and in post-consonantal position. The realization of the apical in these positions varies; some languages choose an apical realization, others a retroflex one, and some allow variation between the two.

From an articulatory point of view, one would expect the apical contrast to neutralize towards the apical alveolar, as the apical alveolar involves a less complex articulation than the retroflex since no displacement of the tongue tip is involved

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[42] The segment /ʈ/ can occur in a number of items in some Dravidian languages word-initially. Zvelebil (1970: 102) explains the occurrence of /ʈ/ word-initially by four processes: assimilation towards following (but not immediately adjacent) retroflex nasals (to be discussed below in section 4.6.2), metathesis, onomatopoetic forms, and borrowings from non-Dravidian languages.

[43] The retroflex phonemes might be chosen as equivalent to English alveolars because the English interdentals /θ/ and /ð/ are represented in Koḍagu by the dentals [t̪] and [d̪], respectively. In order to retain a distinction between the two English coronal series, these phoneme classes are transferred to the two perceptually closest native coronal phonemes (dental and retroflex). A similar shift in coronal categories for the adaptation of English words can be observed in Kannada (Schiffman 1983: 11ff.): *town* [ʈaʊnu] or *end* [ɛɳd̪u] versus *thing* [t̪$^{(h)}$ɪŋ] or *thanks* [t̪$^{(h)}$eːŋksu].

(recall the universal articulatory markedness hierarchy under (2) in chapter 1). Steriade (1995) points out that languages with a contrast between apical dental and apical retroflex have two articulations with displaced tongue tip, as the dental involves a fronting of the tongue. In these languages an articulatory neutralization towards the apical alveolar should be expected, according to Steriade. This occurrence of a third articulatory position in neutralization is possible, but is not reported very often. Due to the tendency of language transcribers to classify occurring segments into the phonemically existing apical categories of a language (either dental or retroflex), this deviation may pass unnoticed. It seems unlikely, however, that languages should employ a new categorical articulation instead of one of the already existing ones because of the general tendency to re-use already learned gestures. Further phonetic studies investigating the actual articulation of apical segments in sites of neutralization are necessary to clarify this point.

The articulatory variation and neutralization observed in the phonotactic patterns of retroflexes is only acceptable if the resulting output shows no large perceptual deviation from the input. It was shown in section 3.5 that retroflexes have strong VC transitions, and that their CV transitions are weaker and more similar to those of apical alveolars. Steriade (1993b) used this fact to explain why the neutralization of apical contrast mostly takes place in word-initial and post-consonantal position: the cues distinguishing between apicals are insufficient in these positions that have no VC transitions, recall the markedness hierarchy under (4) in chapter 1. The less distinct CV cues of apicals can also explain why a language such as Proto-Dravidian has no apical in initial position at all. Furthermore, the lesser saliency implies that a language should not employ a contrast between retroflex and apical alveolar in postconsonantal position without having this contrast in postvocalic position. This was attested by the data above: no language could be found that contrasts alveolar and retroflex apicals in initial or postconsonantal position only.

Flemming (2002) argues that the CV transitional cues and the VOT cues of retroflexes are more contrastive with those of laminals than the apical alveolar or dental cues are. Following from this, Flemming assumes the neutralized apical is retroflex, in order to preserve the contrast with the laminal series. This assumption sounds reasonable but is not confirmed by the data: the examples given in 4.5.1 show no preference for retroflexion in neutralized positions.

In sum, the asymmetrical behaviour of retroflex cues can account for the phonotactic behaviour of this class. The realization of the neutralized category, however, seems to be language-specific. Constraint rankings in an OT framework, which can account for the cross-linguistic phonotactic differences are proposed in section 6.3.6.

4.6 Assimilation of retroflexion

Languages with retroflex segments commonly show assimilation processes involving this specific articulatory class, see (1f). Two kinds of assimilation can be

observed, one of adjacent segments and one of segments which are separated by intervening material, see rule (1f), repeated here as (52).

(52) (a) t̻t → t̻̺ or tt̻ → t̻̺
(b) t̻Vt → t̻Vt̻ or tVt̻ → t̻Vt̻

Examples of local assimilation processes like (52a) are presented in section 4.6.1, examples for long-distance retroflexion (52b) in 4.6.2. A phonetic account for both is proposed in 4.6.3.

Assimilation is topically related to dissimilation processes. Dissimilation of retroflexes occurred for example with Proto-Dravidian consonant sequences such */ɳʈ/, which occur as [nɖ] in several modern Dravidian languages.[44] Another example for dissimilation is the infinitive marker –/ɳaː/ of Punjabi which has a variant [naː] after retroflex segments, cf. /jaːɳ+ɳaː/ 'to know' [jaːɳɳaː] (Bhatia 1993). Dissimilation processes are probably due to the need for increased perceptual distinction. These processes are not further treated in this dissertation.

4.6.1 Local assimilation

Let us first look at examples in which retroflexes affect following segments. Retroflex segments in Swedish and Norwegian assimilate following dentals into retroflexes. Examples from Swedish (from Eliasson 1986: 280) are given in (53).[45]

(53)	/haʈs/	[haʈʂ]	*harts*	'resin'
	/ɛɳst/	[æɳʂʈ]	*Ernst*	(name)
	/vædɻslig/	[væːdʂl̩ig]	*världslig*	'worldly'
	/kvaʈssekel/	[kvaʈʂʂeːkəl]	*kvartssekel*	'quarter-century'

This assimilation is iterative, that is, dentals following the assimilated retroflex are also retroflexed, as all but the first example in (53) illustrate.

Norwegian assimilation of retroflexes has an equivalent in Swedish. An interesting phenomenon concerning Norwegian retroflex assimilation is the formation of the patronymic form, by the addition of the suffix *-sen* /-sn̩/ to a name. According to Kristoffersen (2000: 318), three different conditions for this process have to be distinguished. If the name ends in an /r/, then the two coronals in the suffix are retroflexed and the *r* is deleted: *Persen* [peː.ʂɳ]. If the name ends in a retroflex, *Gjert* [jæʈ], then the initial segment of the suffix will be realized as retroflex. The nasal, however, remains dental: [jæʈ.ʂn̩], not *[jæʈ.ʂɳ]. If the name ends in an assimilated retroflex, *Morten* /moʈn/ [mɔ.ʈɳ],[46] where the retroflexion of

[44] According to Zvelebil (1970: 169), these languages are Kolami, Naikṛi, Parji, Gondi, Konda, Pengo, Kurukh, Malto, Brahui, and Kuvi.

[45] Retroflexion in Swedish does not assimilate from lateral to non-lateral, compare *pärltråd* [pæːl̩troːd] 'string of pearls' to *pärllist* [pæːl̪̩ist] 'pearl molding' (Eliasson 1986: 280). No explanation for this exception seems to be available.

[46] Kristoffersen (ibid.) represents the surface structure of *Morten* with a geminate retroflex stop, in order to encode the shortness of the vowel. A different way of encoding vowel length is to assume an underlying length specification of Norwegian vowels (see discussion in Fretheim 1983), which makes Kristoffersen's move unnecessary.

the final segment originates from the previous retroflex, further spreading is blocked: the output form is [mɔ.ʈɳ.sɳ], not *[mɔ.ʈɳ.ʂɳ] or *[mɔ.ʈɳ.ʂɳ]. A way of summarizing these three conditions is to assume a restriction on the number of retroflex consonants for this process: no more than two retroflex segments are allowed on the surface.

In both Norwegian and Swedish, assimilation of a dental to a retroflex is progressive. A similar rule can be found in some Dravidian and Indo-Aryan languages. In Kannada (or Kanarese), a Dravidian language spoken in the Karnataka state of South India, sequences of a retroflex (lateral, stop or nasal) and a non-retroflex coronal usually show progressive assimilation of the non-retroflex (Schiffman 1983: 8, 16). The examples in (54) illustrate this point.[47]

(54)	/heːl̻-al-ila/	[heːl̻ɭila]	tell-inf-neg	‘didn’t say’
	/kol̻-d-e/	[kolɖə]	obtain-past-1s	‘I obtained’
	/tət̻ilu/	[tətɭu]		‘cradle’
	/kaːɳ̻-d-e/	[kaːɳɖə]	see-past-1s	‘I saw’

In rapid speech, Kannada also shows progressive assimilation of retroflexion with other segments (Sridhar 1990: 303). Furthermore, in colloquial Kannada a voiced retroflex stop is sometimes inserted between a coronal lateral or nasal and [r], see the examples in (55) (Schiffman 1983).

(55)	(a)	/ellaru/	[ɛlɖru] ~ [ɛldru]	‘all people’
	(b)	/eːl̻roː/	[eːlɖroː]	‘get up!’
		/kal̻aru/	[kalɖru]	‘thieves’

Sridhar (1990: 311) claims that if a dental precedes the inserted stop, this stop can be either dental or retroflex, see (55a). If the preceding coronal is retroflex, however, as in the case of (55b), the inserted stop is always retroflex. This follows the general tendency of progressive assimilation of retroflexion. Further assimilation of the /r/ is prevented as Kannada has no retroflex rhotic.

In many Dravidian languages an alternation between a retroflex lateral and a retroflex stop can be observed.[48] According to Zvelebil (1070: 102), this alternation originates historically in a progressive assimilation of /l̻/ + /t/ > /ɭʈ/ and a subsequent deletion of the lateral. Furthermore, the geminate [ɖː] in Telugu and Kannada probably arose from the progressive assimilation of a voiced dental suffix *–d* to a preceding root-final /ʈ/, i.e. /ʈ/ + /d̪/ > /ɖɖ/. Examples are Telugu [aɖːu] and Kannada [aɖːi] ‘to obstruct’ from Proto-Dravidian *aʈ- (Zvelebil 1970: 104).

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[47] The retroflex and the non-retroflex in Kannada are often only adjacent after deletion of an intermediate vowel. This process of vowel deletion and another one of vowel reduction, also observable in the data in (55) are not discussed here.

[48] In South-Dravidian, there is a widespread alternation between [ʈ] and [ɭ], as Zvelebil (p. 101f.) describes, with [ɭ] probably as the original sound: Literary Tamil /amːaviɭam/ ‘with mother’ is realized as [amːaviʈam] in Madurai Tamil. There is also an alternation with [ɳ] in certain items: Tamil [taɳ] ‘coolness, cool’ vs. [taɭi] ‘coolness’, Malayalam [taɳ] ‘cold’, Kannada [taɳ] ‘coldness, cold’. Again, [ɭ] is presumably the underlying phoneme, and Zvelebil (p. 102) proposes the development */l̻/ > [ɭ] / [ɳ] / [ʈ].

Diachronically retroflex stops were introduced into Sanskrit by progressive assimilation of dentals to the already existing retroflex fricatives (recall section 4.3.4 on the diachronic development of the fricative).[49] Thus, the following development occurs: *ʂt > ʂʈ and *ʐd > ʐɖ (Bhat 1973: 33). Examples are given in (56) (from Misra 1967: 68f.); they show that the triggering retroflex fricative was deleted at a later stage, when the retroflex stops had become phonemic.

(56)	*Sanskrit*		*pre-Sanskrit*	*gloss*
	ɳiːɖa	<	*ɳiʂda	‘nest’
	miːɖʰa	<	*miʂɖʰa	‘reward’
	voːɖʰum	<	*vaʂɖʰum	‘to carry’
	leːɖʰi	<	*laʂɖʰi	‘licks’

Another example of the assimilation of retroflexion comes from south-western British dialects that have a retroflex [ɻ] (recall description in section 4.1). In these dialects, an assimilation of the following alveolar to this retroflex segment occurs, so ‘*readers*’ is realized as [ɻiːdəɻz] (Ball & Rahilly 1999: 56). According to Wakelin (1972: 99), the rhotic is deleted in such cases and surfaces as vowel retroflexion (cf. section 4.4): *tears* (verb) [tɛˠːz] and *shirt* [ʃəˠːt]. Besides progressive assimilation these dialects also have regressive assimilation, e.g. *tree* [tɻiː] or *straw* [ʂtɻɔː] (ibid.).

Let us look at examples of processes where retroflexes cause assimilation of the *preceding* segments. Modern Telugu has regressive assimilation after vowel deletion, see the examples in (57) (based on Gilbert 1992).

(57)			
	/paːɳta+ʈeːbilu/	[paːʈʈeːbilu]	‘old table’
	/aɳi+ɖabbaː/	[aɖɖabbaː]	‘that is a can’

In Sanskrit, dentals also undergo regressive assimilation to retroflexes, see (58a) (Whitney 1889: 66f., Allen 1962: 83ff.).

(58)				
	(a)	/t̪aʈ+ɖaukaʈeː/	[t̪aʈɖaukaʈeː]	‘it approaches’
		/t̪aːɳ+ɖimbaːɳ/	[t̪aːɳɖimbaːɳ]	‘those infants’
		/paːt̪aʂ+ʈalaʈi/	[paːt̪aʂʈalaʈi]	‘the foot is disturbed’
	(b)	/t̪aːɲ+ɟaɳaːɳ/	[t̪aːɲɟaɳaːɳ]	‘those people’
		/eːt̪aʈ+tɕʰaʈ̪ʈram/	[eːt̪at̪tɕʰaʈ̪ʈram]	‘this umbrella’
		/t̪aɳaʂ+t̪ɕa/	[t̪aɳat̪ɕa]	‘and then’

The regressive assimilation process in Sanskrit applies also to palatals, see (58b). A dental, however, does not trigger assimilation of a preceding coronal, e.g. /ʂaʈsu/.[50]

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[49] Another source for retroflex segments in Sanskrit were borrowings from Dravidian, see Burrow (1955) and Masica (1991) for discussion and examples. Masica (1991: 157f.) further mentions the introduction of non-sibilant retroflexes via the retroflex rhotic and its syllabic counterpart, which leads to the question of how these segments were introduced into the language. For a possible answer, see section 4.1 above, where it was proposed that rhotic approximants can emerge easily as alternants of non-retroflex coronal rhotics.

[50] On the contrary, one case of progressive assimilation of dental to following retroflex occurs, namely when the retroflex is the fricative [ʂ] (Whitney 1889: 67f.), e.g. /dviʂtas/ [dviʂʈas] or /dveːʂtum/ [dveːʂʈum].

Regressive assimilation is also present in Vietnamese, where retroflex /ʈ/ and /ɳ/ occur after a vowel (word-final) only if the following word has an initial retroflex affricate (Bhat 1973: 45).

Indo-Aryan Punjabi (Bhatia 1993: 347) shows the reverse process of the usually observed one: a retroflex is assimilated to the following nasal dental. Punjabi regressive assimilation of a stem-final retroflex to the following dental nasal of the present-I suffix -/naː/ is exemplified in (59).

(59)	manɳ	'to agree'	+ naː	[manːaː]
	d̲ʒaːɳ	'to know'	+ naː	[d̲ʒaːnːaː]

Besides assimilation to retroflex segments, one can also find assimilation of retroflexes towards other places of articulation. Colloquial Tamil (Zvelebil 1970: 103), for example, has a process whereby retroflexes are assimilated to following non-coronals, namely palatals, velars, and labials. Examples of this process are given in (60).

(60)	*Literary Tamil*	*Colloquial Tamil*	*gloss*
	[uʈkaːrnteːn]	[okkaːndeːn]	'I sat'
	[kaʈci]	[kacci]	'party'
	[keːʈpeːn]	[keːppeːn]	'I shall hear'

This process is not restricted to retroflexes, other coronals such as alveolar /t/ for example assimilate as well.

4.6.2 Non-local assimilation

In a small number of languages retroflex sounds can cause retroflexion of non-adjacent coronal segments. Examples of such long-distance retroflexion occur for instance in Sanskrit, South-Dravidian, and Australian, indicating that it is not a feature specific to one language family or to areal contact.

In Sanskrit *n* is retroflexed when it follows a retroflex continuant [ʂ], or any rhotic. Examples for this so-called *nati* rule are given in (61) with the middle participle –aːn̪a– (Whitney 1889: 65).[51]

(61)	[puraːɳa]	'fill'	+ middle participle
	[t̲ɕakʂaːɳa]	'see'	+ middle participle
	[kʂubʰaːɳa]	'quake'	+ middle participle
	[kr̥paːɳa]	'lament'	+ middle participle

However, the *nati* rule is blocked by intervening non-retroflex coronal consonants: [kʂvedaːna], 'hum' + middle participle (ibid.).

In Dravidian, long-distance retroflexion occurs as a diachronic process. The development of initial retroflex stops in some Dravidian languages is due to the spread of retroflexion from a retroflex nasal occurring after but not adjacent to the

[51] N-retroflexion occurs only when the nasal is followed by a vowel, another nasal or a glide, hence the alternation [brahma**n**] vs. [brahma**ɳ**aː] 'Brahman' (Whitney 1889: 65).

initial segment in the same word, and a deletion of the retroflex nasal at a later stage. Thus, Proto-Dravidian *taɳk- 'to be obtained/ to remain' is [taɳ̣uka] in Malayalam or [taɳku] in Tamil, but [ɖakːu] in Telugu (Zvelebil 1970: 102). Presumably this process was blocked by intervening coronal consonants, though this hypothesis requires further testing.

In the Australian language Mpakwithi the retroflex continuant [ɻ][52] causes retroflexion of the vowel which occurs in the preceding syllable, even if consonants occur between these two segments: /ɡwapɻa/ 'is eating' is realized as [ᵑgwaᶫʈa] (Evans 1995: 739). In Ritharngu or Ritharungo (Heath 1980), spoken in Eastern Arnhem Land, a retroflex causes retroflexion of a preceding vowel even across a glottal stop: /ɭaʔɭa/ 'metal axe' is realized as [ɭaᶫʔɭa] (Heath p. 11).

4.6.3 Phonetic grounding

Assimilation processes are articulatorily motivated by a reduction of the different places of articulation of two (adjacent) segments to one place. This reduction is usually the case if the gestures are made with the same articulator, for instance if both are apical. If the articulators differ, as in sequences of labial and apical, for example, one finds overlap of gestures (see the studies of Browman & Goldstein 1989, and many others). The overlap results in a loss of perceptual cues for one gesture and subsequent reduction of this gesture.

The direction of assimilation is usually regressive, i.e. assimilation of a segment to the following occurs. This direction is motivated by the anticipation of the following gesture during the articulation of the present segment. Apicals, however, show a preference for progressive assimilation, as observed by Steriade (1995, 2001). Applied to retroflexes, this means that they cause a change of the following segment into a retroflex, or that a retroflex itself assimilates to a preceding segment. Steriade accounts for this behaviour by the perceptual strong VC cues of retroflexion, which override the less strong CV cues of other segments: spreading proceeds from the segment possessing more salient place cues to the segment with less salient cues. Thus, a retroflex followed by an apical alveolar or dental has strong VC cues, which override the CV cues of the following apical consonant. A retroflex preceded by an apical alveolar, on the other hand, is itself assimilated to the preceding segment, as the VC cues of the apical alveolar are stronger than the CV transitional cues of the retroflex, as Steriade argues.

The implications of this explanation are, however, not always met. In a sequence of retroflex plus non-retroflex apical, the retroflex segment does not generally determine the output of the assimilation. There are cross-linguistically a number of cases where the retroflex is assimilated to the following apical, as in the examples from Punjabi in (59), where the retroflex nasal assimilated to a following dental nasal. Furthermore, retroflexes can cause regressive assimilation of preceding dentals, as testified by the examples in Sanskrit, British English, and Vietnamese.

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[52] This segment is transcribed as [ɹ] by Evans, but is referred to as retroflex continuant at a later point (p. 740).

Sanskrit even has a process of regressive assimilation of a retroflex to a following dental, which is exactly the opposite of Steriade's prediction.

In sum, there are perceptual reasons why retroflexion should spread preferably towards the following segment, but these motives are not as strong in every language as to result in a universal pattern of progressive assimilation for retroflexes. Local assimilation of retroflexion is in principle not restricted to coronals, but whereas an example could be given for the assimilation of a retroflex to a following velar, palatal or labial in colloquial Tamil, I could find no example of a retroflex segment causing an adjacent non-coronal to turn into a retroflex. A phonetic explanation for this gap cannot be provided here.

For non-local assimilations a different account than for local assimilation has to be put forward, since the segments are not adjacent and thus the process can be blocked by intervening segments. An articulatory explanation for the *nati*-rule in Sanskrit was proposed by Whitney (1889: 65), who assumes that once the tip of the tongue is in the retroflex position, it stays there to make the next nasal coronal contact, unless a segment interferes that demands a different tongue front position, such as another coronal. The same assumption of holding the tongue tip gesture is made by Evans (1995) for the long distance retroflexion in the Australian language Mpakwithi: the retroflexion of the tongue tip, which is independent of the rest of the tongue, can be slower than the movements of the rest of the tongue. This explanation is valid only if the intervening segment is non-coronal. Evans' examples do not contain intervening coronals.

Ritharngu as described by Heath has *vowel* retroflexion across the glottal stop only, where the tongue tip can be held in retroflexed position during the intervening segment. The preservation of the tongue tip gesture is thus a reasonable explanation that can account for the data of the Australian, Indo-Aryan, and Dravidian examples. This articulatory explanation can also account for why coronal segments block the effect: they force the tongue tip to assume a different position and thus inhibit a continuation of the assumed gesture. Furthermore, this accounts for the fact that long-distance retroflexion can only apply to coronal consonants or to vowels which can be articulated with an additional tongue retroflexion (recall section 4.4), not to labials or velars.

No restriction on the direction of influence could be observed for long-distance retroflexion: in Sanskrit the retroflex changed segments that occurred after it, in Telugu segments before it.

Long-distance assimilation is observed very infrequently in languages with retroflexes. This could be explained by the fact that long-distance assimilation, if it indeed involves a retroflex gesture that is held over several segments, affects intervening segments, thus the vowels between trigger and target are retroflexed. This is probably not tolerable in most languages.

An analysis for both local and non-local retroflex assimilation is given in section 6.3.6.

4.7 Excursion: Retroflex fricatives in Toda

In section 2.2.6 the large coronal fricative system of Toda was introduced. Toda has voiced and voiceless fricatives. The following discussion, however, is restricted to the voiceless series. Furthermore, only the apical post-alveolar fricative, transcribed here as a retracted alveolar [s̠] (following Sakthivel 1976, 1977), and the subapical palatal fricative, transcribed as [ʂ], are of interest. It was illustrated in section 2.2.6 that both segments can be considered retroflex, since the apical post-alveolar is similar to retroflex fricatives in other languages, and the subapical palatal is retroflex under every possible definition of retroflexion. Applying the four retroflex properties as postulated in section 2.3, the subapical palatal satisfies all four. The apical post-alveolar also satisfies all four if we follow Ladefoged & Maddieson's (1986) description of this segmental class. Ladefoged (2001: 153) describes this sound as apical alveolar with secondary velarization. According to this description, this sound class would neither satisfy the property of posteriority nor that of sublingual cavity, and thus not be considered a retroflex, see the discussion in section 2.4.3. In the present section the phonological behaviour of both segmental classes is investigated to see whether both show typical retroflex behaviour as given in (1) of this chapter, or whether the apical post-alveolar does not. The latter case would provide evidence for a phonetically retroflex (assuming Ladefoged & Maddieson's (1986) definition) but phonologically non-retroflex class.

The first indication to look at is *front vowel incompatibility*, because this occurs very often with retroflex classes (cf. section 4.3). Both Toda fricatives /s̠/ and /ʂ/ occur after the short and the long high front vowel, see (62a) and (62b), respectively, with short vowels in the left column and long vowels in the right column (Sakthivel 1976: 69ff. and 176ff.).[53]

(62)	(a)	kɪs̠	'to crow'	kiːs̠	'handle (of spoon etc.)'
	(b)	iʂθɑːs̠	'nighttime'	kiːʂ	'Mund of the *Pïːr̠* clan'

The occurrence of the two apical fricatives before the high front vowels seems to be allophonic: the apical post-alveolar /s̠/ occurs only before the short vowel, see (63a), and /ʂ/ only before the long vowel, see (63b) (ibid.).[54]

(63)	(a)	nesɪʃkj	'rice'
	(b)	kɔʂiː	'name of a buffalo'

The examples in (62) and (63) illustrate no particularly retroflex behaviour of the two classes with respect to front vowel incompatability.

The next process that could yield information on the phonologically retroflex status of the apical post-alveolar fricative in Toda is *palatalization*. Sakthivel (1976, 1977) consistently uses the separate symbol of the palatal glide [j] to transcribe both

[53] The first example in (62a) shows vowel lowering of the short /i/ to [ɪ] interconsonantally (Sakthivel 1976: 50), see also the first example under (63a).

[54] The sequence retroflex plus long high front vowel occurs in Toda only word-finally (Sakthivel 1976: 75f.).

the phoneme as well as what others (for instance Emeneau 1984) transcribe as secondary palatalization. I will follow Sakthivel's transcription because I find an incompatibility of retroflexes and secondary palatalization well-supported (as elaborated in 2.5 and 4.3.2.5). The palatal glide occurs only after the apical post-alveolar /s̲/, see the examples in (64) (Sakthivel 1976: 216 and 219), not after the subapical palatal.

(64)	ɯs̲jam	'exactly'
	is̲j	'rat'

Interestingly palatalization occurs after all other subapical palatals in Toda apart from the fricative, see the examples in (65).

(65)	pɪʈjk	'in vain'
	oːɳj	'nail'
	nɪʈj	'Mund of the *Niry* clan'
	kɪɭj	'parrot'

As shown in section 2.2.6, the Toda fricatives are the largest coronal series in this language, the subapical stop contrasts only with a dental and an alveolar, and the nasal, rhotic, and lateral only with an alveolar. The occurrence of palatalization with all very retroflex consonants except the very retroflex fricative may indicate that the stop, nasal, trill, and lateral have a lesser degree of retroflexion, and are presumably articulated more like the apical post-alveolar fricatives, which might be due to the smaller stop, nasal, trill, and lateral inventories (cf. section 2.2.6). This suggestion has to be further investigated.

The palatalization processes therefore make a distinction between the palatal subapical fricative, which behaves in this respect like retroflexes in other languages, and the apical post-alveolar fricative, which does not. The sequence palatal glide plus fricative, however, unites the two classes again: the glide occurs neither before the subapical palatal nor before the apical post-alveolar fricative (but it occurs before other coronal fricatives). This is illustrated e.g. by the fact that the genitive marker *–s̲* changes to a [ʃ] if added to a word ending with a palatal glide, see (66) (Sakthivel 1977: 44f.).

	input	*output*	*gloss*
(66)	ɑɖj – s̲	ɑɖjʃ	'in the pot'
	poːj – s̲	poːjʃ	'in the mouth'
	muːd̲ pɔ̯ɭj – s̲	muːd̲ pɔ̯ɭjʃ	'in three dairies'

Unfortunately, there is no morpheme with an initial *–s̲* that could illustrate a corresponding change of the fricative. The argumentation of an incompatibility of tongue gestures for retroflex and palatal that was applied to account for the non-occurrence of palatalized retroflexes can be used here to account for the non-occurrence of glide-retroflex sequences.

The *phonotactics* of the two fricative classes show no difference, but some behaviour in line with retroflexes (see (1e)): neither the apico-post-alveolar nor the subapical palatal fricative occurs in word-initial position (Sakthivel 1976: 56ff.).

Summing up these observations, the apical post-alveolars behave in some respects phonologically like retroflexes (for instance in its non-occurrence after the palatal glide), in others not (for instance it occurs with a following glide, and in high front vowel context). This result can interpreted in two ways, namely that it is possible to have (i) phonetically and phonologically two retroflex classes, or (ii) a phonetically retroflex, but phonologically non-retroflex class. In the first case, the two retroflex segmental classes nevertheless have to be phonologically distinguished, which is unproblematic if one departs from the traditional feature description of retroflexes as [coronal, –anterior, –distributed], as argued in section 5.2.3 below.

4.8 Conclusion

In this chapter it was illustrated that retroflex segments show cross-linguistically and diachronically homogeneous behaviour with respect to processes such as a preference of back vowel context, incompatibility of front vowel context, and so on. Furthermore, it was shown that this behaviour is phonetically motivated. and that this phonetic grounding can account for the similarity in synchronic rules and diachronic emergence of retroflexes.

Several of these processes have a preference for a specific order: rhotics causing retroflexion usually occur in front of the apical to be retroflexed, and front vowels that are changed in retroflex context are also pre-consonantal. Generalizing away from single processes, retroflexes preferably occur post-vocalically and affect preceding segments. This observation can be accounted for in several ways. First of all, the asymmetrical spread of cues as described in 3.5, with VC cues being stronger than the CV cues of retroflexes, is a cause for a restriction on the occurrence and the direction of influence. Furthermore, studies such as Krakow (1999) show a difference in gestural overlap between a consonant and a preceding vowel compared to a consonant following a vowel: the gestures are much better synchronized in CV gestures, but overlap for VC gestures. The gesture of retroflexion hence influences the preceding vowels, not the following ones.

With respect to the manner of the retroflexes involved in the different processes, some further generalizations can be made. If a single manner class and not the whole class of retroflexes is the trigger or the target of a process, then it is often a retroflex approximant that is changed due to its articulatory instability. Retroflex fricatives, on the other hand, often cause adjacent segments to change to a retroflex, because of their strong internal cues.

Noteworthy in the descriptions in this chapter is the similarity between retroflex segments and rhotics, see the restricted distribution of vowels in front of

both (section 4.3),[55] and the retroflexion of both vowels (section 4.4) and consonants (section 4.1) in rhotic context. These processes are not restricted to apical rhotics, but can partly also be triggered by uvular rhotics, which indicates that it is not a common articulatory property between retroflexes and coronal rhotics (such as tongue tip articulation) but rather a common perceptual characteristic, namely the low F3, that accounts for the common restrictions.

The illustration of a cross-linguistically similar behaviour of the class of retroflexes is not taken as evidence for a universally valid category of retroflexes, let alone, for the innateness of features determining such a category. The rules and restrictions observed in this chapter fall out of the definition of the retroflex class in the preceding chapters 2 and 3. Due to the articulatory criteria of posteriority, apicality, retraction, and sublingual cavity, the so-defined class shares the same articulatory restrictions. Avoidance of front vowels and occurrence in back vowel context, for example, is due to apicality and retraction of the segments (as attested by the fact that other, non-anterior apicals share this property, cf. Bhat 1973). Thus, any segment that satisfies the articulatory criteria proposed in chapter 2 is bound to show this articulatory behaviour. Likewise, the retroflex class was defined as sharing the acoustic features of high/middle F2 and low F3, which account for their perceptual similarity with rhotics and back vowels.

The apical post-alveolar and the subapical palatal in Toda were both shown in section 4.7 to meet the articulatory properties of retroflexion and also to behave partly as retroflexes. If one universal category were assumed, then a language that has two segmental classes both belonging to one universal category would be problematic and impossible to account for.

Several points that were described in the present chapter are worth future research. For the process of retroflexion after rhotics (section 4.1), the question arises whether non-retroflex, non-coronal rhotics can really trigger retroflexion, too. This could be checked by a detailed investigation of the Southern Swedish dialect of Svantesson (2001) to decide whether its retracted alveolar segments fulfil the four articulatory properties of retroflexes developed here in chapter 2. If these segments turn out to be retroflex, this dialect will be an example language for retroflexion in non-coronal rhotic context.

Another point for further study is the diachronic development of retroflex segments from Classical Tibetan to Modern Sino-Tibetan languages (also section 4.1) and the question whether assimilation of velars and labials to coronals took place before retroflexion via rhotics occurred, or whether the velars and labials were retroflexed directly.

Concerning the affinity with back vowels illustrated in section 4.2 and the vowel-lowering processes from section 4.3, more diachronic and synchronic evidence for the articulatory similarity between retroflexes and mid back vowels rather than high back vowels is hoped to be found in the future.

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[55] An exception to this generalization is Scottish English, which can have all vowels before a rhotic (Harris 1994: 255).

The retroflexed vowels of Badaga, which illustrated vowel retroflexion in section 4.4, have to be investigated articulatorily to determine whether they include high front retroflexed vowels or whether the gap in Emeneau's (1939) data was not accidental.

Quite a number of retroflexes showed a dependence on segmental length or prosodic position, a point that was not the focus of the present study but which might yield interesting insights for prosodic theories.

Lastly, I hope that confirming evidence for the processes of retroflexion via velarization and rounding that were left undiscussed here, will be found as well.