The historical development of retroflex consonants in Indo-Aryan*

T. A. Hall
Zentrum für Allgemeine Sprachwissenschaft

1 Introduction

Retroflex consonants in Old Indo-Aryan (i.e. Sanskrit) arose in at least two separate historical stages: (a) the emergence of the retroflex sibilant ṣ (= IPA [ʂ]), followed by (b) the emergence of retroflex stops ṭ, ḍ, ṭʰ, ḍʰ (= IPA [ʈ, ɖ, ʈʰ, ɖʱ] (see, for example, Misra 1967). The general assumption is that the sibilant that was the output of (a) developed from Indo-Iranian *š (IPA [ʃ]), which in turn was derived from Indo-European *s (i.e. Indo-European *s → Indo-Iranian *š → Old Indo-Aryan ṣ). If this is the correct sequence of events then the Indo-Iranian sibilant *š underwent a context-free change to ṣ in Sanskrit (i.e. š → ṣ).

Although most previous studies of Sanskrit historical phonology presuppose this context-free change no satisfactory explanation for its occurrence has been proposed. The present study is an attempt to explain why š became ṣ in the development of Indo-Aryan. The major point I make is that the context-free change š → ṣ was triggered as a repair strategy in order to avoid a phonemic inventory that is otherwise unattested in natural languages.

This article is organized as follows. §2 is devoted to a discussion of the phonetics of the places of articulation that are relevant in my discussion of the Sanskrit historical phonology and to cross-linguistic generalizations regarding possible sibilant contrasts. §3 provides background information on the Sanskrit and Indo-Iranian consonant systems. In §4 I discuss the sources of the retroflex sibilant ṣ in Sanskrit, concentrating on the context-free sound change referred to above. My conclusions are summarized in §5.

2 Phonetics and phonology of postalveolar consonants

In the analysis I posit below for Sanskrit I make reference to the following three places of articulation: retroflex, palatoalveolar, and alveolopalatal. In the present section I discuss the phonetics of sounds produced at these three places and their phonological patterning.

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2.1 Postalveolar places of articulation

The chart in (1) contains IPA symbols for voiced and voiceless stops and fricatives and nasals at seven places of articulation:

(1)	dental	alveolar	retroflex	palatoalveolar	alveolopalatal	palatal	velar
		t, d	ʈ, ɖ		c, ɟ		k, g
		n	ɳ		ɲ		ŋ
	θ, ð	s, z	ʂ, ʐ	ʃ, ʒ	ɕ, ʑ	ç, ʝ	x, ɣ

The most noticeable difference between (1) and most standard IPA charts (e.g. Ladefoged 1990) is that in the former one the three segments [c, ɟ, ɲ] are classified as "alveolopalatal" and not as "palatal". This reclassification is justified by the phonetic fact that sounds like [c, ɟ, ɲ] bear a closer affinity to the fricatives [ɕ, ʑ], as opposed to true palatal fricatives [ç, ʝ], both in terms of place of articulation and the articulator involved in their production. See Recasens (1990: 272), Keating (1991: 36), and Hall (1997: §1) for further discussion on this point.

I employ "postalveolar" here and below as a cover term for the three places of articulation "retroflex", "palatoalveolar", and "alveolopalatal". Retroflex sounds are articulated with the tongue tip or the underside of the tongue, i.e. they are apical or sublaminal. In contrast, sounds produced in the palatoalveolar and the alveolopalatal places utilize the tongue blade and are therefore laminal.[1] The term "alveolopalatal" (sometimes referred to as "prepalatal") describes the place of articulation in the postalveolar region between the palatoalveolar and the palatal places where fricatives and affricates like [ɕ, ʑ, tɕ, dʑ] in languages like Polish are produced (see Pullum & Ladusaw 1986: 31). Alveolopalatals, like palatoalveolars, are always laminal.

2.2 Inventory generalizations

Many languages, especially those indiginous to India and Australia, contrast a retroflex and an alveolopalatal noncontinuant.[2] Postalveolar fricative systems can contrast either a retroflex sound with a palatoalveolar, or a retroflex with an alveolopalatal. Representative examples of occurring postalveolar noncontinuant and fricative contrasts are given in (2)(a) and (b) respectively:

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[1] Phoneticians sometimes assume that palatoalveolar sounds can be apical (e.g. Catford 1988: 90-91). I analyze "apical palatoalveolars" as phonologically retroflex. This view derives support from the fact that both sets of sounds are phonetically similar (i.e. both are postalveolar and apical) and that no language contrasts the two (see also Maddieson 1984, and Hume 1992).

[2] The generalizations in this section are based primarily on Maddieson (1984) and Hall (1997).

(2) Possible postalveolar contrasts

(a) Noncontinuants

/ʈ, c/ Pitta-Pitta (Dixon 1980), Tamil (Christdas 1988)

/ɳ, ɲ/ Pitta-Pitta (Dixon 1980), Tamil (Christdas 1988)

(b) Fricatives

/ʂ, ʃ/ Tolowa (Bright 1964), Toda (Emeneau 1984, Shalev et al 1993), Basque (Hualde 1991)

/ʂ, ɕ/ Pekingese (Ladefoged & Wu 1984)

What all of the systems in (2) have in common is that one of the sounds is apical and the other laminal.

One generalization that I assume to be exceptionless is summarized in (3):

(3) No language can contrast palatoalveolars and alveolopalatals.

The generalization in (3) appears to be an absolute universal because no attested examples exist with surface oppositions of these two types (see Maddieson 1984, and Hall 1996). According to Stevens (1989) both palatoalveolars and alveolopalatals lie in an acoustically stable area and are thus not expected to contribute to phonemic contrasts. This gap makes phonetic sense for noncontinuants if palatoalveolar stops and nasals are nonoccurring segment types (see Lahiri & Blumstein 1984 for discussion).[3] The analysis I propose for Sanskrit in §4 below presupposes that fricatives also obey (3), that is, contrasts like the ones in (4) are nonoccurring:

(4) Nonoccurring contrasts:

/ʃ, ɕ/, /ʒ, ʑ/ etc.

I account formally for the nonexistent systems in (4) by positing that a single set of distinctive features describes both palatoalveolars and alveolopalatals. Following standard approaches to distinctive features (e.g. Chomsky & Halle 1968, Keating 1988) I analyze palatoalveolar and alveolopalatal segments as in (5):

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3 According to Mohanan & Mohanan (1984), Malayalam has a palatoalveolar nasal. However, this language does not violate (3) because this sound does not contrast with another laminal postalveolar nasal.

(5)	s	ʂ	ʃ, ɕ
[coronal]	+	+	+
[anterior]	+	-	-
[distributed]	-	-	+

The feature [distributed] accounts for the distinction between apical and laminal sounds: [-distributed] is interpreted to mean apical (or sublaminal) and [+distributed] laminal. Since palatoalveolars and alveolopalatals are identical phonologically whetever feature(s) that distinguish the two catergories on the phonetic surface are assigned in the phonetic component. This means that [+coronal, -anterior, +distributed] (in addition to [-voice, +continuant]) is phonetically realized in some languages as [ʃ] and in other languages as [ɕ].

Since retroflexes are apical and both palatoalveolars and alveolopalatals are laminal, the statement in (3) implies (6):

(6) If a language contrasts two postalveolar sounds then one will be apical and the other laminal.

Note that the languages in (2) obey (6). Several languages have been discussed in the literature that appear to violate (3) and (6), all of which will be argued below to be only apparent counterexamples.

In some of the languages that seem to contradict (3) and (6) the two segments also differ in terms of some manner feature, or some secondary articulation. Since (3) and (6) are intended to describe oppositions between alveolopalatals and palatoalveolars that agree in all other features these examples do not contradict my claim that palatoalveolars and alveolopalatals are identical phonological entities. For example, Ladefoged (1964) lists eight examples in his survey of sixty two West African languages with palatoalveolars and alveolopalatals, but the two sounds always differ in terms of a secondary articulation, e.g. Twi contrasts the voiceless alveolopalatal fricative /ɕ/ and the voiceless *labialized* palatoalveolar fricative/$ʃ^w$/. Another similar example is Swedish, which is sometimes said to contrast [ɕ] and [ʃ] (see Campbell 1991: 1289). However, Ladefoged & Maddieson (1996), citing Lindblad (1983), note that the Swedish "palatoalveolar" is multiply articulated. This segment is highly rounded, labiodental, velar or velarized and the source of friction is between the lower lip and the upper teeth. In addition, the tongue body is raised and retracted towards the velum to form a fairly narrow constriction. Thus, Swedish "[ʃ]"

is more accurately [ʃʷ]. What this means is that the alleged contrast in Swedish does not involve [ʃ, ɕ], but [ʃʷ, ɕ].

Other examples of languages with apparent palatoalveolar vs. alveolopalatal contrasts involve oppositions between *retroflexes* and alveolopalatals. This is certainly the case in Polish, which is often erroneously referred to as a language with surface contrasts between "[ʃ]" and [ɕ]. (See, for example, Spencer 1986, and Dogil 1990, who employ these IPA symbols). However, Polish "[ʃ]" is phonetically very different from English [ʃ], which is a "true" palatoalveolar because it is produced with the tongue blade.[4] Specifically, Polish "palatoalveolars" are pronounced with a shorter length of constriction (and with velarization). Because the Polish sounds are much closer phonetically to "true" postalveolar apical sibilants, many linguists correctly refer to them as retroflex (e.g. Keating 1991: 35-36, Hume 1992: 104ff).[5]

One language with reliable articulatory data known to me in which a true palatoalveolar [ʃ] and a true alveolopalatal [ɕ] exist on the surface is Nantong Chinese (Ao 1993). However, as Ao (1993: 49-53) points out, [ʃ] and [ɕ] never contrast in Nantong, neither in the underlying representation, nor on the phonetic surface. Nantong Chinese therefore does not violate (3) and (6) because both of these generalizations hold for sounds that contrast.

Occasionally one encounters descriptions of languages that are said to contrast two postalveolar laminal sibilants within the same series, but these analyses often lack the phonetic description necessary to determine whether or not (3) and (6) are really falsified. For example, several Uralic languages are said to have oppositions between palatoalveolars and alveolopalatals (see Wurzel 1975: 175; and Veenker 1987, although neither linguist uses the terms "palatoalveolar" and "alveolopalatal"). Rédei (1975) shows that Syranisch has four postalveolar sibilants he transcribes as " š ", "s' ", " ž ", and "z' ". Both *s'* and *z'* are described as a palatalized *š* and *ž* respectively (p. 103), which implies that they are laminal. If *š, ž* are true palatoalveolars then this language would falsify (6), but Rédei does not discuss the phonetics of *š, ž* in enough detail to determine this. Similar systems are reported for Livonian (Viitso 1975), Moksha Mordvinian (Feoktistov 1984; Veenker 1987: 39) and Erza Mordvinian (Rédei 1984; Veenker 1987: 38). Unfortunately, no mention is made in any of these sources whether or not the nonpalatalized *š* and *ž* are true (laminal) palatoalveolars, or if they are apical (and hence retroflex [ʂ, ʐ]).

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4 See also Jones & Ward's (1969: 134) description of the difference between English [ʃ] and Russian "[ʃ]".

5 See also Chomsky & Halle (1968: 314), who analyze Polish "palatoalvoelars" as [-distributed].

Should the examples cited in the previous paragraph (or other ones unknown to me) turn out to involve true contrasts between palatoalveolars vs. alveolopalatals then the generalizations in (3) and (6) will have to be demoted to markedness statements. That is, a system with /ʂ, ɕ/ would be less marked than one with /ʃ, ɕ/. Importantly, the analysis I propose in the following section for Sanskrit will hold regardless of whether or not oppositions of the type /ʃ/ vs. /ɕ/ are impossible, as expressed in (3), or simply highly marked.

3 Old Indo-Aryan

Old Indo-Aryan[6] (represented below as Sanskrit) had the following inventory of consonants and glides:[7]

(7)	p	t	ṭ	c	k	
	p^h	t^h	$ṭ^h$	c^h	k^h	
	b	d	ḍ	j	g	
	b^h	d^h	$ḍ^h$	j^h	g^h	
	φ	s	ṣ	ś	x	h
	m	n	ṇ	ñ	ŋ	
	v	l	r	y		

(7) contains the phonetic symbols traditionally employed in Indo-Aryan historical phonology. In that system aspirated and murmured stops are reflected uniformly, with the raised [^{h}]. The four segments *c, c^h, j, j^h* were probably stops as opposed to affricates (i.e. IPA [c, c^h, ɟ, $ɟ^ʱ$]; see Allen 1953: 52), *ṭ, ḍ, $ṭ^h$, $ḍ^h$, ṣ, ṇ, r* were retroflex (i.e.

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[6] Old Indo-Aryan (henceforth OIA) corresponds roughly to the period 1500 BC-600 BC (Chatterji 1927: 17, Masica 1991: 51) and is considered to be the earliest stage of Indo-Aryan. OIA is one branch of Indo-Iranian, the others being Nuristani (which is sometimes referred to by the derogatory term "Kafiri", see Masica 1991: 465) and the reconstructed language Old Iranian. The latter language subsequently split into the two (attested) languages Avestan and Old Persian. See Bartholomae (1883), Brugmann (1897a, b), Ghatage (1962), and Mayrhofer (1989) for a discussion of the historical development of the Indo-Iranian daughter languages.

[7] The system of consonants and glides in (7) corresponds to both Early (i.e. Vedic) and later (i.e. Classical) Sanskrit. The six places of articulation in (7) are labial, dental, retroflex, alveolopalatal, velar, and glottal. Traditional descriptions of Sanskrit consonants include Whitney (1889), Wackernagel (1896), Allen (1953), Burrow (1955), and Thumb (1958).

Vedic Sanskrit also had the retroflex laterals ḷ and ḷh, which were the intervocalic realization of *ḍ* and *ḍh* respectively (Masica 1991: 161). Sanskrit *φ, x* and *ñ* are usually analyzed as allophones of other segments because of their limited and hence predictable distribution (see Cho 1990: 162)

IPA [ʈ, ɖ, ʈʰ, ɖʱ, ʂ, ɳ, ɻ]),[8] and *ś* was a voiceless postalveolar laminal sibilant, which I assume to be equivalent to IPA [ɕ].[9]

At an earlier stage in Indo-Iranian prehistory the language probably had the consonants and glides in (8):

(8)	p	t	c	k	
	p^h	t^h		k^h	
	b	d	j	g	
	b^h	d^h	j^h	g^h	
		s	ś		h
	m	n			
		l			
		r			
	w		y		

The inventory in (8) is similar to the reconstructed inventory for Proto-Indo-Iranian posited by Ghatage (1962: 83), and Misra (1967: 42). The major difference is that Ghatage's and Misra's reconstructions also include the palatoalveolar affricates *č, ǰ, ǰʰ* (which derived from Indo-European alveolopalatals **k̂, ĝ, ĝʰ* respectively). In (8) I assume that the sound change that converted *č* to *ś*, and merged *ǰ, ǰʰ* with *j, h* respectively had already occurred. The latter sound changes as well as alternate chronologies will be discussed in greater detail below.

A comparison of (7) and (8) reveals that there were no retroflex sounds in the latter language. The question I consider below is how and why retroflex sounds arose historically in Indo-Aryan. I demonstrate below that an answer to this question can be tied in with the generalizations in (3) and (6) above that govern synchronic systems.

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[8] For typographical reasons Sanskrit retroflex *r* is not usually transcribed as *ṛ* because the latter symbol represents the syllabic *r*, which also existed in the language.

[9] Since most sources agree that *ś* was a voiceless postalveolar laminal sibilant (see below), then this sound was either IPA [ʃ] or IPA [ɕ]. (*ś* could not have been a true palatal fricative (i.e. [ç]), pace Chatterji (1960: 76), because this sound is not a sibilant). Phonological evidence can be adduced that *ś* was IPA [ɕ]: In Sanskrit dentals became alveolopalatal before alveolopalatals (e.g. ut+cariti → uccariti 'rises'; Cho 1990: 66). Importantly, Sanskrit *ś* surfaces in the same environment , e.g. tatas + ca → tataśca 'and then'. If *ś* and *c* have the same place of articulation then they are both alveolopalatal (recall (1)).

Linguists who assume that Sanskrit *ś* was IPA [ʃ] include Allen (1953: 20) and (probably) Whitney (1889: 22), who describes *ś* as "the usual and normal sh-sound". Thumb (1958: 205) states that *ś* is "a palatalized *š* (German sch), close to German ç", a description that comes close to IPA [ɕ]. That few scholars (if any) have stated explicitly that Sanskrit *ś* was IPA [ɕ] can be attributed to the fact that they were unaware that the IPA table distinguishes two postalveolar laminal fricatives.

The emergence of retroflex consonants in Sanskrit is often ascribed to areal influences from Dravidian (e.g. Bloch 1930: 731-733, Emeneau 1954: 284). While there is no questioning the fact that such borrowings took place in the development of Sanskrit, most instances of Sanskrit retroflex segments can be shown to have been the result of sound changes internal to Indo-Aryan[10] (see Wackernagel 1896, Brugmann 1897a, b, Burrow 1955: 96, Thumb 1958: 281-282, and Misra 1967: 64-65). For example, most instances of Sanskrit *ḍ, ḍʰ* derive from a sequence of retroflex sibilant plus corresponding dental stop. This can be illustrated with the data in (9) (from Misra 1967: 68-69):[11]

(9)

Sanskrit		*pre-Sanskrit*	*gloss*
ni:ḍa	<	*niṣda	'nest'
mi:ḍha	<	*miṣdha	'reward'
voḍhum	<	*vaṣdhum	'to carry'
leḍhi	<	*laṣdi	'licks'

In the examples in (9) the retroflexion features assimilated to the following dental stop, thereby producing *ḍ, ḍʰ*. These segments subsequently became phonemic in the pre-Vedic period when the preceding retroflex sibilant deleted.[12]

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[10] Two examples of Dravidian loanwords in Sanskrit containing *ṭ* are *kuṭila* 'crooked', and *kuṭi* 'hut, cottage' (Burrow 1955: 97). Some loanwords with *ṭ, ḍ* are of uncertain origin (see Masica 1991: 157-158), e.g. *kuṭumba* 'household', *ḍimbha* 'newborn child', and *ta:ḍa* 'blow'. Loanwords containing *ṇ* were particularly common in *ṇḍ* clusters (Masica 1991: 160), e.g. *tuṇḍa* 'beak'. See Burrow (1945, 1946) for additional examples.

[11] The general assumption is that pre-Sanskrit *ṣ* (in (9)) had two allophones, *ṣ* and *ẓ*, where the latter sound surfaced only before voiced stops (Misra 1967: 65). Hence, the retroflex sibilant in the pre-Sanskrit forms in (9) was probably *ẓ* phonetically.

The reconstructed forms for the four words in the pre-Sanskrit column in (9) (as well as others of the same structure) are also presupposed by Burrow (1955: 93-94) and Masica (1991: 157). One argument that the retroflex stop in the Sanskrit words in (9) derives from an earlier sibilant is that the cognates in related non-Indo Aryan languages often have a sibilant, e.g. English *nest,* Avestan *mižda* 'reward' .

[12] Many instances of Sanskrit *ṭ, ṭʰ, ṇ* can also be shown to have Indo-European roots. For example, *ṭ* derives from a sequence of ṣ + s or ś + s in final position (Burrow 1955: 96). For another internal source of *ṭ* see below. Sanskrit *ṇ* derived from *n* after a syllabic or nonsyllabic *r*, or *ṣ* anywhere in the word when a vowel, glide or nasal immediately follow and a dental, retroflex, or alveolopalatal does not intervene (Masica 1991: 160), e.g. the *ṇ* in *brahamaṇa:* 'Brahaman'.

There are also many attested examples of "spontaneous" retroflexion, whereby original dentals became retroflex regardless of the environment, i.e. the context-free change t, d, tʰ, dʰ, n, l, s → *ṭ, ḍ, ṭʰ, ḍʰ, ṇ, ḷ, ṣ* occurred; see Burrow (1971). Two examples of Sanskrit words containing retroflex consonants that underwent spontaneous retroflexion are *sthu:ṇa* 'column' (cf. Avestan *stu:na*), and *aṭ* 'to wander', which was earlier *at* (see Burrow 1955: 97).

Pre-Sanskrit *ṣ* had a similar internal history in the sense that it derived both from Indo-European sounds, namely IE **s* after *r, u, k, i,* and IE voiceless alveolopalatal stop before *t* (see below for discussion).

The analysis described in the preceding paragraph presupposes that the retroflex obstruents in (7) came about in (at least) two sequential stages: [13]

(10)(a) the development of the retroflex sibilant *ṣ*

(b) the development of the retroflex stops *ḍ, ḍʰ, ṭ, ṭʰ*

Since *ḍ ḍʰ* in examples like the ones in (9) were triggered by an adjacent *ṣ,* the latter segment clearly arose prior to the former two.

In the following paragraphs I concentrate on the emergence of the retroflex sibilant *ṣ* (i.e. (10)(a)) and show that this development can only be understood within the context of the inventory generalizations discussed in §2.

4 The development of Sanskrit *ṣ*

Since I argue below that there is a connection between the emergence of Sanskrit *ṣ* and the segment *ś* in the inventory in (8), I begin this section by tracing the development of the latter sound.

The Indo-European alveolopalatal stops *$\hat{k}$, $\hat{g}$, $\hat{g}^h$ not followed by *t* became *ś, j, h* respectively in Sanskrit.[14, 15] These changes are usually assumed because of comparative data like the ones in (11) (from Burrow 1955: 72), where Latin represents the centum languages, and Sanskrit and Avestan the satem languages:

(11)	*Latin*	*Sanskrit*	*Avestan*	*gloss*
	centum	śatám	satəm	'hundred'
	genu	ja:nu	za:nu	'knee'
	hiems	hima	zima	'snow'

[13] Misra (1967: 73) argues that *ṭʰ* was the last among the retroflex stops to become phonemic; hence, (10)(b) is not intended to imply that *ḍ, ḍʰ, ṭ, ṭʰ* all entered the language simultaneously. The important point is that there was a pre-Sanskrit stage in which the only retroflex segment present was *ṣ*.

[14] This development is characteristic of the so-called satem languages. See Wackernagel (1896: 227: 229), Brugmann (1897a: 556), Bloomfield (1911), Edgerton (1946: 6-7), Thumb (1958: 286-288), and Allen (1978) for traditional descriptions of these changes. Solta (1965) questions the basic centum vs. satem division. See Tischler (1990) for a defense of the traditional theory.

[15] Another source of Sanskrit *ś* is *s* before *c* (recall note 9), as in *tatas + ca* [tataśca] 'and then' (Cho 1990: 66). IE voiceless alveolopalatal stops after *s* surfaced in Sanskrit as *cʰ* in Sanskrit words like *cha:ya:* 'shadow' (Misra 1967: 53-54)

The initial consonant in the words in (10) derives from IE *$\hat{k}$, $\hat{g}$, $\hat{g}^h$ respectively.

Most investigators have argued that IE *$\hat{k}$, $\hat{g}$, $\hat{g}^h$ underwent an affrication stage before surfacing in Sanskrit as *ś, j, h* (e. g. Morgenstierne 1945: 225-233; Burrow 1955: 73; and Misra 1967: 26-27). These developments are summarized in (11):[16]

(12) IE *$\hat{k}$, $\hat{g}$, $\hat{g}^h$ → č, ǰ, ǰ^h → Sanskrit ś, j, h

Let us assume that immediately prior to the emergence of *ṣ*, the alveolopalatal sibilant *ś* had already entered the language, i.e. *č* had become *ś*, a stage in which the language had the inventory of consonants and glides in (8) above. One might alternatively argue that *ś* arose at a later stage. I consider this possibility below and show that this chronology is also compatible with my analysis. However, for the remainder of this section, I assume that prior to the emergence of *ṣ*, the alveolopalatal sibilant *ś* was in the language.

The general consensus is that Sanskrit *ṣ* had two historical sources: (a) IE **s* after *r, u, k, i* unless an *r* follows, and (b) IE voiceless alveolopalatal stop before *t*. Consider first the data in (13) (from Burrow 1955: 79), which illustrate development (a):[17]

(13)	*IE*	*Sanskrit*	*Avestan*	*gloss*
	*s	víṣa	viša	'poison'
	*s	śúṣka	huška	'dry'
	*s	dákṣiṇa	dašina	'right hand'

The comparative method demands that the retroflex sibilant in these and similar Sanskrit words derive from IE **s* because the corresponding etymons in other Indo-European daughter languages contain *s* (e.g. Sanskrit *mu:ṣ* vs. English *mouse*). The Avestan forms in (13) illustrate that IE **s* after *r, u, k, i* surfaced as palatoalveolar *š* (i.e. IPA [ʃ]) in the Iranian branch of Indo-Iranian.[18]

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[16] Burrow (1955: 73) states that the affrication stage affected all satem languages. Brugmann (1897a: 242ff.) assumes that IE *$\hat{k}$ changed directly into *ś* in Indo-Iranian.

[17] The Sanskrit data in (13) have generated a vast literature over the past hundred years. For historical analyses the reader is referred to Whitney (1889: 180-185), Wackernagel (1896: 230-235), Brugmann (1897b: 728ff.), and Thumb (1958: 305). Synchronic treatments include Zwicky (1970), Vennemann (1974), and Cho (1990: 85-89).

[18] This generalization also holds for Old Persian, e.g. Sanskrit *dhṛṣṇoti* 'dares' vs. Old Persian *adaršnauš* 'he dared'.

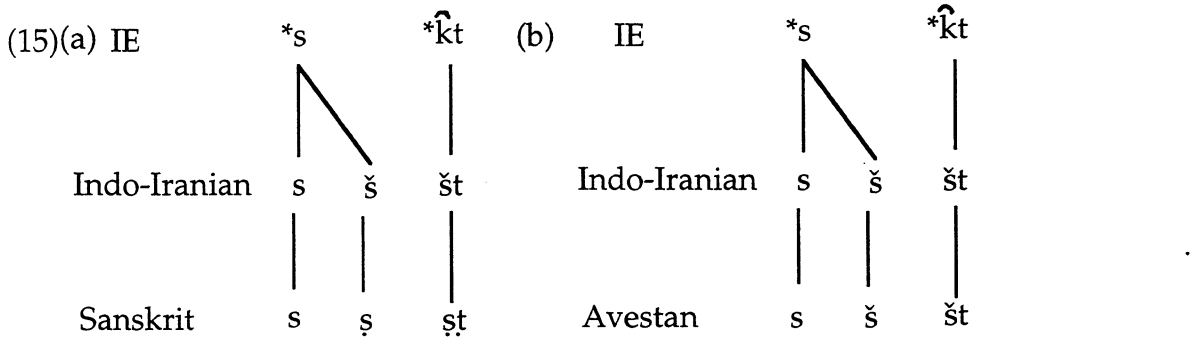
With some qualifications (see below) retroflex sounds are basically nonexistent in Middle and New Iranian dialects (see Gray 1902: 136 and Schmitt 1989: §4). Hence, in New Iranian languages, e.g. Farsi (Jensen 1931, Lambton 1961, Boyle 1966, Majidi 1986) and Kurdish (Mackenzie 1961) the postalveolar sibilants are palatoalveolar, as opposed to retroflex. (One phonetic study to my knowledge (i.e.

The second source of Sanskrit *ṣ* is IE *$\hat{k}$ before *t*. Thus, consider the data in (14), which have been taken from Misra (1967: 30):

(14)	*IE*	*Sanskrit*	*Avestan*	*gloss*
	*kt	aṣṭau-	ašta-	'eight'
	*kt	vaṣṭi	vašti	'wishes' 3rd. sg. pres. ind.

As illustrated in (14), Sanskrit *ṣṭ* in these and similar words corresponds to Avestan *št* (see also Bloomfield 1911, and Burrow 1955: 96-97).

The general assumption in Sanskrit historical phonology - which will be defended below - is that IE **s* and *$\hat{k}$ in examples like the ones in (13) and (14) underwent an intermediate shift to *š*, prior to its emergence in Sanskrit as *ṣ* (e.g. Wackernagel 1896: 230, Brugmann 1897b: 638, 728, Misra 1967: 28-30, and Mayrhofer 1989: 8). Assuming that the changes from IE **s* after *r, u, k, i* and IE *$\hat{k}t$ to palatoalveolar occurred sometime during the Indo-Iranian period, the development of these Indo-European sounds into Sanskrit and Avestan is illustrated below in (15)(a) and (b) respectively:



The palatoalveolar sibilants that emerged during the Indo-Iranian period remained palatolavoelar in Avestan (and Old Persian). In contrast, *š* changed to *ṣ* in Sanskrit.

Smirova & Ejubi 1985: 96) confirms that the postalveolar sibilants in Kurdish are palatoalveolar, as opposed to retroflex).

A detailed description of the phonology of the New Iranian languages is contained in Schmitt (1989). In contrast to the generalization in the preceding paragraph, several modern East Iranian languages have retroflex consonants, e.g. the Southwest dialects of Pashto, Munǰi, Yidgha, Wakhi (see Penzl 1955, Skjærvø 1989a: 371, 1989b). However, the general consensus is that these sounds were not inherited from Indo-Iranian, but that they instead arose at a later stage in the development of the respective language. For example, Geiger (1894: 217) and Morgenstierne (1927: 77-79) show that voiceless retroflex sibilant in Pashto (a sound symbolized by both authors as "ṣ") corresponds to Avestan sr (e.g. Pashto *ṣa* 'good' Avestan *srao;* Pashto *ṣna* 'hip bone', Avestan *sraoni* 'hip'). See also Skjærvø (1989a, b), who agrees that retroflex segments in Pashto (and in the other East Iranian languages) are a relatively late development.

Three arguments can be adduced for the intermediate stage in (15) with the palatoalveolar sibilant *š*. First, the development of IE **s* into *š* after *r, u, k, i* occurred not only in Avestan and Old Persian, but also in Slavic (where **š* surfaced as the velar fricative [x]) and to a limited extent in Baltic (see Martinet 1951, Andersen 1968). If there were indeed an early stage of pre-Indo-Iranian history when this language family and Slavic shared this common development (see Burrow 1955: 18; 79-80; Thumb 1958: 305) then the comparative method demands that the output of this change be *š* and not *ṣ*. What this means is that the sibilant in the Avestan words in (13) and (14) represents the more ancient sound than the *ṣ* in the corresponding Sanskrit forms and that *ṣ* arose out of *š* in Indo-Aryan. Second, and more importantly, the change from IE **k̂* to *š* (with an intermediate affrication stage to *č*) before t makes more sense phonetically than the alternative, which would have IE **k̂t* convert directly into *ṣṭ* in Sanskrit (and to *št* in Avestan). The reason the development from IE **k̂t* → čt → št (→ ṣṭ) is more plausible than IE **k̂t* → ṣṭ is that the alveolopalatal stop, the palatoalveolar affricate and the palatoalveolar sibilant are all postalveolar and laminal. Hence, these changes from **k̂t* → čt → št simply involve manner features alone, i.e. stop → affricate → fricative. If sound change is gradual then these developments make more sense than a discrete change that involves manner *and* place features, i. e. **k̂t* → čt → ṣṭ. Third, the change from palatoalveolar affricate to the corresponding fricative (e.g. č → š) is attested both diachronically (e.g. the development of Old French *č* into New French *š;* Hock 1986: 130) and synchronically (*č* becomes *š* word-finally and before stops, nasals and laterals in Luiseño; Munro & Benson 1973). In contrast, the alternative development (i.e. č → ṣ) is unattested.

The Indo-Iranian developments in (15) (which are reflected in the Avestan forms in (13) and (14)) are expressed in (16)(a) and (b): [19]

(16)(a) IE *s → š / r, u, k, i ___
(b) IE **k̂* → š/ __ t

Again, some linguists have assumed that (16)(a) predated Indo-Iranian because a similar sound change converting IE **s* into *š* occurred in Slavic. The sound change in (16)(b) is traditionally viewed as one that added the phoneme *š* in Indo-Iranian because *š* contrasted with *s* (< IE **s*) before *t* (Misra 1967: 30). This can be illustrated with the Indo-European word **Hesty* 'is' 3rd. sg. pres. ind., which surfaced as *astiy*

[19] IE **z* became *ž* in the same environment as (15)(a). Like its voiceless counterpart, *ž* also became retroflex, but was never phonemicized because it was later deleted (see Misra 1967: 67).

in Old Persian, and *asti* in Sanskrit vs. Sanskrit *vaṣṭi* 'wishes' 3 sg. pres. ind., Avestan *vašti* (< IE **wekty*).

One question that has vexed historical linguists for decades is why IE *$\hat{k}$ became *ṣ* in Sanskrit only in *$\hat{k}t$ clusters and *ś* elsewhere (see Bloomfield 1911 for discussion). (That IE *$\hat{k}$ in the data in (14) could not have become *ś* by (16)(b) is obvious, otherwise the output would have merged with the *ś* segments that derived from IE *$\hat{k}$ in other positions). I assume a stage in IE prehistory in which *š* was an allophone of *ś* in the sense that the former sound only occurred before *t* and the latter in all other positions (see also Burrow 1955: 90).

The sequence of events summarized in (15) presupposes that the change from palatoalveolar to retroflex was a later Indo-Aryan development (for a similar view see Wackernagel 1896: 165, 229, Brugmann 1897a,b: 728, Burrow 1955: 90; 95-96, Misra 1967: 28-29; 65, and Mayrhofer 1989: 8). Thus, if OIA *ṣ* derived from Indo-Iranian *š*, then the following context-free sound change must have occurred sometime in the pre-Vedic period:

(17) š → ṣ

In contrast to the assimilatory change responsible for the development of the retroflex stops *ḍ, ḍʰ* in (9) above, (17) was context-free. What is more, (17) was classically Neogrammarian in the sense that it was exceptionless; that is, every palatoalveolar shifted to retroflex.

In view of the fact that (17) has no obvious phonetic motivation, and that the output was a more marked segment phonologically than its input (see Maddieson 1984: 44-45 who shows that [ʃ] is much more common in synchronic systems than [ʂ]) the obvious question to ask is why this sound change would occur at all.

One could appeal to the existence of Dravidian loanwords with retroflex consonants in them as an explanation. On these same lines one might contend that there must be a connection between such loanwords and the change in (17) because the related languages Avestan and Old Persian had neither (Misra 1967: 63). Although intuitively plausible, the Dravidian loanword hypothesis suffers from several discrepancies. First, the earliest non Indo-Aryan loan words with retroflex consonants in them contained retroflex stops and nasals but apparently no examples are attested with retroflex sibilants (see Burrow 1945, 1946).[20] Hence, the puzzle is

[20] Burrow (1945) lists four Dravidian loans in Sanskrit which contain *ṣ* (e.g. *maṣi* 'ink, lampblack', p. 10). However, none of the cognates in the Dravidian languages contains [ʂ], e.g. Sanskrit *maṣi* is cognate with the Dravidian language Kui *ma:si* 'dirt'. The *s* in this and similar borrowed Dravidian

why the context free change in (17) would affect the dental sibilant and not the dental stops or nasal. Second, the Dravidian loanword hypothesis cannot account for the fact that (17) was exceptionless.

Hock (1986: 79) claims that retroflexion can develop in a nonassimilatory (i.e. context-free) way, tentatively citing the development of Latin ll to [ḍḍ] in Sicilian and Sardinian dialects as an example. The geminate retroflex stop [ḍḍ] was preceded by a stage with the palatoalveolar (in his terminology "palatal") affricate [ʤ]. The retroflex affricate [ḍẓ] developed out of [ʤ] by a context-free sound change because "retroflex is a possible variant of palatal articulation in the sibilants...". By this Hock means that palatoalveolar sibilants can be pronounced either with the tongue tip up, or down, where he regards the former pronunciation as retroflex.

There are good reasons for rejecting such an explanation for (17). Although the "tip-up" pronunciation of English palatoalveolars, whereby the tongue tip is raised to the dental/alveolar region, is possible (cf. Ladefoged & Maddieson 1996: 149-150), the tip does not make contact *behind* the alveolar ridge, which is how retroflex consonants are produced. Thus, Hock's claim that retroflex is an optional pronunciation of palatoalveolars is false.[21]

The explanation I offer below for the sound change in (17) can only be understood by considering the system of sibilants in the respective stages. Since the two developments in (16)(a) and (b) predated the one in (17), the following inventory change occurred:

(18) stage 1: /s, ś/ → stage 2: /s, š, ś/ → stage 3: /s, ṣ, ś/

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words apparently underwent spontaneous retroflexion (recall note 12) and converted to *ṣ*. That none of Burrow's examples of Dravidian loanwords in Sanskrit with *ṣ* contained *ṣ* in the cognate Dravidian languages is hardly surprising in view of the fact that Dravidian languages typically contain no sibilants at all (Zvelebil 1990: 8) and that Proto-Dravidian has been reconstructed without any such sounds (Zvelebil 1970: 76).

[21] In contrast, there may be good reasons to believe that retroflex r is an optional pronunciation of the alveolar *r*. For approximant *r* sounds (IPA [ɹ] = alveolar and [ɻ] = retroflex) the tongue does not come as close to the alveolar ridge as it does for dental/alveolar stops and fricatives like [t, d, s, z]; since the tongue tip is not inhibited in any way, the curling back of the tongue tip behind the alveolar ridge (i.e. [ɻ]) is a conceivable variant pronunciation for [ɹ]. This might account for the development of the Indo-European *r*, which was presumably alveolar, to retroflex in Sanskrit. This change, like the one in (17), was context-free, since all *r*'s became retroflex. (That Sanskrit *r* was retroflex is uncontroversial because this segment caused a following dental *n* to become retroflex; recall note 12. See also Whitney 1889: 47, who notes that Sanskrit *r* is retroflex, i.e. "lingual" in his terminology. Since this sound was not trilled, it was most likely an approximant.) I assume that a similar context free change of a dental *r* to a retroflex *r* occurred in American English.

Stage 1 in (18) corresponds to the system in (8) above for Indo-Iranian, and stage 3 to the Sanskrit system in (7). The palatoalveolar sibilant *š* entered the language by (16)(a) and (b) later in the Indo-Iranian period, thereby producing the system at stage 2, with the three sibilants /s, š, ś/.

Recall from §2 above that no language is attested with the phonemic system of sibilants at stage 2 in (18) (i. e. /š , ś/ = IPA /ʃ, ɕ/). Given this generalization, the transition from stage 2 to stage 3 (by (17)) went into effect in order to eliminate a nonoccurring system and to bring it in line with the generalization in (6). This explanation also accounts for the fact that the output of (17) was a more marked segment than the input. Specifically, an increase in segmental markedness is tolerated in order to alleviate the violation to (3), which, as an absolute universal, takes precedence. Consider now a concrete example. The Sanskrit word *viśati* 'settles' (3 sg. pres. ind.) (from Misra 1967: 66) contained *ś* as early as stage 1, a stage when the *š* in the Avestan (i.e. Indo-Iranian) word *viša* 'poison' (see (13)) was still *s*. When **visa* became *viša* at stage 2 (via (16)(a)) the sound change in (17) was triggered because *ś* and *š* contrasted. [22]

If (3) is a true absolute universal as opposed to a strong cross-linguistic tendency then stage 2 in (18) never really corresponded to a synchronic stage in the language. What this means is that the two developments in (16)(a) and (b), caused (17) to enter the language at the same time. Should (6) prove to be not an absolute universal, but instead a statement reflecting markedness, then this would imply that stage 2 in (18) did correspond to a synchronic system which was eliminated because it was highly unstable.

A question of equal importance is why (17) was exceptionless. The general assumption is that sound changes that are not phonetically motivated (e. g. by being context free) exhibit lexical diffusion effects (see Chen & Wang 1975, Labov 1981, Kiparsky 1988). Indeed, (17) can be contrasted with context-free sound changes in other languages, or the spontaneous retroflexion of dentals referred to above that occurred in Indo-Aryan, that were lexically gradual. One could presumably argue that (17) *was* lexically gradual but that we cannot know this because this sound change was so ancient that the exceptions that used to exist were gradually eliminated and therefore never surfaced, even in the earliest Vedic texts. In light of

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[22] Note that the explanation offered above for (17) is not a classic push chain shift (in the sense of Martinet 1981). In a true push chain shift there is a direct causality between two rules (i) and (ii), where (i) A → B, and (ii) B → C (and A is not C). The reason the Sanskrit developments do not constitute a push chain shift is that rule (17) above (which would correspond to (ii)) was not triggered by the rules in (16) (=rule (i)), but instead by the existence of *ś*. However, Martinet (1981: 55) apparently does allow for independent phonemes to trigger sound changes.

the absence of data, this position is difficult to falsify; however, I contend that (17) must have been exceptionless because all *š* segments had to be expunged from the language at stage 2 in order to eliminate of the contrasts between *š* and *ś*. It is also important to compare (17) with the spontaneous retroflexion of dentals, which was also context-free. Burrow (1971: 559) notes that the latter change affected primarily Old Indo-Aryan (as opposed to Middle Indo-Aryan). Hence, spontaneous retroflexion was also a very ancient sound change - although admittedly not as ancient as (17) - and yet, it was riddled with exceptions.

Other questions pertaining to the transition form stage 2 to stage 3 can be raised at this point. First, if stage 2 in (18) is impossible, then the violation to (3) could presumably be repaired in some other way. In other words, the palatoalveolar produced by (16)(a) and (b) did not necessarily have to become retroflex; it could have merged with one of the other sounds in the language, e.g. *s* or *ś*, or it could have become an entirely new sound. While I cannot say whether or not (17) is the unmarked repair strategy languages employ in order to eliminate violations of (3) that arise diachronically, it is worth noting that palatoalveolars and retroflexes are very similar phonologically, i.e. both are [+coronal, -anterior] according to many theories of distinctive features and only differ in terms of [distributed] (recall (5)). Thus, (17) involves the change of a single feature. In contrast, were *š* to become some other sound, such as *s*, then more than one feature would have to change. This fact therefore might have tipped the scales in favor of converting *š* into *ṣ* (as opposed to some other sound).[23]

While my analysis presupposes that the existence of *ś* was instrumental in the emergence of *ṣ*, one need not necessarily assume as I have in (8) that *ś* was the first postalveolar sibilant to enter Indo-Iranian. There are in fact three logical chronologies: (i) *ś* was in the language before *ṣ* (and hence *š̌*), (ii) *ṣ* (and hence *ś̌*) was in the language before *ś*, and (iii) *š* and *ś* entered the language at the same time. In the preceding paragraphs I assumed (i), but, as I show below, (ii) is compatible with my analysis as well. (Since my treatment follows from the two chronologies in (i) and (ii), (iii) is equally possible). Let us now consider (ii).

Assuming that Indo-Iranian had /s, š/ and that the future *ś* was still the affricate *č*, then the emergence of *ṣ* has a similar explanation. When *č* became *ś* via (12), this

[23] Should the featural explanation be correct then this would imply that a more likely repair strategy at stage 2 in (18) would be the merger of *š* with *ś*. The reason is that *š* and *ś* are phonologically identical in terms of features (recall (5)). At this point I am unaware of languages in which *š* merges with *ś* diachronically.

change then caused *š* to become retroflex by (17). This sequence of events is summarized in (19):

(19) stage 1: /s, š/ → stage 2: /s, š, ś/ → stage 3: /s, ṣ, ś/

Carlton (1990: 96-97) discusses similar facts from Slavic prehistory that suggest that in that language the emergence of *x* (< *š*) (via (16)(a)) preceded the change from IE *$\hat{k}$ to *s*. As mentioned above, IE **s* surfaces in Slavic as the voiceless velar fricative *x* after *r, u, k, i* and before a vowel. Importantly, only IE **s* became *x*, and not the *s* that emerged from *ś* (< IE *$\hat{k}$). This therefore implies that the Slavic equivalent of (16)(a) was older than the spirantization of IE *$\hat{k}$.

In Avestan the facts superficially suggest a similar chronology. For example, the *s* in the Avestan word for "settlement" *vis* (Sanskrit *víś*) derives from IE *$\hat{k}$, but this *s* did not become *š* via (16)(a). However, there is an alternative explanation that presupposes the opposite ordering: Suppose that IE *$\hat{k}$ first became *ś* in all satem languages (or alternatively, only in Indo-Iranian) and this development preceded (16)(a). This *ś* then converted into s in Avestan after (16)(a) had become inactive in the grammar. In fact, there is an additional argument for the alternative sequence of events just described. Stage 2 in (18) (and in (19)) probably occurred at a point later on in the Indo-Iranian era when OIA and Old Iranian were dialects of the same language. OIA dealt with the violation to (3) at this stage by implementing (17), but the illicit inventory also existed in Old Iranian. How was the violation to (6) reconciled in that language? Recall from (11) that Indo-European voiceless alveolopalatal stops not followed by *t* surface regularly as *ś* in Sanskrit, but as *s* in Avestan. One might assume that the development of IE *$\hat{k}$ into *s* in the latter language is an arbitrary fact of Avestan, but if there was an intermediate stage to *ś* (< IE *$\hat{k}$) then a systematic explanation emerges. If IE *$\hat{k}$ became first *ś* in Indo-Iranian, and then this sound shifted to *s* in Avestan, the latter change can be seen as the same kind of context-free change in (17) that brought Sanskrit into conformance with (6). Significantly, the intermediate stage with *ś* derives phonetic support. If sound change is gradual, then the change from a voiceless alveolopalatal stop to a voiceless alveolopalatal fricative (with an intermediate affrication stage) only involves the change of a manner feature, i.e. stop → affricate → fricative.

5. Conclusion

In the preceding paragraphs I have offered an explanation for the context-free sound change in the development of Indo-Aryan that converted all palatoalveolar sibilants

into retroflex sibilants. My claim is that this change was triggered by a sibilant opposition that is otherwise unattested cross-linguistically and that this is the only explanation that accounts for why the change was both context-free and exceptionless.

An obvious question to ask at this point is whether or not retroflex consonants in other languages have a similar historical development. One possible example is Polish. According to Stieber (1973: 55) fifteenth century Polish contrasted /š, ž/ and /ś, ź/, which would be problematic for (3) and (6) as absolute universals if both sets of sounds were [-anterior, +distributed]. Significantly, Stieber (1973: 64) notes that /š, ž/ became "dispalatalized" but that this did not take place before the fifteenth century. If "dispalatalization" involved the change from true palatoalveolar to retroflex (i.e. (17)) and if this change did not occur until *after* /ś, ź/ entered the Polish language in the fifteenth century then the latter change might have been the cause for the former one.

Whether or not the Polish retroflex sibilants, or the retroflex sibilants in other languages, have a historical development that is parallel to the equivalent Sanskrit sounds are questions I leave open for further study.

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