External sandhi in Classical Sanskrit

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November 24, 1992

Abstract

This paper offers a synchronic rule set to fully account for the standard sandhi at word boundaries in classical Sanskrit. Although Sanskrit is often characterized as having a phrasal phonology that is unnatural to the point of artificiality, this rule set shows that phonologically unnatural rules can be isolated in the lexical phonology, where one expects to find rules that require historical explanation. It also shows that with the exception of three rules that have lexical conditions, the rules of external sandhi can be described as syllable-juncture P2 rules rather than as word-juncture rules. Thus they obey Kaisse's theory of sandhi despite her original analysis. It further shows that pada suffixes, which have traditionally been held to exceptionally obey external sandhi, are not exceptional at all when syllable structure is taken into consideration. A computer programme has been developed for testing the rule set over a test suite, and a printout showing the derivation of representative word pairs is included.

1 Introduction

The Sanskrit system of external sandhi—phonological changes that are observable at word boundaries[1]—strikes observers as a natural, or perhaps artificial, wonder. Manuscripts of the classical period regularly show marvelous alternations such as the following, where the left side shows the surface form words would take in isolation, and the right side shows the form they take when combined in the same utterance:

taan + cə = taaN ʃcə

ɽaaməh + ɟəjəti= = ɽaamoo ɟəjəti *but*
    punəh + ɟəjəti = punər ɟəjəti

[1] In Sanskrit grammars, the term *sandhi* applies to phonological changes at all boundaries. I shall follow the predominant modern linguistic usage in applying it only to changes that occur at word boundaries, unless explicitly noted otherwise.

məɦiaa + iʃəh = məɦieeʃəh *but*
swəɽgee + iʃəh = swəɽgə iʃəh *but*
təsmai + iʃəh = təsmaa iʃəh *but*
guɽau + iʃəh = guɽaaʋ iʃəh

Sanskrit may be unique among languages in the amount of criticism it has received for such behaviour. On the one hand, some linguists are disturbed by the fact that such changes are represented in the writing system, and with such regularity: for with infrequent exceptions, classical texts represent sandhi changes between every pair of words in an utterance, regardless of the syntactic relation between the words. So Whitney, 101a: "This euphonic interdependence of the words of a sentence is unknown to any other language in anything like the same degree; and it cannot but be suspected of being at least in part artificial, implying an erection into necessary and invariable rules of what in the living language were only optional practices." And Mayrhofer, in his *Handbuch des Pali*: "Im Gegensatz zu dem überkünstelten, pedantisch durchgeführten System im klassischen Sanskrit ist der Satz-Sandhi ... im Pali ein viel einfacherer und natürlicher."[2] On the other hand, some linguists are upset by the nature of many of the individual rules: Why should just the contact of /n/ with coronal stops occasion the insertion of a sibilant? Why should coronal nasals but not other segments geminate in the position /V̆—#V/ (but not /V̆#—V/)? Why should duals in /-ii/, /-uu/ or /-ee/ (but not /-au/) remain unchanged before vowel-initial words, whereas other words ending in the same sounds suffer sandhi effects? Why should certain nominal inflections *(pada suffixes)* behave with respect to sandhi like separate words?[3] Why should intervocalic stops get voiced word-finally and not word-internally? Because of the well-known respect the literati of the classical period had for Paninean grammar, many people suspect these artifacts are not natural; the linguists smell a linguist, and are nervous.

Some of these arguments can however easily be stood on their head. Nowadays the extensiveness of sandhi effects in spoken language, as well as their arbitrariness (language dependence), is generally recognized. From this vantage, it is the languages *other than* Sanskrit which are artificial, when they give a word a constant spelling no matter how it is actually articulated in context.[4] We can simply be grateful that Sanskrit linguists were concerned with describing sandhi effects from an early date and that it became conventional to represent those effects in all texts throughout our period. As for the veneration of Pāṇini, this is in part overstated by those who ignore just how much the language did evolve since his day, but to the extent that it is applicable, it is no doubt a good thing. All writing traditions coalesce around certain standards. It is a blessing that Sanskrit writing was influenced by the truly excellent linguists of the Paninean

[2] I thank Andrew Garrett for this quote. See also Wackernagel I262c for some further references, including some to Sanskrit's few defenders.

[3] *Pada* means 'word.'

[4] This is of course a rhetorical overstatement. Such writing systems are simply choosing to give prominence to the lexical tier of writing. What makes the Sanskrit writing system particularly intriguing is that it has chosen to represent the segmental tier to the exclusion of any other.

school rather than by the sort of Sunday grammarians who taught generations of English writers not to split infinitives or end sentences with prepositions.

It should be pointed out however that Sanskrit is liable to the broader criticism that it is nobody's native language. Nativists who emphasize the linguistic specialization of the young child's brain for acquiring and transmitting language are likely to object to the fact that in the classical period, Sanskrit was a language learned by upper class males well after acquiring a vernacular as their first language. These linguists would hold that it is therefore dangerous to attempt to generalize about human language from anything that we can learn from this specific language. But the fact of Sanskrit's non-nativeness can be exaggerated. It is by no means a philosophical artificial language, to use Descartes' terminology, or even an Esperanto, which is derived from natural languages but whose effective authority is a rulebook fabricated by a single person; rather it is quite an ordinary descendant of the language of the Vedas (and related dialects). Whitney, whom we might expect to be most alert to the corrupting influences of Paninean grammar, held: "It cannot be too strongly urged that the Sanskrit, even that of the most modern authors, even that of the pandits of the present day, is the successor, by natural processes of tradition, of the older dialects."[5] Even those who do believe that the language did not evolve naturally after Pāṇini's codification–which, as regards external sandhi, is more or less true[6]–need to ask what sort of language Pāṇini was describing. The *communis opinio,* and a conclusion that is hard to avoid when reading his work, is that he described a standard colloquial language of his day, and that his grammar was based on spoken usage, not on philosophical ideals, literary standards, or even (except where explicitly noted) the Vedic scriptures. The worst that can be said is that his language was acrolectal, and somewhat archaic vis-à-vis the emerging Prākṛt dialects of the lower classes, but most agree that it was a bona fide mother tongue. See for example [Bhandarkar 1883] (especially p. 322-336) who, quoting a famous passage in the Mahābhāṣya, argues that Sanskrit was a native tongue for the Brahmanic classes even in Patañjali's day, several centuries after Pāṇini; [Kielhorn 1885], who opines "daß er [Pāṇini] einer Zeit angehört in der das Sanskṛit mehr war als eine Sprache der Gelehrten" (p. 186); and (Leonard) [Bloomfield 1927], who holds that "Pāṇini and Kātyāyana [but not Patañjali] recorded the facts of a standard colloquial language spoken by them as their mother-tongue and as the medium of everyday life; if, like ours, it was archaic in comparison with the normal dialects of the time, it was, like ours, native to many speakers" (p. 66).

The question of the naturalness of the language aside, I shall further argue for the naturalness of Sanskrit sandhi phonology by presenting a credibly natural

[5][Whitney 1884], p. 294.

[6]The main changes are the dropping of certain optional rules, and the simplification of vowel contraction due to the loss of the pitch accent. The MSS also apply sandhi to all word pairs, whereas in the Paninean system this is actually optional. It is possible, by the way, that the optionality of external sandhi actually reflected the fact that sandhi really occurred only in cases of close syntactic contact, and that the ancient grammarians were simply not up to the task of specifying the conditions more adequately. I rather doubt this.

rule set for sandhi. On the way, I would also like to demonstrate that with quite marginal exceptions, sandhi effects can be described by syllable juncture rules rather than by word juncture rules as one might at first expect. There are a few motivations for this. The most straightforward is that, as has been noted over and over again, there is a large overlap between sandhi effects and word-internal phonology.[7] To take just one example, adjacent vowels are contracted when suffixes are added to stems, by and large in the same way as at word junctures. It would be convenient to describe sandhi in such a way that many of the same rules can be used in lexical domains.

Another more theoretical motivation for preferring syllable boundaries is that some theories of phonology have trouble with rules' applying at word boundaries when they do not apply at lower levels. One version of this would deny that the word should be considered a phonological unit at all. Many other prosodic phonologists, while comfortable with the concept of a phonological word, would still like to apply Kiparsky's Strong Domain Hypothesis [Kiparsky 1984], which holds that a grammar can only specify where a rule stops applying, but can't explicitly restrict it from applying at lower levels. Rice for example [Rice 1990] points out that word-final but not word-internal obstruents appear to get voiced intervocalically (/tət + əsti > tədəsti/ vs /məɦiət-aa/), but the SDH is rescued if one views this as a syllable-limit effect. Lexically, C-V junctures get syllabified as -CV, so the C is not in the coda and so does not suffer the change. Before this syllabification, Rice holds that the stem-final C is extrametrical, and hence immune to such rules.

A third motivation is a gut feeling that a grammar is simplified whenever a phonological rule can be shown to operate at a more weakly conditioned stratum. Kaisse's division [Kaisse 1985] of postlexical rules as P1 ("external sandhi") and P2 ("rules of fast speech") is undoubtedly correct in principle, since certain phonological rules (such as French liaison) require access to both lexical and syntactic information; classifying a rule at the lower P2 level should amount to an implicit simplification of its structural condition. Kaisse in fact argued that rules without special lexical or syntactic conditioning *must* be P2 rules, and proclaimed the Sanskrit voicing data, which she courageously used as her first test case, to be very problematic. While it is not quite so obvious to me why sensitivity to word boundaries should not be sufficient cause for establishing a rule as P1, it turns out that my rule set fully justifies Kaisse's theory with respect to sandhi,[8] because the only P1 rules it requires are three rules that have specific lexical conditioning. At the same time, while this work does not refute Selkirk's theory of prosodic domains [Selkirk 1980], it does suggest that Sanskrit was a particularly unfortunate choice for her to demonstrate her theory with.

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[7] This was noted explicitly as long ago as the Prātiśākhyas (Allen, p. 15 n 7 cites the R̥gveda Pr. i.61).

[8] Or perhaps it's the other way around, with Sanskrit needing the justification, since Kaisse then bowed to tradition and attacked Sanskrit as a "partly artificial language, codified by the ancient grammarians", p. 22.

2 The data

This section presents the data that are to be accounted for. First it is to be emphasized that the language under consideration is standard classical Sanskrit, that is, the language that flourished during the first millenium of our era. This is to be distinguished from the Vedic language, often called Vedic Sanskrit, which because of its antiquity (the R̥gveda probably dates back to around 1000 BCE) is the object of greater interest for Indo-Europeanists. I am studying the later language largely because the Vedic texts constitute a mixture in several respects. Being an anthology of hymns from different times and places, the language is more heterogeneous than Classical Sanskrit, which standardized on Pāṇini's dialect. More problematically, the received text of the Vedas contains a mixture of sandhi which is pre-Classical (though not necessarily contemporaneous with the composition of the text) and some which is undeniably later. It is for example unequivocably clear from studying the metre that thousands of hiatus present in the original Vedic hymns have been "corrected" in the recensions. If changes like that could be made even in the face of damage to the metre, one can imagine what sort of changes might have been made that are totally undetectable in the received texts. How, for example, could one demonstrate whether Vedic itself had obstruent voice assimilation, or whether that was added during the transmission of the text in post-Vedic times, since this change would not affect the metre? But while not formally describing the Vedic sandhi, I shall nevertheless mention some of its peculiarities during the discussion of the individual rules.

The language under consideration is practically that described in Pāṇini's Aṣṭādhyāyī, which was probably composed in the fourth century BCE. But the language of the classical period has lost the lexical pitch accent that Pāṇini described, and the texts avail themselves of only a subset of the numerous optional variations he describes. Of course, even those texts present variation too, so I limit myself to the most commonly accepted, core sandhi rules as elucidated in the grammars [Whitney 1889], [Kale 1972], [Müller 1870], [Renou 1968], and [Macdonell 1927], the textbooks [Coulson 1976] and [Goldman 1987], and the sandhi workbook [Emeneau 1968]. There is a very firm consensus as to what these basic rules are. They are employed by textbooks and most normalizing modern (or at least Western) editions. Quite often the discussion will mention how the various alternatives could be accommodated, but I resist the temptation to include such devices as optional or alternative rules in this rule set. I prefer to think of the rule set as the representation of the grammar of some individual ideal speaker, but it is quite difficult to distinguish the options that are a matter of individual choice from those that are dialectal variants.

This paper uses the International Phonetic Alphabet (IPA). There is a temptation to use Indological transcription, since that is remarkably standard and will be encountered in virtually every Sanskrit grammar. But the IPA will be more familiar to linguists, and offers more flexibility in marking distinctions between phones and in denoting underlying or intermediate forms that have no surface manifestation. For Indologists, Table 1 will show the standard tran-

Dev	Indo	IPA	Dev	Indo	IPA
अ	a	ə	लँ	l̃	l̃
आ	ā	aa	म	m	m
ऐ	ai (āi)	ai	अं	ṁ	N
औ	au (āu)	au	न	n	n
ब	b	b	ङ	ṅ	ŋ
भ	bh	b^{h}	ञ	ñ	ɲ
च	c	c	ण	ṇ	ɳ
छ	ch	c^{h}	ओ	o (ō)	oo
द	d	d	प	p	p
ध	dh	d^{h}	फ	ph	p^{h}
ड	ḍ	ɖ	र	r	ɽ
ढ	ḍh	ɖ^{h}	ऋ	ṛ	ɽ̩
ए	e (ē)	ee	ॠ	ṝ	ɽ̩ɽ̩
ग	g	g	स	s	s
घ	gh	g^{h}	श	ś (ç)	ʃ
ह	h	ɦ	ष	ṣ	ʂ
ः	ḥ	h	त	t	t
इ	i	i	थ	th	t^{h}
ई	ī	ii	ट	ṭ	ʈ
ज	j	ɟ	ठ	ṭh	ʈ^{h}
झ	jh	ɟ^{h}	उ	u	u
क	k	k	ऊ	ū	uu
ख	kh	k^{h}	व	v	ʋ, w
ल	l	l	य	y	j
ऌ	ḷ	l̩			

Table 1: Correspondences between standard Indological transcription, the Devanāgarī script, and the IPA.

scriptions and the Devanāgarī characters that correspond to the IPA symbols. I am using /N/ to denote a nasal segment lacking a specific oral articulation, and geminates to represent length in both consonants and vowels.

Since at least a thousand examples would be needed to show just one instance of each relevant pair of phones that can undergo sandhi, I will dispense with the corpus of examples, and present the data in tabular form. The curious can however find many examples in Section 7, which illustrates the operation of the rule system.

Table 2 shows the sandhi of word-final vowels in terms of surface forms. For example, if word 1 ends in /-ə/ and word 2 begins with /ə-/, the sequence of word 1 and word 2 would have /aa/ replacing these two vowels. Except for /c^{h}/, the combination of initial consonant with a final vowel does not result in any change. Although there are words that end in /ɽ̩/ and others that begin in /ɽ̩/, the sandhi of the two seems not to occur in natural texts (Whitney 126, Renou

Final	Initial											
	ə	aa	i	ii	u	uu	ɽ̩	ee	ai	oo	au	c^h
ə	aa	aa	ee	ee	oo	oo	əɽ	ai	ai	au	au	əcc^h
aa	aa	aa	ee	ee	oo	oo	əɽ	ai	ai	au	au	aac^h[1]
i	jə	jaa	ii	ii	ju	juu	jɽ̩	jee	jai	joo	jau	icc^h
ii	jə	jaa	ii	ii	ju	juu	jɽ̩	jee	jai	joo	jau	iic^h
u	ʋə	ʋaa	ʋi	ʋii	uu	uu	ʋɽ̩	ʋee	ʋai	ʋoo	ʋau	ucc^h
uu	ʋə	ʋaa	ʋi	ʋii	uu	uu	ʋɽ̩	ʋee	ʋai	ʋoo	ʋau	uuc^h
ɽ̩	˚ə	ɽaa	ɽi	ɽii	ɽu	ɽuu	•	ɽee	ɽai	ɽoo	ɽau	ɽ̩cc^h
ee	ee	əaa	əi	əii	əu	əuu	əɽ̩	əee	əai	əoo	əau	eec^h
ai	aaə	aaaa	aai	aaii	aau	aauu	aaɽ̩	aaee	aaai	aaoo	aaau	aic^h
oo	oo	əaa	əi	əii	əu	əuu	əɽ̩	əee	əai	əoo	əau	ooc^h
au	aaʋə	aaʋaa	aaʋi	aaʋii	aaʋu	aaʋuu	aaʋɽ̩	aaʋee	aaʋai	aaʋoo	aaʋau	auc^h

Table 2: Result of sandhi when words ending in a final vowel precede words beginning with the specified phone. **Note 1:** The consonant geminates after the preposition /aa/ or the adverb /maa/.

40). Furthermore, /l̩/ and /ɽ̩ɽ̩/ do not occur at word boundaries in naturally occurring words (only in grammatical artifacts such as the name of the sounds themselves or of their letters).

The sandhi of word-final consonants is shown in Tables 3–4. Consonants omitted from the tables do not occur at word boundaries, or are very rare. The segments listed in the "Final" column are the forms that appear in isolated words.

External sandhi is specified as operating between words within an utterance—that is, when there is no pause between them. This is the domain which I shall focus on in this paper. It is also said to apply between elements in a nominal compound; between verbal prefixes (upasargas) and their verb; between the noun stem and the inflectional suffixes /b^{h}jaam/, /b^{h}is/, /b^{h}jas/ and /su/ (the pada suffixes); and between a stem and a secondary suffix beginning with a consonant other than /j/ (Macdonell 16a, Renou 31, Whitney 109, 111). I shall often discuss how these relate to word sandhi, without however attempting as rigorous a description of them.

Sandhi is specified as operating from left to right. That is, when three words A B C are adjacent in a phrase, sandhi applies to C and the output of the sandhi of A and B. This is of course relevant only for very short B. Whitney 127b cites /indɽə + aa + iɦi/ as having the output /indɽeeɦi/, not /indɽaiɦi./

A few words and morphemes have exceptional sandhi. The pronouns /səs/ and /eeʂəs/ (nominative masculine singular) behave before consonants as if they had no final /s/ (Macdonell 48). /b^{h}oos/ and a few other more rare contracted vocatives appear in the form /-oo/ before any voiced segment (Macdonell 49; Whitney 174b). Several words in /-əh/ follow the "elsewhere" /-h/ pattern rather than the more specific /-əh/ pattern. The dual inflectional endings (whether nominal or verbal) /-ii, -uu/ and /-ee/, as well as the pronoun /əmii/ (nominative masculine plural) do not undergo sandhi change as a prior word

Final	Initial									
	V	k^{h}	g^{h}	c^{h}	ɟ^{h}	ʈ^{h}	ɖ^{h}	t^{h}	d^{h}	n
k	gV	kk^{h}	gg^{h}	kc^{h}	gɟ^{h}	kʈ^{h}	gɖ^{h}	kt^{h}	gd^{h}	ŋn
ŋ	ŋV[1]	ŋk^{h}	ŋg^{h}	ŋc^{h}	ŋɟ^{h}	ŋʈ^{h}	ŋɖ^{h}	ŋt^{h}	ŋd^{h}	ŋn
ʈ	ɖV	ʈk^{h}	ɖg^{h}	ʈc^{h}	ɖɟ^{h}	ʈʈ^{h}	ɖɖ^{h}	ʈt^{h}	ɖd^{h}	ɳn
t	dV	tk^{h}	dg^{h}	cc^{h}	ɟɟ^{h}	ʈʈ^{h}	ɖɖ^{h}	tt^{h}	dd^{h}	nn
n	nV[1]	nk^{h}	ng^{h}	Nʃc^{h}	ɲɟ^{h}	Nʂʈ^{h}	ɳɖ^{h}	Nst^{h}	nd^{h}	nn
p	bV	pk^{h}	bg^{h}	pc^{h}	bɟ^{h}	pʈ^{h}	bɖ^{h}	pt^{h}	bd^{h}	mn
m	mV	Nk^{h}	Ng^{h}	Nc^{h}	Nɟ^{h}	Nʈ^{h}	Nɖ^{h}	Nt^{h}	Nd^{h}	Nn
l	lV	lk^{h}	lg^{h}	lc^{h}	lɟ^{h}	lʈ^{h}	lɖ^{h}	lt^{h}	ld^{h}	ln
h	ɽV	hk^{h}	ɽg^{h}	ʃc^{h}	ɽɟ^{h}	ʂʈ^{h}	ɽɖ^{h}	st^{h}	ɽd^{h}	ɽn
əh[2]	əV[3]	əhk^{h}	oog^{h}	əʃc^{h}	ooɟ^{h}	əʂʈ^{h}	ooɖ^{h}	əst^{h}	ood^{h}	oon
aah	aaV	aahk^{h}	aag^{h}	aaʃc^{h}	aaɟ^{h}	aaʂʈ^{h}	aaɖ^{h}	aast^{h}	aad^{h}	aan

Table 3: Sandhi output for word-final consonants (see also next table). V as an initial stands for any vowel; V in the output represents the same vowel. The raised *h* means that the output is aspirated if and only if the initial is. **Note 1:** The nasal geminates after a short vowel. **2:** A few /-əh/ words follow the more general /-h/ pattern. **3:** But /əh/ + /ə/ > /oo/.

Final	Initial										
	p^{h}	b^{h}	m	j	ɽ	l	ʋ	ʃ	ʂ	s	ɦ
k	kp^{h}	gb^{h}	ŋm	gj	g˚	gl	gʋ	kʃ	kʂ	ks	gg$^{\mathrm{h}}$
ŋ	ŋp^{h}	ŋb^{h}	ŋm	ŋj	ŋ˚	ŋl	ŋʋ	ŋʃ	ŋʂ	ŋs	ŋɦ
ʈ	ʈp^{h}	ɖb^{h}	ɳm	ɖj	ɖ˚	ɖl	ɖʋ	ʈʃ	ʈʂ	ʈs	ɖɖ$^{\mathrm{h}}$
t	tp^{h}	db^{h}	nm	dj	dɽ	ll	dʋ	cc$^{\mathrm{h}}$	tʂ	ts	dd$^{\mathrm{h}}$
n	np^{h}	nb^{h}	nm	nj	nɽ	l̃l	nʋ	ɲc$^{\mathrm{h}}$	nʂ	ns	nɦ
p	pp^{h}	bb^{h}	mm	bj	bɽ	bl	bʋ	pʃ	pʂ	ps	bb$^{\mathrm{h}}$
m	Np^{h}	Nb^{h}	Nm	Nj	Nɽ	Nl	Nʋ	Nʃ	Nʂ	Ns	Nɦ
l	lp^{h}	lb^{h}	lm	lj	lɽ	ll	lʋ	lʃ	lʂ	ls	lɦ
h	hp^{h}	ɽb^{h}	ɽm	ɽj	ɽ[1]	ɽl	ɽʋ	hʃ	hʂ	hs	ɽɦ
əh	əhp^{h}	oob^{h}	oom	ooj	ooɽ	ool	ooʋ	əhʃ	əhʂ	əhs	ooɦ
aah	aahp^{h}	aab^{h}	aam	aai	aaɽ	aal	aaʋ	aahʃ	aahʂ	aahs	aaɦ

Table 4: Continuation of preceding table. **Note 1:** With compensatory lengthening of preceding short vowel.

(Pāṇini 1.1.11-12; Renou 42a, [Roberge 1986]). That is, they retain their long syllabic final even when preceding a word that begins with a vowel, resulting in hiatus. Certain indeclinable interjectional particles are also specified as immune to sandhi with the following word. The formulation of the rule varies (Macdonell 24 and Whitney 138f: interjections ending in a vowel; Renou 42b: interjections composed of a single vowel, or ending in a diphthong; Müller 47–50: indeclinables ending in /-oo/ or consisting only of a single vowel, if an interjection; and certain particles; see also Pāṇini 1.1.14-18). In the classical language, this seems to amount to the words /aa/ (the interjection, not the homophonous preposition), /i, u, hee/, and /əɦoo/, none of which are particularly common. Finally, grammarians enumerate many non-lexical circumstances, some quite arcane, in which sandhi does not occur. These include the neighbourhood of vocatives (Coulson p. 67), extra-long vowels (Renou 42c, Whitney 138e, Müller 51), and minor verse boundaries (*pādas*; Macdonell 26, Whitney 125d). These cases, as well as that of interjections, seem to amount to the presence of pause despite lack of punctuation; see further Renou 30. I will treat all of these pauses as given and not try to account for them. However, the pragr̥hyas that are not related to phonological phrasing will require an explanation.

3 Formalism

This paper uses a fairly stodgy formalism. This conservatism is rooted partly in a finding that while many current theories have many valuable insights, the traditional SPE approach appeared quite adequate to describe the processes under consideration. For example, while assimilation looks more perspicuous in an autosegmental feature geometry framework, where place node links get shared, no later rule ever seemed to depend crucially on the fact that such segments had shared, rather than duplicated, features. Also, since later formalisms tend to be extensions to, rather than replacements of, the traditional approach, implementing them for the computerized verification would require substantially more mechanism, which would be otiose in the absence of any real return in actual power. This is particularly true with respect to many of the theorems developed within Lexical Phonology to account for the scope and ordering of rules. Many of these theories constitute great insights, but are not yet at the point where they obviate the need for explicit rule ordering. Since rule ordering alone is sufficient for describing external sandhi, I restrict myself to that mechanism.

Another problem with incorporating too much of the latest theory is that this paper would inevitably appear to be polemic. I do not wish to use this space to attack or defend any of the current theories about the organization of the phonology and its interaction with other components of the grammar, but to explore quite narrowly the role of word and syllable boundaries in Sanskrit sandhi. The scheme is to use a theory that's old enough that the paper will appear to be theory-neutral.

I do assume some version of lexical phonology. Some rules apply within the lexicon, cyclically, at times of derivation; some apply postcyclically; others apply postlexically. Only the postlexical rules have access to the context a word is in. The postlexical rules proper (P2) are noncyclic and do not see word boundaries; some earlier ones (P1) operate at lower prosodic levels and may have some lexical conditioning (e.g., word-specific exceptions). Syllables are a prosodic feature that are accessible throughout the grammar.

3.1 Features

It is convenient to assume that features are organized into nodes, as is advocated in various versions of feature geometry. As shown in Table 5, this paper makes use of such organization, although the grammar rules do not make explicit use of node sharing. When a node is negative, all its subnodes are irrelevant (or, for practical purposes, negative). The table shows segments that appear at any stage in these derivations; some are underlying forms, some are surface forms, and some are forms that arise and disappear in the course of a derivation.

Redundant features are fleshed out before the utterance reaches the sandhi component. This is apparent from the fact that in sandhi obstruents can for example assimilate voice from sonorants, while the voice of sonorants is one of the most obviously redundant features. Because of the irrelevance of underspecification to sandhi, I shall here treat all segments coming into sandhi as being fully specified as per Table 5.

3.2 Syllabic licensing

The syllable certainly has structure, and probably has more than one structure simultaneously (e.g., onset-rhyme vs moras). It is however hard to say which of these structures is basic and which are derived, or whether they are all derived on the fly by parsing segments that have more basic features such as *syll*. After trying several implementations, I eventually decided that overall simplicity favoured treating the syllable components as if they were flat: any advantage that accrued from being able to manipulate the nucleus or coda as a unit was at least outweighed by the necessity of keeping such structures well-formed during manipulations that didn't really care about them. As a result, the rules presented here simply mention *syll* as a segment feature. It would however be of great advantage if we could conceive of syllable structure as an alternative view onto the syllable, which is automatically maintained by parsing the syllable on the fly, and this capability is assumed in the informal discussion. This will often allude to onsets, rhymes, and codas in their normal meaning, as well as light and heavy syllables (the latter being bimoraic, having at least one segment following the nuclear vowel (or the head of the nucleus)).

For those readers familiar with Indian writing systems, I should state at the outset that my treatment of syllabification has nothing to do with the divisions required by the script. With the exception of a few coda consonants that are written diacritically, the script divides the utterance into maximal C_0V units. This should simply be considered a peculiarity of the writing system.

							Place						Laryngeal	
							Labial	Coronal		Dorsal				
	syll	cons	son	cont	lat	nas	lab	cor	ant	high	low	back	voiced	spread
p	−	+	−	−	−	−	+	−			−		−	
p^h	−	+	−	−	−	−	+	−			−		−	+
b	−	+	−	−	−	−	+	−			−		+	−
b^h	−	+	−	−	−	−	+	−			−		+	+
m	−	+	+	−	−	+	+	−			−		+	−
w	−	−	+	+	−	−	+	−		+	−	+	+	−
u	+	−	+	+	−	−	+	−		+	−	+	+	−
ʋ	−	−	+	+	−	−	+	−			−		+	−
t	−	+	−	−	−	−	−	+	+		−		−	
t^h	−	+	−	−	−	−	−	+	+		−		−	+
d	−	+	−	−	−	−	−	+	+		−		+	−
d^h	−	+	−	−	−	−	−	+	+		−		+	+
d^l	−	+	−	−	+	−	−	+	+		−		+	−
n	−	+	+	−	−	+	−	+	+		−		+	−
l	−	+	+	−	+	−	−	+	+		−		+	−
l̩	+	+	+	−	+	−	−	+	+		−		+	−
l̃	−	+	+	−	+	+	−	+	+		−		+	−
s	−	+	−	+	−	−	−	+	+		−		−	
z	−	+	−	+	−	−	−	+	+		−		+	−
z̞	−	−	+	+	−	−	−	+	+		−		+	−
ɽ	−	+	+	+	−	−	−	+	−		−		+	−
ɽ̩	+	+	+	+	−	−	−	+	−		−		+	−
ʈ	−	+	−	−	−	−	−	+	−		−		−	
$ʈ^h$	−	+	−	−	−	−	−	+	−		−		−	+
ɖ	−	+	−	−	−	−	−	+	−		−		+	−
$ɖ^h$	−	+	−	−	−	−	−	+	−		−		+	+
ɳ	−	+	+	−	−	+	−	+	−		−		+	−
ʂ	−	+	−	+	−	−	−	+	−		−		−	
ʐ	−	+	−	+	−	−	−	+	−		−		+	−
c	−	+	−	−	−	−	−	+	−	+	−	−	−	
ch	−	+	−	−	−	−	−	+	−	+	−	−	−	+
ɟ	−	+	−	−	−	−	−	+	−	+	−	−	+	−
$ɟ^h$	−	+	−	−	−	−	−	+	−	+	−	−	+	+
ɲ	−	+	+	−	−	+	−	+	−	+	−	−	+	−
ʃ	−	+	−	+	−	−	−	+	−	+	−	−	−	
j	−	−	+	+	−	−	−	+	−	+	−	−	+	−
i	+	−	+	+	−	−	−	+	−	+	−	−	+	−
k	−	+	−	−	−	−	−	−		+	−	+	−	
k^h	−	+	−	−	−	−	−	−		+	−	+	−	+
g	−	+	−	−	−	−	−	−		+	−	+	+	−
g^h	−	+	−	−	−	−	−	−		+	−	+	+	+
ŋ	−	+	+	−	−	+	−	−		+	−	+	+	−
ɦ	−	+	−	+	−	−			−				+	+
h	−	+	−	+	−	−			−				−	+
N	−	+	+	−	−	+			−				+	−
a	+	−	+	+	−	−	−	−		−	+	+	+	−
ə	+	−	+	+	−	−	−	−		−	−	+	+	−
e	+	−	+	+	−	−			−				+	−
o	+	−	+	+	−	−	+	−		−	−	+	+	−

Table 5: Distinctive features of Sanskrit phones.

At a sufficiently deep level, any sonorant may fill the nucleus, but by the time we shall get hold of them, nasals become /a/ in that position. For present purposes, the nucleus can be any of the [+syll], which are all [−nas +son +cont +voiced −spread] (/u/, /i/, /l̩/, /ɽ̩/, /a/). [+low] segments cannot be licensed outside the nucleus; that is, there is no [−syll] counterpart to /a/, but all the other vowels have one (/w/, /j/, /l/, /˚/).

The rhyme as a whole has a fairly simple structure. All vowels may be long (geminate). /l̩l̩/ does not in fact occur in natural words, but then only one word has short /l̩/, so that gap is not surprising. Vowels may also be followed by a glide ([−cons]) to form a diphthong. On the surface all vowels and diphthongs have at most two segments. During the course of derivation longer sequences are built up, but any past the second seem to behave as glides if such a correspondent exists (i.e., the rules generate /aaa/, becoming surface /aa/, and /iij/, becoming surface /ii/). With the exception of such intermediate extra-long sequences, diphthongs must begin with /a/. As for the rest of the rhyme, the coda does not license laryngeal features; it shall be seen that on the surface, obstruents in the coda take their voice and aspirateness from the next syllable, or are [−Laryngeal] utterance-finally. Palatals are not present except as part of geminates sharing *Place* with the following onset. Unarticulated segments are necessarily spread if continuant (/h/), or else are nasals (/N/). There is an important restriction that on the surface, the coda can contain no more than one segment after the vowel or diphthong, with the rare exception that a stop may appear after a /˚/, but evidence will be adduced for some longer codas earlier in the derivation. The statement of [Steriade 1982] (p. 332) that Sanskrit coda structures are the mirror images of onset structures cannot be credited: she believes that codas can have up to eight consonants, but that it is a coincidence that this never happens. To the contrary, we shall see that the restriction to a single consonant is an important constraint in the derivation of Sanskrit strings.

It is important to also understand the possible onsets a Sanskrit syllable may have, since it is my thesis that many of the so-called sandhi rules depend crucially on lexical syllabification, which follows the maximum onset principle. The onset doesn't change much during derivation. Its structure is as follows, as determined in part by an inspection of the word-initial clusters in Monier-Williams:

Any of the consonants that are introduced lexically can occur singly in the onset (namely, /p, p^h, b, b^h, m, w=ʋ, t, t^h, d, d^h, n, l, s, ɽ, ʈ, $ʈ^h$, ɖ, $ɖ^h$, ɳ, ʂ, c, c^h, ɟ, $ɟ^h$, ʃ, j, k, k^h, g, g^h, ɦ/), and, on the surface, /ŋ/, by resyllabification from the coda.

Any of these can also be followed by a non-identical glide.[9] Most can be followed by a liquid (/l, ˚/), but there are strange gaps: of the sonorants, only

[9] Apparently a syllable can also begin with double /jj/; this would explain words like /pənaajjə/ (cited by Allen, p. 34 n15), since tautosyllabic /aaj/ would get its vowel shortened.

the labial ones can (/m, w/); /ɟ̊/ but no other combination with palatals[10]; no retroflexes or voiceless aspirates; /̊/ but no /l/ after articulated voiced aspirates or coronals.

Any obstruent can be followed by a nasal, with the possible exception of voiceless aspirates and retroflex stops. The ones I actually observed are /kn, gn, g^{h}n, ɟɲ, ɟm, tm, d^{h}m, ʃn, ʃm, s̪ɳ, sn, sm, ɦn, ɦm/, where /ɲ/ and /ɳ/ are assimilated forms of /n/.[11] There is also a rare /mn/. Nasal clusters appear not to be followable by any other segment.

/s/ may precede any unvoiced stop; it assimilates in place to a following coronal (/s̪ʈ/, /ʃc/). These clusters cannot be followed by other segments except glides and /̊/. Steriade, p. 317, argues that /s/ is not really a possible first member of an onset cluster in Sanskrit, but floats extrametrically before the onset. This theory, based largely on patterns of reduplication, appears contradicted by the fact (to her coincidental) that nasals or /s/ do not follow these /sT/ complexes: */skn/, */sks/. But even if Steriade is right about /s/'s being extrasyllabic before oral stops, extrametricality is generally held to disappear postlexically, resulting in full syllabification outside the lexicon ([Myers 1987] citing [Kiparsky 1985]), so the extrametricality would be irrelevant to this study of sandhi. I will therefore make the simplifying assumption that the /s/ really is part of the syllable.

Any unvoiced unaspirated stop except for the palatal /c/ and retroflex /ʈ/ may be followed by /s/; after /k/ (by far the most common case), this becomes /s̪/. These may be followed by a nasal—I note only /ks̪ɳ/ and /ks̪m/—but no other segment.

The exception of retroflexes and voiceless aspirates from many of these clusters is due in part to their rarity, and in part to the related fact that they are not directly of Indo-European origin, but are derived from other sounds only in certain environments (Whitney 38, 46), or borrowed from neighbouring languages.

Steriade, p. 329, claims that these onset patterns all fall out from a language-specific sonority hierarchy, which consists of the features *son, cont, lat, cor,* in descending order. That is, [+son] segments are found inside [−son] segments; among those with the same *son* value, [+cont] ones are inside [−cont] ones, etc. Although this overpredicts a few clusters (*/pt/, */bd/, */kt/, */gd/, */nl/), fails to account for some (/wl/, /ɽj/, and, intentionally, the /sT/ clusters), and has no account for non-local structure in the onset templates (e.g., no */ks̪ʈ/ despite the frequency of /ks̪/ and of /st/), it is a useful and important generalization.

[10] But /c^{h}ɽ/, /c^{h}l/ can arise by ʃ-Desibilation.
[11] /c^{h}m/ and /c^{h}n/ also arise by ʃ-Desibilation.

4 Underlying forms

This rule system assumes a few important differences between the surface forms of individual words and the underlying representation. As will be explained in more detail below, the phones listed in the data Table 2 as /ee, oo, ai/, and /au/ are here treated as underlyingly /aj, aw, aaj/ and /aaw/ (cf. Whitney 28a). The lexicon does not contain /h/, but has /s/ or /˚/ (Wackernagel I263c also advocates many of these underlying forms). The segments /ʋ/ and /ə/ are underlyingly /w/ and /a/. I will also prefer to treat /tʃ/ as the underlying form of all words with /c^h/ or /cc^h/.

The selection of the final consonants that a word has is often considered a part of the study of sandhi. For example, a noun whose stem ends in /g/ or even /ɟ/ before a vowel-initial ending will end in /k/ if the stem appears utterance-finally. By and large, these changes fall out from the facts of feature licensing in codas discussed above. Obstruents become [−Laryngeal −cont], which may be equated with voiceless unaspirated stop;[12] palatals become velars (Pāṇini 8.2.30), but sometimes retroflexes; /ɦ/ becomes velar, but occasionally retroflex or dental (Macdonell 79–81; Whitney 122, 141–142, 145, 147). Some coda clusters are reduced (Pāṇini 8.2.23-24). It is of course difficult to decide how far a study of sandhi should go in accounting for the isolated form of word finals, without first developing an account for a large part of the morphology of the language. The neutralization of voice appears to be postlexical, and certainly the surface voice is determined by the word's neighbour. The neutralization of aspiration could be handled by the same process (Delaryngealization), although the consequent restoration of aspiration to an initial previously suppressed by Grassmann's Law (Whitney 155), a lexical process, indicates that the proper domain for deaspiration is lexical. The alternation of velars and palatals would also seem to be lexically determined: note that the velars may appear even before vowels in some derivatives (Whitney 216a), and that some palatals alternate with retroflexes (Whitney 219). /ɦ/ also has the appearance of being a lexically determined variant of /g^h/ or other voiced aspirates: note that historically, one source is /g^h/ before front vowels, just as the palatals derive from /k/ or /g/ before front vowels, and so one might expect the two sets to behave similarly. As for the desibilation of final /ʂ/ and /ʃ/, one is tempted to treat them as a part of sandhi, but since there are several lexical exceptions (/ʂ/ becomes /ʈ/ before /s/ in nouns, but becomes /k/ in verbs), and since the desibilations parallel the obviously lexical desibilation of /s/ in certain contexts (Whitney 167-168), it seems more likely that desibilation in general is lexical. Even the reduction of the number of segments in the coda must be partly lexical: /-ɽC/ is reduced when -C is a different morpheme, but not when it belongs to the same root as the /˚/ (Wackernagel I261a). In fine, I assume that the lexical phonology has given us codas that already have single consonants, except for /nC/ and

[12] There was however some debate among Indian linguists as to whether the final was to be considered voiced or voiceless (Pāṇini 8.4.56), but the manuscripts always write them voiceless (Whitney 141b, Renou 28a).

Final	Initial										
	a	aa	i	ii	u	uu	ɽ̩	aj	aaj	aw	aaw	tʃ
a	aa	aa	ee	ee	oo	oo	əɽ̩	ai	ai	au	au	əcc^{h}
aa	aa	aa	ee	ee	oo	oo	əɽ̩	ai	ai	au	au	aac^{h}[1]
i	jə	jaa	ii	ii	ju	juu	jɽ̩	jee	jai	joo	jau	icc^{h}
ii	jə	jaa	ii	ii	ju	juu	jɽ̩	jee	jai	joo	jau	iic^{h}
u	ʋə	ʋaa	ʋi	ʋii	uu	uu	ʋɽ̩	ʋee	ʋai	ʋoo	ʋau	ucc^{h}
uu	ʋə	ʋaa	ʋi	ʋii	uu	uu	ʋɽ̩	ʋee	ʋai	ʋoo	ʋau	uuc^{h}
ɽ̩	˚ə	ɽaa	ɽi	ɽii	ɽu	ɽuu	•	ɽee	ɽai	ɽoo	ɽau	ɽ̩cc^{h}
aj	ee	əaa	əi	əii	əu	əuu	əɽ̩	əee	əai	əoo	əau	eec^{h}
aaj	aaə	aaaa	aai	aaii	aau	aauu	aaɽ̩	aaee	aaai	aaoo	aaau	aic^{h}
aw	oo	əaa	əi	əii	əu	əuu	əɽ̩	əee	əai	əoo	əau	ooc^{h}
aaw	aaʋə	aaʋaa	aaʋi	aaʋii	aaʋu	aaʋuu	aaʋɽ̩	aaʋee	aaʋai	aaʋoo	aaʋau	auc^{h}

Table 6: Result of sandhi when words ending in a final vowel precede words beginning with the specified phone. Same as Table 2, modified to use theory-specific segment sequences for inputs. **Note 1:** The consonant geminates after the preposition /aa/ or the adverb /maa/.

permitted /rC/; no fricatives but /s/; and no palatals or /ɦ/.

This is corroborated by the study of nonce words. In his grammar, Pāṇini makes use of sigla *(pratyāhāras),* phoneme class markers that have the form of artificial closed syllables. One may observe that Pāṇini nowhere makes use of laryngeal distinctions in the coda of these sigla, but he does permit them to end in /c/, /ʂ/ and /ʃ/: for example, his very first rule is /vɽ̩dd^{h}iɽaadaic/, with a /c/ in absolute final position. This could be accounted for if one assumes that alternations like /k/ with /c/ and /ʂ/ with /ʈ/ are handled by cyclic lexical rules;[13] the Strict Cycle Condition[14] would ensure that nonce words, which are underived, would be presented unchanged to the postlexical component.

For ease of reference, the sandhi charts, Tables 2–4, are reprinted here as Tables 6–8, this time giving for the inputs the segments that are hypothesized at time of emergence from the lexicon.

Ultimately, the best justification for the choice of the underlying forms is the simplicity and naturalness of the rule system that is built on that choice, but it might not be remiss to briefly justify some of these choices here. Most of them are obvious and have been widely proposed. The choice of /aj/ and /aw/ as the underlying forms of /ee/ and /oo/ is immediately apparent from the sandhi tables. In sandhi, /ee/ and /oo/ are produced precisely where the inputs are /a(a)/ on the left and /i(i)/ or /u(u)/ on the right. As inputs to sandhi, their output before most vowels is /ə/ (/a/); this can be seen as parallel to the dropping of /j/ when /aaj/ (i.e., surface /ai/) appears before the same vowels. It also turns out that in intraword phonology, surface /ee/ and /oo/ before consonants alternate with /ai/ and /aʋ/ before vowels. There are also

[13] One would have to provide, however, as Pāṇini did, that words and compound elements which appear to end in the bare stem actually end in a zero, or subsequently deleted, phoneme.

[14] [Kiparsky 1982] atributes the SCC to Joan Mascaró's 1976 dissertation.

Final	Initial									
	V	k^h	g^h	c^h	ɟ^h	ʈ^h	ɖ^h	t^h	d^h	n
k, g	gV	kk^h	gg^h	kc^h	gɟ^h	kʈ^h	gɖ^h	kt^h	gd^h	ŋn
ŋk	ŋV[1]	ŋk^h	ŋg^h	ŋc^h	ŋɟ^h	ŋʈ^h	ŋɖ^h	ŋt^h	ŋd^h	ŋn
ʈ, ɖ, c, ɟ	ɖV	ʈk^h	ɖg^h	ʈc^h	ɖɟ^h	ʈʈ^h	ɖɖ^h	ʈt^h	ɖd^h	ɳn
t, d	dV	tk^h	dg^h	cc^h	ɟɟ^h	ʈʈ^h	ɖɖ^h	tt^h	dd^h	nn
n	nV[1]	nk^h	ng^h	Nʃc^h	ɲɟ^h	Nʂʈ^h	ɳɖ^h	Nst^h	nd^h	nn
p, b	bV	pk^h	bg^h	pc^h	bɟ^h	pʈ^h	bɖ^h	pt^h	bd^h	mn
m	mV	Nk^h	Ng^h	Nc^h	Nɟ^h	Nʈ^h	Nɖ^h	Nt^h	Nd^h	Nn
l	lV	lk^h	lg^h	lc^h	lɟ^h	lʈ^h	lɖ^h	lt^h	ld^h	ln
s, ɽ	ɽV	hk^h	ɽg^h	ʃc^h	ɽɟ^h	ʂʈ^h	ɽɖ^h	st^h	ɽd^h	ɽn
as	əV[3]	əhk^h	oog^h	əʃc^h	ooɟ^h	əʂʈ^h	ooɖ^h	əst^h	ood^h	oon
aas	aaV	aahk^h	aag^h	aaʃc^h	aaɟ^h	aaʂʈ^h	aaɖ^h	aast^h	aad^h	aan

Table 7: Sandhi output for word-final consonants (see also next table). Same as Table 3, using theory-specific inputs. **Note** 1: The nasal geminates after a short vowel. 3: But /as/ + /a/ > /oo/.

Final	Initial										
	p^h	b^h	m	j	ɽ	l	w	ʃ	ʂ	s	ɦ	∅
k, g	kp^h	gb^h	ŋm	gj	gɽ	gl	gʋ	kʃ	kʂ	ks	gg^h	k
ŋk	ŋp^h	ŋb^h	ŋm	ŋj	ŋɽ	ŋl	ŋʋ	ŋʃ	ŋʂ	ŋs	ŋɦ	ŋ
ʈ, ɖ, c, ɟ	ʈp^h	ɖb^h	ɳm	ɖj	ɖɽ	ɖl	ɖʋ	ʈʃ	ʈʂ	ʈs	ɖɖ^h	ʈ
t, d	tp^h	db^h	nm	dj	dɽ	ll	dʋ	cc^h	tʂ	ts	dd^h	t
n	np^h	nb^h	nm	nj	nɽ	l̃l	nʋ	ɲc^h	nʂ	ns	nɦ	n
p, b	pp^h	bb^h	mm	bj	bɽ	bl	bʋ	pʃ	pʂ	ps	bb^h	p
m	Np^h	Nb^h	Nm	Nj	Nɽ	Nl	Nʋ	Nʃ	Nʂ	Ns	Nɦ	m
l	lp^h	lb^h	lm	lj	lɽ	ll	lʋ	lʃ	lʂ	ls	lɦ	l
s, ɽ	hp^h	ɽb^h	ɽm	ɽj	ɽ[1]	ɽl	ɽʋ	hʃ	hʂ	hs	ɽɦ	h
as	əhp^h	oob^h	oom	ooj	ooɽ	ool	ooʋ	əhʃ	əhʂ	əhs	ooɦ	əh
aas	aahp^h	aab^h	aam	aai	aaɽ	aal	aaʋ	aahʃ	aahʂ	aahs	aaɦ	aah

Table 8: Continuation of preceding table. "∅" column shows pausal forms. **Note** 1: With compensatory lengthening of preceding short vowel.

several alternations where /i/ and /u/ alternate with /ee/ and /oo/, and these happen in the same morphological environments where /r̥/ and /l̥/ alternate with /a˚/ and /al/, suggesting that the actual alternation is between /a/ and zero (full and reduced grade of Proto-Indo-European, usually called guṇa and "normal" grade in Sanskrit). Also, /ee/ and /oo/ correspond to /Vi/ and /Vu/ in other Indo-European languages, so there is a clear historical explanation of how /aj/ and /aw/ could get to be underlying forms (PIE a/e/o became /a/ in Sanskrit).[15] Finally, it is noteworthy that /ee/ and /oo/ appear only long.

Of course, the fact that Sanskrit has separate surface diphthongs /ai/ and /au/[16] is initially alarming, but it turns out that there are also strong arguments for assuming that these are underlyingly something else, namely, /aaj/ and /aaw/. The sandhi tables are again convincing. When the diphthongs are finals of the prior word before a vowel, the output always has long /aa/. And the diphthongs appear as the output of sandhi only when the input is /a(a)/ before surface /ee/ or /oo/, which we have already seen to be underlying /aj/ and /aw/. So /a(a)/ plus /i/ produces /aj/ (/ee/), but /a(a)/ plus /aj/ produces the /aaj/ (/ai/) diphthong: it arises precisely when there is one more /a/ unit on the right than in the forms that produce the monophthongs /ee/ and /oo/. Considerations of lexical phonology and morphology also lead to the same conclusions.

With rare exceptions, /h/ occurs only at the end of words or compound elements. Historically, it corresponds to /s/ or /r/ in other Indo-European languages. Among the evidence that these segments are still underlying in Sanskrit is the fact that the sandhi of /h/ before voiced segments is generally /˚/, and that it appears as a sibilant before many voiceless segments. Phonetically, it would be quite natural for an underlying /s/ to become the forms seen in the sandhi tables: another sibilant (through assimilation), /h/ (through lenition), or /˚/ (rhotacization), or for /˚/ to do the same (perhaps via a derhoticization to /s̥/), but it would be unexpected for an underlying /h/ to turn into these segments. There is also much morphological evidence: for example, the nominative /mənəh/ corresponds to the instrumental /mənəsaa/. Evidence that Sanskrit actually retains the distinction /s/ vs. /˚/ and does not, for example, collapse both to /s/, is small but overwhelming: the sandhi of prior elements ending in what I claim to be underlying /-as/ is different from those ending in underlying /-a˚/; the latter are the /-əh/ words that Table 3 mentioned as behaving exceptionally like general /-h/ words. This distinction by and large corresponds with the etymological facts. However, after other vowels there does not seem to be any synchronic evidence in favour of retention of the distinction, so I shall assume /s/ as the source of /h/ in those cases. As will be discussed later, /s/ or /˚/ is subject to the dearticulation when it is in the syllable coda.

[15] Allen p. 31 mentions evidence for the diphthongal value at surface level in some early Indian dialects.

[16] The distinction between i and j, as well as u and w, should be ignored. I use the former, vocalic, symbols in surface phonetic forms, but the latter, nonsyllabic, symbols for underlying forms and virtually the entire length of the derivation.

That /ʋ/ is underlyingly /w/ is evident from the phoneme's close connection to /u/ in the sandhi as well as in the morphology: vocative /ʋəd^{h}u/ vs. instrumental /ʋəd^{h}ʋaa/ 'woman'. It is also known that /w/ is the historical precursor of the sound in Proto-Indo-European.

That /ə/ is underlyingly /a/ was explicitly noted by Pāṇini in his celebrated rule "a ə"—/a/ goes to /ə/, which followed all other rules in his grammar. The vowel appears to remain open in the (surface) diphthongs /ai/ and /au/ (which Pāṇini treated as unitary, therefore not subject to his rule), so there is a complementary distribution to account for. Another structural argument is that there is no short /a/ (except in these diphthongs) or long /ə/. In sandhi and in certain morphological processes it is apparent that /aa/ is the long form of /ə/, or the result of combining two /ə/. For these reasons, it seems best to join Pāṇini in treating the /ə/ as a very surfacy variant of /a/.

The traditional explanation for the /c^{h}/ vs. /cc^{h}/ alternation, dating back at least to Pāṇini, is that underlying /c^{h}/ geminates in certain positions: word-internally, at the beginning of a word after a word ending in a short vowel, at the beginning of a word after the words /maa/ or /aa/, and optionally at the beginning of a word after other long vowels. However, when one includes this option, this enumeration includes all instances in which a geminate is structurally permitted (since word-internal /c^{h}/ is always intervocalic). Since no other segment spontaneously geminates simply because it is in a position that permits geminates, it seems much more natural to assume that the geminate is underlying, but is reduced whenever it ends up in a position where geminates are not allowed. The only phenomenon that would require some special attention then is the option of degeminating word-initially after long vowels (except for the two enumerated words). Here there seems to be some compromise or wavering between a tendency to generalize utterance-initial conditions for word-initial segments and a tendency to consider the segment stream without reference to word boundaries. If one consistently avails oneself of the option of using single segments after /$\bar{\mathrm{V}}$/, the determining factor would appear to be syllable length: the /c^{h}c^{h}/ sequence is degeminated only if that would not change the weight of the syllable. One may go a step further, however. In external sandhi, /cc^{h}/ is generated by the heterosyllabic sequence /t-ʃ/, so there may be some advantage in assuming that that sequence underlies other /(c)c^{h}/ as well. The single /c^{h}/ variant could be viewed as a reduction in tautosyllabic /tʃ/. The sandhi rule needed, therefore, would be one that splits /tʃ/ when preceded by an intralexical vowel (a postlexical rule can split the sequence after short vowels). This theory is supported by historical considerations. The source of Sanskrit /(c)c^{h}/ is PIE /sk$'^{h}$/, and */k$'^{(h)}$/ regularly becomes /ʃ/ ([Murti 1984], p. 137, 159). Since /s/ sometimes becomes /t/ before sibilants (Whitney 167), it is reasonable to conclude that */sk$'^{h}$/ developed into /tʃ/. Despite these arguments, however, some attention should be given to the opposite theory. Whitney (227b) appears to doubt that /cc^{h}/ really exists: perhaps the reduplication is an artificial acknowledgement of the fact that /c^{h}/ always makes the preceding syllable heavy, a relic of its historical origin. This would explain the tendency to defer the 'gemination' word-initially after a long vowel. This is also supported by the fact that manuscripts generally write simple /c^h/ (viz., छ). One might counter these arguments with the observations that Whitney would need to invoke some special rule to let /c^h/ make position; that one would expect by his theory that word-internal /c^h/ should not have to geminate after long vowels; and that the manuscripts' usage could reflect the uselessness of writing the geminateness since that is predictable and carries no functional load.

It has not yet been mentioned that a few words that are said to have exceptional sandhi would seem instead to have exceptional underlying forms. The /b^hoos/ words, which drop the /s/ before voiced sounds instead of rhotacizing it as other /-oos/ words do (such as /təjoos/, 'of those two'), would appear to actually come out of the lexicon with the /oo/ instead of the /aw/ sequence that is posited for other surface /oo/ words. This could either be an underlying form, or perhaps the output of a postcyclic rule reducing an irregularly syllabified /b^haw-as/ (the older form of the word is /b^həʋəs/, reflecting a deeper /b^ha-was/).[17] The sandhi of /b^hoos/ will follow automatically from my treatment of /s/ after non-high vowels (compare the sandhi of /-aas/).

Of the words that retain their final vowels as such even before vowel-initial words (the so-called pragr̥hya words), it has already been mentioned that the interjections may well do so because of phrasing effects, which effectively put them into a separate utterance (so opines also Roberge, citing Bartholomae). The dual endings mentioned above probably do so because of their peculiar phonological form as they leave the lexicon. But since that peculiarity can be ascribed to the workings of a lexical rule, I will defer discussion of that until the in-depth discussion of the rule system. The word /əmii/ probably has underlyingly the same ending that the dual ending picks up—namely, the extra-long /əmiij/; but see the rule Dual Pragrhyatva for more details. This is likely to be explained as analogy with dual /-ii/, since this is not otherwise a plural ending.

Finally, it might bear repeating that I assume that the words leaving the lexicon have been syllabified by the maximum onset principle, in accordance with the onset pattern described in Section 3.2 above.

5 Rules

The formalism used here should be quite familiar as a basic SPE-style rule system. The rules apply in the order listed (except for some of the early rules, which are lexical and hence can apply cyclically, in compounding). When a rule is invoked, it can however apply several times to the same string, moving from left to right.[18] I agree with Selkirk and Steriade in a total abhorrence of boundary segments, and yet I use them throughout. This is for the sake of

[17] Allen, p. 42–43, considers these to be word-internal cases of abhinihita sandhi. Note however that we could not simply apply the postlexical Abhinihita rule, since the final /s/, by then potentially the glide /z̩/, could block its application.

[18] It is fortunate that the rule set has no cases of regressive assimilation affecting multiple segments. The general solution would be for the rule to retry all positions in the string after a successful application, i.e., multiple left-right passes.

fidelity to the automated rule set, where manipulation of strings is much easier than the manipulation of a prosodic hierarchy. Although boundary symbols may not be fully equivalent to domains, no significant differences result in this rule set. The symbols used here are SB, WB, and UB for syllable, word, and utterance boundaries. For the sake of simplicity, I further specify that all rules must explicitly specify any boundary they span, which Selkirk requires only for domain juncture rules. For consistency, then, I will mention SB even when adjacent to a WB.

The first six rules belong to the lexical phonology, the rest are postlexical. Of the latter, m-Dearticulation, sas-Apocope, Intralexical tʃ-Splitting, and om-Protection are P1 rules; the rest are P2 rules that ignore word boundaries.

It is sometimes difficult to make much sense of individual rules in a large rule set. I have tried to correct this by providing at each rule synopses as to what rules feed the rule and which rules it feeds, but I imagine that there will still be ample cause for confusion. In such an event, it might be helpful to peek ahead to Section 7, where a large number of examples are presented with full derivations.

This is of course a strictly synchronic rule set. This probably would not bear mentioning were it not for the fact that Sanskrit studies have been so intricately tied up with the question of the diachrony of the Indo-European languages. Most of the references I make to earlier works are to works written in that tradition. Since synchrony so often recapitulates diachrony, it would be negligent to let prior work go unacknowledged because the earlier scholars were not actually talking about synchronic rules in a generative grammar; on the other hand, it would make for extreme verbosity if I were to explicitly comment whenever references are to diachronic rather than synchronic rules. I hope my ellipsis will not prove too inconvenient to the reader.

1. Depalatalization

$$\begin{bmatrix} +\text{cons} \\ +\text{Coronal} \\ +\text{Dorsal} \end{bmatrix} > \begin{bmatrix} -\text{Dorsal} \end{bmatrix} \;/\; \_\_ \;\text{SB}$$

Palatal consonants become retroflex in a coda. This rule may be surprising, since it is well known that /c/ and /ɟ/ alternate with final velars. But it is more likely that that alternation is attributable to a lexical rule that changes original velars to palatals in certain prevocalic environments. This particular rule handles the residual cases, where /ɟ/ alternates with retroflexes (Whitney 219b); and this is the general alternation for /ʃ/ (Whitney 218). This /ɟ/ (as found in roots like /mr̩ɟ/) behaves like /ʃ/ before consonants, even to the point of becoming /k/ before verbal /s/ and /ʂ/ before dental stops. Indeed, one is tempted to posit an underlying /ʒ/. The general source of these two sounds are the PIE palatals.

This process is arguably postlexical. It is included among the lexical rules largely because Pāṇini admitted palatals in the codas of nonce words: /əc/ 'vowel'; /əʃ/ 'voiced sound'. This is more easily accounted for by allowing the lexicon to irregularly emit these sounds, since postlexical rules should be exceptionless.

2. ʂ-Desibilation

$$\begin{bmatrix} -\text{son} \\ +\text{cont} \\ -\text{ant} \end{bmatrix} > \begin{bmatrix} -\text{cont} \end{bmatrix} / \_\_ \text{ SB}$$

/ʂ/ becomes /ʈ/ in syllable codas. This applies mostly to /ʂ/ derived from /s/ by the lexical rule of Ruki (not treated here), and to those arising from underlying palatals by the Depalatalization rule above. Cf. Whitney 226b.

Again, the presence of Paninean nonce words like /ɟʰəʂ/ 'voiced aspirate' suggests that this rule is lexical.

3. ɽ-Desonorization

$$\begin{bmatrix} +\text{cons} \\ -\text{syll} \\ +\text{son} \\ +\text{cont} \\ +\text{Coronal} \\ -\text{Dorsal} \end{bmatrix} > \begin{bmatrix} -\text{son} \end{bmatrix} / \_\_ \text{ SB WB}$$

//̊ becomes /ʐ/ at the end of a word.

This rule accounts for the fact that word-final //̊ does not behave as other sonorants, which remain voiced word-finally, but rather, like obstruents, which are subject to voicing assimilation affects. This is not the case at the end of word-internal syllables (Whitney 165); note for example /dvaaɽ̊ʂu/ 'doors (locative)', where the //̊ remains a sonorant. This example is incidentally interesting because /-su/ is traditionally accounted among the pada suffixes, which entail external sandhi; yet the //̊ remains unchanged here, in defiance of the sandhi rule. Note also that the /s/ of the suffix assimilates to the //̊, which assimilation normally occurs only intralexically in the classical language.

This /ʐ/ is not subject to z-Gliding, which affects only /z/ (< /s/) after /a/ (hence the separate entry for /-as/ in the consonant sandhi tables 7–8); but like /z/ it is subject to Rhotacization, so in most voiced environments it behaves like underlying /s/. In pause or before voiceless segments, Delaryngealization changes this to /ʂ/, which behaves like /s/ (Pāṇini 8.3.15). It should be noted that this rule set depends on the fact that all /ʂ/ come from original //̊. In particular, the lexical rule Ruki (not treated here), by which some /s/ become retroflex, is held not to take effect word-finally. This essentially Paninean approach is opposite from Allen's (p. 57–60), who, as did Wackernagel, uses final /ʂ/ to distinguish the sandhi of /-i(i)s/ and /-u(u)s/ from that of /-a(a)s/.

This rule applies cyclically to words forming compounds. For example, /punəhpunəh/ is from /punar + punar/ via /punaʐ/. There are however several examples of compounds inherited from Vedic where the rule did not apply within compounds. See Wackernagel I284c.

4. Dual Pragrhyatva

   $\emptyset > \big[-\text{syll}\big]_i \;/\; \big[-\text{syll}\big]\;\big[+\text{syll}\big]\;\mathrm{X}_i \;\_\_\; \text{SB WB}_{+dual\ pragrhya}$

   The dual endings /ii/, /aj/, /uu/ add a homorganic glide (confer Pāṇini 1.1.11, which declares them pragr̥hya; [Bloomfield 1882:40n], who maintained they were extra long; [Oldenberg 1890], who agrees, at least in the case of /aj/).

   As hinted before, some if not all of the pragr̥hya words actually have an additional final glide when they enter the postlexical rules. All dual endings for nouns have this property, as well as all verbal dual endings that are homophonous with a noun dual ending. That suggests this lexical redundancy rule, to extend the final segment of morphemes in the class here described.

   Historically, this is apparently a case of analogy. [Oldenberg 1890] noted that the noun dual ending /-ee/ is originally /eej/ (i.e., stem /-a/ plus dual ending /-ii/, the /-ai-/ monophthongizing to /ee/). The other dual endings are then treated as pragr̥hya by analogy (Wackernagel I270b, 273a). [Roberge 1986], on the other hand, feels that the language originally had pragr̥hya and non-pragr̥hya alternants for all final long vowels, and that dual /-ii/ and /-uu/ (over against, e.g., fem. sg. /-ii/) selected pragr̥hya not so much because of analogy with dual /-ee/, but in order not to lose the vowel length (through Vowel Shortening) which was the sole exponent of the dualness (contrasting, e.g., with locative short /-i/). He agrees however that the pragr̥hyatva of verbal dual endings is entirely analogical. (Wackernagel I273a reports Oldenberg's finding that they were only occasionally pragr̥hya in the earlier language.)

   The effect of this rule is to block Vowel Shortening and Vowel Contraction, because the duals end in a glide, not a vowel. Before a vowel, the glide will be deleted by Udgraaha, leaving a hiatus. This dovetails with the fact that all other hiatus produced by sandhi are formed by the prevocalic deletion of a coda glide. For example, /swaɽgaj + indɽas/ surfaces as /swəɽgə indɽəh/; I will also be arguing that the apocope of /s/ in /a(a)s/ before vowels progresses through an intermediate glide. When not before a vowel, one would expect the glide to be retained, but a later rule deletes all coda glides except for a single one after /a(a)/.

5. aaw-Extension

   $\emptyset > \mathrm{X}_i \;/\; \big[+\text{low}\big]\;\big[+\text{low}\big]\;\begin{bmatrix}+\text{lab}\\-\text{cons}\end{bmatrix}_i \;\_\_\; \text{SB WB}$

   Words ending in /aaw/ add another /w/.

   This is closely related in effect to the preceding rule, but invokes no special lexical properties. The nominal dual vocalic ending I did not mention above is underlyingly /-aaw/. Accounts of sandhi universally say that /-aaw/ is not counted among the pragr̥hya endings, because it surfaces as /-aaʋ/ before a vowel, instead of remaining /-aaw/ and inducing hiatus. Confer for example Roberge, who rejects the "analogy" explanation of the pragr̥hyatva of dual /-ii/, /-uu/ in part because /-aaw/ "combines freely" (p. 57). But I argue that the dual morpheme /-aaw/ is very much pragr̥hya, and in fact, has generalized to bringing in all words ending in /-aaw/, whether dual or not. If the ending /-aaw/ were not pragr̥hya, the final /w/ would simply drop before vowel-initial words; compare /tasmaaj + adadat > tasmaa adadat/. Instead, all of the segments are retained, as in pragr̥hya words. The only distinction is that since long diphthongs are not subject to monophthongization (*contra* /-aw/ becoming /oo/), the glide element remains salient and emerges as dentalized /ʋ/. Failure to perceive this rather obvious fact of the pragr̥hyatva of /-aaw/ may be attributed to the surface form, where there is the more opaque alternation /-au/ vs /-aaʋ/ (-औ vs -आव्).

Why the rule should have generalized from the dual ending to all final /-aaw/ is a matter for conjecture. This could be due to the high frequency with which instances of /-aaw/ are found as a dual affix. There might also be some other analogies brought into play. Most other instances of /-aaw/ are found as a locative singular ending, and there is a locative /-ii/ that is pragr̥hya in Vedic; and as a nominative pronoun ending, and the pronoun /əmii/ is pragr̥hya. There may be enough /-aaw/ that are pragr̥hya by origin or analogy that the feature was analogized to all instances of that sound at the end of a word.

The effect of this rule is to protect /-aaw/ from being reduced to /-aa/ by Udgraaha; since that rule only deletes one glide, /-aaww/ will come out as /-aaw/ before a vowel. The /w/ will move into the next onset by Onset Filling, and then change to /ʋ/ by w-Dentalization. On the other hand, when the extended /-aaww/ appears finally or before a consonant, Long Glide Reduction and Long Diphthong Reduction will shorten this to /aw/. aaw-Extension appears to be optional in some dialects; some older texts end up dropping the single /w/ before vowels, producing hiatus (Whitney 134c). On the other hand, the earliest Vedic pattern appeared to have /aa/ before consonants, /au/ before vowels (Wackernagel III18bα; see [Sommer 1924] for a full treatment of the subject).

It is difficult to say whether this rule applies to prior elements of compounds, since there are so few stems that end in /-aaw/ (Whitney 360 counts only /naaw/ 'ship' and /glaaw/ 'ball', and Monier-Williams lists no compounds beginning with the latter), and partly because there are so few words ending in glides overall (Whitney lists five) that it is hard to say whether Udgraaha applies to them. The regular form of /naaw/ in compounds before vowels appears to be /naaʋ-/, so either this rule applies, or Udgraaha does not.

6. ns-Extension

   $\emptyset > \mathrm{s} \;/\; \begin{bmatrix} +\mathrm{nas} \\ +\mathrm{Coronal} \end{bmatrix} \text{ — SB WB}$

   Words ending in /n/ add /s/ (cf. Pāṇini 8.3.7, Whitney 208, Wackernagel I279-280). Pāṇini excepts the word /praʃaan/.

   The fact that /-n/ words add a sibilant before words beginning with certain other sounds (voiceless coronal stops) is often considered to be one of the most bizarre features of Sanskrit phonology. But if one simply turns this rule on its head, it becomes quite natural. The lexical rule provides that no word can really end in /n/; all the words which seem to end in /n/ really end in /ns/. Later P2 rules cause them to drop the /s/ in many quite natural environments. There is no particular reason why a lexical rule, such as ns-Extension, must be phonologically natural. This one certainly arises from a generalization of the fact that most forms that end in /n/ in pausa really were historically reductions of original /n(t)s/; Whitney 208a counts them as three fourths of all apparent /-n/ words. Andrew Garrett (*voce*) has also pointed out that the proto-language had no inflectional endings in /-n/ at all.

   Before voiced segments, this added /s/ will become //̊ by Voice Assimilation and Rhotacization. The resulting /-n/̊ final will simplify to /nn/ before a vowel after a short vowel (Nasal Gemination), but in other environments it reduces to /n/ (CC-Apocope; that is, the segment is deleted only where the syllable weight would not be reduced, otherwise it assimilates). These reductions accord with the general tendency of Sanskrit not to allow consonant clusters in codas. Otherwise (when not before voiced segments), the /s/ becomes /h/ by Sibilant Dearticulation, which may then become /ʂ/ or /ʃ/, or remain /s/, by Visarga Resyllabification and Fricative Assimilation, in which case the /n/ becomes /N/ by Nasal Dearticulation; or this /h/ may be dropped by CC-Apocope.

   This rule applies only at the very end of the lexicon, after compounding. It turns out that compounding invokes another rule, namely, the dropping of /n/ in prior elements. Historically, this is because most final /-n/ is actually part of a derivative suffix, which appeared in two grades: full /-an/ and reduced /n̩/. In the Indo-Aryan languages, syllabic /n̩/ turned into /a/, leading to the appearance that the alternation involves dropping the consonant rather than dropping the vowel; this was then generalized to apply also to final /-in/. The same thing occurs when /-an/ words take suffixes that begin with consonants. But the dropping of /n/ in compounding occurs even before vowels (except for the privative suffix /an-/), leaving a hiatus that leads to vowel merger: /ɽaɟan + indɽas > ɽəɟeendɽəh/. This dropping of /n/ has the appearance of a lexical phonological rule in the classical language.

   In Vedic, the insertion of /s/ was not always made (Whitney 208b). Wackernagel says that it appears in Vedic particularly where historically justified, so for some forms of the language, there probably was neither a lexical coda simplification nor an ns-Insertion. When there was an /ns/ in Vedic, there took effect a peculiar dearticulation whereby the /n/ became /N/ after a long vowel (Whitney 209, Wackernagel I279b). This dearticulation is reminiscent of the later Nasal Dearticulation, but not identical with it, since it preceded z-Gliding. Wackernagel (citing Bopp as the originator of the idea) is convinced that the dearticulation occurred after long vowels because these are found more often in forms like the accusative plural ending, which has originally /-ns/, with no /t/. The end result was /aaN/, but after the other long vowels /Ns/, /Nh/, or /Nr/ (via Voice Assimilation, z-Gliding, Rhotacization, Udgraaha, z̥-Deletion, Sibilant Dearticulation, Visarga Resyllabification, and Sibilant Assimilation).

This concludes the inventory of lexical rules. The following four rules are word juncture rules. The test programme does not itself distinguish such rules—it cares only about the sequencing and the fact that the above have WB at the end of the rule and those below have WB within the rule—but the distinction is of theoretical importance.

7. m-Dearticulation

$$\begin{bmatrix} +\text{lab} \\ +\text{nas} \end{bmatrix} > \begin{bmatrix} -\text{Place} \end{bmatrix} \;/\; \_\_ \text{ SB WB SB } \begin{bmatrix} -\text{syll} \end{bmatrix}$$

Words ending in /m/ dearticulate it to /N/ before an onset (Pāṇini 8.3.23). Many manuscripts and inscriptions write so utterance-finally as well (Wackernagel I260b, Renou 28b), although this may just be a spelling convention. This rule applies also to the prior elements of compounds. It has the drawback of contradicting Kaisse's claim [Kaisse 1985] that P1 rules must have some lexical or syntactic conditioning. Although I do not necessarily subscribe to that as an absolute restriction on sandhi, I do agree that it would be preferable to have the fewest possible number of sandhi rules, and in cases like this, when there is no lexical or syntactic conditioning, one can't help but hope that some other mechanism can be found.

There are a few sneaky approaches one could take. One would be to make this a lexical rule that dearticulates /m/ at the end of all words, then have a separate P2 rule that changes /N/ to /m/ utterance-finally or before a vowel. By themselves the phonetics would be curious but not outlandish (/m/ could be some sort of default nasal, though there seems no other evidence for that assumption), but beyond that this approach would have at least three unsatisfactory characteristics: it requires an additional rule; the condition for the (re)articulation of /N/ is an unnatural disjunction; and the lexical rule would be introducing an allophone that is not otherwise needed as a distinctive segment in the lexical component of the grammar. Nevertheless this approach could be taken if the desire to observe Kaisse's constraint is overriding.

Another way out would be to consider /N/ to be an archiphoneme which is articulated at the place of the following stop; then its phonetic realization before word-initial stops would agree with the word-internal realization, and so everything could be handled by P2 rules. [Deshpande] describes this conception of /N/ as the general consensus of the ancient linguists, and certainly many manuscripts treat its spelling (the anusvāra dot) as a mere abbreviation for homorganic nasals, using it also word-internally. But Pāṇini, in making the assimilation of /N/ optional (8.4.59), is clearly drawing a distinction.

A third approach would be to note that the native linguists offered options that require only postlexical rules. Word-final /m/ is optionally assimilated in place to a stop or semivowel other than /˚/ (Pāṇini 8.4.58-59)[19] (before /j/, /l/, or /w/ becoming /j̃/, /l̃/, /w̃/); else is /N/; furthermore, the initial /ɦ/ of an onset cluster is optionally ignored (having no Place feature; Pāṇini 8.3.26-27 provides so for /ɦ/ + nasal clusters). See further Whitney 213, who does not even consider the possibility that there is a distinction between anusvāra and articulated homorganic nasals before a stop, and Wackernagel I283. With the exception of the nasalized semivowels, which would not be produced word-internally since /m/ can form an onset cluster with the semivowels, these are the same as the outcomes of word-internal /m/, so we could completely dispense with any lexical rule for word-final /m/, and do everything in P2 rules. This is the approach taken by Selkirk, who makes "Assimilation of m" and "Anuṣvara of m" *U*-span rules.

8. sas Apocope

   $X > \emptyset$ / __ SB WB$_{+s\ drop}$ SB C

   A certain class of words drop the final /s/ before a consonant. This actually amounts to only two words, /sas/ 'that' and /ajṣas/ 'this' (Pāṇini 6.1.132), though /sjas/ may optionally behave so in the older verse (6.1.-133).

   This rule is quite pedestrian, and in structure and scope reminds one of the English rule deleting /n/ in *an* before a consonant. The extremely high frequency of the word may have been one factor leading to the exceptional apocope, which eases pronunciation.

   Before consonants then, /sas/ will appear as /sə/, undergoing only a-Raising. The only other notable effect is that before /tʃ/ words, the full geminate /cc^{h}/ will appear, since Intralexical tʃ-Splitting is later than this rule. Utterance finally, /sas/ appears as /səh/, with the /-s/ undergoing Sibilant Dearticulation. Before vowels, /sas/ acts as any /-as/ word, being subject to Voice Assimilation (/saz/), z-Gliding (/saz̯/), Abhinihita before short /a-/ words (/soo/), else Udgraaha (/sa/) then a-Raising (/sə/).

   This is the first rule that is undeniably a true rule of external sandhi, since word-internal /s/ do not delete before consonants. In the R̥gveda,

[19] Recall that /˚/ cannot be geminate, so /˜ɽr/ is ruled out.

however, /sas/ regularly drops its /s/ even before vowels (resulting in vowel contraction, Pāṇini 6.1.134, Whitney 176b, Allen, p. 79), which suggests that in that version of the language /sas/ dropped /s/ as a lexical rule without regard to context (or perhaps rather that the lexical entry /sa/ was exceptionally marked to not combine with the /s/ morpheme at all in the Vedic period).

9. Intralexical tʃ-Splitting

   $$(\mathrm{SB}\ \mathrm{WB}_{+no\ degem})\ \mathrm{SB} \begin{bmatrix} -\mathrm{cont} \\ +\mathrm{Coronal} \end{bmatrix}_t > \mathrm{C}_t\ \mathrm{SB}\ /\ \mathrm{V}\ \_\_ \begin{bmatrix} -\mathrm{son} \\ +\mathrm{high} \end{bmatrix}$$

   The affricate /tʃ/ loses the /t/ to the preceding syllable if that ends in a vowel, provided the syllable is intralexical or in one of the words *aa* or *maa*. After Dental Assimilation and ʃ-Desibilation, this will surface as /cc$^{\mathrm{h}}$/. Confer Pāṇini 6.1.73-76, Whitney 227.

   I have already discussed the motivation for this rule, in particular my rejection of the traditional formulation positing a gemination of underlying /c$^{\mathrm{h}}$/. /maa/ was treated regularly (it did not require splitting) in the Ṛgveda. /aa/ and /maa/ in classical Sanskrit are no doubt treated as if intralexical because of their close syntactic relationship with a following verb. /aa/ is a verbal prefix (and there are several other cases where verbal prefixes combine with their verb by special lexical rules), and /maa/ 'not, lest' could be considered virtually a negative injunctive prefix. One might speculate that these words originally did not allow splitting when preceding words other than their host verb, but the antiquity of the generalization and the tendency of most manuscripts to not distinguish geminate from non-geminate /(c)c$^{\mathrm{h}}$/ probably makes this question unanswerable in the absence of explicit testimony from the ancient linguists.

   Like sas-Apocope, this is undeniably a word-juncture sandhi rule; also like it, it has lexical idiosyncrasies. According to the traditional formulation of Pāṇini, this rule is in part optional; nothing actually forbids words from splitting the /tʃ/ cluster after long vowels even at word boundaries. Since the rest of this rule has no lexical restrictions, such a version of Sanskrit would have one less word-juncture rule.

   Manuscripts quite often write simply /c$^{\mathrm{h}}$/ where double /cc$^{\mathrm{h}}$/ is expected, especially word-internally. I agree with Allen (p. 47, n 6) in attributing that fact to the redundancy of the doubling.

   This rule must follow sas-Apocope, since, for example, /sas tʃaagas/ surfaces as /səcc$^{\mathrm{h}}$aagəh/.[20]

10. om-Protection

    $$[+\mathrm{low}]\ ([+\mathrm{low}])\ \mathrm{WB}\ \mathrm{SB} > \emptyset\ /\ \_\_\ \mathrm{C}_0\ \mathrm{SB}\ \mathrm{WB}_{+a\ zap}$$

    The rime /a(a)/ is dropped before the word *om*, /awm/, the only element in the *a zap* word set. Whitney 137b mentions several sporadic instances in

[20] I am indebted to Andrew Daniels for this observation.

the older language where /a(a)/ is lost before diphthongs. That Classical Sanskrit grammaticalized this rule to apply strictly before *om* (Pāṇini 6.1.95, Wackernagel I269c) is surely due to a desire to preserve the acoustic nature of the mystic syllable, which would otherwise emerge as /aum/ in this environment, by Like Vowel Contraction.

11. WB erasure

    WB > ∅

12. SB simplification

    SB > ∅ / SB —

    These two rules provide for erasure of the word boundary; the second of them is purely epiphenomenal, arising from my preference for notationally collapsing the notions of adjacent syllable ends and syllable beginnings into one syllable boundary token. One may also conceive of these rules as a fence demarcating the beginning of postlexical rules in the pure sense of the word (i.e., P2 rules): the following are the rules in the sandhi system that make no reference to any lexical idiosyncrasy or word boundaries at all (Selkirk's *U*-rules).

13. Vowel Shortening

    $\left[\,+\mathrm{syll}\right]_i > \emptyset \;/\; \mathrm{X}_i$ — SB V

    Long vowels at the end of a syllable shorten before another syllable beginning with a vowel (Wackernagel I267b, 269bβ). In the (unnatural) case where /ṛṛ/ or /ḷḷ/ should occur at the end of a syllable in hiatus, these would be shortened too.

    The import of this rule for the data under consideration is to simplify to a certain extent the following rules of vowel contraction. However, the Indian linguists say that this rule applies even when contraction is optionally omitted (Pāṇini 6.1.127–128), and certainly in the Vedic language many contacting nuclei simply underwent Vowel Shortening without merging (as revealed by the metre, even where the scripture is normalizing). These considerations suggest that Sanskrit has Vowel Shortening. Historically, the alternation probably arose because PIE laryngeals, a major source of long vowels in the language, caused compensatory lengthening upon their disappearance only if they appeared in syllable codas (i.e., not before vowels, where they would syllabify with the next syllable, silently disappearing or becoming a glide); so [Kuiper 1947], following [Kuryłowicz 1935:28–29].

    Even in the standard language described here, it can be seen that Vowel Shortening is current. In the vowel sandhi table (6), it is obvious that the length of the prior vowel has no effect on the outcome of vowel-vowel sandhi, whereas the length of the posterior vowel is often significant. A compelling contrast is that /a + i/ and /aa + i/ both produce /ee/, but /a + ee/ produces /ai/. This becomes clearer if one takes a look at the underlying phonetics: /a(a) + i/ > /aj/ (> /ee/), but /a(a) + aj/ >

/aaj/ (> /ai/). Thus even though the language structure can accommodate a sequence like /aaj/, a prior /aa/ does not contribute to it. The sandhi /aa/ + /ɽ̩/ > /ə̊/ is also telling, since there is no structural reason why one couldn't have /aaɽ̩/. Sanskrit therefore requires a rule of Vowel Shortening, whose effect is to make vowel-vowel sandhi with prior /aa/, /ii/, /uu/ behave just like prior /a/, /i/, /u/. Wackernagel cites Benfey as making this same argument in 1846.

The rule applies to compounds, and is useful in word-internal environments as well. For example, the instrumental singular of /deeʋii/ 'goddess', formed by adding /aa/, is /deeʋjaa/, which suggests shortening the /ii/ then desyllabifying it (Ksaipra) just as would happen in sandhi. The nominative dual of /kənjaa/, formed by adding /ii/, is /kənjee/.

A curious case is that if a verb beginning in the vowel /ɽ̩-/ is prefixed by a preposition ending in /-aa/, and in certain nominal compounds as well (Müller 44), the result is normally /aaɽ̩-/, as if this rule were skipped and the form were directly fed into Ksaipra (Pāṇini 6.1.91, Whitney 137a). This should be impossible, since that does not regularly happen in compounding (/maɦaa + ɽ̩ʂis > məɦaɽ̩ʂih/), and the syntactic information to differentiate those cases should be absent at this point. However, it is also the case the verbal prefixes ending in short /-a/ also produce the result /aaɽ̩-/ (See Wackernagel I269bγ). This datum confirms the impression that a lexical rule is responsible for this long /aa/, and that the postlexical morphology is handed /aaɽ̩-/ already in that form.

14. Like Vowel Contraction.

    SB > $\emptyset$ / V$_i$ — V$_i$

    If a syllable ends in the same vowel that the next syllable begins with (ignoring quantity), the two syllables merge (Pāṇini 6.1.101, Whitney 126, Wackernagel I269a, Allen p. 29–34). All the vowels are kept as such for the time being, even though there may be three of them: Long Diphthong Reduction will take care of the extra mora. In addition to the relevant entries in the sandhi table, this would also handle the cases /ɽ̩(ɽ̩)/ + /ɽ̩(ɽ̩)/, for which this would predict /ɽ̩ɽ̩/, and /l̩(l̩) + /l̩(l̩)/, which would give /l̩l̩/, both of which are given as the normal form by Müller 52. But other grammarians give a host of other possibilities (/ɽ̩ + ɽ̩/ > /ɽ̩/ or / ˚ ɽ̩/ or /ɽ̩-ɽ̩/; /l̩ + l̩/ > /l̩/ or /ɽ̩ɽ̩/ (Renou 40a).

    This and the following two rules are part of a conspiracy to get rid of all original hiatus by merging syllables (Whitney 125). Curiously, however, a later rule, Udgraaha, will introduce new hiatus.

    This rule applies also in compounds and doubtless word-internally as well. The classical language has no instance of like vowels (or any two vowels, except for two words discussed later) coming into contact within a word on the surface;[21] some simplification occurs whenever the morphology would introduce that. To a large extent the hiatus is blocked by special lexical rules (e.g., nouns ending in vowel X rarely add an inflectional ending ending in vowel X), but instances of Like Vowel Contraction occur here and there. For example, the nominative plural non-neuter ending is /-as/; when added to stems ending in /-a/, the result is /-aas/.

In Pāṇini's time, the Vedic pitch accent was still part of the language. Underlyingly, the way this worked was that words had a distinguished tone (H) on exactly one syllable (Pāṇini 6.1.158), though some words had none. The question then arises, what happens to the tones when two syllables merge? As one would expect in a one-tone system, the general behaviour appears to be that iff either syllable had H, the result will have H (Pāṇini 8.2.5), with two H tones merging to one; and this is in general the case for Like Vowel Merge. There are however versions of Sanskrit where the combination of a High with a following non-High produces a falling tone (Müller, App. II, 10). These dialects must have introduced a two-tone system (unassociated vowels get Low) before this rule, so that the falling tone is a result of H and L occurring in that order on the same syllable. According to Whitney 128, this two-tone option for Like Vowel Merge (resulting in a falling tone) was in the Vedic texts evident only for the case where two (originally) short /i/ merged, except in the Taittirīya texts, where the exception was for two short /u/! These exceptions are difficult to explain, and would require at least a special rule preceding Vowel Shortening, which I won't attempt here. For further rules affecting tones, see under o-Abhinihita.

There appear to be a few cases where the resultant vowel is short, especially if followed by a glide. This is particularly true in the case of verbal prefixes in /-a/[22] being attached to most verbs beginning /aw-/ or /aj-/ (Pāṇini 6.1.94) and for several nominal compounds, for both of which cases a lexical explanation can easily be given. See om-Protection above for the case where this regularly happens between words.

Not taken into account in this rule set is a similar, optional rule whereby like (or even homorganic) *consonants* may be simplified if preceded or followed by another consonant (Pāṇini 8.4.65, Whitney 232). Manuscripts did this most often for dental geminates before /̥/ or /w/ (Renou 8). This rule would also apply word-internally.

15. Diphthongization

$$\text{SB V}_i\ (\text{V}_i) > \left[\,-\text{syll}\,\right]_i \;/\; \left[\,+\text{low}\,\right] \;\_\_\; \left\{ \begin{array}{c} \text{C} \\ \text{SB} \end{array} \right\}$$

[21] Metrical considerations indicate that the hiatus was quite common in the Vedic language; for example, the genitive plural suffix /-aa-naam/ often was trisyllabic /-aa-na-am/ (Whitney 329f). Whitney 129e estimates that inter-word coalescence fails in the R̥gveda about 12% of the time.

[22] Of course this discussion also includes words originally ending in /-aa/, because of Vowel Shortening.

If one syllable ends in /a/ and the next begins with a vowel (which by now cannot be /a/, because of Like Vowel Contraction), that vowel, short or long, becomes nonsyllabic (/i(i)/ > /j/, /u(u)/ > /w/, /ɽ̩/ > /̊/), resulting in a syllable merger (Pāṇini 6.1.87, 1.1.51, Whitney 127, Wackernagel I267, 269b, Allen p. 36–37). The unnatural cases of initial /ɽ̩ɽ̩/ and /ɭ̩(ɭ̩)/ would likewise be expected to give /̊/ and /l/ respectively, which are the forms given by Whitney and Müller 52.

This happens also in compounds and in word-internal phonology as well. For example, the locative singular of /kaaməh/ is /kaama + i > kaamaj > kaamee/. The words that appear on the surface as /titəuh/ and /pɽəugəm/ are apparent exceptions to this rule (Whitney 125b). But these surface forms are precisely what one would get if there were a glide inserted between these vowels, but irregularly associated with the prior syllable in contravention of the maximum onset principle. Fortunately we know that the latter varies with a /-j-/ form and the former, perhaps with an /-s-/. If the lexicon emitted the forms /ti-tas-us/ and /praj-u-gam/, the right surface forms would be achieved despite the Diphthongization rule (see Udgraaha).

The remarks made above on the accent system in pre-Classical Sanskrit apply here as well, although in this case, the combination of high /a/ and low second vowel seems in practice to have led uniformly to a high (not falling) diphthong in the R̥gveda. The falling contour was also also permitted or required by various linguists.

Among options not treated here, Pāṇini cites Śākalya (6.1.128) as holding that initial /ɽ̩/ does not have to desyllabify. And Pāṇini (8.4.46, 49, 50, 52, *contra* Śākalya (8.4.51)) was followed by many manuscripts in geminating a consonant (other than /ɦ/ or a prevocalic sibilant) after /V̆̊/ (Renou 7, where less frequent geminations are also discussed). This case, which applies also word-internallly, could of course also arise in this sandhi, when the posterior word begins with /ɽ̩/, which gets changed to /̊/.

16. Ksaipra

    V_i SB > $\left[-\mathrm{syll} \right]_i$ / — V

    If one syllable ends in a vowel (which by now must be a short vowel other than /a/) and the next begins with a vowel (which by now must be of different quality), the syllables merge by making the first vowel nonsyllabic (/i/ > /j/, /u/ > /w/, /ɽ̩/ > /̊/, and the unnatural case of /ɭ̩/ would be expected to give /l/ (so Müller 52); Pāṇini 6.1.77, Whitney 129, Wackernagel 270, Selkirk's Glide Formation, Allen p. 35–36). The rule is useful in word-internal phonology as well; confer the example of /deeʋjaa/ discussed under Vowel Shortening. This rule is only sporadically observed in the Vedic language ([Edgren 1885] finds it observed only 1.3% of the time in interword environments, and only a third of the time between elements of compounds), and has several apparent exceptions in the lexical phonology, where a glide is sometimes inserted to break the hiatus before this rule can get to it (Whitney 129a-d). The Indian linguists held this rule to be optional (Pāṇini 6.1.127, citing Śākalya), except in compounds (Wackernagel 270d, Renou 41a).

Remarks on early Sanskrit accent are about as for Like Vowel Contraction, although in this case, combination of H prior syllable with non-H posterior syllable actually results in a falling tone in all dialects: that is, there is a true HL combination in the syllable, realized as a falling contour (Pāṇini 8.2.4, Whitney 130). This must be due to Ksaipra's being introduced historically later than the other syllable-merging rules; it is also ordered later synchronically, at a point where all dialects have had a rule introducing a new, contrasting Low tone on all unassociated vowels. To sum up what has happened with tones so far: all dialects have a single lexical tone H, and introduce a contrasting L postlexically. If the dialect orders this early (before Like Vowel Merge), all combinations of H + L syllables will form a falling contour; if late (just before Ksaipra), only Ksaipra (and the later Abhinihita rules) will produce falling contours, and the others will have simply the one H. See also o-Abhinihita for further developments.

Pāṇini has a strange rule (8.4.47, 52) permitting the gemination of any articulated consonant in the environment $/\breve{V}\_\_C/$. If this rule is followed, then this sort of Ksaipra will end up geminating the consonant that preceded the original vowel. 8.4.46 furthermore implies that if the prior word ends in /-Vɽi/ before Ksaipra, the resultant /j/ may be geminated.

17. Delaryngealization

$\left[\, -\text{son} \right] > \left[\, -\text{Laryngeal} \right] \; / \; \_\_ \; \text{SB}$

An obstruent in a coda loses its voice and aspiration (Pāṇini 8.4.56, Whitney 141). This loss of aspiration has in part or full already happened lexically, since it reverses Grassmann's Law deaspiration of root initials;[23] but nothing is lost by generalizing this rule to lose the entire Laryngeal node. Some weak evidence in favour of this idea is that one does not seem to find nonce words with /ɦ/ or distinctive aspiration in their coda, even though other (lexical) restrictions appear to be disregardable in such words (see the earlier discussion in the section Underlying Forms). In utterance-final position, the segment remains in this voiceless state; but if followed by another syllable, it is subject to Voice Assimilation, which see below for more discussion.

18. Voice Assimilation

$\left[\, -\text{Laryngeal} \right] > \left[\, \alpha\text{voice} \right] \; / \; \_\_ \; \text{SB} \; \left[\, \alpha\text{voice} \right]$

If a syllable ends in an obstruent (in practice, /p/, /t/, /ʈ/, /k/, /ʂ/ (from /̊/), /s/, all of which having passed through Delaryngealization), it

[23]Grassmann's Law causes aspirates to deaspirate preceding aspirates that occur in the same root.

takes on the voice of the following segment (becoming /b/, /d/, /ɖ/, /g/, /ʐ/, /z/) (Pāṇini 8.4.53, Whitney 157–159, 174, Wackernagel I276a-b, 285, Allen p. 53–54, 58–59, 61, 91). The last two of these forms never appear on the surface. /ʐ/ will always get turned (back) into an /̊/ by Rhotacization. The /z/ too will normally be subject to Rhotacization,[24] but because it can also appear after /n/ (because of ns-Extension), it may further get turned into /n/ by n-Gemination, or be deleted by CC-Apocope. Either of these /̊/ may also disappear by ɽ-Degemination. /z/, unlike /ʐ/, will also be subject to z-Gliding after /a/; this often gets dropped by z-Glide Deletion or Udgraaha, but may also result in /oo/ by o-Abhinihita or o-Monophthongization. The stops, on the other hand, often appear in the cited form on the surface, but they too are subject to further changes in the right environment. They are subject to Nasalization before nasal stops, and /d/ may turn into another coronal by Dental Assimilation before another coronal stop, or fully assimilate to /l/ by Dental Assimilation and Lateral Sonorization.

The syllable boundary is a crucial part of this rule, since obstruents may appear before sonorants in onset clusters without becoming voiced. Confer Steriade, p. 272ff, who finds that syllable divisions are a condition for voicing assimilation in Greek and Latin, and [Hooper 1972], who finds the same for Spanish (p. 530). That the conditioning is syllable-limited rather than word-limited in Sanskrit was noted by Rice. It is a tendency to ignore syllable structure that leads most observers to claim that Obstruent Voice Assimilation is a word juncture rule, or at least to posit a completely different (lexical) rule for obstruent voice assimilation before other obstruents:[25] Selkirk has a *U*-span rule Obstruent Cluster Voicing Assimilation in addition to a *W*-juncture rule for intervocalic voicing, and argues against the desirability of collapsing the two. In fact, however, it clearly applies word internally as well, since differently-voiced obstruents do not appear adjacent even within a word (Whitney 117a). The reason why internal obstruent plus sonorant pairs are not so affected is because they are tautosyllabic, by the maximum onset principle. Excluding Voice Assimilation from word-internal domains led to the classification of inflectional endings beginning in /b^h/ as pada suffixes, because, e.g., stem-final dentals all become /d/ before these suffixes (there being a necessary syllable boundary there.)

19. z-Gliding

$$\begin{bmatrix} +\text{ant} \\ +\text{cont} \\ +\text{voice} \end{bmatrix} > \begin{bmatrix} -\text{cons} \\ +\text{son} \end{bmatrix} / \begin{bmatrix} +\text{syll} \\ -\text{high} \end{bmatrix}_a (\mathrm{V}_a) \text{ —}$$

[24] Allen (p. 58–60), who does not recognize ɽ-Desonorization as such, has all cases of rhotacization as coming via /ʐ/ from /ṣ/, the Ruki form of /s/ after vowels other than /a(a)/. This follows Wackernagel I285a.

[25] For example, Whitney 110 accounts the voicing effect of sonorants on obstruents as the most conspicuous distinction of external sandhi.

If a syllable ends in /a(a)z/ or /o(o)z/, the /z/ becomes a glide.

This has rarely been proposed as a rule of Sanskrit sandhi.[26] After all, the /z̯/ never appears on the surface, and certainly plays no major role in the phonemic inventories of the world's languages. But structural considerations make its presence rather obvious. /z/ (i.e., /s/ before a voiced segment) after /(a)a/ behaves like the other glides, /j/ and /w/: it is subject to Udgraaha (disappearing before a vowel-initial syllable) and o-Abhinihita (/az̯ a/ > /oo/) and o-Monophthongization just like /w/. And the environment in which it has this behaviour—after short or long /a/—is precisely the environment which licenses coda glides in Sanskrit: no heterorganic glide occurs in a coda except after /a/. It is of course a puzzle why precisely /z/ should be affected and not, for example, other voiced sounds such as the sonorants. Perhaps this is part of a conspiracy (along with, for example, Rhotacization), to get rid of voiced fricatives, which exist neither underlyingly nor on the surface but which get generated by Obstruent Voice Assimilation. This is the tack taken by Allen (p. 61), who ignores the diphthong-licensing effects of the /a(a)/ and hypothesizes that glides are inserted to make up for the deletion of the illegal /z/. For references to many other theories of the sandhi of voiced /s/ after /a(a)/, see Wackernagel I285b.

In Vedic, z-Gliding happened even after the /aaN/ that arose in Vedic ns-Extension.

Heterosyllabic /as/ sequences are not affected by this rule, so, for example, /manasaa/, the instrumental singular of /manas/. Failure to recognize the effect of syllable boundaries led earlier linguists to classify inflectional endings like /-b^{h}is/ as pada suffixes. In reality, they simply close the syllable, since /s/ may not precede voiced stops in onset clusters, leaving /ma-nas-b^{h}is/ subject to these rules: /ma-naz̯-b^{h}is/ and eventually /manoob^{h}is/.

20. Rhotacization

$$\begin{bmatrix} +\text{cons} \\ +\text{cont} \\ +\text{voice} \\ -\text{spread} \end{bmatrix} > \begin{bmatrix} +\text{son} \\ -\text{ant} \end{bmatrix}$$

Any /z/ that did not fall prey to z-Gliding becomes /̊/, which often survives to the surface. This may further get turned into /n/ by n-Gemination (in codas after /n/), or be deleted by CC-Apocope or ɽ-Degemination. This rule definitely applies word-internally: the instrumental plural of

[26] Allen comes closest in specifying /w/ after all short /a/ (p. 63), else /j/ intervocalically (p. 61), else ∅ (p. 72). This follows in large part some of the Indian linguists. Note Pāṇini has /as/ > /aw/ (but contrast [Bloomfield 1882], who has a quizzical view that the /o/ quality is not diphthongal but was inherited from PIE); 8.3.17 has /s/ > /j/ in /b^{h}oos/ words (which Pāṇini also claims to be an acceptable surface form). But probably none have posited a special glide that uniformly applies after all non-high vowels.

/həʋis/ ‘oblation’ is /hawis + b^h^is > ha-wiz-b^h^is > ha-wir-b^h^is > hə-ʋir-b^h^ih/. The rule also applies to /ʑ/, which is the voiced form of /ʂ̥/, the desonorized /r̥/. Thus underlying /r̥/ ends up as /r̥/ again before voiced sounds (Wackernagel I284a).

21. e-Abhinihita

$$[+\text{low}]\begin{bmatrix}-\text{cons}\\+\text{cor}\\-\text{ant}\end{bmatrix}\ \text{SB}\ [+\text{low}] > \text{e e} \,/\, \left\{\begin{matrix}\text{SB}\\ [-\text{low}]\end{matrix}\right\} \text{—} \left\{\begin{matrix}[+\text{cons}]\\ \text{SB}\end{matrix}\right\}$$

If a syllable ends in (short) /aj/ and the next begins with short,[27] non-diphthongal[28] /a/, the sequence /aja/ is replaced by long /ee/ (Pāṇini 6.1.109).

Since the prior word would end in /ee/ in its surface form, this phenomenon is usually taken to be an elision of the initial /a/ in the posterior word, and the standard European orthography (less common in India), which spells the /ee/, then marks a word boundary and uses an *avagraha* as a sign of /a/-elision, reinforces this point of view. But it is hard to understand why an /a/ should elide precisely after /aj/ but not /aaj/ or other consonants. Rather, I prefer Oldenberg's [1890] interpretation that this is a wholesale monophthongization of the three segments. Allen makes the same statement, and he supports this by the fact (as did [Bloomfield 1882], but for a different formulation of the rule) that, in the older language, which had a pitch accent, the resulting tone was as described above under Ksaipra; for example, High /aj/ plus Low /a/ becomes falling (HL) /ee/ (see for other references Wackernagel (I272bβ), who himself prefers /aja/ > /eea/ > /ee/); Bloomfield and Allen would have expected the Low to disappear if its vowel had been deleted, resulting in an High tone on the surface vowel. Nowadays, however, it is widely accepted that tones often reassign themselves when their host vowel is deleted ([Goldsmith 1990], p. 27-29), so this fact is not probative.

e- and o-Abhinihita was not a rule for the majority of Vedic speakers: Whitney reports (135c) that it occurs less than 2% of the time that the input conditions obtain. Oldenberg notes that since the written form /e-a/ scanned with the prior syllable light, the real pronunciation was /aja/. Similarly in o-Abhinihita, there were two short /a/ separated by /w/ or (in the case of /-as/) some reflex of /z/. This theory was not universally accepted, but seems quite satisfactory to me, at least synchronically as an intermediate form.

The prediction is that this should regularly happen in compounds, but I know of no data. Compounds are regularly formed with the stem of the prior element, but I know of no stems that end in /aj/. And the situation

[27] Whitney 135d reports a few loci where long /aa/ undergoes Abhinihita.

[28] Allen suggests (p. 43–44) that the structural description could be simplified by having Monophthongization precede Abhinihita. But Udgraaha must precede Monophthongization, and so that would then have to be complicated so as not to cause apocope before short /a/.

probably would not arise word-internally, since lexical resyllabification should put the glide into the following onset, leaving the word ineligible for this rule.

22. o-Abhinihita

$$\left[+\text{low}\right] \begin{bmatrix} -\text{cons} \\ \left\{\begin{matrix}+\text{ant}\\+\text{lab}\end{matrix}\right\}\end{bmatrix} \text{SB} \left[+\text{low}\right] > \text{o o} \;/\; \left\{\begin{matrix}\text{SB}\\ \left[-\text{low}\right]\end{matrix}\right\} \;—\; \left\{\begin{matrix}\left[+\text{cons}\right]\\ \text{SB}\end{matrix}\right\}$$

Like e-Abhinihita, but works when the final glide is /w/ or /z̯/ (see references for e-Abhinihita, and Whitney 175a). Note the necessary ordering after Voice Assimilation and z-Gliding, which are the only source of /z̯/.

These /ee/ and /oo/ all survive to the surface. It is clear that the reduction of /aj/ > /ee/ and /aw/ > /oo/ are the same process, involving complete assimilation in backness and fusional assimilation in height. But it is unclear why /az̯a/ should monophthongize to /oo/: the coronal, non-labial value of the /z̯/ would seem to suggest an /ee/ target, which, incidentally, happened word-internally as a historical process (e.g., the imperative of /as/ is /eedhi/, Whitney 636).

The only really clear case of a stem ending in /-aw/ is /gaw/, 'cow'. On the basis of this word it is hard to tell whether o-Abhinihita applies in compounds, as the theory would predict. There is for example the word /gaw + aʃwas > gooʃwəh/, where o-Abhinihita clearly applies; but there are also numerous compounds where the surface form has the hiatus /gooə/ (as if from a stem /goow-/! Wackernagel (I272bγ) sees this as a Classical misreading of Vedic /gawa-/) or /gəʊə/ (without o-Abhinihita or Udgraaha; Pāṇini 6.1.122 holds that Abhinihita is optional for this word in compounding) or /gəʊaa/ (from an irregular stem /gawa-/, Pāṇini 6.1.123-124). Clearly a good deal of lexical idiosyncrasy is at work here. In inflection, of course, the conditions for o-Abhinihita would never arise, since syllabification would never segment /aw-a/.

As mentioned above, Abhinihita in the pitch dialects produces results as for Ksaipra: H + L gives a falling contour. This is the last of the rules that contract syllables and thereby have an indirect impact on tones. Later in the rule set for those dialects, some simplifications occur: double like tones on a syllable become one (a universal tendency), and LH becomes H, Sanskrit nowhere tolerating a rising tone. Even later, there is in those dialects a suite of rules that generates the surface phonetic tonal system, which comprises three tones. Lows are raised to a new Mid tone after a High or (iteratively) after a Mid (that is, all Lows after the first High in an utterance become Mid); then an M is dissimilated to L immediately before a H; and then an H is copied onto an immediately following M vowel, resulting in a falling contour. The upshot is that a syllable before the high pitch is low, and the syllable after it is a falling contour, unless it is one of those low syllables. Pāṇini's description apparently requires HL contours (resulting from Ksaipra or Abhinihita) to become HM, like the HM contours generated by these rules; the Ṛgveda Prātiśākhya keeps that distinction, but provides that H linked to a single vowel, that is, the original lexical high tone, gets reduced in pitch to an M. In the Rigveda, therefore, the accentuation of the text does not explicitly mark the syllable bearing the lexical accent, since that is M like most vowels, but marks only the L before it and the falling contour after it. See further Appendix II of Müller.

23. Udgraaha

$$\begin{bmatrix} -\text{cons} \\ -\text{syll} \end{bmatrix} > \emptyset \;/\; \_\_ \;\text{SB V}$$

Glides are deleted at the end of a syllable if the next begins with a vowel (Pāṇini 8.3.19, Whitney 132). This is very much like Vowel Contraction, which also deletes a [−cons] segment before a vowel. But unlike the earlier rules of Vowel Contraction, Diphthongization and Ksaipra, which conspire to get rid of hiatus (contact of syllable nuclei), this rule creates hiatus where none existed before. The hiatus remains to the surface, since this rule follows all of the contraction rules.

This rule set apportions more work to Udgraaha than is ordinarily assumed. In addition to the surface alternations /ee/ and /ə/, /ai/ and /aa/, /oo/ and /ə/, this also accounts for the alternations /əh/ and /ə/, and /aah/ and /aa/, since the underlying /s/ (whence /h/ in the one alternant) has become /z̩/ by Voice Assimilation and z-Gliding. I also invoke it to explain the pragr̥hya inflections, giving a unified account for all sources of hiatus: those terminations have an extra glide at the end which this rule strips before vowels.

Udgraaha obviously follows Like Vowel Contraction, Diphthongization and Ksaipra, since the resultant hiatus is preserved;[29] Voice Assimilation and z Gliding, since they convert some /s/ to /z̩/, which is subject to this apocope; and the Abhinihita rules, since this rule does not bleed them. Udgraaha was held to be optional by some of the Indian linguists[30] (the Paninean rule says Śākalya makes it mandatory), in which case the remaining glide was held to be weakly articulated (Pāṇini 8.3.18), but the manuscripts uniformly drop the glide (Whitney 133a).

This rule cannot apply word-internally, since the lexicon would have resyllabified the glide with the next syllable before this rule could get hold of the word. As mentioned before, it is difficult to say whether this applies within compounding, since so few stems end in glides and these words have a host of lexicalized forms. Renou 41b claims it does not. Certainly forms like /gəi̯ṣṭi/ exist, where this rule has applied; there are also forms like /gəʋiṣṭi/, where it has not. I would hypothesize that the latter forms are

[29] In Vedic, the hiatus is occasionally resolved by combining the syllables. Monophthongization may then apply (Wackernagel I268).

[30] But the apocope is mandatory before the particle /u/ (Müller 39.3n, Renou 41b).

lexically resyllabified, although it is hard to say whether that is the regular rule for compounds or whether there are simply a host of lexicalized exceptions.

24. e-Monophthongization

$$\left[\,+\text{low}\right] \begin{bmatrix} -\text{cons} \\ +\text{cor} \\ -\text{ant} \end{bmatrix} > \text{e e} \;/\; \left\{ \begin{array}{l} \text{SB} \\ \left[\,-\text{low}\right] \end{array} \right\} \;\text{—}\; \left\{ \begin{array}{l} \left[\,+\text{cons}\right] \\ \text{SB} \end{array} \right\}$$

The sequence short /a/ followed by /j/ becomes long /ee/ (Wackernagel 269bα-β, Selkirk's Vowel Contraction; cf. Pāṇini 6.1.78, in reverse). This is very much like e-Abhinihita, but follows it, e-Abhinihita being more specific. These /ee/ all survive to the surface.

This rule clearly applies to compounds and also to word-internal environments; confer the example /kaama + i > kaamee/ discussed under Diphthongization. It gives the appearance of being violated in the case of the augment, which is a vowel prefixed to certain past tense verb forms. This is regularly /a-/, but before words beginning with a vowel, there is no monophthongization (Pāṇini 6.1.90, Whitney 136a): e.g., the augmented form of /unətti/ is /aunət/. But the idea that this rule is skipped is incorrect. Rather, it appears that a long /aa/ is lexically added to the first syllable, a morphological process called vr̥ddhi. Evidence that this is so comes from verbs in /ɽ̥-/, where the augmented form begins /aaɽ̥-/, not simply /ə̊/ (Macdonell 128). This is corroborated by the fact that the earlier language sometimes used /aa-/ as the augment, even before consonants (Whitney 585a).

25. o-Monophthongization

$$\left[\,+\text{low}\right] \begin{bmatrix} -\text{cons} \\ \left\{ \begin{array}{l} +\text{ant} \\ +\text{lab} \end{array} \right\} \end{bmatrix} > \text{o o} \;/\; \left\{ \begin{array}{l} \text{SB} \\ \left[\,-\text{low}\right] \end{array} \right\} \;\text{—}\; \left\{ \begin{array}{l} \left[\,+\text{cons}\right] \\ \text{SB} \end{array} \right\}$$

The sequence short /a/ followed by /w/ or /z̞/ becomes long /oo/. This is of course essentially the same as e-Monophthongization. It follows o-Abhinihita as well as Voice Assimilation and z-Gliding, which produce /z̞/.

26. Long Glide Reduction

$$\left[\,-\text{cons}\right] > \emptyset \;/\; \text{V } \text{C}_0 \left[\,-\text{low}\right] \_\_$$

Glides (/j/, /w/) in codas delete when not following /a(a)/. This brings the diphthongs into conformance with the surface-level constraints on diphthongs; see the section on Syllabic Licensing above. This rule handles the deletion of the extra glides that pragr̥hya words have, when they were not deleted by Udgraaha. It follows z-Gliding, one of the sources of those glides (in the case of /b^{h}oos/).

27. ẓ-Deletion

$\begin{bmatrix} -\text{cons} \\ +\text{ant} \end{bmatrix} > \emptyset$

Any remaining /ẓ/ is deleted (cf. Whitney 175c, 177, Pāṇini 8.3.22). This rule follows Voice Assimilation and z-Gliding, the source of all /ẓ/, and o-Abhinihita, Udgraaha, and o-Monophthongization, which it would otherwise bleed. This rule is invoked when /ẓ/ follows a long vowel, since the other rules take effect after short /a/.

No ready examples of the application of this rule in compounding come to mind, since no noun stems end in /-aas/. There do however seem to be word-internal cases of the application of this rule; for example, the imperative /ʃaas + d^hi > ʃaazd^hi > ʃaaẓd^hi > ʃaad$^\text{h}$i/ (Whitney 166).

28. Nasalization

$\begin{bmatrix} -\text{cont} \\ -\text{lat} \end{bmatrix} > \begin{bmatrix} +\text{nas} \\ +\text{son} \end{bmatrix} / \_\_ \text{ SB } \begin{bmatrix} +\text{nas} \end{bmatrix}$

Stops become nasals at the end of a syllable before a nasal (Pāṇini 8.4.45, Whitney 161, Wackernagel I276c, Selkirk's Stop to Nasal, Allen p. 92). The only nasals at this point are voiced nasal stops, so the final stops will already be voiced (viz., /g/, /ɖ/, /d/, /b/) by Voice Assimilation. This assimilation changes them into /ŋ/, /ɳ/, /n/, /m/, which form they retain to the surface. Renou 33a says there are even Paninean options for nasalization before a nasalized vowel, and that /l/ ([+lat]) can nasalize (> /l̃/).

This rule is held to be optional, but in practice is almost always applied (Macdonell 33, Whitney). It applies to compounds. But the syllable boundary is a crucial part of this rule. Stops may appear before nasals in onset clusters in Sanskrit, and these are not subject to Nasalization. Thus there is little opportunity for this rule to apply word-internally. But /-na/ as a suffix or past participle marker does occasion nasalization: /ənnəm/ 'food' from /ad-/ 'eat'; /c$^\text{h}$innəh/ 'cut' from /c$^\text{h}$id-/ 'cut' (Whitney 161b, 957d), and so do the rarer /-ni-/ and /-naa-/ (Renou 33a). It is possible that this rule can be leveraged, by having the lexicon produce for these rules an irregular syllabification, /ad-nam/, /c$^\text{h}$id-nas/.

In a Lexical Phonology/Morphology context, one might be tempted in fact to define a special stratum for suffixes like /-na/. The earlier stratum, for inflection and many primary suffixes, would include full resyllabification by the maximum onset principle at every cycle. The stratum with /-na/ in it, along with certain other primary suffixes, would resyllabify only consonants before vowels or glides. The third would include prefixing, compounding, and the attachment of some secondary suffixes, and would entail rules like /ɽ̥-Desonorization/ but no resyllabification. Confer Steriade, chapter 3, for more discussion of how different syllabification rules may apply at different levels. She finds that Greek too does not create complex onsets beyond level 1.

29. Postlexical tʃ-Splitting

$$\text{SB} \begin{bmatrix} -\text{cont} \\ +\text{Coronal} \end{bmatrix}_t > \text{C}_t \ \text{SB} \ / \begin{Bmatrix} \text{C} \\ \text{SB} \end{Bmatrix} \text{V} \ \text{—} \begin{bmatrix} -\text{son} \\ +\text{high} \end{bmatrix}$$

A /tʃ/ cluster loses the /t/ to the previous syllable if that is monomoraic. This ensures that the sequence will emerge as /cc$^{\text{h}}$/ (by Dental Assimilation and ʃ-Desibilation), rescued from the following rule. Cf. Pāṇini 6.1.73.

30. tʃ-Simplification

$$\begin{bmatrix} -\text{cont} \\ +\text{Coronal} \end{bmatrix} \begin{bmatrix} -\text{son} \\ \alpha\text{Place} \\ +\text{high} \end{bmatrix} > \text{c}^{\text{h}}$$

A /tʃ/ (onset) cluster simplifies to /c$^{\text{h}}$/. These are the affricates remaining after Intralexical tʃ-Splitting and Postlexical tʃ-Splitting split off /t/ within words or after short vowels. Note that this and the preceding rule are complements: /tʃ/ is simplified to a single segment unless that would change the weight of the preceding syllable.

31. Sibilant Dearticulation

$$\begin{bmatrix} -\text{son} \\ +\text{cont} \end{bmatrix} > \begin{bmatrix} -\text{Place} \\ +\text{spread} \end{bmatrix} / \ \text{V} \ \text{C}_0 \ \text{—}$$

Sibilants (/s/, /ʂ/) dearticulate in syllable codas (Whitney 170a, Selkirk's Visarga at Pause). Steriade, p. 64, describes this as the sibilant's acquiring the place of articulation of the preceding vowel. This rule follows Voice Assimilation, since the resultant *z* sounds are handled differently and are not subject to this rule. The /h/ produced by this dearticulation may survive to the surface, but it is also subject to Visarga Resyllabification and, when preceded by /n/, CC-Apocope. There are also varieties of the language where the sibilant is dropped before sibilant plus stop combinations, and according to some, even when an initial /s/ is followed by any consonant (Renou 36, Wackernagel I287b-c); that rule is not included here. Allen p. 76 describes it as a degemination which is permitted because the remaining /sC/ is enough to keep the syllable heavy.

In external sandhi, the /ʂ/ comes originally from an underlying /̊/, which is lexically turned into a voiceless obstruent word-finally (ɽ-Desonorization). The /s/ that feed into this rule may be underlying, or may have been lexically added to /-n/ words (ns-Extension).

/s/ can form an onset cluster with most voiceless sounds, so there is little opportunity for this to apply word-internally. There are a few words, most notably /duhk$^{\text{h}}$əh/ 'uneasy', where the word-internal presence of an /h/, which is not normally an underlying segment, suggests that this word is underlyingly /dus-k^has/, with irregular syllabification, as if it were a compound (and some Indian grammarians did try to make it out to be a compound, see Monier-Williams); this would let us leverage this rule. However, a more clear-cut case is afforded by the fact that /s/ cannot form onset clusters with another sibilant, and fortunately there are nouns ending in /s/ that take an inflectional suffix beginning with /s-/, viz., the locative plural /su-/. This is commonly styled a pada suffix because the final /-s/ turns to /-h/ in this environment: /ɦawis + su > ɦawihsu > ɦəʋihsu/. But not only does the invoking of this syllable-sensitive P2 rule easily explain the phenomenon without redress to any special lexical properties for the suffix, but it also avoids being embarrassed by the fact that words ending in /-/ do *not* behave as if in external sandhi before /-su/: /giiɽ + su > giiɽṣu/.

Vedic occasionally had /s/ here instead of the expected /h/, especially before /p/ and /k/ (Whitney 171, Wackernagel I286c). [Hale 1990] has adduced evidence that this irregular treatment may be explained by reference to Indo-European s-mobile forms as well as by syntactic phrasing. Of 73 cases in the R̥gveda where this /s/ appears before /k/, all but five turn out to be s-mobile words. So the /s/ would actually come from the following word, the preceding continuant deleted by the optional rule discussed above, whereby a continuant gets deleted before /sC/ clusters. The case of /p/ is not so convenient, but it does appear that the outcome /s/ is particularly likely when there is a close syntactic relationship between the words, such as Noun-Postposition or Genitive-HeadNoun (especially for head noun /pati-/). Hale notices furthermore that the /s/ appears only when the underlying sound is /s/, not //, and only when the following consonant is single, not a member of a consonant cluster. It follows that a likely cause of this phenomenon then is some sort of resyllabification of the /s/ with the onset of the following word; resyllabification into a stop cluster would be impossible, since it has been shown above (Syllabic Licensing) that /spC/ is an impossible onset. This lexical-like resyllabification is further indicated by the fact that this /s/ may even undergo the lexical process of Ruki (Pāṇini 8.3.44). The complex of facts also recalls Selkirk's hypothesis that Ruki in Vedic is an *F*-domain rule; perhaps Vedic also had a syllabification rule that operated on this domain.

32. Visarga Resyllabification

$$\begin{bmatrix}+\text{cons}\\-\text{son}\\+\text{cont}\end{bmatrix}_h \text{SB} > \text{SB } \text{C}_h \;/\; \_\_ \begin{bmatrix}-\text{cont}\\+\text{Coronal}\end{bmatrix} \begin{bmatrix}+\text{son}\end{bmatrix}$$

A syllable-final fricative (all of which have by this time become by Sibilant Dearticulation /h/, called *visarga* in Sanskrit) moves into the onset of a following syllable that begins with an unvoiced coronal stop. This feeds Fricative Assimilation, resulting in the clusters /ʃc/, /ṣʈ/, and /st/. The net effect is that word-final sibilants (/s/, including that introduced by ns-Extension, and /ṣ/, from /˚/ by ṛ-Desonorization) do not end up as /h/ in this environment, but appear instead to merely assimilate Place features. That resyllabification is involved is suggested by the fact that all sibilant-tenuis onsets are homorganic, indicating that a rule of Fricative Assimilation operates over onsets. The supposition is further supported by the fact that the assimilation does not take place if the stop is followed by an obstruent: that is, underlying sibilants remain /h/ before /ts/ (Pāṇini 8.3.35, Whitney 173b, Wackernagel I286d, Allen p. 77). This makes sense if one recalls that sC clusters cannot be followed by obstruents. It would appear that /h/ follows the same syllabification constraints as do sibilants, which is not too strange when one considers that the group constitutes all the fricatives of the language, and that voiced /ɦ/ is also a legal first element of an onset cluster. It might appear that it would be more natural to order this resyllabification before Sibilant Dearticulation: then sibilants would resyllabify before coronal stops if available, potentially assimilating, and others would go to /h/. Instead, this rule set turns all the sibilants into /h/, only to turn many of them back into sibilants again. By itself this may seem strange, but there is a version of the language where /h/ resyllabifies and assimilates before all (unvoiced) stops (Pāṇini 8.3.37, Wackernagel I286cα, Renou 36). If the resyllabification had happened before the dearticulation, then there would falsely be no distinction between original /s-k/, which gives /x-k/ in that dialect, and the original cluster /sk/, which ends up as /sk/. It seems convenient to follow the ordering found in that dialect, since it has no undesirable consequences here. The Vedic facts mentioned above under Sibilant Dearticulation provide some insight as to how this state of affairs might have come about. At some point the language must have had sporadic resyllabifications between closely related words of all types, then this phenomena occurred particularly with final /s/ before oral stops. There might well have been two parallel developments at this point. An "aspirating" dialect that dearticulated final /s/ might have generalized the fact of resyllabification before all stops. Another dialect (ours) that acquired the dearticulation rule only later might have reanalyzed the rule as applying only before coronals, since sibilant assimilation in onsets would have made that resyllabification more salient. This is all pure speculation, of course, but it does show that the attested state of affairs has at least one believable explanation. Although linguists have not mentioned resyllabification as an explanation of the assimilations, Steriade, p. 64, accomplishes much the same thing by providing that the final sibilant (prior to the dearticulation rule) be autosegmentally linked to the Place of the following stop. In her system, such linkage would prevent the /s/ from becoming /h/ later, much as would be the case for geminate linking. Her theory would be hostile to this resyllabification hypothesis, since it maintains that sT clusters do not build true syllable onsets, and even holds that assimilation cannot take place within a syllable (p. 272). Her analysis, however, does not explain why the assimilation is blocked by following obstruents.

33. Fricative Assimilation

$$\begin{bmatrix}+\text{cons}\\+\text{cont}\end{bmatrix} > \text{SB}\begin{bmatrix}\alpha\text{Place}\\-\text{spread}\end{bmatrix} \ / \ \text{SB} \ \_\_ \begin{bmatrix}-\text{cont}\\+\text{Coronal}\\\alpha\text{Place}\end{bmatrix}$$

/s/ or /h/ takes on the place of articulation of a Coronal stop following in the same onset (yielding /ʃc/, /ṣṭ/, /st/) (Whitney 170c, 208, Wackernagel I284d, 286a-b, Allen p. 74, Hale p. 88–89). In sandhi, these sibilants come from Visarga Resyllabification, but the rule can also apply to lexical entities, since fricatives (/s/) in an onset undergo the same assimilation. Thus Monier-Williams lists words beginning with /ʃc-/, /ṣṭ-/ and /st-/, but not */sc-/, etc.

A not uncommon variation, particularly in the South, is for the assimilation to take place even before fricatives, i.e., as if the description were [−son] instead of [−cont] (Pāṇini 8.4.40–41, Whitney 172, Allen p. 75). The assimilation is total. Since this does not seem to be blocked by a following obstruent, and since there is no reason to believe that onsets can begin with two sibilants, whether identical or not, it would appear that the SB would be optional in that version.

Another variant assimilates the putative underlyingly tautosyllabic lexical /s/ only before coronals, but assimilates /h/ from the sandhi of /-s/ before all stops (see Visarga Resyllabification above, and Pāṇini 8.3.37, Wackernagel I286cα, Renou 36). This dialect would need two rules, since /s/ and /h/ produce different outputs before non-coronals.

34. Nasal Dearticulation

$$\begin{bmatrix}+\text{nas}\end{bmatrix} > \begin{bmatrix}-\text{Place}\end{bmatrix} \ / \ \_\_ \ \text{SB}\begin{bmatrix}+\text{Coronal}\\-\text{son}\\+\text{cont}\end{bmatrix}$$

/n/ becomes dearticulated before a sibilant (Whitney 208). In sandhi the only relevant participant is word-final /n/, which lexically became /ns/ by ns-Extension, and appears before a voiceless coronal stop, /s/ therefore remaining as some coronal sibilant by Sibilant Dearticulation, Visarga Resyllabification and Fricative Assimilation. This /N/ plus sibilant will be the surface form. Word-final /-m/, on the other hand, is already /N/ by m-Dearticulation, and so this rule applies vacuously to it.

This rule is quite prolific word-internally (Whitney 204, 212); for example, the second singular present is formed by adding /-si/, and for /ɦan/ this surfaces as /ɦəN-si/. And articulated nasals (/m, n/) never appear before a sibilant in the interior of a word (Whitney 117c). Note however that in external combination, final /-n/ words do not dearticulate before initial sibilant words; this is because the /s/ added in ns-Extension is by this point /h/ (by Sibilant Dearticulation), protecting the /n/ from this contact. The surface form (after CC-Apocope) will be /-n S-/. It is interesting to note that, because of the theory of pada suffixes, Indian grammarians held that stems ending in /n/ would not change before the ending /-su/, as per external sandhi. But the only examples Whitney finds (204a) are in accord with with this rule set, namely /-Nsu-/.

35. n-Gemination

$$\text{X SB} > \text{SB X}_n \ / \left\{ \begin{array}{c} \text{SB} \\ \text{C} \end{array} \right\} \text{V} \left[+\text{cons} \right]_n \text{—} \text{V}$$

Syllable-final non-glide consonant clusters (in practice, /n̊/ or /ŋg/; it is said that /ɳ/ participates in this gemination, but I know of no examples[31]) become geminates by progressive assimilation after a short vowel when the next syllable begins with a vowel (cf. Pāṇini 8.3.32, Whitney 210. [Bartholomae 1887] almost agrees with my derivation: his /ns/ > /nz/ > /nn/ leaves out only Rhotacization. He rejects however a derivation of /ŋŋ/ directly from /ŋg/, since he recognizes no distinction of word or syllable boundaries.). This should be considered in conjunction with the next rule, which deletes other syllable-final consonants. In accordance with the strong tendency in Sanskrit to avoid multiple consonants in a coda, the second consonant is lost, but with a compensatory lengthening just in case the syllable would have become light as a result of the loss.

This rule is generally presented as a gemination of an underlying lone nasal, which is unmotivated. Making the assumption that putative /-n/ words are really (postlexically) /-ns/ words makes this phenomenon, as well as the appearance of fricatives before voiceless stops, much more natural. Similarly, /-ŋ/ words are all underlyingly /-ŋk/ words (from even deeper /-nc/ forms; Allen p. 55). These rules permit us to account for both the loss of the /k/ and the gemination in the same phonetically natural way. The explanation here offered also accounts for the fact that final /-n/ and /-ŋ/ are subject to gemination, whereas /m/ (which never derives from /n/) nor any other dental or velar sound does so. It is also noteworthy that gemination is held not to apply to artificial terms like /tiŋ/ (Renou 34a). This can be explained by the fact that these are not reduced from a */tink/, for example, but are formed out of whole cloth in the lexicon. The rules never apply word-internally or in compounds, since the structural description is never met there.

The metre indicates that the gemination was sometimes omitted in Vedic (Whitney 210a). Allen (p. 56), as did Wackernagel, reports that single /n/ surfaces there primarily when the word has a historically justified final cluster. He also reports an interesting suggestion by Oldenberg that metric evidence indicates that Vedic also had a similar rule for /-ɽt/ (geminating to /-ɽɽ/ in V̆—V, /ɽ/ elsewhere; invariably written as if /-ɽ-/, but always making the prior syllable heavy).

[31] Müller 72 and Renou 34a both give /sugaɳ + aastaj/ "he sits counting well", but /sugaɳ/ is an artificial word (Monier-Williams). If real examples exist, they will by this point have added an /s/ by ns-Extension, and therefore this rule will apply.

36. CC-Apocope

$$X > \emptyset \;/\; V\ C_0 \left\{ \begin{array}{c} -\text{cont} \\ -\text{son} \end{array} \right\} \_\_$$

Any segment is deleted after a consonant other than a glide or /ɽ/ in the coda; see also n-Gemination above. This happens notably with the clusters /nh/ (from /ns/ by Visarga Dearticulation, itself from /n/ by ns-Extension), /nɽ/ (from /ns/ by Voice Assimilation), /ŋk/ and /ŋg/ (from /nk/ by Voice Assimilation). These /-n(s)/ words almost always end up without the sibilant on the surface, which is why /n sT/ sandhi is usually looked upon as an insertion process, rather than as a survival.

37. Dental Assimilation

$$\begin{bmatrix} +\text{ant} \\ -\text{cont} \\ -\text{lat} \end{bmatrix} > \begin{bmatrix} \alpha\text{Place} \\ \beta\text{lat} \end{bmatrix} \;/\; \_\_\ \text{SB} \begin{bmatrix} +\text{Coronal} \\ -\text{nas} \\ \left\{ \begin{array}{c} -\text{cont} \\ +\text{high} \end{array} \right\} \\ \alpha\text{Place} \\ \beta\text{lat} \end{bmatrix}$$

/t/, /d/ (from /t/ via Voice Assimilation) or /n/ (from /ns/, exposed by CC-Apocope) at the end of a syllable assimilates in place to a coronal (palatal, dental, retroflex) oral stop or /l/ beginning the next syllable (Pāṇini 8.4.40–44, 60, Whitney 162, 199a, 202, 203, 206, Wackernagel I276d, 277bβ, 281b, Allen p. 91–93). The laterality of the /l/ is also assimilated, resulting in the lateral stop /d^l/ (subsequently /l/ by Lateral Sonorization) or (from /n/) the nasal lateral /l̃/, which survives to the surface. Dentals also assimilate before /ʃ/ ([+cont +high]) in the rare event that ʃ-Desibilation does not occur; but not before /ʂ/ (Pāṇini 8.4.43).

Steriade, following [Kiparsky 1973], uses Dental Assimilation to account for the assimilation of final /s/ to initial coronal stops (p. 64). That laudable economy would however make other things more awkward. It bypasses Sibilant Resyllabification, which was shown above to have some useful properties. It could not directly explain the assimilation of /ʂ/ < /ɽ/, since retroflexes do not assimilate. More crucially, CC-Apocope must follow Resyllabification, lest it bleed it; but CC-Apocope of strings like /nz ɖ/ leaves /n ɖ/, itself (correctly) subject to Dental Assimilation.

Many of the manuscripts neglect to write the assimilation of /n/ before /ɟ/ (Whitney 202c). Although it is possible that the writers did not have this assimilation (*contra* all the linguists), it seems more likely that they neglected to note the change because /ɲ/ is strictly an allophone of /n/ (occurring only next to a palatal); this explanation is given by Allen p. 84 n40. Many manuscripts also fail to write /l̃/ as such, preferring the notation /n/ (Whitney 206a); this may be referred to the same cause.

This rule seems to have no overt application word-internally, since there are no endings beginning with non-dental coronals, but it does apply after verbal prefixes (/ut/) and in compounds. It is however noticeable that articulated nasals are always homorganic with following stops, so one could specify underlying /n/ and use this rule as part of a strategy to derive their surface form. There is also a very similar lexical process by which dentals assimilate progressively to a preceding coronal.

38. Lateral Sonorization

$\left[+\text{lat}\right] > \left[+\text{son}\right]$

The lateral stop /d^{l}/ becomes an ordinary /l/ (Whitney 162). This adjunct to Dental Assimilation merely provides that laterals generated by that rule must be sonorant. It applies in compounds and verbal prefixes (/ut/), and can safely apply to word-internal sequences, since /d^{l}/ never appears on the surface.

39. Onset Filling

$\text{C}_i \text{ SB} > \text{SB C}_i \ / \ \_\_ \ \text{V}$

Syllable-final consonants are resyllabified with a following vowel. This rule is necessary to account for the fact that underlying /aaw/ gets interpreted as /aa-ʋ/ before a vowel (but Long Diphthong Reduction will reduce it to /aw/ elsewhere). It also leads directly toward the surface syllabification of the string, which is completed by Coda Filling, below. CV syllabification appears to be a universal rule (Steriade, p. 78), and applies several times in the derivation of Sanskrit strings even when, as here, maximum onset resyllabification is not done.

40. w-Dentalization

$$\begin{bmatrix} -\text{syll} \\ -\text{cons} \\ +\text{lab} \end{bmatrix} > \left[-\text{Dorsal}\right] \ / \ \left\{ \begin{array}{l} \text{SB} \\ \left[-\text{low}\right] \end{array} \right\} \ \_\_$$

/w/ becomes a labiodental glide /ʋ/ except in diphthongs. This applies word-internally as well as in sandhi. It must follow Onset Filling, since /aaw/ before a vowel ends up as dentalized /aa-ʋ/. Thus /-aaw/ words are basically pragr̥hya; the variation before a vowel is a late, essentially phonetic change.

41. Long Diphthong Reduction

$\text{V}_{i}{}_{1}^{2} > \emptyset \ / \ \_\_ \ \text{V}_i \ \left[-\text{cons}\right]$

Long vowels shorten before a tautosyllabic glide or vowel (i.e., long diphthongs and extra-long vowels become bimoraic). This is in conformity to a surface-level constraint on rhyme structure in Sanskrit. Long Glide Reduction above, although it focusses on the need for /a/ to license diphthongs, also works in this direction. Long Diphthong Reduction must follow Onset Filling, since underlying /aawV/ retains the long vowel (> /aa-ʋV/ by that rule).

This rule can also be useful for word-internal processes. For example, the nominative/accusative dual suffix for non-neuter nouns is /-aaww/; when combined with a /-a/ stem noun, the result is not /-aaaww/, but /-aw/. Certainly the language nowhere has vowels or diphthongs longer than two segments.[32]

42. Glide Vocalization

    $[-\text{cons}] > [+\text{syll}]$ / $[+\text{low}]$ C_0 —

    The diphthongs /ay/ and /aw/ are realized as /ai/ and /au/.

    The Paninean system of sigla generates artificial words ending in /əj/ and /əʊ/; e.g., /cʰəʊ/, which denotes coronal voiceless stops. These can be handled by assuming that the lexicon spits out forms that anomalously already have a /ə/ in them. This rule will only affect glides following /a/.

43. Coda Filling

    SB $C_i > C_i$ SB / V — C

    Empty codas are filled by taking the first segment from a following branching onset. Thus vowels followed by two or more consonants are always in a closed syllable. This accords with the description of syllabification in most of the Prātiśākhyas ([Mishra 1972]),[33] and gives a straightforward explanation of Sanskrit poetry, which, like the Greek, is based on patterns of light (1-moraic, open C$\breve{\text{V}}$) and heavy (2-moraic, C$\bar{\text{V}}$ or CVC) syllables (Macdonell, Appendix II). It is important to note that syllabification is built generatively, that a word may have different syllabifications in the course of its derivation. Much of the syllable-based behaviour described in this paper would have made no sense if one had assumed that all VC segments are tautosyllabic before another C, as they apparently are on the surface.

    This rule must be ordered after Glide Vocalization, since there are some rather unusual cases of originally tautosyllabic doubled glides, which must be distinguised from the heterosyllabic case for the purpose of vocalization and a-Raising (see below). Thus /ma-ji a-tra/ becomes /ma-jja-tra/, /maj-ja-tra/, then /məj-jə-trə/, but /a-smaaj jas/ becomes /a-smaj-jah/, /ə-smai-jəh/.

    Taking a tack from Steriade, another way of looking at this rule would be to say that the coda elements really were not part of the syllable before this point, but were stray segments. This may help explain why they are subject to so much assimilation, which, in autosegmental terms, is the forming of links to following elements: it would not be unintuitive to

[32] I have ignored throughout the case of the *pluta* vowels, which are said to be trimoraic. It seems clear that the prolongation is strictly intonational (see for example the description in Whitney 78). Furthermore, the claim that pluta vowels are pragr̥hya (Pāṇini 6.1.125) is almost certainly merely a reflection of the fact that they are utterance-final.

[33] The R̥gveda Prātiśākhyas also allow onsets much like those here specified for underlying forms.

suggest that segments lacking a link to the syllable may be more inclined to form a link at least to some of the nodes of other segments. In particular it explains why these elements could be deleted without compensatory lengthening taking place (Steriade, p. 223), even when directly after a vowel. Without taking a firm stand on this issue, I do note that rules involving compensatory lengthening or other effects of the coda on other parts of the phonetic string can be (and here are) ordered after this coda-filling rule.

44. ɦ-Articulation

$$\begin{bmatrix} -\text{Place} \end{bmatrix} > \begin{bmatrix} -\text{cont} \\ \alpha\text{Place} \end{bmatrix} \; / \; \begin{bmatrix} -\text{cont} \\ -\text{lat} \\ -\text{nas} \\ \alpha\text{Place} \end{bmatrix} \text{SB} \;\_\_$$

/ɦ/ at the beginning of a syllable becomes a breathy voiced stop homorganic with an oral stop preceding it (Pāṇini 8.4.62, Wackernagel I278c, Whitney 163, Allen p. 93). By Voice Assimilation that oral stop will have already become voiced, so the end result, which survives to the surface, are the forms /gg^h/, /$ɖɖ^h$/, /dd^h/, /bb^h/.

This applies to compounds and to verbal prefixes (/ud-hatas/ > /ud-d^hatas/), but there are probably no cases where it applies word-internally (Whitney); the only suffix that I know of beginning in /ɦ-/ is the imperative /-ɦi/, and this is an allomorph of /-d^hi/ used only after vowels. On the other hand there are certainly no word-internal cases of /ɦ/ appearing after a stop, so there is no harm in letting this rule apply postlexically. The Indian linguists held this rule to be optional, but it is almost invariably applied in the manuscripts (Whitney 163a).

45. ʃ-Desibilation

$$\begin{bmatrix} -\text{son} \\ +\text{cont} \\ \alpha\text{Place} \\ +\text{high} \\ +\text{cor} \\ -\text{ant} \end{bmatrix} > \begin{bmatrix} -\text{cont} \\ +\text{spread} \end{bmatrix} \; / \; \begin{bmatrix} -\text{cont} \\ \alpha\text{Place} \end{bmatrix} \text{SB} \;\_\_\; \begin{bmatrix} +\text{son} \end{bmatrix}$$

/ʃ/ becomes /c^h/ at the beginning of a syllable after /c/ or /ñ/ (Pāṇini 8.4.63, Whitney 203, Wackernagel I278a, Allen p. 85–86, 91–92). This must follow CC-Apocope and Dental Assimilation, so that /ns/ words will by this time present a bare /ñ/ to feed this rule, and /t/ will have become /c/. The process appears to be a progressive assimilation of the non-continuousness of the preceding stop. The resulting /c^h/ survives to the surface. This rule applies to verbal prefixes (/ut/) and compounding (in the case of /-t/), and in my analysis of /c^h/ applies also word-internally, where /(c)c^h/ words are considered underlyingly /tʃ/. Pāṇini held that the rule was optional between words, and applied after all oral stops, and barred its application when the /c^h/ would be followed by nasals or /l/, no doubt because those do not normally form an onset, but this restriction was relaxed by later commentators, who allowed clusters analogous to those formed by many other stops. This leaves only the case of initial /ʃc/, where the onset /c^hc-/ would clearly be illegal and is ruled out by my formulation of this rule (the [+son]); but this case is rare enough that it is often ignored.

A somewhat related optional rule not included in this set is an insertion of /t/ between /ʈ/ and /s/ (Whitney 199e, Wackernagel I278b). This excrescence would seem to be a timing phenomenon, where the tongue shifts to the dental position perceptibly before the frication begins. Similarly the frequently followed option of adding a stop homorganic to the nasal between a nasal and sibilant (Pāṇini 8.3.28, 30, 31, Whitney 207, 211, Wackernagel I282, Allen p. 84–85).

46. ɽ-Compensatory Degemination

$$\text{ɽ} > \mathrm{V}_i \;/\; \left\{ \begin{array}{c} \mathrm{SB} \\ \mathrm{C} \end{array} \right\} \mathrm{V}_i \;\text{—}\; \mathrm{SB}\ \text{ɽ}$$

A syllable-final /ɽ/ after a short vowel disappears before another /ɽ/, resulting in compensatory lengthening (Pāṇini 8.3.14, 6.3.111; Whitney 179; Wackernagel I284b; Allen p. 70). This is clearly part of the same rule as the following, here separated because of a weakness in the notation. The idea is that geminate / ˚ɽ/ is not tolerated by the language (a restriction common in many languages, apparently because the tapped /ɽ/ is considered a necessarily extra-short sound, in contrast with the voiced stop /d/), but if the simplification would turn a heavy syllable light, the vowel is lengthened. / ˚ɽ/ never appears word-internally.

47. ɽ-Degemination

$$\text{ɽ} > \emptyset \;/\; \text{—}\; \mathrm{SB}\ \text{ɽ}$$

Other /ɽ-ɽ/ sequences degeminate (without compensatory lengthening). See the above rule.

48. a-Raising

$$\left[\,+\mathrm{low}\,\right] > \left[\,-\mathrm{low}\,\right] \;/\; \left\{ \begin{array}{c} \mathrm{C} \\ \mathrm{SB} \end{array} \right\} \text{—} \left\{ \begin{array}{l} \left[\,+\mathrm{cons}\,\right] \\ \mathrm{SB} \end{array} \right\}$$

Short /a/ becomes /ə/ except within a diphthong (Pāṇini 8.4.68). This is an allophony that applies everywhere, including word-internally.

6 Final comments

This rule suite appears to be sufficient to account for the core sandhi rules of classical Sanskrit: although the interaction of four dozen sequential rules can be complex, an automated test suite of hundreds of examples gave correct derivations in all cases. In the absence of formal metrics, I hope the reader will agree that by and large the P2 rules are quite natural. I also hope that the lexical rules have been given a plausible historical explanation, which is all that they require.

Beyond this, I have tried to show that almost all of the phonological alternations seen in sandhi can be described in terms of syllable-boundary conditions rather than word-boundary conditions. This, granted, is not the same as showing that they *must* be described so. But I think at least three factors strongly suggest the advisability of such an approach. First, it seems advisable as a matter of course to prefer to describe phenomena by pure P2 rules whenever possible, and the syllable has more of a claim to being a pure P2 domain than does the word, since the latter has no physical correlate. Secondly, I have shown that a great many of the rules actively solve problems of morphological phonology, and that of those that do not apply at derived environments, the vast majority can be viewed as explaining why their input condition is not found in the surface forms of lexemes. Lastly, I have shown that this approach obviates the need to specially classify certain inflectional endings as "pada" suffixes. The fact that their phonology usually (but not always) mirrors that of word sandhi falls out naturally from their phonological structure (the initial /b^h/, /d^h/ and /s/), which usually demands syllabification in their own onset, which brings about the syllable boundary which is the key factor triggering the phonological changes in this rule set.

It was mentioned in the Data section that external sandhi is traditionally held to apply in more contexts than just at word boundaries and before the pada suffixes. The elements of nominal compounds as a rule do seem to behave like separate words. That is, each component of the compound appears to suffer all the lexical rules that can apply to words, and then it is pasted together with the other element, with the compound not undergoing the resyllabification that is triggered by other morphological processes. Most crucially, prior elements ending in /ɽ/ regularly show up as /h/ on the surface before voiceless consonants. Since /ɽ/ can otherwise surface at the end of the syllable, this shows that the treatment of the sandhi compounds can be ascribed to their status as individual words, not just to the preservation of syllable boundaries. Nevertheless, there are many lexicalized exceptions, including cases where /ɽ/ is not desonorized, cases where the compound is clearly resyllabified (/nəməskəɽooti/, where /-hk-/ would have been expected, Pāṇini 8.3.40), cases where special forms of stems are used for compounding (confer the 'cow' compounds discussed above under o-Abhinihita and Udgraaha), and cases where lexical phonological rules apply across the whole compound (see for example Whitney 185–187, 193). Much the same can be said for the verbal prefixes (upasargas), where the treatment of /antaɽ-/, of which the /ɽ/ desonorizes before voiceless consonants, is decisive. Here the special behaviour of upasargas before verbs in /ɽ/ underscores the lexicalized peculiarities that can colour what is essentially a word sandhi process.

The claim that secondary suffixes take external sandhi is harder to evaluate, partly because the number of lexicalized exceptions increases alarmingly, and partly because many of the words are inherited from the older language, where the sandhi rules were different. There does appear to be a trend toward increasingly treating secondary suffixes with the rules of external sandhi; the Vedic languages shows less than a dozen clear cases (Whitney 111d). I can only summarize that the treatment of such suffixes is very much a mixed bag. It seems that most of the suffixes most of the time take internal sandhi; this is certainly true for all suffixes beginning with vowels or /j/, but also others like /-wan/ and /-win/. Others, like /-want/ and /-mant/, are mixed; others, like /-maja-/ and /-tana-/, clearly take external sandhi. Phonetics enters into the equation, but the different treatment of suffixes with the same initial shows that much of the distinction is lexically determined. Derivations such as /mənoomə̧jəh/ from /manas+majas/ show that at the very least, some of these suffixes do seem to form derivatives that have not been resyllabified; /sm-/ should be able to form an onset, and surface unchanged. Might it be the case then that these suffixes simply trigger rules that forego resyllabification? In at least some cases it must be more than that, since forms like /ciɽəNtənəh/ (from /ciɽam/) and /pɽaatəstənəh/ (from /pɽaataɽ/) show evidence of the first element's having undergone the lexical rules of m-Dearticulation and r-Desonorization. I would conclude therefore that the claim that secondary suffixes undergo external sandhi is a bit too baldly stated, but at least some of the suffixes are combined to their stem by a compounding process. This is probably what Whitney meant when he said that external sandhi is especially common "before secondary suffixes having a markedly distinct office" (111d), and so Wackernagel I288b. Others with a less distinct office may combine with their stem in a special stratum that resyllabifies consonants before vowels or glides but does not otherwise form complex onsets.

By way of summary, this is the model of Sanskrit sandhi which emerges from this study. Within the lexicon, strata which handle inflectional morphology and primary derivational morphology form stems and words, with resyllabification by maximizing onsets in each cycle. Pada suffixes are adjoined here, and are in no way exceptional. There may be an additional stratum for those secondary suffixes which occasion resyllabification only of consonants before vowels or glides. Compounds are formed from morphs without further resyllabification;[34] prefixes and some suffixes traditionally treated as secondary derivational suffixes are best treated as elements of compounds. One or two rules such as ɽ-Desonorization apply before the cycles of that stratum. Postlexically, the words are inserted into the syntax, and two or three lexically-sensitive P1 word-juncture rules take effect. Then there are a host of P2 rules, which account for most of the sandhi effects. These are insensitive to word boundaries, treating alike word-internal syllable boundaries and those that occur between words in a sentence.

[34] But they are subject to reaccenting in the pre-classical language. Verbal compounds and, exceptionally, nominal ones, may be subject to further lexical processes (particularly retroflexing of some /s/ and /n/). Certain lexicalized compounds can even be analyzed as exceptionally undergoing resyllabification, but this is not productive. It should further be noted that compounds have certain lexical phonological rules of their own (such as dropping /-n/ in prior elements), and may select stems differing from those used in inflection.

7 Sample derivations

This is the result of running the rule system over a test suite that consists of all examples in [Emeneau 1968], supplemented by distinctive examples from [Goldman 1987] and a few other sources as needed. They are organized by the final of the first word (as shown in Tables 2–4), and subsorted by the initial of the second word.

1:	# -wa-naj-[dual-pragrhya] -a-tɽa- #
Dual pragrhyatva:	# -wa-najj-[dual-pragrhya] -a-tɽa- #
WB erasure:	#-wa-najj–a-tɽa-#
SB simplification:	#-wa-najj-a-tɽa-#
Udgraaha:	#-wa-naj-a-tɽa-#
e-Monophthongization:	#-wa-nee-a-tɽa-#
w-Dentalization:	#-ʋa-nee-a-tɽa-#
Coda Filling:	#-ʋa-nee-at-ɽa-#
a-Raising:	#-ʋə-nee-ət-ɽə-#

2:	# -ja-ɟaj-taj-[dual-pragrhya] -u-b^haaw- #
Dual pragrhyatva:	# -ja-ɟaj-tajj-[dual-pragrhya] -u-b^haaw- #
aaw-Extension:	# -ja-ɟaj-tajj-[dual-pragrhya] -u-b^haaww- #
WB erasure:	#-ja-ɟaj-tajj–u-b^haaww-#
SB simplification:	#-ja-ɟaj-tajj-u-b^haaww-#
Udgraaha:	#-ja-ɟaj-taj-u-b^haaww-#
e-Monophthongization:	#-ja-ɟee-tee-u-b^haaww-#
Long Glide Reduction:	#-ja-ɟee-tee-u-b^haaw-#
Long Diphthong Reduction:	#-ja-ɟee-tee-u-b^haw-#
Glide Vocalization:	#-ja-ɟee-tee-u-b^hau-#
a-Raising:	#-jə-ɟee-tee-u-b^hau-#

3:	# -ka-njaj-[dual-pragrhya] -aa-ga-tʃa-tas- #
Dual pragrhyatva:	# -ka-njajj-[dual-pragrhya] -aa-ga-tʃa-tas- #
Intralexical tsh-Splitting:	# -ka-njajj-[dual-pragrhya] -aa-gat-ʃa-tas- #
WB erasure:	#-ka-njajj–aa-gat-ʃa-tas-#
SB simplification:	#-ka-njajj-aa-gat-ʃa-tas-#
Udgraaha:	#-ka-njaj-aa-gat-ʃa-tas-#
e-Monophthongization:	#-ka-njee-aa-gat-ʃa-tas-#
Sibilant Dearticulation:	#-ka-njee-aa-gat-ʃa-tah-#
Dental Assimilation:	#-ka-njee-aa-gac-ʃa-tah-#
Coda Filling:	#-kan-jee-aa-gac-ʃa-tah-#
sh-Desibilation:	#-kan-jee-aa-gac-c^ha-tah-#
a-Raising:	#-kən-jee-aa-gəc-c^hə-təh-#

4:	# -ban-d^{h}uu-[dual-pragrhya] -aa-saa-tajj- #
Dual pragrhyatva:	# -ban-d^{h}uuw-[dual-pragrhya] -aa-saa-tajj- #
WB erasure:	#-ban-d^{h}uuw–aa-saa-tajj-#
SB simplification:	#-ban-d^{h}uuw-aa-saa-tajj-#
Udgraaha:	#-ban-d^{h}uu-aa-saa-tajj-#
e-Monophthongization:	#-ban-d^{h}uu-aa-saa-teej-#
Long Glide Reduction:	#-ban-d^{h}uu-aa-saa-tee-#
a-Raising:	#-bən-d^{h}uu-aa-saa-tee-#

5:	# -ban-d^{h}uu-[dual-pragrhya] -jat- #
Dual pragrhyatva:	# -ban-d^{h}uuw-[dual-pragrhya] -jat- #
WB erasure:	#-ban-d^{h}uuw–jat-#
SB simplification:	#-ban-d^{h}uuw-jat-#
Long Glide Reduction:	#-ban-d^{h}uu-jat-#
a-Raising:	#-bən-d^{h}uu-jət-#

6:	# -ta-tɽa- -a-sti- #
WB erasure:	#-ta-tɽa–a-sti-#
SB simplification:	#-ta-tɽa-a-sti-#
Like Vowel Contraction:	#-ta-tɽaa-sti-#
Coda Filling:	#-tat-ɽaas-ti-#
a-Raising:	#-tət-ɽaas-ti-#

7:	# -sa-ɦa- -aa-ga-tʃa-ti- #
Intralexical tsh-Splitting:	# -sa-ɦa- -aa-gat-ʃa-ti- #
WB erasure:	#-sa-ɦa–aa-gat-ʃa-ti-#
SB simplification:	#-sa-ɦa-aa-gat-ʃa-ti-#
Like Vowel Contraction:	#-sa-ɦaaa-gat-ʃa-ti-#
Dental Assimilation:	#-sa-ɦaaa-gac-ʃa-ti-#
Long Diphthong Reduction:	#-sa-ɦaa-gac-ʃa-ti-#
sh-Desibilation:	#-sa-ɦaa-gac-c^{h}a-ti-#
a-Raising:	#-sə-ɦaa-gəc-c^{h}ə-ti-#

8:	# -ta-tɽa- -i-ɦa-taj- #
WB erasure:	#-ta-tɽa–i-ɦa-taj-#
SB simplification:	#-ta-tɽa-i-ɦa-taj-#
Diphthongization:	#-ta-tɽaj-ɦa-taj-#
e-Monophthongization:	#-ta-tɽee-ɦa-tee-#
Coda Filling:	#-tat-ɽee-ɦa-tee-#
a-Raising:	#-tət-ɽee-ɦə-tee-#

9:	# -lam-ba- -u-da-ɽa- #
WB erasure:	#-lam-ba–u-da-ɽa-#
SB simplification:	#-lam-ba-u-da-ɽa-#
Diphthongization:	#-lam-baw-da-ɽa-#
o-Monophthongization:	#-lam-boo-da-ɽa-#
a-Raising:	#-ləm-boo-də-ɽə-#

10:	# -bɽa-ɦma- -ɽ̩-ʂi- #
WB erasure:	#-bɽa-ɦma–ɽ̩-ʂi-#
SB simplification:	#-bɽa-ɦma-ɽ̩-ʂi-#
Diphthongization:	#-bɽa-ɦmaɽ-ʂi-#
Coda Filling:	#-bɽaɦ-maɽ-ʂi-#
a-Raising:	#-bɽəɦ-məɽ-ʂi-#

11:	# -ta-tɽa- -aj-ti- #
WB erasure:	#-ta-tɽa–aj-ti-#
SB simplification:	#-ta-tɽa-aj-ti-#
Like Vowel Contraction:	#-ta-tɽaaj-ti-#
Long Diphthong Reduction:	#-ta-tɽaj-ti-#
Glide Vocalization:	#-ta-tɽai-ti-#
Coda Filling:	#-tat-ɽai-ti-#
a-Raising:	#-tət-ɽai-ti-#

12:	# -ga-tʃa- -aaj-ʃwa-ɽjam- #
Intralexical tsh-Splitting:	# -gat-ʃa- -aaj-ʃwa-ɽjam- #
WB erasure:	#-gat-ʃa–aaj-ʃwa-ɽjam-#
SB simplification:	#-gat-ʃa-aaj-ʃwa-ɽjam-#
Like Vowel Contraction:	#-gat-ʃaaaj-ʃwa-ɽjam-#
Dental Assimilation:	#-gac-ʃaaaj-ʃwa-ɽjam-#
w-Dentalization:	#-gac-ʃaaaj-ʃʋa-ɽjam-#
Long Diphthong Reduction:	#-gac-ʃaj-ʃʋa-ɽjam-#
Glide Vocalization:	#-gac-ʃai-ʃʋa-ɽjam-#
Coda Filling:	#-gac-ʃaiʃ-ʋaɽ-jam-#
sh-Desibilation:	#-gac-c^haiʃ-ʋaɽ-jam-#
a-Raising:	#-gəc-c^haiʃ-ʋəɽ-jəm-#

13:	# -ja-tʃa- -aaw-dum-ba-ɽam- #
Intralexical tsh-Splitting:	# -jat-ʃa- -aaw-dum-ba-ɽam- #
WB erasure:	#-jat-ʃa–aaw-dum-ba-ɽam-#
SB simplification:	#-jat-ʃa-aaw-dum-ba-ɽam-#
Like Vowel Contraction:	#-jat-ʃaaaw-dum-ba-ɽam-#
Dental Assimilation:	#-jac-ʃaaaw-dum-ba-ɽam-#
Long Diphthong Reduction:	#-jac-ʃaw-dum-ba-ɽam-#
Glide Vocalization:	#-jac-ʃau-dum-ba-ɽam-#
sh-Desibilation:	#-jac-c^{h}au-dum-ba-ɽam-#
a-Raising:	#-jəc-c^{h}au-dum-bə-ɽəm-#

14:	# -ta-wa- -tʃaa-jaa- #
WB erasure:	#-ta-wa–tʃaa-jaa-#
SB simplification:	#-ta-wa-tʃaa-jaa-#
Postlexical tsh Splitting:	#-ta-wat-ʃaa-jaa-#
Dental Assimilation:	#-ta-wac-ʃaa-jaa-#
w-Dentalization:	#-ta-ʋac-ʃaa-jaa-#
sh-Desibilation:	#-ta-ʋac-c^{h}aa-jaa-#
a-Raising:	#-tə-ʋəc-c^{h}aa-jaa-#

15:	# -tʃaa-jaa- #
WB erasure:	#-tʃaa-jaa-#
tsh Simplification:	#-c^{h}aa-jaa-#

16:	# -sii-ta-jaa- -a-ga-tʃat- #
Intralexical tsh-Splitting:	# -sii-ta-jaa- -a-gat-ʃat- #
WB erasure:	#-sii-ta-jaa–a-gat-ʃat-#
SB simplification:	#-sii-ta-jaa-a-gat-ʃat-#
Vowel Shortening:	#-sii-ta-ja-a-gat-ʃat-#
Like Vowel Contraction:	#-sii-ta-jaa-gat-ʃat-#
Dental Assimilation:	#-sii-ta-jaa-gac-ʃat-#
sh-Desibilation:	#-sii-ta-jaa-gac-c^{h}at-#
a-Raising:	#-sii-tə-jaa-gəc-c^{h}ət-#

17:	# -ta-t^{h}aa- -aa-staj- #
WB erasure:	#-ta-t^{h}aa–aa-staj-#
SB simplification:	#-ta-t^{h}aa-aa-staj-#
Vowel Shortening:	#-ta-t^{h}a-aa-staj-#
Like Vowel Contraction:	#-ta-t^{h}aaa-staj-#
e-Monophthongization:	#-ta-t^{h}aaa-stee-#
Long Diphthong Reduction:	#-ta-t^{h}aa-stee-#
Coda Filling:	#-ta-t^{h}aas-tee-#
a-Raising:	#-tə-t^{h}aas-tee-#

18:	# -ma-ɦaa- -ii-ʃa- #
WB erasure:	#-ma-ɦaa–ii-ʃa-#
SB simplification:	#-ma-ɦaa-ii-ʃa-#
Vowel Shortening:	#-ma-ɦa-ii-ʃa-#
Diphthongization:	#-ma-ɦaj-ʃa-#
e-Monophthongization:	#-ma-ɦee-ʃa-#
a-Raising:	#-mə-ɦee-ʃə-#

19:	# -ta-t^{h}aa- -uk-tam- #
WB erasure:	#-ta-t^{h}aa–uk-tam-#
SB simplification:	#-ta-t^{h}aa-uk-tam-#
Vowel Shortening:	#-ta-t^{h}a-uk-tam-#
Diphthongization:	#-ta-t^{h}awk-tam-#
o-Monophthongization:	#-ta-t^{h}ook-tam-#
a-Raising:	#-tə-t^{h}ook-təm-#

20:	# -ma-ɦaa- -ɽ̩-ʂi- #
WB erasure:	#-ma-ɦaa–ɽ̩-ʂi-#
SB simplification:	#-ma-ɦaa-ɽ̩-ʂi-#
Vowel Shortening:	#-ma-ɦa-ɽ̩-ʂi-#
Diphthongization:	#-ma-ɦaɽ-ʂi-#
a-Raising:	#-mə-ɦəɽ-ʂi-#

21:	# -pu-ɽaa- -aj-ta-smin- #
ns-Extension:	# -pu-ɽaa- -aj-ta-smins- #
WB erasure:	#-pu-ɽaa–aj-ta-smins-#
SB simplification:	#-pu-ɽaa-aj-ta-smins-#
Vowel Shortening:	#-pu-ɽa-aj-ta-smins-#
Like Vowel Contraction:	#-pu-ɽaaj-ta-smins-#
Sibilant Dearticulation:	#-pu-ɽaaj-ta-sminh-#
CC-Apocope:	#-pu-ɽaaj-ta-smin-#
Long Diphthong Reduction:	#-pu-ɽaj-ta-smin-#
Glide Vocalization:	#-pu-ɽai-ta-smin-#
Coda Filling:	#-pu-ɽai-tas-min-#
a-Raising:	#-pu-ɽai-təs-min-#

22:	# -saa- -aw-da-nam- #
WB erasure:	#-saa–aw-da-nam-#
SB simplification:	#-saa-aw-da-nam-#
Vowel Shortening:	#-sa-aw-da-nam-#
Like Vowel Contraction:	#-saaw-da-nam-#
Long Diphthong Reduction:	#-saw-da-nam-#
Glide Vocalization:	#-sau-da-nam-#
a-Raising:	#-sau-də-nəm-#

23:	# -kaa- -awm-[a-zap] #
awm Protection:	# -kawm-[a-zap] #
WB erasure:	#-kawm-#
o-Monophthongization:	#-koom-#

24:	# -maa-[no-degem] -tʃi-dat- #
Intralexical tsh-Splitting:	# -maat-ʃi-dat- #
WB erasure:	#-maat-ʃi-dat-#
Dental Assimilation:	#-maac-ʃi-dat-#
sh-Desibilation:	#-maac-c^hi-dat-#
a-Raising:	#-maac-c^hi-dət-#

25:	# -a-sti- -a-tɽa- #
WB erasure:	#-a-sti–a-tɽa-#
SB simplification:	#-a-sti-a-tɽa-#
Ksaipra:	#-a-stja-tɽa-#
Coda Filling:	#-as-tjat-ɽa-#
a-Raising:	#-əs-tjət-ɽə-#

26:	# -ma-ji- -aaw-ɽa-sam- #
WB erasure:	#-ma-ji–aaw-ɽa-sam-#
SB simplification:	#-ma-ji-aaw-ɽa-sam-#
Ksaipra:	#-ma-jjaaw-ɽa-sam-#
Long Diphthong Reduction:	#-ma-jjaw-ɽa-sam-#
Glide Vocalization:	#-ma-jjau-ɽa-sam-#
Coda Filling:	#-maj-jau-ɽa-sam-#
a-Raising:	#-məj-jau-ɽə-səm-#

27:	# -a-sti- -i-ɦa- #
WB erasure:	#-a-sti–i-ɦa-#
SB simplification:	#-a-sti-i-ɦa-#
Like Vowel Contraction:	#-a-stii-ɦa-#
Coda Filling:	#-as-tii-ɦa-#
a-Raising:	#-əs-tii-ɦə-#

28:	# -i-ti- -uk-tam- #
WB erasure:	#-i-ti–uk-tam-#
SB simplification:	#-i-ti-uk-tam-#
Ksaipra:	#-i-tjuk-tam-#
Coda Filling:	#-it-juk-tam-#
a-Raising:	#-it-juk-təm-#

29:	# -gaɽ-da-b^{h}ii- -i-jam- #
WB erasure:	#-gaɽ-da-b^{h}ii–i-jam-#
SB simplification:	#-gaɽ-da-b^{h}ii-i-jam-#
Vowel Shortening:	#-gaɽ-da-b^{h}i-i-jam-#
Like Vowel Contraction:	#-gaɽ-da-b^{h}ii-jam-#
a-Raising:	#-gəɽ-də-b^{h}ii-jəm-#

30:	# -ɟa-ja-tu- -aa-ɽja-pu-tɽas- #
WB erasure:	#-ɟa-ja-tu–aa-ɽja-pu-tɽas-#
SB simplification:	#-ɟa-ja-tu-aa-ɽja-pu-tɽas-#
Ksaipra:	#-ɟa-ja-twaa-ɽja-pu-tɽas-#
Sibilant Dearticulation:	#-ɟa-ja-twaa-ɽja-pu-tɽah-#
w-Dentalization:	#-ɟa-ja-tʋaa-ɽja-pu-tɽah-#
Coda Filling:	#-ɟa-jat-ʋaaɽ-ja-put-ɽah-#
a-Raising:	#-ɟə-jət-ʋaaɽ-jə-put-ɽəh-#

31:	# -ku-ɽu- -ut-ta-ma- #
WB erasure:	#-ku-ɽu–ut-ta-ma-#
SB simplification:	#-ku-ɽu-ut-ta-ma-#
Like Vowel Contraction:	#-ku-ɽuut-ta-ma-#
a-Raising:	#-ku-ɽuut-tə-mə-#

32:	# -wi-d^{h}aj-ʂu- -aj-wa- #
WB erasure:	#-wi-d^{h}aj-ʂu–aj-wa-#
SB simplification:	#-wi-d^{h}aj-ʂu-aj-wa-#
Ksaipra:	#-wi-d^{h}aj-ʂwaj-wa-#
e-Monophthongization:	#-wi-d^{h}ee-ʂwee-wa-#
w-Dentalization:	#-ʋi-d^{h}ee-ʂʋee-ʋa-#
Coda Filling:	#-ʋi-d^{h}eeʂ-ʋee-ʋa-#
a-Raising:	#-ʋi-d^{h}eeʂ-ʋee-ʋə-#

33:	# -pi-tɽ- -ii-psi-tam- #
WB erasure:	#-pi-tɽ–ii-psi-tam-#
SB simplification:	#-pi-tɽ-ii-psi-tam-#
Ksaipra:	#-pi-tɽii-psi-tam-#
Coda Filling:	#-pit-ɽiip-si-tam-#
a-Raising:	#-pit-ɽiip-si-təm-#

34:	# -wa-naj- -a-sti- #
WB erasure:	#-wa-naj–a-sti-#
SB simplification:	#-wa-naj-a-sti-#
e-Abhinihita:	#-wa-nee-sti-#
w-Dentalization:	#-ʋa-nee-sti-#
Coda Filling:	#-ʋa-nees-ti-#
a-Raising:	#-ʋə-nees-ti-#

35:	# -swaɽ-gaj- -in-dɽas- #
WB erasure:	#-swaɽ-gaj–in-dɽas-#
SB simplification:	#-swaɽ-gaj-in-dɽas-#
Udgraaha:	#-swaɽ-ga-in-dɽas-#
Sibilant Dearticulation:	#-swaɽ-ga-in-dɽah-#
w-Dentalization:	#-sʋaɽ-ga-in-dɽah-#
a-Raising:	#-sʋəɽ-gə-in-dɽəh-#

36:	# -saN-daj-haj- -aj-wa- #
WB erasure:	#-saN-daj-haj–aj-wa-#
SB simplification:	#-saN-daj-haj-aj-wa-#
Udgraaha:	#-saN-daj-ha-aj-wa-#
e-Monophthongization:	#-saN-dee-ha-ee-wa-#
w-Dentalization:	#-saN-dee-ha-ee-ʋa-#
a-Raising:	#-səN-dee-hə-ee-ʋə-#

37:	# -taaw- -a-tɽa- #
aaw-Extension:	# -taaww- -a-tɽa- #
WB erasure:	#-taaww–a-tɽa-#
SB simplification:	#-taaww-a-tɽa-#
Udgraaha:	#-taaw-a-tɽa-#
Onset Filling:	#-taa-wa-tɽa-#
w-Dentalization:	#-taa-ʋa-tɽa-#
Coda Filling:	#-taa-ʋat-ɽa-#
a-Raising:	#-taa-ʋət-ɽə-#

38:	# -u-b^{h}aaw- -aj-wa- #
aaw-Extension:	# -u-b^{h}aaww- -aj-wa- #
WB erasure:	#-u-b^{h}aaww–aj-wa-#
SB simplification:	#-u-b^{h}aaww-aj-wa-#
Udgraaha:	#-u-b^{h}aaw-aj-wa-#
e-Monophthongization:	#-u-b^{h}aaw-ee-wa-#
Onset Filling:	#-u-b^{h}aa-wee-wa-#
w-Dentalization:	#-u-b^{h}aa-ʋee-ʋa-#
a-Raising:	#-u-b^{h}aa-ʋee-ʋə-#

39:	# -waak- -a-sti- #
WB erasure:	#-waak–a-sti-#
SB simplification:	#-waak-a-sti-#
Voice Assimilation:	#-waag-a-sti-#
Onset Filling:	#-waa-ga-sti-#
w-Dentalization:	#-ʋaa-ga-sti-#
Coda Filling:	#-ʋaa-gas-ti-#
a-Raising:	#-ʋaa-gəs-ti-#

40:	# -waak- -ma-ma- #
WB erasure:	#-waak–ma-ma-#
SB simplification:	#-waak-ma-ma-#
Voice Assimilation:	#-waag-ma-ma-#
Nasalization:	#-waaŋ-ma-ma-#
w-Dentalization:	#-ʋaaŋ-ma-ma-#
a-Raising:	#-ʋaaŋ-mə-mə-#

41:	# -waak- -ɦi- #
WB erasure:	#-waak–ɦi-#
SB simplification:	#-waak-ɦi-#
Voice Assimilation:	#-waag-ɦi-#
w-Dentalization:	#-ʋaag-ɦi-#
h-Articulation:	#-ʋaag-g^{h}i-#

42:	# -pɽa-tjaŋk- -ut- #
WB erasure:	#-pɽa-tjaŋk–ut-#
SB simplification:	#-pɽa-tjaŋk-ut-#
Voice Assimilation:	#-pɽa-tjaŋg-ut-#
n-Gemination:	#-pɽa-tjaŋ-ŋut-#
Coda Filling:	#-pɽat-jaŋ-ŋut-#
a-Raising:	#-pɽət-jəŋ-ŋut-#

43:	# -pɽa-tjaŋk- -tu- #
WB erasure:	#-pɽa-tjaŋk–tu-#
SB simplification:	#-pɽa-tjaŋk-tu-#
CC-Apocope:	#-pɽa-tjaŋ-tu-#
Coda Filling:	#-pɽat-jaŋ-tu-#
a-Raising:	#-pɽət-jəŋ-tu-#

44:	# -uuɽg- #
WB erasure:	#-uuɽg-#
Delaryngealization:	#-uuɽk-#

45:	# -sa-mɽaaɟ- #
Depalatalization:	# -sa-mɽaaɖ- #
WB erasure:	#-sa-mɽaaɖ-#
Delaryngealization:	#-sa-mɽaaʈ-#
Coda Filling:	#-sam-ɽaaʈ-#
a-Raising:	#-səm-ɽaaʈ-#

46:	# -sa-mɽaaɟ- -a-tɽa- #
Depalatalization:	# -sa-mɽaaɖ- -a-tɽa- #
WB erasure:	#-sa-mɽaaɖ–a-tɽa-#
SB simplification:	#-sa-mɽaaɖ-a-tɽa-#
Delaryngealization:	#-sa-mɽaaʈ-a-tɽa-#
Voice Assimilation:	#-sa-mɽaaɖ-a-tɽa-#
Onset Filling:	#-sa-mɽaa-ɖa-tɽa-#
Coda Filling:	#-sam-ɽaa-ɖat-ɽa-#
a-Raising:	#-səm-ɽaa-ɖət-ɽə-#

47:	# -sa-mɽaaɟ- -ca- #
Depalatalization:	# -sa-mɽaaɖ- -ca- #
WB erasure:	#-sa-mɽaaɖ–ca-#
SB simplification:	#-sa-mɽaaɖ-ca-#
Delaryngealization:	#-sa-mɽaaʈ-ca-#
Coda Filling:	#-sam-ɽaaʈ-ca-#
a-Raising:	#-səm-ɽaaʈ-cə-#

48:	# -sa-mɽaaɟ-b^{h}is- #
Depalatalization:	# -sa-mɽaaɖ-b^{h}is- #
WB erasure:	#-sa-mɽaaɖ-b^{h}is-#
Delaryngealization:	#-sa-mɽaaʈ-b^{h}is-#
Voice Assimilation:	#-sa-mɽaaɖ-b^{h}is-#
Sibilant Dearticulation:	#-sa-mɽaaɖ-b^{h}ih-#
Coda Filling:	#-sam-ɽaaɖ-b^{h}ih-#
a-Raising:	#-səm-ɽaaɖ-b^{h}ih-#

49:	# -aa-siit- -a-su-ɽas- #
WB erasure:	#-aa-siit–a-su-ɽas-#
SB simplification:	#-aa-siit-a-su-ɽas-#
Voice Assimilation:	#-aa-siid-a-su-ɽas-#
Sibilant Dearticulation:	#-aa-siid-a-su-ɽah-#
Onset Filling:	#-aa-sii-da-su-ɽah-#
a-Raising:	#-aa-sii-də-su-ɽəh-#

50:	# -tat- -ca- #
WB erasure:	#-tat–ca-#
SB simplification:	#-tat-ca-#
Dental Assimilation:	#-tac-ca-#
a-Raising:	#-təc-cə-#

51:	# -tat- -ɟa-lam- #
WB erasure:	#-tat–ɟa-lam-#
SB simplification:	#-tat-ɟa-lam-#
Voice Assimilation:	#-tad-ɟa-lam-#
Dental Assimilation:	#-taɟ-ɟa-lam-#
a-Raising:	#-təɟ-ɟə-ləm-#

52:	# -tat- -ʈii-kaa- #
WB erasure:	#-tat–ʈii-kaa-#
SB simplification:	#-tat-ʈii-kaa-#
Dental Assimilation:	#-taʈ-ʈii-kaa-#
a-Raising:	#-təʈ-ʈii-kaa-#

53:	# -cajt- -na- #
WB erasure:	#-cajt–na-#
SB simplification:	#-cajt-na-#
Voice Assimilation:	#-cajd-na-#
e-Monophthongization:	#-ceed-na-#
Nasalization:	#-ceen-na-#
a-Raising:	#-ceen-nə-#

54:	# -kɽaw-d^{h}aat- -b^{h}a-wa-ti- #
WB erasure:	#-kɽaw-d^{h}aat–b^{h}a-wa-ti-#
SB simplification:	#-kɽaw-d^{h}aat-b^{h}a-wa-ti-#
Voice Assimilation:	#-kɽaw-d^{h}aad-b^{h}a-wa-ti-#
o-Monophthongization:	#-kɽoo-d^{h}aad-b^{h}a-wa-ti-#
w-Dentalization:	#-kɽoo-d^{h}aad-b^{h}a-ʋa-ti-#
a-Raising:	#-kɽoo-d^{h}aad-b^{h}ə-ʋə-ti-#

55:	# -tat- -mi-tɽam- #
WB erasure:	#-tat–mi-tɽam-#
SB simplification:	#-tat-mi-tɽam-#
Voice Assimilation:	#-tad-mi-tɽam-#
Nasalization:	#-tan-mi-tɽam-#
Coda Filling:	#-tan-mit-ɽam-#
a-Raising:	#-tən-mit-ɽəm-#

56:	# -tat- -la-b^{h}a-taj- #
WB erasure:	#-tat–la-b^{h}a-taj-#
SB simplification:	#-tat-la-b^{h}a-taj-#
Voice Assimilation:	#-tad-la-b^{h}a-taj-#
e-Monophthongization:	#-tad-la-b^{h}a-tee-#
Dental Assimilation:	#-tad^{l}-la-b^{h}a-tee-#
Lateral Sonorization:	#-tal-la-b^{h}a-tee-#
a-Raising:	#-təl-lə-b^{h}ə-tee-#

57:	# -tat- -ʃɽ̩-ɳaw-ti- #
WB erasure:	#-tat–ʃɽ̩-ɳaw-ti-#
SB simplification:	#-tat-ʃɽ̩-ɳaw-ti-#
o-Monophthongization:	#-tat-ʃɽ̩-ɳoo-ti-#
Dental Assimilation:	#-tac-ʃɽ̩-ɳoo-ti-#
sh-Desibilation:	#-tac-c^{h}ɽ̩-ɳoo-ti-#
a-Raising:	#-təc-c^{h}ɽ̩-ɳoo-ti-#

58:	# -tat- -scaw-ta-ti- #
WB erasure:	#-tat–scaw-ta-ti-#
SB simplification:	#-tat-scaw-ta-ti-#
o-Monophthongization:	#-tat-scoo-ta-ti-#
Fricative Assimilation:	#-tat-ʃcoo-ta-ti-#
Dental Assimilation:	#-tac-ʃcoo-ta-ti-#
a-Raising:	#-təc-ʃcoo-tə-ti-#

59:	# -saN-maw-ɦiaat- -smɽ̩-ti-wi-b^{h}ɽa-mas- #
WB erasure:	#-saN-maw-ɦiaat–smɽ̩-ti-wi-b^{h}ɽa-mas-#
SB simplification:	#-saN-maw-ɦiaat-smɽ̩-ti-wi-b^{h}ɽa-mas-#
o-Monophthongization:	#-saN-moo-ɦiaat-smɽ̩-ti-wi-b^{h}ɽa-mas-#
Sibilant Dearticulation:	#-saN-moo-ɦiaat-smɽ̩-ti-wi-b^{h}ɽa-mah-#
w-Dentalization:	#-saN-moo-ɦiaat-smɽ̩-ti-ʋi-b^{h}ɽa-mah-#
Coda Filling:	#-saN-moo-ɦiaat-smɽ̩-ti-ʋib^{h}-ɽa-mah-#
a-Raising:	#-səN-moo-ɦiaat-smɽ̩-ti-ʋib^{h}-ɽə-məh-#

60:	# -tat- -ɦii-ɽa-ɳjam- #
WB erasure:	#-tat–ɦii-ɽa-ɳjam-#
SB simplification:	#-tat-ɦii-ɽa-ɳjam-#
Voice Assimilation:	#-tad-ɦii-ɽa-ɳjam-#
Coda Filling:	#-tad-ɦii-ɽaɳ-jam-#
h-Articulation:	#-tad-d^{h}i-ɽaɳ-jam-#
a-Raising:	#-təd-d^{h}i-ɽəɳ-jəm-#

61:	# -a-gni-mat^{h}- #
WB erasure:	#-a-gni-mat^{h}-#
Delaryngealization:	#-a-gni-mat-#
Coda Filling:	#-ag-ni-mat-#
a-Raising:	#-əg-ni-mət-#

62:	# -su-ɦiɽ̩d- #
WB erasure:	#-su-ɦiɽ̩d-#
Delaryngealization:	#-su-ɦiɽ̩t-#

63:	# -wii-ɽud^{h}- #
WB erasure:	#-wii-ɽud^{h}-#
Delaryngealization:	#-wii-ɽut-#
w-Dentalization:	#-ʋii-ɽut-#

64:	# -ɦa-san- -a-ga-tʃat- #
ns-Extension:	# -ɦa-sans- -a-ga-tʃat- #
Intralexical tsh-Splitting:	# -ɦa-sans- -a-gat-ʃat- #
WB erasure:	#-ɦa-sans–a-gat-ʃat-#
SB simplification:	#-ɦa-sans-a-gat-ʃat-#
Voice Assimilation:	#-ɦa-sanz-a-gat-ʃat-#
Rhotacization:	#-ɦa-sanɽ-a-gat-ʃat-#
n-Gemination:	#-ɦa-san-na-gat-ʃat-#
Dental Assimilation:	#-ɦa-san-na-gac-ʃat-#
sh-Desibilation:	#-ɦa-san-na-gac-cʰat-#
a-Raising:	#-ɦə-sən-nə-gəc-cʰət-#

65:	# -stu-wan- -aa-ga-tʃa-ti- #
ns-Extension:	# -stu-wans- -aa-ga-tʃa-ti- #
Intralexical tsh-Splitting:	# -stu-wans- -aa-gat-ʃa-ti- #
WB erasure:	#-stu-wans–aa-gat-ʃa-ti-#
SB simplification:	#-stu-wans-aa-gat-ʃa-ti-#
Voice Assimilation:	#-stu-wanz-aa-gat-ʃa-ti-#
Rhotacization:	#-stu-wanɽ-aa-gat-ʃa-ti-#
n-Gemination:	#-stu-wan-naa-gat-ʃa-ti-#
Dental Assimilation:	#-stu-wan-naa-gac-ʃa-ti-#
w-Dentalization:	#-stu-ʋan-naa-gac-ʃa-ti-#
sh-Desibilation:	#-stu-ʋan-naa-gac-cʰa-ti-#
a-Raising:	#-stu-ʋən-naa-gəc-cʰə-ti-#

66:	# -a-ʃwaan- -caw-ɽa-ja-ti- #
ns-Extension:	# -a-ʃwaans- -caw-ɽa-ja-ti- #
WB erasure:	#-a-ʃwaans–caw-ɽa-ja-ti-#
SB simplification:	#-a-ʃwaans-caw-ɽa-ja-ti-#
o-Monophthongization:	#-a-ʃwaans-coo-ɽa-ja-ti-#
Sibilant Dearticulation:	#-a-ʃwaanh-coo-ɽa-ja-ti-#
Visarga Resyllabification:	#-a-ʃwaan-hcoo-ɽa-ja-ti-#
Fricative Assimilation:	#-a-ʃwaan-ʃcoo-ɽa-ja-ti-#
Nasal Dearticulation:	#-a-ʃwaaN-ʃcoo-ɽa-ja-ti-#
w-Dentalization:	#-a-ʃʋaaN-ʃcoo-ɽa-ja-ti-#
Coda Filling:	#-aʃ-ʋaaN-ʃcoo-ɽa-ja-ti-#
a-Raising:	#-əʃ-ʋaaN-ʃcoo-ɽə-jə-ti-#

67:	# -daj-waan- -ɟa-ja-ti- #
ns-Extension:	# -daj-waans- -ɟa-ja-ti- #
WB erasure:	#-daj-waans–ɟa-ja-ti-#
SB simplification:	#-daj-waans-ɟa-ja-ti-#
Voice Assimilation:	#-daj-waanz-ɟa-ja-ti-#
Rhotacization:	#-daj-waanɽ-ɟa-ja-ti-#
e-Monophthongization:	#-dee-waanɽ-ɟa-ja-ti-#
CC-Apocope:	#-dee-waan-ɟa-ja-ti-#
Dental Assimilation:	#-dee-waaɲ-ɟa-ja-ti-#
w-Dentalization:	#-dee-ʋaaɲ-ɟa-ja-ti-#
a-Raising:	#-dee-ʋaaɲ-ɟə-jə-ti-#

68:	# -b^{h}a-waan- -twa-ɽa-ti- #
ns-Extension:	# -b^{h}a-waans- -twa-ɽa-ti- #
WB erasure:	#-b^{h}a-waans–twa-ɽa-ti-#
SB simplification:	#-b^{h}a-waans-twa-ɽa-ti-#
Sibilant Dearticulation:	#-b^{h}a-waanh-twa-ɽa-ti-#
Visarga Resyllabification:	#-b^{h}a-waan-htwa-ɽa-ti-#
Fricative Assimilation:	#-b^{h}a-waan-stwa-ɽa-ti-#
Nasal Dearticulation:	#-b^{h}a-waaN-stwa-ɽa-ti-#
w-Dentalization:	#-b^{h}a-ʋaaN-stʋa-ɽa-ti-#
a-Raising:	#-b^{h}ə-ʋaaN-stʋə-ɽə-ti-#

69:	# -a-smaan- -ni-dan-ti- #
ns-Extension:	# -a-smaans- -ni-dan-ti- #
WB erasure:	#-a-smaans–ni-dan-ti-#
SB simplification:	#-a-smaans-ni-dan-ti-#
Voice Assimilation:	#-a-smaanz-ni-dan-ti-#
Rhotacization:	#-a-smaanɽ-ni-dan-ti-#
CC-Apocope:	#-a-smaan-ni-dan-ti-#
Coda Filling:	#-as-maan-ni-dan-ti-#
a-Raising:	#-əs-maan-ni-dən-ti-#

70:	# -ka-paɽ-da-kaan- -pɽaa-pnaw-mi- #
ns-Extension:	# -ka-paɽ-da-kaans- -pɽaa-pnaw-mi- #
WB erasure:	#-ka-paɽ-da-kaans–pɽaa-pnaw-mi-#
SB simplification:	#-ka-paɽ-da-kaans-pɽaa-pnaw-mi-#
o-Monophthongization:	#-ka-paɽ-da-kaans-pɽaa-pnoo-mi-#
Sibilant Dearticulation:	#-ka-paɽ-da-kaanh-pɽaa-pnoo-mi-#
CC-Apocope:	#-ka-paɽ-da-kaan-pɽaa-pnoo-mi-#
Coda Filling:	#-ka-paɽ-da-kaan-pɽaap-noo-mi-#
a-Raising:	#-kə-pəɽ-də-kaan-pɽaap-noo-mi-#

71:	# -a-ʃwaan- -la-b^{h}a-taj- #
ns-Extension:	# -a-ʃwaans- -la-b^{h}a-taj- #
WB erasure:	#-a-ʃwaans–la-b^{h}a-taj-#
SB simplification:	#-a-ʃwaans-la-b^{h}a-taj-#
Voice Assimilation:	#-a-ʃwaanz-la-b^{h}a-taj-#
Rhotacization:	#-a-ʃwaanɽ-la-b^{h}a-taj-#
e-Monophthongization:	#-a-ʃwaanɽ-la-b^{h}a-tee-#
CC-Apocope:	#-a-ʃwaan-la-b^{h}a-tee-#
Dental Assimilation:	#-a-ʃwaal̃-la-b^{h}a-tee-#
w-Dentalization:	#-a-ʃʋaal̃-la-b^{h}a-tee-#
Coda Filling:	#-aʃ-ʋaal̃-la-b^{h}a-tee-#
a-Raising:	#-əʃ-ʋaal̃-lə-b^{h}ə-tee-#

72:	# -daj-waan- -ʃɽ̩-ɳaw-ti- #
ns-Extension:	# -daj-waans- -ʃɽ̩-ɳaw-ti- #
WB erasure:	#-daj-waans–ʃɽ̩-ɳaw-ti-#
SB simplification:	#-daj-waans-ʃɽ̩-ɳaw-ti-#
e-Monophthongization:	#-dee-waans-ʃɽ̩-ɳaw-ti-#
o-Monophthongization:	#-dee-waans-ʃɽ̩-ɳoo-ti-#
Sibilant Dearticulation:	#-dee-waanh-ʃɽ̩-ɳoo-ti-#
CC-Apocope:	#-dee-waan-ʃɽ̩-ɳoo-ti-#
Dental Assimilation:	#-dee-waaɲ-ʃɽ̩-ɳoo-ti-#
w-Dentalization:	#-dee-ʋaaɲ-ʃɽ̩-ɳoo-ti-#
sh-Desibilation:	#-dee-ʋaaɲ-c^{h}ɽ̩-ɳoo-ti-#

73:	# -ap- -ɟa- #
WB erasure:	#-ap–ɟa-#
SB simplification:	#-ap-ɟa-#
Voice Assimilation:	#-ab-ɟa-#
a-Raising:	#-əb-ɟə-#

74:	# -a-nu-ʂʈub^{h}- #
WB erasure:	#-a-nu-ʂʈub^{h}-#
Delaryngealization:	#-a-nu-ʂʈup-#
Coda Filling:	#-a-nuʂ-ʈup-#
a-Raising:	#-ə-nuʂ-ʈup-#

75:	# -tam- -a-waw-cat- #
WB erasure:	#-tam–a-waw-cat-#
SB simplification:	#-tam-a-waw-cat-#
o-Monophthongization:	#-tam-a-woo-cat-#
Onset Filling:	#-ta-ma-woo-cat-#
w-Dentalization:	#-ta-ma-ʋoo-cat-#
a-Raising:	#-tə-mə-ʋoo-cət-#

76:	# -wa-nam- -ga-tʃa-ti- #
m-Dearticulation:	# -wa-naN- -ga-tʃa-ti- #
Intralexical tsh-Splitting:	# -wa-naN- -gat-ʃa-ti- #
WB erasure:	#-wa-naN–gat-ʃa-ti-#
SB simplification:	#-wa-naN-gat-ʃa-ti-#
Dental Assimilation:	#-wa-naN-gac-ʃa-ti-#
w-Dentalization:	#-ʋa-naN-gac-ʃa-ti-#
sh-Desibilation:	#-ʋa-naN-gac-c^{h}a-ti-#
a-Raising:	#-ʋə-nəN-gəc-c^{h}ə-ti-#

77:	# -tam- -ca- #
m-Dearticulation:	# -taN- -ca- #
WB erasure:	#-taN–ca-#
SB simplification:	#-taN-ca-#
a-Raising:	#-təN-cə-#

78:	# -tam- -tʃaa-jam- #
m-Dearticulation:	# -taN- -tʃaa-jam- #
WB erasure:	#-taN–tʃaa-jam-#
SB simplification:	#-taN-tʃaa-jam-#
tsh Simplification:	#-taN-c^{h}aa-jam-#
a-Raising:	#-təN-c^{h}aa-jəm-#

79:	# -daj-wam- -pa-ʃja-ti- #
m-Dearticulation:	# -daj-waN- -pa-ʃja-ti- #
WB erasure:	#-daj-waN–pa-ʃja-ti-#
SB simplification:	#-daj-waN-pa-ʃja-ti-#
e-Monophthongization:	#-dee-waN-pa-ʃja-ti-#
w-Dentalization:	#-dee-ʋaN-pa-ʃja-ti-#
Coda Filling:	#-dee-ʋaN-paʃ-ja-ti-#
a-Raising:	#-dee-ʋəN-pəʃ-jə-ti-#

80:	# -ʋiʃ- #
Depalatalization:	# -ʋiʂ- #
.s-Desibilization:	# -ʋiʈ- #
WB erasure:	#-ʋiʈ-#

81:	# -ʋiʃ- -a-tɽa- #
Depalatalization:	# -ʋiʂ- -a-tɽa- #
.s-Desibilization:	# -ʋiʈ- -a-tɽa- #
WB erasure:	#-ʋiʈ–a-tɽa-#
SB simplification:	#-ʋiʈ-a-tɽa-#
Voice Assimilation:	#-ʋiɖ-a-tɽa-#
Onset Filling:	#-ʋi-ɖa-tɽa-#
Coda Filling:	#-ʋi-ɖat-ɽa-#
a-Raising:	#-ʋi-ɖət-ɽə-#

82:	# -ʋiʃ- -ca- #
Depalatalization:	# -ʋiʂ- -ca- #
.s-Desibilization:	# -ʋiʈ- -ca- #
WB erasure:	#-ʋiʈ–ca-#
SB simplification:	#-ʋiʈ-ca-#
a-Raising:	#-ʋiʈ-cə-#

83:	# -ʋiʃ-b^{h}is- #
Depalatalization:	# -ʋiʂ-b^{h}is- #
.s-Desibilization:	# -ʋiʈ-b^{h}is- #
WB erasure:	#-ʋiʈ-b^{h}is-#
Voice Assimilation:	#-ʋiɖ-b^{h}is-#
Sibilant Dearticulation:	#-ʋiɖ-b^{h}ih-#

84:	# -dʋiʂ- #
.s-Desibilization:	# -dʋiʈ- #
WB erasure:	#-dʋiʈ-#

85:	# -dʋiʂ- -a-tɽa- #
.s-Desibilization:	# -dʋiʈ- -a-tɽa- #
WB erasure:	#-dʋiʈ–a-tɽa-#
SB simplification:	#-dʋiʈ-a-tɽa-#
Voice Assimilation:	#-dʋiɖ-a-tɽa-#
Onset Filling:	#-dʋi-ɖa-tɽa-#
Coda Filling:	#-dʋi-ɖat-ɽa-#
a-Raising:	#-dʋi-ɖət-ɽə-#

86:	# -dʋiʂ- -ca- #
.s-Desibilization:	# -dʋiʈ- -ca- #
WB erasure:	#-dʋiʈ–ca-#
SB simplification:	#-dʋiʈ-ca-#
a-Raising:	#-dʋiʈ-cə-#

87:	# -dʋiʂ-b^{h}is- #
.s-Desibilization:	# -dʋiʈ-b^{h}is- #
WB erasure:	#-dʋiʈ-b^{h}is-#
Voice Assimilation:	#-dʋiɖ-b^{h}is-#
Sibilant Dearticulation:	#-dʋiɖ-b^{h}ih-#

88:	# -a-gnis- -a-sti- #
WB erasure:	#-a-gnis–a-sti-#
SB simplification:	#-a-gnis-a-sti-#
Voice Assimilation:	#-a-gniz-a-sti-#
Rhotacization:	#-a-gniɽ-a-sti-#
Onset Filling:	#-a-gni-ɽa-sti-#
Coda Filling:	#-ag-ni-ɽas-ti-#
a-Raising:	#-əg-ni-ɽəs-ti-#

89:	# -wi-ʂɳaws- -aa-ju-d^{h}am- #
WB erasure:	#-wi-ʂɳaws–aa-ju-d^{h}am-#
SB simplification:	#-wi-ʂɳaws-aa-ju-d^{h}am-#
Voice Assimilation:	#-wi-ʂɳawz-aa-ju-d^{h}am-#
Rhotacization:	#-wi-ʂɳawɽ-aa-ju-d^{h}am-#
o-Monophthongization:	#-wi-ʂɳooɽ-aa-ju-d^{h}am-#
Onset Filling:	#-wi-ʂɳoo-ɽaa-ju-d^{h}am-#
w-Dentalization:	#-ʋi-ʂɳoo-ɽaa-ju-d^{h}am-#
Coda Filling:	#-ʋiʂ-ɳoo-ɽaa-ju-d^{h}am-#
a-Raising:	#-ʋiʂ-ɳoo-ɽaa-ju-d^{h}əm-#

90:	# -a-gnis- -i-wa- #
WB erasure:	#-a-gnis–i-wa-#
SB simplification:	#-a-gnis-i-wa-#
Voice Assimilation:	#-a-gniz-i-wa-#
Rhotacization:	#-a-gniɽ-i-wa-#
Onset Filling:	#-a-gni-ɽi-wa-#
w-Dentalization:	#-a-gni-ɽi-ʋa-#
Coda Filling:	#-ag-ni-ɽi-ʋa-#
a-Raising:	#-əg-ni-ɽi-ʋə-#

91:	# -ɦa-ɽis- -k^{h}a-na-ti- #
WB erasure:	#-ɦa-ɽis–k^{h}a-na-ti-#
SB simplification:	#-ɦa-ɽis-k^{h}a-na-ti-#
Sibilant Dearticulation:	#-ɦa-ɽih-k^{h}a-na-ti-#
a-Raising:	#-ɦə-ɽih-k^{h}ə-nə-ti-#

92:	# -ɦa-ɽajs- -gaaws- #
WB erasure:	#-ɦa-ɽajs–gaaws-#
SB simplification:	#-ɦa-ɽajs-gaaws-#
Voice Assimilation:	#-ɦa-ɽajz-gaaws-#
Rhotacization:	#-ɦa-ɽajɽ-gaaws-#
e-Monophthongization:	#-ɦa-ɽeeɽ-gaaws-#
Sibilant Dearticulation:	#-ɦa-ɽeeɽ-gaawh-#
Long Diphthong Reduction:	#-ɦa-ɽeeɽ-gawh-#
Glide Vocalization:	#-ɦa-ɽeeɽ-gauh-#
a-Raising:	#-ɦə-ɽeeɽ-gauh-#

93:	# -ɦa-ɽis- -ca-la-ti- #
WB erasure:	#-ɦa-ɽis–ca-la-ti-#
SB simplification:	#-ɦa-ɽis-ca-la-ti-#
Sibilant Dearticulation:	#-ɦa-ɽih-ca-la-ti-#
Visarga Resyllabification:	#-ɦa-ɽi-hca-la-ti-#
Fricative Assimilation:	#-ɦa-ɽi-ʃca-la-ti-#
Coda Filling:	#-ɦa-ɽiʃ-ca-la-ti-#
a-Raising:	#-ɦə-ɽiʃ-cə-lə-ti-#

94:	# -wi-ʂɳaws- -tʃaa-jaa- #
WB erasure:	#-wi-ʂɳaws–tʃaa-jaa-#
SB simplification:	#-wi-ʂɳaws-tʃaa-jaa-#
o-Monophthongization:	#-wi-ʂɳoos-tʃaa-jaa-#
tsh Simplification:	#-wi-ʂɳoos-c^{h}aa-jaa-#
Sibilant Dearticulation:	#-wi-ʂɳooh-c^{h}aa-jaa-#
Visarga Resyllabification:	#-wi-ʂɳoo-hc^{h}aa-jaa-#
Fricative Assimilation:	#-wi-ʂɳoo-ʃc^{h}aa-jaa-#
w-Dentalization:	#-ʋi-ʂɳoo-ʃc^{h}aa-jaa-#
Coda Filling:	#-ʋiʂ-ɳooʃ-c^{h}aa-jaa-#

95:	# -ɦa-ɽis- -ʈii-kaam- #
WB erasure:	#-ɦa-ɽis–ʈii-kaam-#
SB simplification:	#-ɦa-ɽis-ʈii-kaam-#
Sibilant Dearticulation:	#-ɦa-ɽih-ʈii-kaam-#
Visarga Resyllabification:	#-ɦa-ɽi-hʈii-kaam-#
Fricative Assimilation:	#-ɦa-ɽi-ʂʈii-kaam-#
Coda Filling:	#-ɦa-ɽiʂ-ʈii-kaam-#
a-Raising:	#-ɦə-ɽiʂ-ʈii-kaam-#

96:	# -ca-kʂus- -taj- #
WB erasure:	#-ca-kʂus–taj-#
SB simplification:	#-ca-kʂus-taj-#
e-Monophthongization:	#-ca-kʂus-tee-#
Sibilant Dearticulation:	#-ca-kʂuh-tee-#
Visarga Resyllabification:	#-ca-kʂu-htee-#
Fricative Assimilation:	#-ca-kʂu-stee-#
Coda Filling:	#-cak-ʂus-tee-#
a-Raising:	#-cək-ʂus-tee-#

97:	# -ga-tis- -na- #
WB erasure:	#-ga-tis–na-#
SB simplification:	#-ga-tis-na-#
Voice Assimilation:	#-ga-tiz-na-#
Rhotacization:	#-ga-tiɽ-na-#
a-Raising:	#-gə-tiɽ-nə-#

98:	# -ɦə-ɽis- -pa-ʃja-ti- #
WB erasure:	#-ɦə-ɽis–pa-ʃja-ti-#
SB simplification:	#-ɦə-ɽis-pa-ʃja-ti-#
Sibilant Dearticulation:	#-ɦə-ɽih-pa-ʃja-ti-#
Coda Filling:	#-ɦə-ɽih-paʃ-ja-ti-#
a-Raising:	#-ɦə-ɽih-pəʃ-jə-ti-#

99:	# -a-ti-t^{h}is- -ja-sja- #
WB erasure:	#-a-ti-t^{h}is–ja-sja-#
SB simplification:	#-a-ti-t^{h}is-ja-sja-#
Voice Assimilation:	#-a-ti-t^{h}iz-ja-sja-#
Rhotacization:	#-a-ti-t^{h}iɽ-ja-sja-#
Coda Filling:	#-a-ti-t^{h}iɽ-jas-ja-#
a-Raising:	#-ə-ti-t^{h}iɽ-jəs-jə-#

100:	# -a-gnis- -ɽaw-ca-taj- #
WB erasure:	#-a-gnis–ɽaw-ca-taj-#
SB simplification:	#-a-gnis-ɽaw-ca-taj-#
Voice Assimilation:	#-a-gniz-ɽaw-ca-taj-#
Rhotacization:	#-a-gniɽ-ɽaw-ca-taj-#
e-Monophthongization:	#-a-gniɽ-ɽaw-ca-tee-#
o-Monophthongization:	#-a-gniɽ-ɽoo-ca-tee-#
Coda Filling:	#-ag-niɽ-ɽoo-ca-tee-#
r-Compensatory Degemination:	#-ag-nii-ɽoo-ca-tee-#
a-Raising:	#-əg-nii-ɽoo-cə-tee-#

101:	# -taajs- -ɽaa-ɟaa- #
WB erasure:	#-taajs–ɽaa-ɟaa-#
SB simplification:	#-taajs-ɽaa-ɟaa-#
Voice Assimilation:	#-taajz-ɽaa-ɟaa-#
Rhotacization:	#-taajɽ-ɽaa-ɟaa-#
Long Diphthong Reduction:	#-tajɽ-ɽaa-ɟaa-#
Glide Vocalization:	#-taiɽ-ɽaa-ɟaa-#
r-Degemination:	#-tai-ɽaa-ɟaa-#

102:	# -daj-was- -a-sti- #
WB erasure:	#-daj-was–a-sti-#
SB simplification:	#-daj-was-a-sti-#
Voice Assimilation:	#-daj-waz-a-sti-#
z-Gliding:	#-daj-waz̞-a-sti-#
o-Abhinihita:	#-daj-woo-sti-#
e-Monophthongization:	#-dee-woo-sti-#
w-Dentalization:	#-dee-ʋoo-sti-#
Coda Filling:	#-dee-ʋoos-ti-#

103:	# -daj-was- -aa-staj- #
WB erasure:	#-daj-was–aa-staj-#
SB simplification:	#-daj-was-aa-staj-#
Voice Assimilation:	#-daj-waz-aa-staj-#
z-Gliding:	#-daj-waz̞-aa-staj-#
Udgraaha:	#-daj-wa-aa-staj-#
e-Monophthongization:	#-dee-wa-aa-stee-#
w-Dentalization:	#-dee-ʋa-aa-stee-#
Coda Filling:	#-dee-ʋa-aas-tee-#
a-Raising:	#-dee-ʋə-aas-tee-#

104:	# -daj-was- -i-ɦa- #
WB erasure:	#-daj-was–i-ɦa-#
SB simplification:	#-daj-was-i-ɦa-#
Voice Assimilation:	#-daj-waz-i-ɦa-#
z-Gliding:	#-daj-waz̞-i-ɦa-#
Udgraaha:	#-daj-wa-i-ɦa-#
e-Monophthongization:	#-dee-wa-i-ɦa-#
w-Dentalization:	#-dee-ʋa-i-ɦa-#
a-Raising:	#-dee-ʋə-i-ɦə-#

105:	# -ɽaa-mas- -u-waa-ca- #
WB erasure:	#-ɽaa-mas–u-waa-ca-#
SB simplification:	#-ɽaa-mas-u-waa-ca-#
Voice Assimilation:	#-ɽaa-maz-u-waa-ca-#
z-Gliding:	#-ɽaa-maz̞-u-waa-ca-#
Udgraaha:	#-ɽaa-ma-u-waa-ca-#
w-Dentalization:	#-ɽaa-ma-u-ʋaa-ca-#
a-Raising:	#-ɽaa-mə-u-ʋaa-cə-#

106:	# -a-njas- -kas- #
WB erasure:	#-a-njas–kas-#
SB simplification:	#-a-njas-kas-#
Sibilant Dearticulation:	#-a-njah-kah-#
Coda Filling:	#-an-jah-kah-#
a-Raising:	#-ən-jəh-kəh-#

107:	# -daj-was- -ga-tʃa-ti- #
Intralexical tsh-Splitting:	# -daj-was- -gat-ʃa-ti- #
WB erasure:	#-daj-was–gat-ʃa-ti-#
SB simplification:	#-daj-was-gat-ʃa-ti-#
Voice Assimilation:	#-daj-waz-gat-ʃa-ti-#
z-Gliding:	#-daj-waz̞-gat-ʃa-ti-#
e-Monophthongization:	#-dee-waz̞-gat-ʃa-ti-#
o-Monophthongization:	#-dee-woo-gat-ʃa-ti-#
Dental Assimilation:	#-dee-woo-gac-ʃa-ti-#
w-Dentalization:	#-dee-ʋoo-gac-ʃa-ti-#
sh-Desibilation:	#-dee-ʋoo-gac-c^ha-ti-#
a-Raising:	#-dee-ʋoo-gəc-c^hə-ti-#

108:	# -ta-tas- -ca- #
WB erasure:	#-ta-tas–ca-#
SB simplification:	#-ta-tas-ca-#
Sibilant Dearticulation:	#-ta-tah-ca-#
Visarga Resyllabification:	#-ta-ta-hca-#
Fricative Assimilation:	#-ta-ta-ʃca-#
Coda Filling:	#-ta-taʃ-ca-#
a-Raising:	#-tə-təʃ-cə-#

109:	# -ta-tas- -tam- #
WB erasure:	#-ta-tas–tam-#
SB simplification:	#-ta-tas-tam-#
Sibilant Dearticulation:	#-ta-tah-tam-#
Visarga Resyllabification:	#-ta-ta-htam-#
Fricative Assimilation:	#-ta-ta-stam-#
Coda Filling:	#-ta-tas-tam-#
a-Raising:	#-tə-təs-təm-#

110:	# -ɽaa-mas- -pa-ʃja-ti- #
WB erasure:	#-ɽaa-mas–pa-ʃja-ti-#
SB simplification:	#-ɽaa-mas-pa-ʃja-ti-#
Sibilant Dearticulation:	#-ɽaa-mah-pa-ʃja-ti-#
Coda Filling:	#-ɽaa-mah-paʃ-ja-ti-#
a-Raising:	#-ɽaa-məh-pəʃ-jə-ti-#

111:	# -a-ɦas- -ma-ɦat- #
WB erasure:	#-a-ɦas–ma-ɦat-#
SB simplification:	#-a-ɦas-ma-ɦat-#
Voice Assimilation:	#-a-ɦaz-ma-ɦat-#
z-Gliding:	#-a-ɦaz̝-ma-ɦat-#
o-Monophthongization:	#-a-ɦoo-ma-ɦat-#
a-Raising:	#-ə-ɦoo-mə-ɦət-#

112:	# -pa-ʃja-tas- -ɽaa-ɟɲas- #
WB erasure:	#-pa-ʃja-tas–ɽaa-ɟɲas-#
SB simplification:	#-pa-ʃja-tas-ɽaa-ɟɲas-#
Voice Assimilation:	#-pa-ʃja-taz-ɽaa-ɟɲas-#
z-Gliding:	#-pa-ʃja-taz̝-ɽaa-ɟɲas-#
o-Monophthongization:	#-pa-ʃja-too-ɽaa-ɟɲas-#
Sibilant Dearticulation:	#-pa-ʃja-too-ɽaa-ɟɲah-#
Coda Filling:	#-paʃ-ja-too-ɽaaɟ-ɲah-#
a-Raising:	#-pəʃ-jə-too-ɽaaɟ-ɲəh-#

113:	# -ɽaa-mas- -sii-taam- #
WB erasure:	#-ɽaa-mas–sii-taam-#
SB simplification:	#-ɽaa-mas-sii-taam-#
Sibilant Dearticulation:	#-ɽaa-mah-sii-taam-#
a-Raising:	#-ɽaa-məh-sii-taam-#

114:	# -maaɽ-ɟaa-ɽas- -ɦii- #
WB erasure:	#-maaɽ-ɟaa-ɽas–ɦii-#
SB simplification:	#-maaɽ-ɟaa-ɽas-ɦii-#
Voice Assimilation:	#-maaɽ-ɟaa-ɽaz-ɦii-#
z-Gliding:	#-maaɽ-ɟaa-ɽaz̝-ɦii-#
o-Monophthongization:	#-maaɽ-ɟaa-ɽoo-ɦii-#

115:	# -sas-[s-drop] -a-wa-gɽa-ɦas- #
WB erasure:	#-sas–a-wa-gɽa-ɦas-#
SB simplification:	#-sas-a-wa-gɽa-ɦas-#
Voice Assimilation:	#-saz-a-wa-gɽa-ɦas-#
z-Gliding:	#-saz̝-a-wa-gɽa-ɦas-#
o-Abhinihita:	#-soo-wa-gɽa-ɦas-#
Sibilant Dearticulation:	#-soo-wa-gɽa-ɦah-#
w-Dentalization:	#-soo-ʋa-gɽa-ɦah-#
Coda Filling:	#-soo-ʋag-ɽa-ɦah-#
a-Raising:	#-soo-ʋəg-ɽə-ɦəh-#

116:	# -sas-[s-drop] -ɽ̩-ʂis- #
WB erasure:	#-sas–ɽ̩-ʂis-#
SB simplification:	#-sas-ɽ̩-ʂis-#
Voice Assimilation:	#-saz-ɽ̩-ʂis-#
z-Gliding:	#-saz̝-ɽ̩-ʂis-#
Udgraaha:	#-sa-ɽ̩-ʂis-#
Sibilant Dearticulation:	#-sa-ɽ̩-ʂih-#
a-Raising:	#-sə-ɽ̩-ʂih-#

117:	# -sas-[s-drop] -ga-tʃa-ti- #
sas Apocope:	# -sa-[s-drop] -ga-tʃa-ti- #
Intralexical tsh-Splitting:	# -sa-[s-drop] -gat-ʃa-ti- #
WB erasure:	#-sa–gat-ʃa-ti-#
SB simplification:	#-sa-gat-ʃa-ti-#
Dental Assimilation:	#-sa-gac-ʃa-ti-#
sh-Desibilation:	#-sa-gac-cʰa-ti-#
a-Raising:	#-sə-gəc-cʰə-ti-#

118:	# -sas-[s-drop] -tʃaa-gas- #
sas Apocope:	# -sa-[s-drop] -tʃaa-gas- #
WB erasure:	#-sa–tʃaa-gas-#
SB simplification:	#-sa-tʃaa-gas-#
Postlexical tsh Splitting:	#-sat-ʃaa-gas-#
Sibilant Dearticulation:	#-sat-ʃaa-gah-#
Dental Assimilation:	#-sac-ʃaa-gah-#
sh-Desibilation:	#-sac-c^{h}aa-gah-#
a-Raising:	#-səc-c^{h}aa-gəh-#

119:	# -aj-ʂas-[s-drop] -bɽaa-ɦma-ɳas- #
sas Apocope:	# -aj-ʂa-[s-drop] -bɽaa-ɦma-ɳas- #
WB erasure:	#-aj-ʂa–bɽaa-ɦma-ɳas-#
SB simplification:	#-aj-ʂa-bɽaa-ɦma-ɳas-#
e-Monophthongization:	#-ee-ʂa-bɽaa-ɦma-ɳas-#
Sibilant Dearticulation:	#-ee-ʂa-bɽaa-ɦma-ɳah-#
Coda Filling:	#-ee-ʂab-ɽaaɦ-ma-ɳah-#
a-Raising:	#-ee-ʂəb-ɽaaɦ-mə-ɳəh-#

120:	# -b^{h}oos- -daj-wa- #
WB erasure:	#-b^{h}oos–daj-wa-#
SB simplification:	#-b^{h}oos-daj-wa-#
Voice Assimilation:	#-b^{h}ooz-daj-wa-#
z-Gliding:	#-b^{h}ooz̩-daj-wa-#
e-Monophthongization:	#-b^{h}ooz̩-dee-wa-#
Long Glide Reduction:	#-b^{h}oo-dee-wa-#
w-Dentalization:	#-b^{h}oo-dee-ʋa-#
a-Raising:	#-b^{h}oo-dee-ʋə-#

121:	# -b^{h}oos- -b^{h}oos- #
WB erasure:	#-b^{h}oos–b^{h}oos-#
SB simplification:	#-b^{h}oos-b^{h}oos-#
Voice Assimilation:	#-b^{h}ooz-b^{h}oos-#
z-Gliding:	#-b^{h}ooz̩-b^{h}oos-#
Long Glide Reduction:	#-b^{h}oo-b^{h}oos-#
Sibilant Dearticulation:	#-b^{h}oo-b^{h}ooh-#

122:	# -pɽaa-taɽ- -aa-ga-mi-ʂja-ti- #
r-Desonorization:	# -pɽaa-taʐ- -aa-ga-mi-ʂja-ti- #
WB erasure:	#-pɽaa-taʐ–aa-ga-mi-ʂja-ti-#
SB simplification:	#-pɽaa-taʐ-aa-ga-mi-ʂja-ti-#
Delaryngealization:	#-pɽaa-taʂ-aa-ga-mi-ʂja-ti-#
Voice Assimilation:	#-pɽaa-taʐ-aa-ga-mi-ʂja-ti-#
Rhotacization:	#-pɽaa-taɽ-aa-ga-mi-ʂja-ti-#
Onset Filling:	#-pɽaa-ta-ɽaa-ga-mi-ʂja-ti-#
Coda Filling:	#-pɽaa-ta-ɽaa-ga-miʂ-ja-ti-#
a-Raising:	#-pɽaa-tə-ɽaa-gə-miʂ-jə-ti-#

123:	# -pu-naɽ- -ga-tʃa-ti- #
r-Desonorization:	# -pu-naʐ- -ga-tʃa-ti- #
Intralexical tsh-Splitting:	# -pu-naʐ- -gat-ʃa-ti- #
WB erasure:	#-pu-naʐ–gat-ʃa-ti-#
SB simplification:	#-pu-naʐ-gat-ʃa-ti-#
Delaryngealization:	#-pu-naʂ-gat-ʃa-ti-#
Voice Assimilation:	#-pu-naʐ-gat-ʃa-ti-#
Rhotacization:	#-pu-naɽ-gat-ʃa-ti-#
Dental Assimilation:	#-pu-naɽ-gac-ʃa-ti-#
sh-Desibilation:	#-pu-naɽ-gac-c^{h}a-ti-#
a-Raising:	#-pu-nəɽ-gəc-c^{h}ə-ti-#

124:	# -pu-naɽ- -ca- #
r-Desonorization:	# -pu-naʐ- -ca- #
WB erasure:	#-pu-naʐ–ca-#
SB simplification:	#-pu-naʐ-ca-#
Delaryngealization:	#-pu-naʂ-ca-#
Sibilant Dearticulation:	#-pu-nah-ca-#
Visarga Resyllabification:	#-pu-na-hca-#
Fricative Assimilation:	#-pu-na-ʃca-#
Coda Filling:	#-pu-naʃ-ca-#
a-Raising:	#-pu-nəʃ-cə-#

125:	# -pu-naɽ- -daa-na-waan- #
r-Desonorization:	# -pu-naʐ- -daa-na-waan- #
ns-Extension:	# -pu-naʐ- -daa-na-waans- #
WB erasure:	#-pu-naʐ–daa-na-waans-#
SB simplification:	#-pu-naʐ-daa-na-waans-#
Delaryngealization:	#-pu-naʂ-daa-na-waans-#
Voice Assimilation:	#-pu-naʐ-daa-na-waans-#
Rhotacization:	#-pu-naɽ-daa-na-waans-#
Sibilant Dearticulation:	#-pu-naɽ-daa-na-waanh-#
CC-Apocope:	#-pu-naɽ-daa-na-waan-#
w-Dentalization:	#-pu-naɽ-daa-na-ʋaan-#
a-Raising:	#-pu-nəɽ-daa-nə-ʋaan-#

126:	# -pu-naɽ- -pu-naɽ- #
r-Desonorization:	# -pu-naʐ- -pu-naʐ- #
WB erasure:	#-pu-naʐ–pu-naʐ-#
SB simplification:	#-pu-naʐ-pu-naʐ-#
Delaryngealization:	#-pu-naʂ-pu-naʂ-#
Sibilant Dearticulation:	#-pu-nah-pu-nah-#
a-Raising:	#-pu-nəh-pu-nəh-#

127:	# -pu-naɽ- -ɽaw-ca-taj- #
r-Desonorization:	# -pu-naʐ- -ɽaw-ca-taj- #
WB erasure:	#-pu-naʐ–ɽaw-ca-taj-#
SB simplification:	#-pu-naʐ-ɽaw-ca-taj-#
Delaryngealization:	#-pu-naʂ-ɽaw-ca-taj-#
Voice Assimilation:	#-pu-naʐ-ɽaw-ca-taj-#
Rhotacization:	#-pu-naɽ-ɽaw-ca-taj-#
e-Monophthongization:	#-pu-naɽ-ɽaw-ca-tee-#
o-Monophthongization:	#-pu-naɽ-ɽoo-ca-tee-#
r-Compensatory Degemination:	#-pu-naa-ɽoo-ca-tee-#
a-Raising:	#-pu-naa-ɽoo-cə-tee-#

128:	# -pu-naɽ- -skan-d^{h}aj- #
r-Desonorization:	# -pu-naʐ- -skan-d^{h}aj- #
WB erasure:	#-pu-naʐ–skan-d^{h}aj-#
SB simplification:	#-pu-naʐ-skan-d^{h}aj-#
Delaryngealization:	#-pu-naʂ-skan-d^{h}aj-#
e-Monophthongization:	#-pu-naʂ-skan-d^{h}ee-#
Sibilant Dearticulation:	#-pu-nah-skan-d^{h}ee-#
a-Raising:	#-pu-nəh-skən-d^{h}ee-#

129:	# -daj-waas- -aa-sa-taj- #
WB erasure:	#-daj-waas–aa-sa-taj-#
SB simplification:	#-daj-waas-aa-sa-taj-#
Voice Assimilation:	#-daj-waaz-aa-sa-taj-#
z-Gliding:	#-daj-waaz̞-aa-sa-taj-#
Udgraaha:	#-daj-waa-aa-sa-taj-#
e-Monophthongization:	#-dee-waa-aa-sa-tee-#
w-Dentalization:	#-dee-ʋaa-aa-sa-tee-#
a-Raising:	#-dee-ʋaa-aa-sə-tee-#

130:	# -ʃaa-wa-kaas- -k^{h}aa-di-taas- #
WB erasure:	#-ʃaa-wa-kaas–k^{h}aa-di-taas-#
SB simplification:	#-ʃaa-wa-kaas-k^{h}aa-di-taas-#
Sibilant Dearticulation:	#-ʃaa-wa-kaah-k^{h}aa-di-taah-#
w-Dentalization:	#-ʃaa-ʋa-kaah-k^{h}aa-di-taah-#
a-Raising:	#-ʃaa-ʋə-kaah-k^{h}aa-di-taah-#

131:	# -daj-waas- -ga-tʃan-ti- #
Intralexical tsh-Splitting:	# -daj-waas- -gat-ʃan-ti- #
WB erasure:	#-daj-waas–gat-ʃan-ti-#
SB simplification:	#-daj-waas-gat-ʃan-ti-#
Voice Assimilation:	#-daj-waaz-gat-ʃan-ti-#
z-Gliding:	#-daj-waaz̞-gat-ʃan-ti-#
e-Monophthongization:	#-dee-waaz̞-gat-ʃan-ti-#
z-Glide Deletion:	#-dee-waa-gat-ʃan-ti-#
Dental Assimilation:	#-dee-waa-gac-ʃan-ti-#
w-Dentalization:	#-dee-ʋaa-gac-ʃan-ti-#
sh-Desibilation:	#-dee-ʋaa-gac-c^{h}an-ti-#
a-Raising:	#-dee-ʋaa-gəc-c^{h}ən-ti-#

132:	# -ɦa-taas- -wii-ɽaas- #
WB erasure:	#-ɦa-taas–wii-ɽaas-#
SB simplification:	#-ɦa-taas-wii-ɽaas-#
Voice Assimilation:	#-ɦa-taaz-wii-ɽaas-#
z-Gliding:	#-ɦa-taaz̞-wii-ɽaas-#
z-Glide Deletion:	#-ɦa-taa-wii-ɽaas-#
Sibilant Dearticulation:	#-ɦa-taa-wii-ɽaah-#
w-Dentalization:	#-ɦa-taa-ʋii-ɽaah-#
a-Raising:	#-ɦə-taa-ʋii-ɽaah-#

133:	# -maaɽ-ɟaa-ɽaas- -ɦi- #
WB erasure:	#-maaɽ-ɟaa-ɽaas–ɦi-#
SB simplification:	#-maaɽ-ɟaa-ɽaas-ɦi-#
Voice Assimilation:	#-maaɽ-ɟaa-ɽaaz-ɦi-#
z-Gliding:	#-maaɽ-ɟaa-ɽaaz̞-ɦi-#
z-Glide Deletion:	#-maaɽ-ɟaa-ɽaa-ɦi-#

No errors.

8 The programme

A separately available annex to this paper is a rather long printout of a series of computer programmes written with the ultimate aim of verifying the sandhi rule set that was presented above. Despite the impression I may have given at times, I fully realize that a computer and a test suite do not prove the rule set correct: there may always be problems with the programmes, there are even more likely to be gaps in the test suite, and most importantly, correct outputs are not the only measure of a rule set. But on the other hand, large data sets and rule systems soon become unwieldy, and every little bit of verification helps. I certainly uncovered dozens of errors in the rules, and particularly, unexpected interactions between the rules, by using the verifier.

The system is somewhat larger than it strictly needs to be because of two secondary goals. One was to divide the system into two parts, one which would build the grammar, and the other which would use that grammar to run the test suite. This decoupling permits repeated invocations of the verifier with the same grammar to run faster than if the verifier had to build the parser from scratch each time. A more important goal was to make the grammar declarative. The entire rule system, the phonetic feature system of the language, and a definition of the features in each segment are declared in data files with a reasonably familiar syntax. Within quite broad parameters, the rule system can be changed without the necessity of doing any programming. The act of parsing and interpreting the data files is a large part of what the decoupled first half of the system does.

Since details of the working of the programme will be of interest to a specialized audience, I will not go into length here, but will refer the interested reader to the documentation files (READMEs) provided with the printouts. I should however mention that the programmes are written in ANSI C, lex, and yacc for HP-UX 8.0, a version of Unix.

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