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著者（英）	Yasuko Suzuki
journal or publication title	Journal of Inquiry and Research
volume	100
page range	1-19
year	2014-09
URL	http://doi.org/10.18956/00006038

関西外国語大学 研究論集 第100号（2014年 9 月）
Journal of Inquiry and Research, No.100 (September 2014)

The class of semivowels in Sanskrit*

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Abstract

In Sanskrit, both liquids /l r/ and glides /j w/ alternate with their syllabic counterparts and form a single class of semivowels in the traditional grammar. The four semivowels, however, show distinct behaviors in various phonological processes. That is, in consonant clusters, /w/ but not the others may occur before another semivowel in the onset. As a target of sandhis, final /r/ merges with the dental sibilant /s/ in most contexts. As a trigger of sandhis, /l/ shows comparable behaviors to oral stops in causing oral gesture assimilation while /r/ tends to cause debuccalization of the preceding consonant. In gemination, /w/ and /l/ may become the target instead of the adjacent non-continuant while /r/ is excluded from the target. In Middle Indo-Aryan assimilation and initial cluster simplification, the four semivowels show different degrees of resistance to loss.

Asymmetrical behaviors of semivowels are attributed to the phonetic differences of these four sounds instead of the universal feature system, sonority, or the prosodic structure. The phonetic properties that lead to idiosyncratic behaviors are: /l/ with a lingual contact in parallel with stops, /w/ realized as a voiced fricative instead of an approximant, and /r/ with a wider aperture than the other three semivowels. These articulatory properties lead to the hierarchy /l/ < /w/ < /j/ < /r/ with an ascending order of vocalicity, which in turn dominates their phonological behaviors.

Keywords: Sanskrit, semivowels, phonotactics, sandhi, gemination

1. Introduction

Consonants that belong to the same classes by the manners of articulation, which include liquids and glides or semivowels, generally show phonetic similarity, behave in a parallel fashion in various phonological processes, and are arranged within a syllable in accordance with the sonority of each class. On the other hand, a number of studies have shown lack of class uniformity and variability in phonological behaviors.

In the traditional grammar of Sanskrit, the class of semivowels subsumes liquids /l r/ and glides /j w/ (usually transliterated as *y* and *v*, respectively), both of which have vocalic

counterparts, i.e. high vowels for glides and syllabic liquids for liquids (Allen 1953; Cardona 2003; Scharf and Hyman 2012). Although they share the property of having a syllabic counterpart, each member of the four semivowels in Sanskrit shows heterogeneous behaviors in phonotactics, sandhi processes, gemination, and consonant cluster changes in Middle Indo-Aryan. This paper argues that the asymmetry is attributed to the phonetic differences of these four sounds instead of the universal feature system, sonority, and the prosodic structure. More specifically, /l/ has a lingual contact and in this respect more consonantal than the other semivowels. The phonetic realization of Sanskrit /w/ is a labiodental fricative and thus more consonantal than the other glide /j/. Various pieces of evidence show that /r/ has a wider aperture and thus is more vocalic than the other three semivowels. These articulatory features lead to the hierarchy /l/ < /w/ < /j/ < /r/ in the ascending order of vocalicity, which in turn is realized in different phonological behaviors of the four semivowels.

In what follows, section 2 gives an inventory of consonants in Sanskrit and discusses phonetic properties of semivowels. The next four sections discuss different phonological behaviors of semivowels: phonotactics in section 3, sandhis in section 4, gemination in section 5, and developments of consonant clusters in Middle Indo-Aryan in section 6. Finally, section 7 provides conclusions.

2. Status and properties of Sanskrit semivowels

The table in (1) below gives a list of consonants in Sanskrit. In the traditional grammar there are three major classes of consonants, i.e. (i) oral and nasal stops with five places and five series, (ii) semivowels, and (iii) sibilants as well as the voiced glottal fricative and two non-phonemic sounds, i.e. visarga that derives from *s* or *r* and anusvāra that derives from nasal stops (Whitney 1889:§75; Macdonell 1910:§4; Allen 1953:20; Masica 1991:157–61; Cardona 2003:110; Kobayashi 2004:§11).

(1)

		velar	palatal	retroflex	dental	labial	no specific oral place
Stops							
voiceless	plain	k	c	ṭ	t	p	
	aspirate	k^h	c^h	$ṭ^h$	t^h	p^h	
voiced	plain	g	j	ḍ	d	b	
	aspirate	g^h	j^h	$ḍ^h$	d^h	b^h	

nasal	ṅ	ñ	ṇ	n	m	
Semivowels		y	r	l	v	
(Vowels that alternate with semivowels		i	ṛ	ḷ	u)	
Sibilants		ś	ṣ	s		
voiced fricative						h
voiceless fricative						ḥ (visarga)
nasal						ṁ (anusvāra)

As already stated, semivowels alternate with syllabic counterparts such as *pit**ṛ**b^{h}is* 'father, ins.pl.' vs. *pit**r**ā* 'father, ins.sg.'; *ak**ḷ**pat* 'he was able' vs. *kal**p**ate* 'he is able'; *mad^{h}**u*** 'honey' vs. *mad^{h}**v**asti* 'it is honey'; *vā**ri*** 'water' vs. *vā**ry**atra* 'water here'. In the traditional grammar, semivowels are placed between oral and nasal stops, on the one hand, and sibilants and consonants without a specific oral place on the other, in accordance with the degree of aperture (Allen 1953:24–6; Straka 1964:301–2, 313; Scharf and Hyman 2012:128–9, 132–9). The class is called *antaḥsthā* 'standing between', that is, between vowels and consonants due to the shared vocalic/consonantal variability or between stops and sibilants in the order of consonants (Whitney 1889:§51a; Allen 1953:29; Mishra 1972:147–8).

While liquids and glides form a single phonological class in Sanskrit, the two are normally independent classes especially because liquids are not syllabic in a number of languages. However, the two classes share exclusively certain articulatory properties and are characterized as 'approximants' or 'frictionless continuants' (Spencer 1996:14). In phonotactics, both classes serve as the second member of common initial clusters (Wright 2004; Proctor 2009:23–5; Parker 2012b). On the other hand, it has been observed cross-linguistically that the rhotic is more vocalic than the liquid and that the liquid may behave as non-continuants (Ladefoged and Maddieson 1996:216; Kirchner 2001:111–2; Mielke 2005; Proctor 2009:38–45).

In spite of the shared property of vocalic/consonantal alternation, the four semivowels in Sanskrit do not necessarily share the property of sonorancy and differ in a number of respects as will be shown below and Allen (1953:27) considers the classification as phonological. The following descriptions of Sanskrit semivowels are ascribed to native grammarians and may involve dialectal variations (Whitney 1889:§§51–8; Wackernagel 1896: §§178–96; Macdonell 1910:§§49–52; Varma 1929:6–8; Allen 1953:53–5, 57; Mishra 1972:147–54;

Renou 1975:§5; Masica 1991:160–1; Cardona 2003:109; Kobayashi 2004:§§65–6; Scharf and Hyman 2012:65, 71–2).

Of the two liquids, *r* is characterized as retroflex as given in (1), but is variously described as retroflex, dental, or alveolar depending on the phonetic treatises. The Sanskrit rhotic *r* is unique among semivowels in that it does not occur in geminate nor is nasalized. In sandhis it behaves in parallel with the sibilant *s*: see section 4 below. On the other hand, *l* is dental to alveolar or postdental in place and behaves partly in parallel with oral stops and partly with glides. In prehistoric stages, the two liquids merged in either one or the distinction was retained depending on the dialects (Burrow 1973:83–5; Masica 1991:161). The attested stages have both, but, possibly as a remnant of the earlier stages, there is only one root with syllabic *l*, i.e. *kḷp-* 'be able', and the syllabic *l* has no long counterpart *ḹ* (Whitney 1889:§26; Wackernagel 1896:§31; Allen 1953:55). On the other hand, syllabic *ṛ* is not uncommon and there is a long counterpart *ṝ* (e.g. *pitṝn* 'fathers, acc.pl.') although rare.

Of the two glides, *y* is palatal and may alternate with the voiced palatal stop *j* by strengthening. The labiodental *v* historically derives from bilabial *w* and not *b*, but is described as a voiced fricative and may be strengthened or confused with the bilabial stop *b*. Both glides have different realizations depending on the context: e.g. 'heavy' when initial and after a nasal, *h*, or *r* and 'light' in word-final position (Varma 1929:126–36; Allen 1953:28–9). In contrast to liquids, glides occur only in the onset but are vocalized in the coda except for geminates that strand over the sequential coda and onset, e.g. *śayyā* 'bed', *vavvola-* 'acacia arabica'.

The next four sections show heterogeneous behaviors of Sanskrit semivowels and argue that they are to be attributed to the phonetic properties as described in this section.

3. Phonotactics

Sonority, which is defined based on classes of sounds as in (2), has generally been accepted as a notion that governs the order of segments within a syllable under the following generalization called the Sonority Sequencing Principle: consonants in onset clusters are arranged so that the sonority rises towards the nucleus and that in the coda forms a mirror image (Hooper 1976:206; Selkirk 1984:116; Clements 1990; Blevins 1995:210–2; Hall 2006:330; Zec 2007:177–9; Parker 2011:116–2, 2012b).

(2) stops < fricatives < nasals < liquids < glides < vowels
lower sonority higher sonority

Although the generalization has been supported by numerous phonological analyses, the notion of sonority, the Sonority Sequencing Principle, and other generalizations based on sonority have been criticized by a number of studies because sonority lacks a uniform phonetic foundation and also because the principle has both systematic and sporadic exceptions (Ohala and Kawasaki-Fukumori 1997; Wright 2004). Alternatives to the principle that have been proposed to explain consonant sequences are robust phonetic properties of consonants: perceptual/auditory/acoustic properties (Kawasaki-Fukumori 1992; Ohala and Kawasaki-Fukumori 1997; Wright 2001, 2004; Henke, Kaisse, and Wright 2012) and articulatory properties (Proctor 2009; Proctor and Walker 2012). This section examines phonotactics in Sanskrit that involves semivowels, showing that the observed patterns pose another challenge to the analysis based on sonority.

In Sanskrit there are initial clusters of two distinct semivowels (also Kobayashi 2004:§65) in addition to a number of initial bi-consonantal clusters that consist of an obstruent and a semivowel, e.g. *ty-*, *gr-*, *pl-*, and *sv-*. As given in (3), *v* may precede any other semivowel while there are also sporadic examples in Monier-Williams (1899/1984) where other semivowels occur as the first member of the initial clusters. The first two clusters in (3), i.e. *vy-* and *vr-*, are common and are in Masica's (1991:161) list of initial clusters. On the other hand, Monier-Williams (1899/1984) lists only a few words beginning with *vl-*.

(3) *vy-* ***vy****āg*^{h}*ra-* 'tiger', ***vy****at*^{h}*ayati* 'he torments'
vr- ***vr****ata-* 'vow', ***vr****ajati* 'he proceeds'
vl- ***vl****īnāti* 'he presses down', ***vl****eṣka-* 'a snare'

Given that *v* is a glide, onset clusters in (3) are problems for the Sonority Sequencing Principle that is based on consonant classes as in (2). The initial clusters given in (3) would imply that *v* is less sonorous than *y*, *r*, and *l*, which contradicts with (2). Further, the rarity of initial *vl-* as opposed to *vy-* and *vr-* may be attributed to the Sonority Dispersion Principle, according to which clusters with a greater sonority difference are preferred over those with a smaller one (Clements 1990:302–11; Parker 2011:1173–5, 2012b). In this interpretation, however, one must presuppose that *l* is less sonorous than *r*, which again militates against

the conventional classification in terms of sonority in (2).

Phonotactics as are given can only be accounted for in terms of both phonological classes and phonetic properties that affect consonant sequencing. The apparently anomalous pattern follows from the phonetic property of Sanskrit *v* that it is realized as a fricative. Studies have shown that perceptual cues of fricatives are robust enough to be salient in pre-consonantal position (Kawasaki-Fukumori 1992; Ohala and Kawasaki-Fukumori 1997; Wright 2001, 2004). In this respect initial *v*-semivowel clusters are comparable to fricative-semivowel clusters: *śy-*, *śr-*, *śv-*; *sy-*, *sr-*, *sv-*; *hr-*, *hl-*, *hv-* where *v* may also occur as the second member of the cluster as a semivowel. That is, on the one hand, *v* is fricative-like in that it may precede another semivowel in initial clusters. On the other hand, it is a semivowel in that it occurs as the second member of initial clusters after a stop or a fricative, e.g. ***kv****a* 'where', ***dv****a* 'two', ***śv****eta-* 'white', ***sv****ādu-* 'sweet', ***hv****ayati* 'he calls'. Due to its phonological characterization and phonetic realization, therefore, *v* is ambivalent in Sanskrit phonotactics.

On the other hand, examination of medial clusters in Masica (1991:161–2) and Turner and Turner (1971) shows that there are apparently no coda clusters that indicate distributional differences among semivowels in lack of clusters of two distinct liquids such as *rl*. In final position only one consonant is allowed: underlying consonant clusters are simplified by deleting all but the first, e.g. *tudants* 'pressing (pr.ppl., nom.sg.)' > *tudan*, except for *r*C clusters such as *ūrk* 'strength' and *amārṭ* 'wiped clean' (Whitney 1889:§150; Wackernagel 1896:§261; Burrow 1973:100–1; Renou 1975:§29; Masica 1991:162; Cardona 2003:115). As a final consonant, *l* may occur although rare but *r* must be devoiced and debuccalized: see section 4.1 below (Whitney 1889:§144; Wackernagel 1896:§260c).

As a nucleus, there is a clear asymmetry between the two liquids as stated in section 2 above: there are good number of instances of *ṛ*, rarely those of *ṝ* and *ḷ*, and none of *ḹ*. Although the asymmetry may be a result of historical confusion of the two liquids, it may suggest that *r* is more vocalic than *l* and thus is a better candidate for the nucleus than *l*.

In sum, productive *vy-* and *vr-* initial clusters suggest that *v* is more consonantal than at least *y* and *r* while a few words have *vl-* cluster. This property of *v* apparently follows from its phonetic value as a fricative and can hardly be accounted for in terms of sonority. On the other hand, the presence of the final *r*C-clusters as well as the frequency of syllabic *ṛ* as opposed to *ḷ* suggests that *r* is closer to vowels than the other semivowels. The cross-linguistic asymmetry between *r* and *l* has been noted by earlier literature such as Proctor (2009) and Proctor and Walker (2012). Although it may be possible to attribute the

asymmetry to the higher sonority of *r* than *l*, such a proliferation of the sonority hierarchy is a questionable move.

4. Sandhis involving semivowels

4.1. Semivowels as targets

The consonants that are allowed in word-final position and thus are targets of external sandhis form a subset of those given in (1). Of the four semivowels, glides do not occur finally, *l* is rare and unchanged (see section 3 above), and only *r* is subject to various sandhi processes depending on the contexts. Final *r* merges with *s* in most contexts, which is the only sibilant that occurs word-finally. The merger of *r* and *s* is reasonable in that they both have lingual stricture in the dental/alveolar region (Kobayashi 2004:§104). The alternation is supported by the phonetic realization of the rhotic as a voiced retroflex fricative in Mandarin Chinese (Spencer 1996:19; also Proctor 2009:7–8) and rhotacism of *s* in voiced environments in some languages such as Latin and Proto-Germanic, leading to synchronic alternation of the two (Hock 1991a:81–2; Wiese 2011:724–5).

As a target of sandhi processes, both *r* and *s* tend to be realized as *r* when followed by a voiced sound, on the one hand, and a sibilant or visarga when followed by a voiceless sound or a pause, on the other hand (Whitney 1889:§§164–79; Wackernagel 1896:§§284–7; Allen 1953:100–1, 1972:70–9; Renou 1975:§§28, 36–9; Cardona 2003:117–9; Kobayashi 2004:§104). As in (4a), *r* before a voiced sound is unchanged except before *r* where it is dropped with a compensatory lengthening of the preceding vowel. The only difference between *r* and *s* is the outcome of *s* after short *a* and before a voiced sound: as in (4b) final *-as* becomes *-o* and the following vowel is dropped if it is short *a* but remains unchanged otherwise. However, i.e. after vowels other than short *a*, the outcomes of the final *s* are the same as those of *r*: compare (4c) with (4a).

(4) a. *puna**r** rakṣati* > *pun**ā** rakṣati* 'he protects again'
*puna**r** jayati* (no change) 'he wins again'
*puna**r** atra* (no change) 'again here'

b. *deva**s** rakṣati* > *dev**o** rakṣati* 'the god protects'
*deva**s** jayati* > *dev**o** jayati* 'the god wins'

*deva**s** atra* > *dev**o** 'tra* 'the god is here'

c. *kavi**s** rakṣati* > *kav**ī** rakṣati* 'the poet protects'
*kavi**s** jayati* > *kavi**r** jayati* 'the poet wins'
*kavi**s** atra* > *kavi**r** atra* 'the poet is here'

Loss of *r* before *r* is attributed to lack of geminate *r* in Sanskrit. The change of *-as* to *-o* implies vocalization of *-s* to *-u* in a voiced context with a subsequent monophthongization of *-au* to *-o*.

When followed by a voiceless sound or in utterance-final position, both *r* and *s* are realized as a voiceless fricative as in (5). The outcome agrees in place when the following stop is coronal, but otherwise, i.e. when followed by labial or velar consonants or in utterance-final position, it is a glottal fricative or visarga. Before sibilants, the outcome may either be a visarga or the same sibilant.

(5) a. *puna**r** carati* > *puna**ś** carati* 'he wanders again'
*puna**r** tatra* > *puna**s** tatra* 'again there'
*puna**r** karoti* > *puna**ḥ** karoti* 'he makes again'
*puna**r** sīdati* > *puna**ḥ** sīdati* ~ *puna**s** sīdati* 'he sits again'
*puna**r*** > *puna**ḥ*** 'again'

b. *deva**s** carati* > *deva**ś** carati* 'the god wanders'
*deva**s** tatra* > *deva**s** tatra* 'the god is there'
*deva**s** karoti* > *deva**ḥ** karoti* 'the god makes'
*deva**s** sīdati* > *deva**ḥ** sīdati* ~ *deva**s** sīdati* 'the god sits'
*deva**s*** > *deva**ḥ*** 'the god'

While the behavior of *r* as a target of external sandhi cannot be compared with that of the other three semivowels that do not or barely occur in the same environments, loss of final *r* before the following *r* to avoid geminates is an idiosyncracy of *r*. On the one hand, other consonants that lack the geminate counterpart are *h*, visarga, and anusvāra, the latter two of which do not occur in the onset (Wackernagel 1896:§96; Macdonell 1910:§30; Kobayashi 2004:§66). The fact that these three lack a specific oral gesture suggests that *r* has a wider

aperture than the other consonants with an oral stricture. On the other hand, prohibition of geminate *r* is comparable to avoidance of hiatus by vowel merger or devocalization of high vowels as in *c*^{h}*āyā atra* > *c*^{h}*āyātra* 'a shade is here', *mad*^{h}*u atra* > *mad*^{h}*vatra* 'honey is here' (Whitney 1889:§§125–38; Wackernagel 1896:§§267–74; Allen 1972:29–45; Renou 1975:§§25, 40–2; Cardona 2003:111–4). Lack of geminate *r* in any position is in sharp contrast with the presence of geminates of *s*, whether it is originally *s* or *r*, e.g. *puna**ss** sīdati* in (5a) and *deva**ss** sīdati* in (5b), or geminates of the other semivowels.

4.2. Semivowels as triggers

Because all the four semivowels may occur initially, they may condition assimilatory processes of the preceding word-final sounds. The observed phonological patterns show the two types of contrasts: first, *r* as opposed to the other three and, second, *l* as opposed to the other three.

The earlier stage shows the contrast between *r* and the other three with respect to the outcome of the preceding labial nasal. In certain Vedic traditions final *m* becomes a nasalized semivowel before semivowels *y l v* by regressive assimilation of the oral gesture as illustrated in (6) (Whitney 1889:§§71c, 213d; Wackernagel 1896:§283c; Macdonell 1910:§75.4; Allen 1972:80–1; Cardona 2003:116–7; Suzuki 2013).[1]

(6) *ya**m** ya**m** yujam kṛṇute brahmaṇaspatis* > *ya**ỹ** ya**ỹ** yujàṅ kṛṇ̲ute brahmàṇ̲aspatiḥ*
'whomever Brahmaṇaspati makes an ally' (RV 2.25.1d)
*ta**m** lokam* > *ta**l̃** l̲okam* (VS 20.25) 'that world'
*agnim dūta**m** vṛṇīmahe* > *a̲gnin dūta**ṽ** vṛ̲ṇīmahe̲* (RV 1.12.1a)
'We choose Agni as messenger.'

On the other hand, *m* before *r* becomes anusvāra by debuccalization as well as before fricatives as in (7) (Whitney 1889:§213e; Wackernagel 1896:§283d; Macdonell 1910:§75.3; Allen 1972:81–3; Cardona 2003:116; Suzuki 2013).

(7) *aha**m** rakṣāmi* > *aha**ṁ** rakṣāmi* 'I am protecting'
*aha**m** śaye* > *aha**ṁ** śaye* 'I am lying'
*aha**m** hasāmi* > *aha**ṁ** hasāmi* 'I am laughing'

In later Sanskrit, *m* is debuccalized and becomes anusvāra before glides as well as *r*: see (8d, e) below. Only *l* causes assimilation of *m* as is given in (6) or may optionally become anusvāra: see (8a) below.

Among the four semivowels, *l* but not the others tends to trigger the type of assimilation of the preceding consonant that stops do. More specifically, dental and labial nasals and dental stops undergo assimilation of oral gesture to the following *l*, leaving only nasality behind, as in (8a). The processes are parallel with those before coronal stops where dental and labial nasals and dental stops undergo assimilation in place as in (8b). In contrast, before *r*, *y*, and *v*, the dental nasal remains unchanged, the labial nasal is debuccalized, and oral stops assimilate only in voice as in (8c–e) (Whitney 1889:§§202, 206, 213; Wackernagel 1896:§§276d, 281, 283b, c; Macdonell 1910:§§75–7; Allen 1953:39, 1972:80–1, 83–4, 91–3; Cardona 2003:115–7; Suzuki 2013).

(8) a. *b*^{h}*avā**n*** *lunāti* > *b*^{h}*avā**l̃*** *lunāti* 'you cut'
*ta**m*** *lunāti* > *ta**l̃*** *lunāti* ~ *ta**ṁ*** *lunāti* 'he cuts him'
*ta**t*** *lunāti* > *ta**l*** *lunāti* 'he cuts that'

b. *b*^{h}*avā**n*** *jayati* > *b*^{h}*avā**ñ*** *jayati* 'you win'
*ta**m*** *jayati* > *ta**ñ*** *jayati* 'he wins him'
*ta**t*** *jayati* > *ta**j*** *jayati* 'he wins that'

c. *b*^{h}*avā**n*** *rakṣati* (no change) 'you protect'
*ta**m*** *rakṣati* > *ta**ṁ*** *rakṣati* 'he protects him'
*ta**t*** *rakṣati* > *ta**d*** *rakṣati* 'he protects that'

d. *b*^{h}*avā**n*** *yajati* (no change) 'you sacrifice'
*ta**m*** *yajati* > *ta**ṁ*** *yajati* 'he sacrifices him'
*ta**t*** *yajati* > *ta**d*** *yajati* 'he sacrifices that'

e. *b*^{h}*avā**n*** *vindati* (no change) 'you find'
*ta**m*** *vindati* > *ta**ṁ*** *vindati* 'he finds him'
*ta**t*** *vindati* > *ta**d*** *vindati* 'he finds that'

Of the four semivowels, therefore, the degree of causing debuccalization of the preceding sound is: *r* > *y v* > *l* in the descending order while the degree of causing assimilation of the oral gesture is the reverse of this hierarchy. Together with lack of geminte *r* as well as *h*, the difference is best attributed to the degree of oral aperture: *r* is most likely to cause debuccalization and does not cause assimilation in oral gesture because it has a greater aperture and is more vocalic than the other semivowels. In contrast, *l* is most likely to cause assimilation in oral gesture and is least likely to cause debuccalization because it has a lingual contact in parallel with stops. The glides, i.e. *y v*, are between these two. As has been shown, the four semivowels do not form a natural class as a trigger of sandhis.

5. Gemination

Sanskrit shows gemination in consonant clusters, typically intervocalic biconsonantal clusters, described by various phonetic treatises and attested in inscriptions and manuscripts (Whitney 1889:§§228–9; Wackernagel 1896:§96–8; Varma 1929: 63–78, 107–25; Hock 1991b: 128–32; Vaux 1992; Kobayashi 2001, 2004:§23; Cardona 2003: 120, n.d.:50–66; Suzuki 2012). As a rule, gemination affects the first consonant of the cluster or, if the first is *r* or *h*, which cannot be geminated, the second. Thus, stops and sibilants followed by a semivowel become geminates as in (9a) and consonants including semivowels preceded by *r* or *h* are geminated as in (9b).

(9) a. *adya* > *a**dd**ya* 'today'
amuṣya > *amu**ṣṣ**ya* 'of that one'
cakra- > *ca**kk**ra-* 'wheel'
ā tvā > *ā**tt**vā* 'hither you'
viśvataḥ > *vi**śś**vataḥ* 'everywhere'
uru prat^{h}*asva* > *uru**pp**rat*^{h}*a**ss**va* 'spread wide'

b. *art*^{h}*a-* > *ar**tt**h**a-* 'purpose'
darśapūrṇamāsa > *darśapūr**ṇṇ**amāsa* 'new and full moon rites'
sūryasya > *sūr**yy**asya* 'of the sun'
bahvīḥ > *bah**vv**īḥ* 'many'

When a semivowel is the first member of the cluster, there are some examples where *v* is

geminated before *y* as in (10a), but in the clusters of *l* and a stop and those of *v* and a nasal, the second gets geminated instead with an optional variant with gemination of the first.

(10) a. *daivyā* > *dai**vv**yā* 'divine'
pṛt^{h}ivyām > *pṛt^{h}i**vv**yām* 'earth'

b. *kalpān juhoti* > *kal**pp**āñjuhoti* 'offers with the kalpa mantras' cf. *ka**ll**pāñjuhoti*
vib^{h}udāvne > *vib^{h}udāv**nn**e* 'who grants power' cf. *vib^{h}udā**vv**ne*

In spite of the rule, therefore, oral and nasal stops are preferred targets of gemination over semivowels and this tendency is attributed by Suzuki (2012) to the oral closure or less aperture of stops. Among semivowels, examples in (10) show that *l* with a partial closure and *v* with a labiodental stricture are more susceptible to gemination than *y*, which in turn may geminate after *r* that lacks a geminate counterpart as in (9b). The hierarchy of susceptibility to gemination is thus: *l v* > *y* > *r* in the decreasing order, which is in accordance with the findings of the previous sections.

6. Middle Indo-Aryan consonant cluster changes

Lack of class unity among semivowels is also observed in consonant cluster changes in Middle Indo-Aryan. Middle Indo-Aryan is known for extensive total assimilation of medial clusters and simplification of initial clusters (Ghatage 1962; Pischel 1981:§§268–334; Masica 1991:171–80; Geiger 1994:§51–4; von Hinüber 2001:§§225–61; Oberlies 2001:95–105, 2003:177–9; Suzuki 2002; Bubenik 2003:217–8). The outcome of assimilation or simplification depends on the classes of consonants that form the clusters rather than the order of consonants.

In medial positions, sibilants, nasals, and semivowels assimilate to stops irrespective of their order; further, semivowels assimilate to sibilants and nasals. Initial clusters are simplified in a parallel fashion. To take some examples from Pali, in ***sv**a**pn**a-* > ***s**o**pp**a-* 'sleep' the resultant consonant is the first and not the second in both initial and medial clusters. On the other hand, in ***sp**a**rś**a-* > ***p^h**a**ss**a-* 'touch', the second consonant is the outcome in both initial and medial clusters.[2] When the cluster consists of two distinct stops or nasals, then the outcome is a geminate of the second consonant by regressive assimilation, e.g. *sa**pt**a-* > *sa**tt**a-* 'seven', *ni**mn**a-* > *ni**nn**a-* 'deep, low'. However, when the cluster consists of two distinct

semivowels, the direction of assimilation depends not on the order but on which semivowels form the cluster as in (11) (Pischel 1981:§§286, 287, 296; Geiger 1994:§52.5, 54.6; von Hinüber 2001:§226.1, 225, 229; Oberlies 2001:99; 2003:178–9). The implied hierarchical relation is *l* > *v* > *y* > *r* in the descending order of dominance in assimilation.

(11) a. Progressive assimilation	implied dominance relation
*bi**lv**a-* > *bi**ll**a-* 'fruit of Aegle marmelos'	*l* > *v*
*ka**ly**a-* > *ka**ll**a-* 'ready, possible'	*l* > *y*
parivy**aya-* (> *pari**vv**aya-*) > *pari**bb**aya-* 'expenditure'	*v* > *y*
vyātta-* > *vatta-* 'opened wide (of mouth)'	
*tī**vr**a-* (> *ti**vv**a-*) > *ti**bb**a-* 'sharp'	*v* > *r*
vrāta-* > *vatta-* 'religious observance'	
b. Regressive assimilation	
*du**rl**ab^{h}a-* > *du**ll**ab^{h}a-* 'difficult to attain'	*l* > *r*
*sa**rv**a-* (> *sa**vv**a-*) > *sa**bb**a-* 'all'	*v* > *r*
*ā**ry**a-* > *a**yy**a-* 'venerable'	*y* > *r*

Given that the outcome of assimilation is determined by the classes of consonants rather than their order, earlier studies have proposed that the consonant that wins out is determined by the sonority hierarchy, in which case, the more sonorous assimilates to the less sonorous (Grammont 1971:185–9; Hankamer and Aissen 1974:134; Junghare 1979:126–9; Hock 1991a:64–5, 1991b; Geiger 1994:§51). However, while assimilation between different classes of consonants, i.e. stops, sibilants, nasals, and semivowels, conforms to the prediction of this analysis, assimilation between different semivowels as exemplified in (11) does not follow from the hypothesis, which would predict that glides assimilate to liquids and that the clusters of two distinct glides or liquids undergo regressive assimilation (Wetzels and Hermans 1985; Cho 1999). Thus, clusters that consist of *r* and a glide are to become geminate *r*, which is prohibited in Sanskrit, instead of geminate glides as observed in (11).

As an alternative, some studies have assumed that the onset-initial consonant dominates in assimilation, thus *vrāta-* > *vatta-* in (11a) where the first consonant in the cluster is onset-initial but *ār-ya-* > *ayya-* in (11b) where the second consonant is onset-initial (Wetzels and Hermans 1985:215–6; also Murray 1982; Vaux1992; Cho 1999). However, there are

counterexamples: *l* in *l*-initial clusters such as *bi**lv**a-* > *bi**ll**a-* and *ka**ly**a-* > *ka**ll**a-* in (11a) is in the coda but yet dominates assimilation. It is thus not the onset-initial consonant that dominates assimilation.

The only solution, therefore, is to assume that consonant cluster changes are governed by the hierarchy not of sonority but some sort of strength or articulatory property including aperture (von Hinüber 2001:§226; Oberlies 2001:99; Suzuki 2002:64 (II)). And this hierarchy is in accordance with the observations made in the previous three sections. The evidence of initial and final clusters examined in section 3 suggests the hierarchies *v* > *y r* and *l* > *r*, respectively, of occurring in peripheral positions in the syllable. Section 4 has shown that the hierarchy *l* > *y v* > *r* governs the likelihood of causing oral gesture assimilation or, inversely, of debuccalization. Further, section 5 has established the hierarchy *l v* > *y* > *r* of the susceptibility to gemination. These observations together would lead to the hierarchy: *l* > *v* > *y* > *r* in the descending order of consonantality or the ascending order of vocalicity. As has been shown, the hierarchical relation of semivowels observed in medial cluster assimilation and initial cluster simplification in Middle Indo-Aryan languages can only be accounted for in light of the phonological behaviors of semivowels in Sanskrit.

7. Conclusions

While sharing the property of vocalic/consonantal alternation, the four semivowels in Sanskrit show heterogeneous phonotactic and phonological behaviors and undergo different developments in Middle Indo-Aryan. These different behaviors naturally follow from the hierarchy *l* < *v* < *y* < *r* with an ascending order of vocalicity, which in turn is attributed to the various phonetic properties of semivowels, i.e. partial closure of *l*, phonetic realization of *v* as a labiodental fricative, and a wider aperture of *r*.

The proposed interpretation is couched on and provides additional evidence for the phonetically based phonology in seeking behind phonological phenomena articulatory motivations (Browman and Goldstein 1989, 1990, 1991, 1992; Blevins 2004; Proctor 2009; Proctor and Walker 2012) and perceptual motivations (Ohala 1981, 1990, 1997, 2005; Kawasaki-Fukumori 1992; Ohala and Kawasaki-Fukumori 1997; Wright 2001, 2004; Blevins 2004; Martin and Peperkamp 2011), but argues against analyses based on the abstract notions including sonority and prosodic structure.

Notes

* I thank two anonymous reviewers for invaluable comments and suggestions for improvement, This work was supported by JSPS KAKENHI Grant Number 25370450.

1 The underlines and grave accents represent pitch, which is irrelevant for the discussions here.

2 As shown in the examples given, the outcome of sibilant–stop clusters is an aspirated stop because the deleted sibilant leaves aspiration behind (Pischel 1981:§§301–11; Masica 1991:172, 177; von Hinüber 2001:§228; Oberlies 2001:98, 2003:177–8; Bubenik 2003:218). The outcome of the medial cluster *rś* is a dental sibilant and not palatal because the three places of sibilants merged into the dental (Pischel 1981:§227; Masica 1991:168; von Hinüber 2001:§219; Oberlies 2001:70, 2003:175; Bubenik 2003:216). These additional changes are irrelevant to the discussions here.

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