Consonant Cluster Changes in Pali : Toward Restricting the Phonological Patterns (Part 1)

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Consonant Cluster Changes in Pali:

Toward Restricting the Phonological Patterns* Part I

Yasuko Suzuki

1. Introduction

In its development from Sanskrit, Pali underwent extensive changes that affected consonant clusters, i.e. (1a) bi-directional complete assimilation, (1b) metathesis of *h* and a sonorant, (1c) weakening of sibilants into *h* before nasals followed by metathesis, and (1d) simplification of initial clusters (cf. Mayrhofer 1951, Pischel 1981, Geiger 1994, Hazra 1994, Oberlies 2001, von Hinüber 2001).

(1) a. Assimilation

takra	>	takka	'whey'
karka	>	kakka	'a precious stone'

b. Metathesis

cihna	>	cinha	'sign'
jihvā	>	jivhā	'tongue'

c. Weakening of sibilants (with metathesis)

vismaya	>	vimhaya	'astonishment'

d. Simplification of initial clusters

mrakṣa	>	makk^{h}a	'anger'
sparśa	>	p^{h}assa	'touch'

As a result, medial clusters that are allowed in Pali are geminates, clusters with a nasal as the first member, and sonorants followed by *h* (cf. Oberlies 2001: 96).

While the earlier scholars have treated assimilation, metathesis, and sibilant reduction as separate phenomena (cf. Junghare 1979, Pischel 1981, Hock 1991a, b, Geiger 1994, Hazra 1994, Oberlies 2001), this paper claims that the four changes as shown in (1) are different realizations of a single uniform process, i.e. assimilation governed by the strength hierarchy of consonants as given in (2) (cf. von Hinüber 2001 and Oberlies 2001).

(2) stops nasals sibilants *l v y r*

stronger ←――――――――――――――――――――→ weaker

In this assimilation, the consonant weaker in the hierarchy assimilates to the one stronger in the hierarchy. Different realizations in (1) are due to interference of other factors such as interaction of the oral and glottal gestures and distribution of aspiration. Based on the assumption that a sonorant followed by *h* is an aspirated geminate nasal (cf. von Hinüber 2001; also Junghare 1979), apparent metathesis in (1b) follows from spread of oral gesture with change in timing of aspiration. Also, reduction of sibilants and metathesis given in (1c) is assimilation of sibilants to nasals, leaving aspiration behind.

The hierarchy given in (2) is based in part on the degree of oral stricture of each group of consonants. Because of this, consonants with an oral closure, i.e. stops and nasals, are stronger than fricatives that lack an oral closure. The effect of assimilation is to maximize the contrast between a consonant sequence and the adjacent vowel(s), especially in terms of the degree of aperture.

A second aspect of various changes given in (1) is simplification of the syllable structure. As a result of various processes, Pali syllable allows only one consonant in both onset and coda. A coda consonant may only have nasality of its own (i.e. either nasal or non-nasal) and must share other features with the following consonant. Therefore, according to the proposed analysis, the possible medial clusters in Pali are only geminates and NC.

The analysis as given in this paper is in harmony with other phonological changes that affected phonological patterns in Pali, i.e. two-mora conspiracy, monophthongization, and change and loss of word-final consonants: they all aim at the same direction of restricting the phonological patterns.

The theoretical framework used in this paper is that of Optimality Theory as developed in Prince and Smolensky (1993) and other works. This framework better reflects the direction of various changes than the rule-based approach.

The paper consists of two parts. Part I (this volume) presents an inventory of consonants of Sanskrit and Pali (section 2.1), illustrates changes of bi-consonantal clusters in medial and initial positions in Pali (sections 2.2-2.5) with a summary of consonant cluster changes (section 2.6), and critically evaluates three previous analyses of assimilation (section 3). Part II outlines the six assumptions that underlie the proposed analysis (section 4.1), presents an analysis based on these assumptions in terms of Optimality Theory as outlined above (section 4.2), and shows that other changes such as two-mora conspiracy and changes in word-final consonants follow from the assumptions of the proposed analysis (section 5).

2. Data

This section presents, first, the consonant inventories of Sanskrit and Pali as background information. Since oral stricture is important in assimilation as outlined in section 1, consonants with and those without an oral stricture are listed under separate headings (section 2.1). As will be shown below, the consonant inventory of Pali is little different from that of Sanskrit (cf. Oberlies 2001: 70). However, the inventory of consonant clusters in Pali are vastly simplified due to assimilation and other processes. The purpose of this section is to give the relevant data which are responsible for this simplification: (i) developments of medial bi-consonantal clusters which consist only of the consonants with an oral stricture (section 2.2), (ii) metathesis and reduction of sibilants (section 2.3), (iii) developments of medial clusters involving the consonants without an oral stricture called visarga and anusvāra (section 2.4), and (iv) simplification of initial clusters (section 2.5) with a summary of developments of medial and initial bi-consonantal clusters (section 2.6). The fate of each consonant cluster, i.e. whether it underwent assimilation, was affected by metathesis, or remained unchanged, depends on which group of consonants form the cluster.

The data given in this section are taken from Mayrhofer (1951), Turner (1966) together with Turner and Turner (1971), and Geiger (1994).

This section discusses changes of bi-consonantal clusters only in order to make the comparison easier with the previous analyses which focus on bi-consonantal clusters (e.g. Hankamer and Aissen 1974, Murray 1981, Hock 1991a, b). Clusters of more than two consonants will be discussed in section 5.1 in Part II. As will be shown, the analysis of bi-consonantal clusters can be extended to poly-consonantal clusters.

2.1. The consonant systems of Sanskrit and Pali

The table in (3) shows the consonant inventory in Sanskrit with consonants with an oral stricture and those without an oral stricture under separate headings (cf. Whitney 1889: §§ 31-75, Wackernagel 1957: §§ 96-227).

(3) a. Consonants with an oral stricture:

	velar	palatal	retroflex	dental	labial
STOPS (T)					
voiceless unaspirated	k	c	ṭ	t	p
voiceless aspirated	k^h	c^h	$ṭ^h$	t^h	p^h
voiced unaspirated	g	j	ḍ	d	b
voiced aspirated	g^h	j^h	$ḍ^h$	d^h	b^h
NASALS (N)	ṅ	ñ	ṇ	n	m
SIBILANTS (S)		ś	ṣ	s	
SEMIVOWELS (R)					
liquids			r	l	
glides		y			v

b. Consonants without an oral stricture:

	h
Visarga	ḥ
Anusvāra	ṁ

Consonants in (3a) are divided into four major categories, i.e. stops, nasals, sibilants, and semivowels, which are indicated by T, N, S, and R, respectively, in the following discussions. Semivowels correspond to liquids and glides in a more common grouping. They are called semivowels because in Sanskrit all the four consonants that belong to this group alternate with a vocalic counterpart depending on context.

Among the consonants without an oral stricture in (3b) *h* is voiced and may occur in both onset and coda in voiced environment other than word-finally, while visarga is voiceless and occurs only in coda preceding a voiceless consonant or in word-final position. Although *h* and visarga are historically distinct, synchronically they are in complementary distribution. Anusvāra is a nasal without a specific oral stricture and is restricted to the coda position.

The table in (4) shows the consonant inventory of Pali that developed from Sanskrit, again with consonants with an oral stricture and those without one under separate headings (cf. Mayrhofer 1951: §§ 116-162, Geiger 1994: § 2, Hazra 1994: 50-51).

(4) a. Consonants with an oral stricture:

	velar	palatal	retroflex	dental	labial
STOPS (T)					
voiceless unaspirated	k	c	ṭ	t	p
voiceless aspirated	kʰ	cʰ	ṭʰ	tʰ	pʰ
voiced unaspirated	g	j	ḍ	d	b
voiced aspirated	gʰ	jʰ	ḍʰ	dʰ	bʰ
NASALS (N)	ṅ	ñ	ṇ	n	m
SIBILANT (S)				s	
SEMIVOWELS (R)					
liquids			r	l	
			ḷ		
			ḷʰ		
glides		y			v

b. Consonants without an oral stricture:

	h
Anusvāra	ṁ

As is clear from the comparison of (3) and (4), the consonant inventory of Pali is nearly identical with that of Sanskrit. The difference between the two is the following. Sibilants have lost the contrast in points of articulation and merged as dental *s* (cf. von Hinüber 2001: § 219, Oberlies 2001: 70). Visarga has been lost. The retroflex laterals that have been added, i.e. *ḷ* and *ḷʰ*, correspond to *ḍ* and *ḍʰ*, respectively, in intervocalic position (cf. Geiger 1994: § 2).

2.2. Assimilation of medial bi-consonantal clusters

In Pali many of the bi-consonantal medial clusters underwent complete assimilation. Among those with an oral stricture, the only types of consonant clusters that were not affected by assimilation are SN-clusters that underwent sibilant reduction and metathesis (cf. section 2.3 below) and NT-clusters that were unchanged (see this section below). The direction of assimilation is either progressive or regressive depending on the consonants that form the cluster.

There have been proposals as to how this direction of assimilation is determined (see section 3 for details). A number of scholars support the analysis based on the sonority hierarchy or some kind of strength hierarchy among consonants as given in (5). In this analysis, the more sonorous consonant assimilates to the less sonorous one (cf. Grammont 1971: 185-189, Hankamer and Aissen 1974, Junghare 1979: 126-129, Hock 1991a: 64-65, 1991b, Geiger 1994: §§ 51-54; also von Hinüber 2001: § 226 and Oberlies 2001: 96, 99).[1]

(5) Stops Sibilants Nasals *l v y r*

less sonorous ⟵⟶ more sonorous

The other two analyses which will be discussed in section 3 are based on syllable structure instead of the hierarchical relationship of consonants.

As will be shown below, most of the cases of assimilation conform to this sonority hypothesis, although there are some exceptions among clusters that consist of a stop and a nasal (see the discussions below). In this section the data will be presented in light of this most common analysis.

The bi-consonantal clusters that underwent progressive assimilation in Pali are shown in (6) below (cf. Geiger 1994: § 53 and Hazra 1994: 77-78).

(6) a. TS > TT^{h}			
akṣi	>	akk^{h}i	'eye'
mokṣa	>	mokk^{h}a	'solution'
b. T$^{(h)}$N > TT$^{(h)}$			
svapna	>	soppa	'sleep'
ab^{h}imat^{h}nāti	>	ab^{h}imatt^{h}ati	'rubs, grinds'
c^{h}adman	>	c^{h}addan	'veil, cover'
c. T$^{(h)}$R > TT$^{(h)}$			
śukla	>	sukka	'white'
takra	>	takka	'whey'
ad^{h}van	>	add^{h}an	'way'
lab^{h}ya	>	labb^{h}a	'attainable'
d. NR > NN			
kiṇva	>	kiṇṇa	'ferment'
ramya	>	ramma	'graceful'
e. SR > SS			
miśra	>	missa	'mixed'
vayasya	>	vayassa	'friend'
aśva	>	assa	'horse'

All of the bi-consonantal clusters given in (6) have the less sonorous member as their first element in conformity with the prediction of the sonority analysis.

Although the data in (6) show complete assimilation, aspiration behaves independently of this assimilation. As the examples in (6a) show, when the input consists of a stop and a sibilant, the output cluster is aspirated even when the stop in input is not aspirated (cf. Oberlies 2001: 98). In this respect Pali assimilation is different from ordinary complete assimilation. In addition, aspiration in output clusters is always associated with the second member of the output geminate, as (6a) and some of the examples in (6b) and (6c) show. These facts suggest, first, that sibilants as well as aspirated stops involve aspiration (cf. Wetzels and Hermans 1985, Vaux 1998), second, that aspiration behaves independently of other features in this assimilation (cf. Wetzels and Hermans 1985), and, third, that aspiration is associated with the onset position in Pali (cf. Hock 1985: 539, Lombardi 1995). At any rate it is necessary to assume that assimilation does not involve aspiration.

In contrast, many of the other bi-consonantal clusters underwent regressive assimilation, as shown in (7) (cf. Geiger §§52, 54, Hazra 1994: 77-78).

(7) a. ST$^{(h)}$ > TT^{h}

āścarya	>	acc^{h}ariya	'miraculous'
niṣka	>	nekk^{h}a	'gold ornament'
āsp^{h}oṭayati	>	app^{h}oṭeti	'claps the hands'

b. RT$^{(h)}$ > TT$^{(h)}$

karka	>	kakka	'a precious stone'
anarg^{h}a	>	anagg^{h}a	'pricelessness'
valgu	>	vaggu	'beautiful'

c. RN > NN

kalmāṣa	>	kammāsa	'spotted'
jīrṇa	>	jiṇṇa	'old'
carman	>	camma	'leather'

d. RS > SS

karṣaka	>	kassaka	'farmer'
sparśa	>	p^{h}assa	'touch'

In these clusters the second member is less sonorous than the first, again as predicted by the sonority analysis. Here again, aspiration is realized on the second member of the output if the input has a sibilant, as in (7a), or an aspirated stop, as in (7b).

When the input cluster consists of two distinct stops or nasals, the sonority analysis does not make any prediction as to the direction of assimilation. In this case the cluster is subject to regressive assimilation, which is the unmarked option as opposed to progressive assimilation, as in (8) (cf. Mayrhofer 1951: § 167, Geiger 1994: § 52, von Hinüber 2001: § 226.2, Oberlies 2001: 98).

(8) a. $T_1T_2^{(h)} > T_2T_2^{(h)}$

sakt^h^i	>	satt^h^i	'thigh'
mudga	>	mugga	'bean'
sapta	>	satta	'seven'

b. $N_1N_2 > N_2N_2$

nimna	>	ninna	'deep, low'
unmūlayati	>	ummūleti	'uproots'

On the other hand, when the input cluster consists of two different semivowels, the direction of assimilation is determined by which consonants form the input cluster. Thus as shown in (9), *v*, *y*, and *r* assimilate to *l*; *y* and *r* to *v*; and *r* to all the others (Geiger §§ 52, 54, Oberlies 2001: 99). Furthermore, geminate *vv*, which results from assimilation, becomes *bb* through strengthening.

(9) $R_1R_2 > R_1R_1$ or R_2R_2

				the implied hierarchical relation
bilva	>	billa	'(a kind of fruit)'	l is less sonorous than v
kalya	>	kalla	'ready, possible'	l < y
durlab^h^a	>	dullab^h^a	'difficult to attain'	l < r
parivyaya	>	paribbaya	'expenditure'	v < y
sarva	>	sabba	'all'	v < r
tīvra	>	tibba	'sharp'	v < r
ārya	>	ayya	'venerable'	y < r

The patterns of assimilation as shown in (9) indicate that there is a hierarchical relationship among four semivowels, as shown in (10) (cf. Hankamer and Aissen 1974: 134, Junghare 1994, Geiger 1994: § 51, Oberlies 2001: 99).

(10) Sonority hierarchy of Pali semivowels

(less sonorous) ⟵⟶ (more sonorous)

l *v* *y* *r*

Lastly, the examples in (11) involve mutual assimilation. The input cluster consists of a coronal (i.e. dental or retroflex) stop or nasal and *y*, and the output is a stop or nasal geminate as expected but palatal in place (cf. Mayrhofer 1951: §§ 171, 180; Geiger 1994: § 55, von Hinüber 2001: §§ 247-250, Oberlies 2001: 96-7).

(11) a. T$^{(h)}$/N[coronal]+y > TT$^{(h)}$/NN[palatal]

satya	>	sacca	'true'
rat^{h}yā	>	racc^{h}ā	'street'
c^{h}idyate	>	c^{h}ijjati	'is split'
anya	>	añña	'another'
karmaṇya	>	kammañña	'ready for use'
piṇyāka	>	piññāka	'oil-cake'

Also, some of TS-clusters, i.e. *ts*, *ps*, and some of *kṣ*, developed into geminate palatals even if the input does not have a palatal (cf. Geiger 1994: §§ 56-57, Hazra 1994: 79-80, von Hinüber 2001: §§ 232-238, Oberlies 2001: 105-106).

(11) b. TS > cc^{h}

akṣi	>	acc^{h}i	'eye' beside akk^{h}i
matsya	>	macc^{h}a	'fish'
apsaras	>	acc^{h}arā	'female divinity'

This development is again expected in that the result is a geminate stop, but unexpected in that it is palatal.

Several types of consonant clusters are either exempted from assimilation or develop in a way different from what is predicted by the sonority analysis. SN-clusters and hN/hR-clusters are exempted from assimilation and undergo a different development (cf. section 2.3 below). Many of the clusters that consist of a nasal and a stop in either order are also exceptions to the sonority analysis. First, homorganic NT-clusters remain unchanged, as in (12a) (cf. Mayrhofer 1951: § 165).

(12) a. NT$^{(h)}$ > NT$^{(h)}$

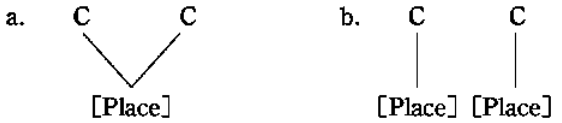
pañca	>	pañca	'five'
aṇḍa	>	aṇḍa	'egg'
and^{h}a	>	and^{h}a	'blind'
kampaka	>	kampaka	'trembling'

Second, *-jñ-* goes to geminate *-ññ-* instead of the expected *-jj-*, as in (12b) (cf. Geiger 1994: § 53.1, von Hinüber 2001: § 251, Oberlies 2001: 98).

(12) b. jñ > ññ

yajña	>	yañña	'sacrifice'
ajñāta	>	aññāta	'unknown'

These exceptions to the sonority hypothesis have certain properties in common. First, they consist of a nasal and a stop in either order. In contrast to other consonants, both nasals and stops have an oral closure and share the features [+consonantal, -continuant]. Second, these consonant clusters are homorganic. Thus members of these exceptional clusters share place features and are partially linked in structure as in (13a) rather than as in (13b).

(13)


This sharing of features appears to be the cause of their aberrant behavior (cf. Wetzels and Hermans 1985 and Cho 1990). At any rate, homorganic NT- or TN-clusters cause a problem for other analyses as well, as will be discussed in section 3 in more detail.

As shown above, the direction of complete assimilation is correctly predicted by the sonority analysis in most cases. However, some clusters are exempted from assimilation and either remain unchanged (i.e. NT) or undergo a different development (i.e. SN, Rh, and Nh). Some others undergo assimilation, but the outcome does not conform to the pattern predicted by the sonority hypothesis (i.e. *jñ*). These distinct developments require explanation.

2.3. Metathesis and reduction of sibilants

Both hN/hR-clusters and SN-clusters resulted in a sequence of a sonorant and *h* in Pali.

Inherited *h* and a sonorant consonant were metathesized, as shown in (14) (cf. Mayrhofer 1951: § 182, Hock 1985: 539, Geiger 1994: § 49, Hazra 1994: 76, von Hinüber 2001: §§ 245-246, Oberlies 2001: 107).

(14) hN/hR > Nh/Rh

aparāhṇa	>	aparaṇha	'afternoon'
cihna	>	cinha	'sign'
jihma	>	jimha	'crooked, false'
duhyate	>	duyhati	'is milked'
jihvā	>	jivhā	'tongue'

Aspiration is a glottal gesture, while articulation of nasals and semivowels is mainly supraglottal. Thus metathesis as represented by the Pali phenomenon in (14) may better be interpreted as a shift in timing of these two independent gestures than a switch of two gestures (cf. Hock 1985: 539). That is, aspiration and sonorant articulation interact but are separate in metathesis as given in (14), as are assimilation and aspiration, as discussed in section 2.2 above.

SN-clusters have the same outcome as hN-clusters and resulted in Nh, as shown in (15) (cf.

Mayrhofer 1951: § 182, Geiger 1994: § 50, Hazra 1994: 76, Oberlies 2001: 108).

(15) SN > Nh

aśmanā	>	amhanā	'with the stone'
uṣṇa	>	uṇha	'hot, heat'
grīṣma	>	gimha	'summer'
vismaya	>	vimhaya	'astonishment'

The development as given in (15) is treated by some scholars (e.g. Hock 1985: 539, 543-544, Oberlies 2001: 108; also Pischel 1981: § 312) as a two-step process. That is, sibilants before nasals were reduced to ***h***, and then the resultant hN-clusters underwent metathesis like other inherited hN-clusters: SN > hN > Nh. It is a curious fact that, while both hR and hN underwent metathesis (cf. (14) above), SR-clusters became SS through assimilation instead of becoming Rh like SN-clusters. Alternatively, SN-clusters could have undergone assimilation and become SS like SR-clusters: in fact this is the outcome that is predicted by the sonority approach.

On the other hand, the Pali outcomes of ST- and SN-clusters, i.e. TT^h and Nh, respectively, both have aspiration associated with the second element of the output cluster and thus are similar in this respect. Because of this similarity, Junghare (1979) and Hock (1991b) propose a similar analysis for ST-clusters to that of SN-clusters that has been just discussed. That is, they extend the sibilant reduction to the position adjacent to stops as well as before nasals and apply metathesis and assimilation to the output of extended sibilant reduction, i.e. ST > hT > Th > TT^h in parallel with SN > hN > Nh (Junghare 1979: her rules of *s*-Softening: 64-66, Metathesis: 66-69, and *h*-Assimilation: 86-91, and Hock 1991b: 129-131). However, to my knowledge, the intermediate stage of either, i.e. hT or hN, is not attested and thus this analysis remains only a possibility. In addition, it is still not clear why comparable sibilant reduction did not affect SR-clusters.

In contrast, von Hinüber (2001: § 242) proposes to analyze SN-clusters in parallel with ST-clusters on the assumption that orthographic Nh is actually an aspirated geminate nasal (cf. also Junghare 1979: 124-126). That is, the sibilant was reduced to aspiration with the spread of the nasal articulation. According to von Hinüber, the interpretation of Nh as an aspirated geminate is indirectly suggested by the development such as *niḥsneha* > **ninnheha* > *ninneha*. An aspirated geminate nasal had to be written either Nh or NNh because there is no letter which represents an aspirated nasal in the script. Between these two Nh was chosen because sequences of three consonant letters had to be avoided. Thus, in contrast to the sonority hierarchy as given above in (5), von Hinüber assumes that sibilants are weaker than nasals in his hierarchy (cf. § 226.1).

In addition to the Pali outcomes of SN-clusters, he suggests that Nh of other sources and Rh may have been aspirated sonorants although he seems to assume metathesis instead of assimilation for the development of hN/hR clusters given in (14) (cf. §§ 245-246). However, Junghare (1979: 126) claims that at least *vh* is more likely non-geminate: *vvʰ* is unlikely because *vv* is not allowed in Pali (cf. (9) above).

In the proposal that will be discussed below in section 4, I agree with von Hinüber (2001) in that sibilants are placed between stops and nasals in the hierarchy that governs Pali assimilation. However, the proposed analysis differs somewhat from von Hinüber's in that both apparent metathesis and sibilant reduction follow from assimilation and distributional restriction on aspiration. Although I agree with von Hinüber in that at least Nh and possibly also Rh are aspirated geminates in Pali, the analysis itself works whether the orthographic Nh/Rh is an aspirated geminate or a sequence of a sonorant and *h*. At any rate, SN-clusters and hN/hR-clusters do not have to be exceptions to assimilation.

2.4. Consonant clusters involving visarga and anusvāra

Consonant clusters with visarga show in part similar patterns to ST-clusters discussed in section 2.2 above. Visarga occurs only before a voiceless stop or a sibilant in Sanskrit and is assimilated to the following voiceless consonant in Pali, as in (16).

(16) a. ḥ$T^{(h)}$ > TT^{h}

duḥkʰa	>	dukkʰa	'sorrow'
b. ḥS > SS			
niḥśeṣa	>	nissesa	'whole, all'
niḥsarati	>	nissarati	'comes out'

The sonority analysis might assume that *ḥ* is more sonorous than stops and sibilants. Note, however, that visarga is aspiration which lacks an oral stricture. Since assimilation does not involve aspiration, as discussed in section 2.2, it is more reasonable to assume that the oral stricture of the following stop or sibilant simply spreads to the preceding slot with aspiration, while this aspiration is either realized in the onset-position in the case of stops or incorporated into the sibilant articulation.

On the other hand, consonant clusters with anusvāra show similar patterns with NT-clusters (cf. section 2.2 above). Anusvāra may precede any consonant and acquires the point of articulation of the following stop or nasal, as in (17a, b).

(17) a. ṁ$T^{(h)}$ > $NT^{(h)}$

saṁgata	>	saṅgata	'met'
kiṁcid	>	kiñcid	'anything'
saṁpʰulla	>	sampʰulla	'full-blown'

b. ṁN > NN

saṁmata	>	sammata	'agreed'
kiṁnara	>	kinnara	'a little bird with a head like a man's'

However, if it is followed by a consonant without an oral closure, i.e. a sibilant, a semivowel, or *h*, it remains the same, as in (17c-e).

(17) c. ṁS > ṁS

daṁśati	>	daṁsati	'bites'
piṁṣati	>	piṁsati	'grinds'
haṁsa	>	haṁsa	'goose'

d. ṁR > ṁR

saṁvṛta	>	saṁvuta	'closed'
saṁyoga	>	saṁyoga	'union'
saṁrambʰa	>	saṁrambʰa	'anger'

e. ṁh > ṁh

saṁhāra	>	saṁhāra	'bringing together'

The development as given in (17) is similar to the development of NT-clusters in that nasality in coda remains. Further, the cluster becomes homorganic only when the consonant following anusvāra has an oral closure. That is, nasals can share their place only with a consonant with an oral closure.

As a result of the various changes in medial bi-consonantal clusters discussed in sections 2.2-2.4, possible medial clusters in Pali are geminates, NC, and Nh/Rh. As will be shown below in section 5, consonant clusters that consist of more than two consonants are also reduced to these three types of bi-consonantal clusters. Since the syllable boundary divides any of the two members of these clusters, the Pali syllable allows only one consonant in both onset and coda in medial position as a result of the changes discussed so far (cf. Vaux 1992: 293). The next section will show that this restriction on onset is extended to word-initial position as well.

2.5. Changes of initial clusters

Pali allows only a single consonant in word-initial position. Inherited initial clusters are simplified in the same way as medial clusters are affected (cf. von Hinüber 2001: § 612). The only difference between the two positions is that input clusters in initial position are more restricted than those in medial position due to the sonority sequencing principle.

As for those clusters that are affected by assimilation in medial position, in initial position either the first consonant (cf. (18a, c, d, f, g)) or the second consonant (cf. (18b, e)) remains depending on which consonants form the cluster (cf. Mayrhofer 1951: §§ 167, 182, Geiger 1994: §§ 50, 53-56, Oberlies 2001: 93-95).

(18) a. TS > T^h

kṣuda	>	k^{h}uda	'hunger'
tsaru	>	t^{h}aru	'hilt of sword'
b. TN > N (only *jñ* > *ñ*)			
jñāta	>	ñāta	'known'
c. T$^{(h)}$R > T$^{(h)}$			
b^{h}rātar	>	b^{h}atar	'brother'
dvija	>	dija	'twice-born'
trāṇa	>	tāṇa	'protection'
d. NR > N			
mrakṣa	>	makk^{h}a	'anger'
e. ST$^{(h)}$ > T^h			
sk^{h}alati	>	k^{h}alati	'stumbles'
stanayati	>	t^{h}aneti	'thunders'
sparśa	>	p^{h}assa	'touch'
f. SR > S			
srotas	>	sota	'stream'
syandana	>	sandana	'chariot'
śveta	>	seta	'white'
g. RR > R			
vyātta	>	vatta	'opened wide (of mouth)'
vrata	>	vata	'religious observance'

TS-clusters in (18a) and ST-clusters in (18e) change into a single aspirated stop comparable to an aspirated geminate in medial position: aspiration remains even if the source of aspiration disappears.

The only initial TN-clusters in input is *jñ*. As this cluster develops into *ññ* in medial position, it becomes single *ñ* in initial position contrary to the prediction of the sonority hypothesis (cf. (18b)). In all the other combinations given in (18a, c-g), the less sonorous wins over the more sonorous, as predicted by the sonority analysis.

The consonant clusters that undergo metathesis instead of assimilation in medial position (cf. (14) and (15) above) are affected further by epenthesis because complex onset is not allowed, as in (19a, b) (Geiger 1994: §§ 49-50, Oberlies 2001: 93-94).

(19) a. SN > NVh

snāti	>	nahāti	'bathes'
smita	>	mihita	'smiling'

b. hR > RVh

hrasva	>	rahassa	'small, light'

In parallel with medial Nh/Rh, von Hinüber (2001: §§ 240-241) assumes that the outcome in (19) was originally an aspirated sonorant. Thus, as in initial ST (cf. (18e)), in (19a) the sibilant is lost, leaving aspiration behind. Moreover, Oberlies (2001: 93) lists the unepenthesized forms with Nh (e.g. *mhita* 'smile') and assumes that the initial Nh is an aspirated nasal because otherwise only single consonants are allowed initially (cf. also Pischel 1981: § 210). In (19b) the glottal gesture of *h* and the oral gesture of the semivowel coalesce.

The parallelism between initial cluster simplification and medial cluster assimilation indicates that changes in both positions are governed by the same principles. Section 4 in Part II will show that these principles consist of several interacting factors, i.e. strength relation among consonants, syllable structure constraints on onset and coda, restriction on the distribution of aspiration, and persistence of nasality in coda position.

2.6. Summary of developments of medial and initial bi-consonantal clusters

The table in (20) summarizes the development of various medial clusters. The first column and the first row correspond to the first and the second consonant of the input cluster. "–" indicates that the given combination is absent in Sanskrit. The clusters with * are either exceptions or exempted from the complete assimilation based on the sonority hierarchy.

(20) Changes of medial clusters in Pali

1\2	$T^{(h)}$	S	N	R	h
$T^{(h)}$	$T_2T_2^{(h)}$	TT^h	$TT^{(h)}$/*ññ	$TT^{(h)}$	–
S	TT^h	SS	*Nh	SS	–
N	*$NT^{(h)}$	–	N_2N_2	NN	*Nh
R	$TT^{(h)}$	SS	NN	R_1R_1/R_2R_2	*Rh
h	–	–	*Nh	*Rh	–
ḥ	$TT^{(h)}$	SS	–	–	–
ṁ	*$NT^{(h)}$	*ṁS	NN	*ṁR	*ṁh

The data as presented in sections 2.2-2.4 and in (20) show three types of developments of medial bi-consonantal clusters. First, the majority of consonant clusters undergo complete assimilation and result in geminates (cf. (21i)). Second, consonant clusters with a nasal as their first member undergo either place assimilation only (ṁT > NT; cf. (21ii)) or no assimilation at all (NT, ṁS, ṁR; cf. (21ii)). Third, SN-clusters and clusters consisting of a sonorant and *h* in either order result in the sequence of N/R + *h* (cf. (21iii)).

(21) Three types of developments of consonant clusters:

(i) Assimilation (cf. (6)-(9), (11), (12b), (16));

(ii) NT/ṁC-clusters that undergo no or place assimilation (cf. (12a), (17));

(iii) SN-, *h*N-, N*h*-, *h*R-, R*h*-clusters that result in N/R*h*-clusters (cf. (14), (15)).

As already pointed out above, it is not clear from the way the data are presented in (20) why certain consonant clusters do not undergo assimilation or are exceptions to assimilation although assimilation is otherwise quite extensive. However, if we assume, with von Hinüber (2001), that Nh/Rh-clusters are in fact aspirated geminate sonorants in Pali (cf. section 2.3), then the third possibility of medial cluster developments in (21iii) above is in fact a case of assimilation and thus is incorporated in (21i). Thus the only exceptions to assimilation are clusters with a nasal as their first member given in (21ii).

The table in (22) shows the possible medial clusters in Pali as a result of assimilation and other processes in most of the previous analyses.

(22) Medial consonant clusters in Pali

T	S	N	R	segment type
$TT^{(h)}$	SS	NN	RR	geminate
$NT^{(h)}$	–	–	–	NC
–	–	Nh	Rh	Ch
–	ṁS	–	ṁR	ṁC

Again, if we assume, with von Hinüber (2001), that Nh/Rh-clusters are aspirated geminate sonorants (cf. section 2.3) and if we assume that ṁS- and ṁR-clusters are parallel with NT-clusters (cf. section 2.4), possible medial clusters are geminates with or without aspiration and NC, as shown in (23) (cf. von Hinüber 2001: § 225).

(23) Medial consonant clusters in Pali

<table>
<tr><th>T</th><th>N</th><th>S</th><th>R</th><th>segment type</th></tr>
<tr><td>TT^h</td><td>Nh</td><td rowspan="2">SS</td><td>Rh</td><td>geminate with aspiration</td></tr>
<tr><td>TT</td><td rowspan="2">NN</td><td>RR</td><td>geminate without aspiration</td></tr>
<tr><td>$NT^{(h)}$</td><td>ṁS</td><td>ṁR</td><td>NC</td></tr>
</table>

Since sibilants inherently have aspiration (cf. section 2.2), there is no distinction between geminate sibilants with and without aspiration. NC with a nasal as its second member, i.e. NN, is a geminate nasal without aspiration. In contrast to (22), the table in (23) has no gaps.

Initial clusters have two courses of developments which correspond to (21i) and (21iii) above, i.e. those that are affected by simplification and those that are affected by epenthesis (cf. section 2.5 above). The table in (24) shows comparable developments of initial bi-consonantal clusters. Again the outputs with an asterisk do not conform to the patterns predicted by the sonority approach.

(24) Changes of initial clusters in Pali

1\2	$T^{(h)}$	S	N	R
$T^{(h)}$	–	T^h	*N	$T^{(h)}$
S	T^h	–	*NVh	S
N	–	–	–	N
R	–	–	–	R_l
h	–	–	–	*RVh

With the assumption that NVh and RVh are in fact aspirated sonorants (cf. section 2.5 above), all the initial bi-consonantal clusters are simplified in the same way as medial clusters are assimilated.

3. Critique of previous analyses of assimilation

This section critically evaluates three previous analyses of Pali assimilation. The first analysis claims that Pali assimilation is governed by the sonority hierarchy, as outlined above in section 2.2 (cf. Grammont 1950, Hankamer and Aissen 1974, Junghare 1979, Hock 1991a, 1991b, and Geiger 1994; section 3.1). I show that many of the counterexamples to this analysis that have been pointed out in the literature are not genuine problems. However, as already discussed in section 2, this approach fails to explain why certain clusters are exempted from assimilation. The second analysis proposed by Wetzels and Hermans (1985) claims that Pali assimilation is governed by the onset-initial consonant in Sanskrit (cf. section 3.2). This second approach is untenable because the patterns of Pali assimilation cannot be always associated with the onset-initial consonant. The third proposal claims that what appeared to be assimilation in Pali is at least in part a result of gemination of one of the members of the cluster and deletion of the ungeminated consonant (cf. Varma 1929, Murray 1982, Vaux 1992, Cho 1990; section 3.3). However, although Sanskrit gemination is a historical fact, it is a distinct process from Pali assimilation nor is there any evidence that Pali had its own gemination process. Thus none of these approaches can properly handle all the observed facts discussed in section 2.

3.1. Assimilation based on the sonority hierarchy

As already outlined above in section 2.2, several scholars have claimed that in Pali assimilation the more sonorous consonant assimilates to the less sonorous one on the hierarchy given in (25) (same as (5) in section 2.2; cf. Grammont 1971: 185-189, Hankamer and Aissen 1974: 134, Junghare 1979: 126-129, and Hock 1991a: 64-65, 1991b, Geiger 1994: §51).

(25) Sonority hierarchy

Stops   Sibilants   Nasals   *l v y r*

less sonorous ⟵⟶ more sonorous

Section 2 have shown that this sonority approach cannot effectively distinguish between those clusters that are affected by assimilation and those that undergo different developments. Also, the behavior of aspiration requires separate treatment.

In addition, the opponents of the sonority approach have questioned the validity of the sonority hierarchy as given in (25) and pointed out a number of apparent counterexamples to the patterns predicted by this analysis. Below I examine these two problems raised by the opponents and show that these are either not genuine problems or apply to other approaches as well.

As for the first problem of the sonority hierarchy, the one given in (25) has *r* as the element with a greater sonority than *v* and *y*. However, the sonority hierarchy usually has liquids including *r* as elements less sonorous than glides, as shown in (26) (Sievers 1901, Jespersen 1913, Grammont 1971, de Saussure 1978, Hooper 1976, Vennemann 1988, Clements 1990, etc.).

(26) Sonority hierarchy

Stops Sibilants Nasals Liquids Glides

less sonorous ⟵⟶ more sonorous

Because of this difference between the two sonority scales, some scholars have expressed skepticism against the proposed hierarchy of Pali as given in (25) (cf. Wetzels and Hermans 1985 and Cho 1990: 215).

However, possible initial clusters and the patterns of reduplication in Sanskrit indicate that, unlike the common sonority hierarchy given in (26), the semivowel *v* is less sonorous than *y* and *r*. In Sanskrit *vy-* and *vr-* are permissible initial clusters, as shown in (27).

(27)	vy-	vyaya	'expense'
		vyāg^{h}ra	'tiger'
	vr-	vrajati	'goes'

This alone does not provide evidence that *v* is less sonorous than *y* or *r* because there are initial clusters such as *sp-*, *st-*, and *sk-* that violate the sonority sequencing principle. However, initial clusters with a rise in sonority and those with a fall in sonority such as *sp-*, *st-*, and *sk-* show different patterns of reduplication. For both of the clusters given in (27), only the first consonant is realized in the reduplicated syllable, as (28a) shows, and this is the pattern of the initial clusters with a rise in sonority (cf. Steriade 1998: 108-9, 113-4, 120-1).

(28) a. Initial clusters with rise in sonority

	root	perfect	
	vraj-	vavrāja	'to proceed'
	vyadh-	vivyādha	'to pierce'
Cf.	prac^{h}-	paprac^{h}a	'to ask'
	mluc-	mumloca	'to set'

b. Initial clusters with fall in sonority

	st^{h}ā-	tast^{h}au	'to stand'

On the other hand, when initial clusters have a decrease in sonority, then the less sonorous, second consonant is realized in the reduplicated syllable, as in (28b). In this way the syllable structure in Sanskrit shows that *v* is less sonorous than *r* and *y* and thus that there should be some language-specific fluctuation in the allegedly universal sonority hierarchy.

While the order among semivowels in (25) has independent justification, there is a potential problem of the sonority approach that has not been discussed in the literature. In contrast to the order among semivowels, the strength relationship between nasals and sibilants cannot actually be determined because in this approach SN-clusters are exempted from assimilation. It is just that sibilants are normally assumed to be weaker than nasals and that this assumption does not contradict the observed facts.

Other than the problem concerning the sonority hierarchy, a number of counterexamples to the sonority approach have been pointed out in the previous work. The most problematical is the clusters that consist of a nasal and a stop. Beside NT-clusters and *-jñ-* that were already discussed in sections 2.2 and 2.5 above, there are other examples of TN- and NT-clusters that developed into NN, as shown in (29).

(29) a. TN > NN

nudna	>	nunna	'removed'

(Cf. Hankamer and Aissen 1974, Wetzels and Hermans 1985: 215, and Cho 1990: 214-5)

b. NT > NN

ālambana	>	ārammaṇa	'basis, object'
pañcāśat	>	paññāsa	'fifty'

(Cf. Murray 1982: 168)

The first case of *-dn-* > *-nn-* is spurious. The form **nudna* represents the morphological structure of the word consisting of the verbal root *nud-* and the past passive participle suffix *-na*, but already at the earliest stage of Sanskrit the stem is realized as *nunna-* due to the exceptional application of the external sandhi (cf. Whitney 1885: 92, 1889: §§ 161b, 952d). Pali inherited this form from Sanskrit and thus assimilation is irrelevant in this case.

The change of NT > NN in (29b), on the other hand, is not a productive pattern. Turner (1966: 62) lists the following two items from the root *lamb-* 'to hang down', both with expected *-mb-* instead of *-mm-* (Turner does not have the item *ālambana*), as in (30).

(30) ālamba	>	ālamba	'support'
ālambate	>	ālambati	'holds on to'

Furthermore, he has thirty items with the root *pañca-* 'five', twelve of which have corresponding

Pali forms. Eight of them show the Pali form with the expected *-ñc-*, two have the doublet with *-ñc-* and a geminate nasal in Pali, and the rest, namely two instances which include *pañcāśat*, have only the Pali form with a geminate nasal. The predominant pattern, therefore, is that NT-clusters in Sanskrit remain the same in Pali. The reason why there are examples with a geminate nasal along with NT-clusters, while TT is not attested, is that nasality in coda may not be affected and that for some reason this nasality has spread to the following onset position (cf. section 4.2.5 in Part II). At any rate, as already pointed out in section 2.2 above, those clusters that show an unexpected development are homorganic and thus are partially linked in structure.

To recapitulate, the Pali outcomes of Sanskrit NT and TN (except *jñ*) are usually NT and TT, respectively. The cases which do not conform to the pattern predicted by the sonority approach are NT-clusters which remain the same and *-jñ-* which becomes *-ññ-* instead of the predicted *-jj-*. These are indeed problems for the sonority analysis, but, as I will show below in sections 3.2 and 3.3, meet no satisfactory solution in the alternatives, either.

As another type of counterexamples to the sonority hypothesis, Varma (1929: 109-110) and Geiger (1994: § 57) list a number of examples of a compound with *ud* as its first member where *-ts-* (< *-d#s-*) across the morpheme boundary developed into *-ss-* (cf. (31a)) along with the rare cases of the expected geminate stop *-cc^h-* (cf. (31b)):

(31)	a. utsanna	>	ussanna	'raised'
	utśīrṣaka	>	ussīsaka	'pillow'
	b. utsaṅga	>	ucc^haṅga	'hip, lap'
	utśiṣṭa	>	ucc^hiṭṭ^ha	'left over'

Although these might appear to be genuine counterexamples to the sonority analysis (cf. Murray 1982: fn. 13), the assimilation across the morphological boundary is regressive no matter which consonant follows *ud*. That is, when *ud* is followed by a stop, as in (32a), assimilation is regressive as expected. Further, when *ud* is followed by some other consonant, as in (32b) (and also (31a)), assimilation is again regressive contrary to the prediction of the sonority approach.

(32) a. Regressive assimilation as expected

utkarṇa	>	ukkaṇṇa	'with ears up'
udb^hava	>	ubb^hava	'origin, birth'

b. Regressive assimilation contrary to the prediction

udvartate	>	ubbattati	'rises'
udyoga	>	uyyoga	'departure'
udroka	>	ulloka[2]	'bright'

The motivation for the aberrancy in the above examples is to preserve the association of the second component with its morphologically related words, e.g. *ussīsaka* 'pillow' with *sīsa* 'head', *uyyoga* 'departure' with *yoga* 'yoking'. If the assimilation had been progressive in these examples, then the cluster across the boundary would have ended up either in *-tt-* or *-dd-* in all cases, which would make the second component indiscernible or at least hard to distinguish. Here the choice of output is governed by a morphological factor rather than by the sonority hierarchy (cf. von Hinüber 2001: § 237 and Oberlies 2001: 111-112), but output is still the same type, i.e. geminates. The given examples, therefore, cannot be considered as counterexamples to the proposed generalization.

In order to solve at least some of the problems which accompany the sonority analysis, von Hinüber (2001: § 226) and Oberlies (2001: 99) propose the hierarchy in (33) (cf. fn. 1).

(33) stops – nasals – palatals – sibilants – *l* – *v* – *y* – *r*

This hierarchy is different from the sonority hierarchy given in (25) above in that palatal stops are weaker than nasals. This is because *jñ* regularly develops into *ñ*(*ñ*) and because *ñc* may become *ññ*. However, palatal stops are not always weaker than palatal nasals. For example, *ñc* may remain unchanged instead of becoming a geminate nasal. Further, as shown in (29b) above, non-palatal NT-clusters such as *mb* may also become a geminate nasal. These facts speak against the claim that palatal stops but not other stops are weaker than nasals. In addition, NT-clusters that remain unchanged must be exempted from assimilation at any rate. Therefore, in the proposed analysis which will be discussed in section 4, I will not adopt the assumption that palatal stops are weaker than nasals. Instead I assume, as the sonority approach, that all stops are grouped together.

Another difference between von Hinüber's hierarchy and the sonority hierarchy is that in the revised hierarchy in (33) nasals are stronger than sibilants. That is, as discussed above in section 2.3, von Hinüber assumes that the Pali outcome of an SN-cluster is an aspirated geminate nasal and thus that sibilants assimilate to nasals, leaving aspiration behind. As already mentioned, I will incorporate this assumption in the proposed analysis.

In sum, genuine counterexamples to the sonority hypothesis are, first, clusters with a nasal as their first member that undergo no change or assimilation only in place and, second, *-jñ-* that becomes *-ññ-*. Another problem of the sonority approach is that it fails to explain why these two types of consonant clusters together with SN-clusters and clusters with *h* show different developments from the majority of consonant clusters that undergo assimilation. However, these problems also apply to the other approaches that will be discussed in the next two sections.

3.2. Assimilation based on possible word-initial clusters

Wetzels and Hermans (1985: 215-6) proposed that Pali assimilation is based on syllable structure and can be defined in terms of the notion of possible word-initial clusters in Sanskrit. That is, if the consonant cluster is a possible initial cluster in Sanskrit, then the cluster is affected by progressive assimilation, as in (34a). On the other hand, if the consonant cluster is not a possible initial cluster in Sanskrit, then the cluster is affected by regressive assimilation, as in (34b).

(34) a. $C_1C_2 > C_1C_1$ iff C_1C_2 is a possible initial cluster;

b. $C_1C_2 > C_2C_2$ iff C_1C_2 is not a possible initial cluster.

That is, in Wetzels and Hermans's approach the onset-initial consonant, i.e. C_1 in (34′a) and C_2 in (34′b), dominates the other element in the cluster.

(34′) a. $\$C_1C_2 > C_1C_1$

b. $C_1\$C_2 > C_2C_2$

There are in fact numerous assimilation processes whereby the coda consonant assimilates to the following onset consonant. For example, in Pali assimilation TT/NN-clusters are affected by regressive assimilation (cf. (8) in section 2.2 above). This fact indicates that the onset consonant dominates the preceding coda consonant. Moreover, in reduplication only the first consonant of the initial cluster is reproduced in the reduplicated syllable if this cluster conforms to the sonority sequencing principle (cf. (28a) above). This fact again implies the dominance of the onset-initial consonant over the non-initial consonant(s) in the same cluster. In this respect Wetzels and Hermans's approach has an independent ground. However, the syllable structure in Sanskrit cannot always predict the actual course of development in Pali. The changes in (35) show that possible word-initial clusters in Sanskrit do not always match the pattern of assimilation in Pali (cf. also Cho 1990: 223-4).

(35) Attested: Predicted:

a. *jñ*	>	*ññ*	**jj*	cf. (34a)
b. ST	>	TT^h	*SS	cf. (34a)
c. *ly*	>	*ll*	**yy*	cf. (34b)
d. *lv*	>	*ll*	**vv/bb*	cf. (34b)
e. SN	>	Nh	*SS	cf. (34a)
f. NT	(unchanged)		*TT	cf. (34b)

The clusters in (35a, b) are possible initial clusters in Sanskrit, but, contrary to their analysis, undergo regressive assimilation. On the other hand, the clusters in (35c, d) are not possible initial clusters in Sanskrit, but, again contrary to their analysis, undergo progressive assimilation.

The clusters in (35e, f) do not undergo assimilation.

Although (35a, e, f) also constitute problems for the sonority approach, (35b, c, d) are additional counterexamples to Wetzels and Hermans's approach based on syllable structure. While the dominance of the onset-initial consonant is an attractive idea, consonant cluster changes in Pali do not coincide with possible initial clusters in Sanskrit. Moreover, as the sonority approach, Wetzels and Hermans's approach cannot effectively distinguish between those which conform to their analysis and those which do not.

Section 3.3 below will discuss Cho (1990)'s similar proposal based on syllabification peculiar to Pali. I will show that, although many of the onset-initial consonants are those that persist in assimilation, the patterns of Pali assimilation do not directly follow from the onset-initial consonant.

3.3. Gemination cum deletion

Several scholars have proposed that at least part of apparent assimilation in Pali developed from gemination of one of the consonants in the cluster, while the other consonant was later deleted (cf. Varma 1929, Murray 1982, Cho 1990: 210-231, Vaux 1992: 293). This approach is supported by the fact that Sanskrit had gemination. For example, Murray (1982) claims that progressive assimilation is cross-linguistically rare and thus unlikely in Pali as well. Following Varma (1929: chap. 5), he argues that the seemingly progressive assimilation has the intermediate stage with the geminated first consonant followed by the deletion of the second consonant, as shown in (36). On the other hand, regressive assimilation is a genuine assimilation whereby the onset consonant dominates the preceding coda consonant.

(36)	C_1C_2	>	$C_1C_1C_2$	>	C_1C_1		
E.g.	svapna	>	soppna	>	soppa	'sleep'	
	miśra	>	missra	>	missa	'mixed'	
	ramya	>	rammya	>	ramma	'graceful'	

but $C_1C_2 > C_2C_2$ by assimilation

The sequence of a liquid and a stop is an exception to this generalization. Although its Pali outcome is apparently affected by regressive assimilation, Murray claims that liquid-stop cluster must have undergone gemination, as in (37).

(37)	kar$ka	>	kark$ka	>	kakka	'a precious stone'
	kil$biṣa	>	kilb$bisa	>	kibbisa	'sin'

Such parallel treatment of regressive and progressive assimilation undermines Murray's motivation that progressive assimilation is cross-linguistically rare. That is, since regressive assimilation is common, assuming gemination for examples in (37) cannot be motivated.

In addition, as Hock (1991b) notes, there are examples where the pattern of Sanskrit gemination does not coincide with the pattern of Pali assimilation. For example, as (38) shows, when the consonant cluster consists of two different stops, the first is geminated in Sanskrit, while the second gets geminated in Pali (cf. Hock 1991b: 130).

(38) Sanskrit geminated form: *yukta* > *yukkta* 'yoked'; but Pali *yutta*

The treatment of aspiration in the development TS > TT^h is also problematical (cf. Murray 1982: fn. 13, Hock 1991b: 129). Under the gemination hypothesis, the expected course of development would be as follows: TS > TTS > TT. Because the consonant slot that governs the sibilant itself is deleted, it is not clear how the output cluster gets aspiration as actually observed.

A further problem is the treatment of initial cluster simplification. Because initial clusters are never geminated in Sanskrit, they cannot go through the same course of developments as the medial clusters shown in (36) or (37). In this respect, Murray (1985) argues that they are simplified in analogy with the medial cluster developments. This assumption requires distinct treatments for medial and initial clusters. In addition, Murray's assumption implies that initial cluster simplification is chronologically later than medial cluster changes. However, as already discussed in section 2.5 above, onset clusters are simplified both medially and initially (cf. also section 5.1 in Part II) and there is no evidence to assume that simplification of initial clusters followed simplification of medial clusters.

As a different version of the gemination approach, Cho (1990: 225-231) assumes, unlike Murray, that both regressive and progressive assimilation in Pali follow from gemination. In her analysis the first consonant of the onset gets geminated in Pali. Thus, if both of the consonants of the cluster form an onset, the outcome is an apparent progressive assimilation, as in (39a). On the other hand, if the syllable boundary separates the two consonants of the cluster, the outcome is apparent regressive assimilation, as in (39b).

(39)	a. ta$**kra**	>	takkra	>	takka	'whey'
	b. kil$**bi**ṣa	>	kilbbisa	>	kibbisa	'sin'

Another difference between Murray's approach and Cho's is that Cho assumes that gemination that lead to apparent assimilation in Pali is a distinct process from that of Sanskrit. This assumption is made to cope with the difference between Sanskrit gemination and Pali assimilation, as illustrated above in (38). According to Cho, both Sanskrit and Pali gemination affect the onset-initial consonant. However, since syllabification is different in Sanskrit and Pali, gemination in the two languages may have different outcomes. For example, TT-clusters are syllabified as $TT in Sanskrit but T$T in Pali. As a result, while Sanskrit gemination affects the first stop (e.g. *yu$kta* > *yukkta* 'yoked'), Pali has the outcome with gemination of the second consonant (e.g. *yuk$ta* > *yuktta* > *yutta*) (cf. Cho 1990: 230). By positing a distinct process of syllabification and gemination, Cho avoids the problems of both Wetzels and Hermans's syllable structure approach and Murray's gemination approach as discussed above. However, Cho's analysis lacks independent justification. Although Sanskrit gemination is a historical fact, there is no evidence whatsoever that Pali had a separate gemination process. There is also no justification for the proposed Pali syllabification that conditions Pali gemination because most of input clusters do not exist in Pali. For example, since medial *-lv-* develops into *-ll-* (e.g. *bi$lva* > *billva* > *billa*), Cho is obliged to assume that *lv* is a possible initial cluster in Pali (Cho 1990: 230). However, Sanskrit has initial *vl-* (e.g. *vlēpita* 'caused to be crushed') but no *lv-*. Even if syllabification may be different in Sanskrit and in Pali, lack of initial *lv* in Sanskrit strongly argues against the proposed syllabification. In addition, Pali supplies no independent evidence for Cho's syllabification because there is no initial cluster in the attested forms. Below I examine further whether the patterns of Pali assimilation can be associated with the onset-initial consonant. I will show that these two do not show exact correspondences although there is much overlap.

As the sonority approach fails to distinguish in a principled way those clusters that undergo assimilation from those that undergo different developments (cf. section 3.1 above), Cho's approach suffers from a similar problem. In her approach not all the consonant clusters undergo gemination. First, homorganic clusters such as NT-clusters and *jñ* are not affected by gemination. In these clusters the onset-initial consonant shares place with the preceding coda consonant and, according to Cho, this structure cannot be geminated (Cho 1990: 230-231). Second, consonant clusters given in (40) undergo 'coalescence' instead of gemination, i.e. *jñ* (cf. (40a)), clusters that consist of a coronal stop/nasal and *y* (cf. (40b); also (11a) in section 2.2), and clusters that result in aspirated stops (cf. (40c)).

(40) a. rājñā > raññā
b. satya > sacca 'true'
c. asti > $att^{h}i$ 'is'

It is not clear why certain clusters are subject to coalescence instead of gemination and why NT-clusters in general do not undergo coalescence, while *jñ* regularly does.

For the reasons stated above and especially for lack of independent evidence for the alleged Pali syllabification and gemination, Cho's proposal cannot be supported. Also, due to lack of exact correspondences between Sanskrit gemination and Pali assimilation, the apparent assimilation in Pali must be a genuine case of assimilation rather than the result of gemination.

While Cho's (1990) analysis and Wetzels and Hermans's (1982) discussed in section 3.2 are untenable, they raise an important question of whether the consonant that dominates in Pali assimilation can be defined in terms of syllable structure, i.e. whether the consonant that wins out is the onset-initial one, as they assume. The assumption is justified by the cross-linguistic patterns of assimilation and reduplication, as stated above. As a third alternative, I tentatively pursue the possibility of associating patterns of Pali assimilation with onset-initial consonants in the opposite direction. That is, I posit hypothetical syllabification based on the outcomes of Pali assimilation and then examine if this syllabification is justified or at least plausible. With the assumption that Pali assimilation is governed by the onset-initial consonant, syllabification in (41) follows from Pali assimilation. The list excludes SN, clusters with *h*, and NT which have been treated as exempted from assimilation in most of the previous analyses (cf. sections 2.2, 2.3, and 2.6).

(41) Syllabification that follows from consonant cluster changes

a. $CC

$TS **$TN** (except for jñ) $TR **$NR** $vr $vy **$lv** **$ly**

b. C$C

j$ñ S$T R$T R$N ḥ$T ḥ$S ṁ$C

The items in boldface in this list are not very likely. Although some instances of $TS, $TN, and $NR, e.g. *kṣ*, *jñ*, *mr*, are attested word-initial clusters in Sanskrit, others do not occur initially. In addition, these initial clusters are rare cross-linguistically. Thus it is questionable if these clusters form an onset in medial position as well. Also, neither *$lv* nor *$ly* are attested as initial-clusters in Sanskrit, although *vl-* is (e.g. *vlēpita* 'caused to be crushed'). Thus, although many of the consonants that dominate in Pali assimilation are in onset-initial position, the correspondence between the onset-initial consonant and the dominant consonant in Pali assimilation cannot be proved in all cases.

As a conclusion of this section, the previous analyses, i.e. the sonority approach, the initial cluster approach, and the gemination approach, all fail to explain why clusters consisting of a nasal and a stop and clusters that undergo metathesis do not appear to undergo regular assimilation. Furthermore, onset-initial position cannot always determine the outcome of the changes nor is gemination relevant to the consonant cluster changes in Pali. Instead, as will be shown in section 4, Pali assimilation is governed by the consonant strength hierarchy based on the degree of oral stricture, which is similar to the hierarchy proposed by von Hinüber (2001) and Oberlies (2001). Also, Pali assimilation affects all consonant clusters instead of leaving some clusters unaffected. Different appearances such as metathesis or lack of assimilation follow from other factors that interact with assimilation.

Notes

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1. As an alternative to the sonority hierarchy given in (5), von Hinüber (2001: § 226) and Oberlies (2001: 99) propose the hierarchy: (non-palatal) occlusives – nasals – palatals – sibilants – *l* – *v* – *y* – *r*. I follow von Hinüber's (2001: § 239) interpretation that sibilants assimilate to nasals, which motivated this hierarchy. However, although both von Hinüber and Oberlies seem to assume that *h*+sonorant clusters undergo metathesis, I claim below that metathesis follow from assimilation and restriction on aspiration (cf. section 4 in Part II). Their analysis will be discussed in more detail below in section 3.
2. Geminate *r* is not allowed in Pali and thus is strengthened to *ll*.

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