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The Relevance of Syllable Structure in Place Assimilation

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0. The relationship between syllable structure and assimilation has not been explored in full in the generative phonology. In the literature there has been a common assumption that the coda consonant assimilates to the onset consonant because the weak coda position is dominated by the strong onset position (Vennemann 1972, Hooper 1976, Murray 1982). In this paper, I argue against that claim and propose that the coda-target condition (i.e. the target being in the coda) should be identified as one essential condition in place assimilation. I am going to illustrate that coda consonants assimilate (but not necessarily to onset consonants) when the other conditions are met.

First, I will present two cases discussed in the literature, and then argue that a stronger case can be made for Sanskrit, in which the target's being in the coda, though not a sufficient one, is a necessary condition in predicting all and only the types of assimilation in the language.

1. Harris (1969) analyzes Spanish homorganic nasal assimilation in terms of two rules to account for the data in (1): first, nasals assimilate to all consonants other than glides within and across word boundaries, and second, nasals assimilate to glides only across word-boundaries.¹

(1) Spanish Nasal Assimilation (Harris 1969, Hooper 1976, Penny 1986)

Word-Internal	Across word boundaries
campo 'field'	son [m] perros 'they are dogs'
canto 'I sing'	son [n] tigres 'they are tigers'
banco 'bank'	son [ŋ] carros 'they are cars'
enfriar [mf] 'to cool'	han [m] fregado 'they have scoured'
ensillar [ns] 'to saddle'	han [n] sido 'the have been'
nieto [njetɔ] 'grandson'	un hielo [uñ jelo] 'a piece of ice'
nuevo [nweBo] 'new'	un huevo [uɲ weBo] 'an egg'

Since glides trigger assimilation only across word-boundaries, Harris (1969) was forced to posit two rules. In his two-rule approach, glides are excluded from triggering assimilation within words by stipulating that only consonants with the feature [+consonantal] act as triggers within words, whereas across words any consonant can trigger the rule. Hooper (1976) observes that Nasal Assimilation can be viewed as a single rule if one incorporates the notion of

syllable structure. In particular, she argues that the rule applies when the nasal and the consonant are in different syllables. In *nieto* and *nuevo* there is no assimilation because the target and the trigger are tautosyllabic. Since the consonant in the stronger position influences the consonant in the weaker position, Nasal assimilation in Spanish occurs before the glides (*y* and *w*), but only when the nasal is syllable-final and the glide is syllable-initial (Penny 1986). Spanish illustrates that assimilation rules are somehow related to syllable structure because specifying the directionality of the rule application as from right to left is not sufficient to distinguish between the different behavior of the two kinds of glides. However, it does not, in itself, argue for the coda-target condition since it is possible to formulate the rule as applying either when the target and the trigger are heterosyllabic, or one can even say that the trigger has to be in the syllable-initial position.

Place assimilation in Central Catalan (Mascaró 1987) shows that the target of place assimilation should be characterized as occupying the coda, though the trigger does not have to be in the onset. As illustrated in the examples in (2), there is regressive assimilation, which appears to spread the place features of the onset of the following syllable to the preceding coda consonant when the coda consonant is dental. The last example shows that this apparent leftward spread is in fact a case of coda target: in *añf*, /s/ assimilates to /ñ/ even though the trigger precedes the target and the trigger is not in the onset.

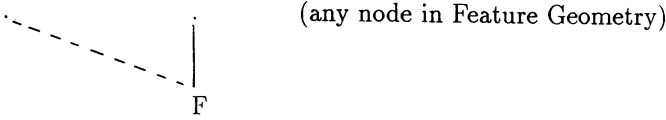
(2) Catalan Place Assimilation (Mascaró 1987)

- set beus → sebbeus 'seven voices'
 - set kosins → sekkosins 'seven cousins'
 - son beus → sombeus 'they are voices.'
 - son kosins → soŋ kosins 'they are cousins.'
- añ+ s → añʃ 'years'

Another case confirming the relevance of the coda target condition is Korean, in which in some rare coda clusters, a dental assimilates to a neighboring coda consonant progressively (Cho 1988). The fact that we normally find regressive assimilation (i.e. the right-to-left directionality) is, then, due to the fortuitous surface fact that there is usually one coda consonant and one onset consonant.

2. I make the following theoretical assumptions. First, in Autosegmental Phonology rules of assimilation involve not a change or a copy but a reassociation of the features of one segment, so that they come to include the other segment in their scope. This operation of reassociation is called spreading as shown in (3), and it is the sole mechanism of assimilation rules (Goldsmith 1979, Steriade 1982, Hayes 1986).

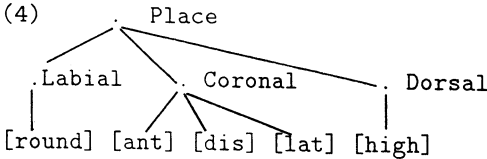
(3) Assimilation as Spreading



Another often-noted generalization regarding assimilation is the asymmetry between possible propagating values; i.e. assimilation tends to spread marked feature specification to segments. This asymmetry finds its natural explanation in Underspecification Theory which requires marked values to be specified and unmarked values unspecified (Kiparsky 1982, Archangeli and Pulleyblank forthcoming). I assume Radical Underspecification where every predictable feature specification is absent in underlying representation so that there is a stage in which only marked feature specifications are present and play a role in assimilation.

Another theoretical assumption that is crucial in predicting only the kinds of assimilation that actually occur is the principle of Structure Preservation (Kiparsky 1985, Borowsky 1986), which is expressed in terms of constraints that apply in underlying representations and to each stage in the derivation up to the level at which they are turned off.

Also I assume that segments are not unordered feature bundles but that they are hierarchically organized, following Clements (1985) Sagey (1986) and McCarthy (1988). I will adopt the representation of the Place Node for Sanskrit, as shown in (4).



Lastly, following Steriade (1987), I assume that assimilations result from setting up the values of a very limited set of universal parameters, such as the site of spreading, the locality condition, the specification on the target and (or) trigger, and directionality.

3. Sanskrit Coronal Assimilation comprises the retroflexion, palatalization and lateralization of dentals. Although the three processes appear unrelated on the surface, I will argue that, once the coda target condition is adopted in place assimilation, they can be unified as one rule which spreads the Coronal Node, rather than individual features.

(5) shows the coronal consonants of Sanskrit.

(5) Sanskrit Coronal Consonants

	dental	retrofl	palatal
stops	t	ṭ	c
	d	ḍ	j
	n	ṇ	
liquids	l	r	
fricatives	s	ṣ	ś

Focussing on the Coronal Node, I will assume that the features [anterior], [distributed] and [lateral] are its dependents (Levin (1987)) in order to distinguish the four types of coronal consonants (dental, retroflex, palatal and lateral). (6b) lists all the features assumed to be present underlyingly. For instance, /t/ will not be marked for any feature specification, and /n/ will be marked only for the feature [+nas] though it has no specification of place features.

(6) a. Feature Specifications

dentals: +ant, -dis

retroflexes: -ant, -dis

palatals: -ant, +dis

laterals: +lat, +ant, -dis

b. Underlying Feature Specifications

dentals :

retroflexes: -ant, -dis

palatals: -ant

laterals: +lat

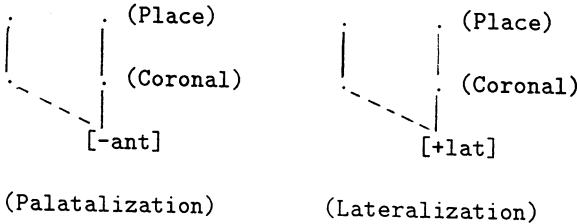
Under the assumption that only specified features spread, it is not surprising that a dental becomes a palatal and a lateral in the right environment. I will discuss palatalization and lateralization first, since they appear to be considerably more regular than retroflexion. As illustrated in (7), all dental consonants *t*, *s*, *n* assimilate to whatever palatal consonant follows them,² and *t* and *n* assimilate to a following lateral.³

(7) Palatal/ Lateral Assimilation

mahān + kaviḥ →	mahānkaviḥ	'great poet'
mahān + bhāgaḥ →	mahānbhāgaḥ	'illustrious'
tān + janān →	tāñjanān	'those people'
trīn + lokān →	trīllokān	'three worlds'
ut + carati →	uccarati	'rise'
etat + chattram →	etacchattram	'this umbrella'
vidyut + jāyate →	vidyujjāyate	'the dawn is born'
tat + labhate →	tallabhate	'it takes'
tatas + ca →	tataś ca	'and then'

At this point, the Palatal/Lateral Assimilation can be tentatively formulated as spreading the relevant feature, [-ant] and [+lat] respectively, as shown in (8).⁴

(8) Palatalization/Lateralization



Now let us discuss Retroflex Assimilation. On the surface, Retroflex Assimilation seems to behave quite differently from lateralization and palatalization. Some relevant examples are listed in (9a), and (9b) is a table which shows what happens to the potential targets, which is represented by the first column, when they are followed by the potential triggers in the first row. 'Yes' represents assimilation while 'no' represents non-assimilation. Some of the potential targets undergo different rules which bleed the assimilation rule.

(9) a. Retroflex Assimilation

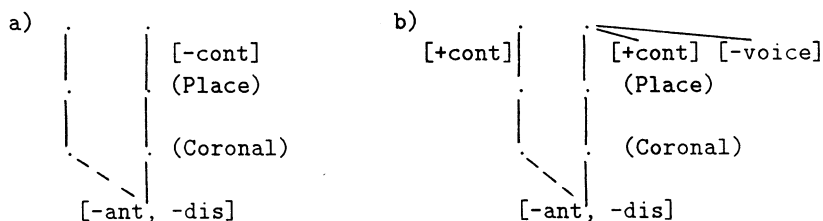
tān + ḍimbhān →	tāṇḍimbhān	'those infants'
tat + ḍhaukate →	taṭḍhaukate	'it approaches'
tat + ṭīkā →	taṭṭīkā	'the commentary about that'
pādas + ṭalati →	pādaṣṭalati	'the foot is disturbed'
pātas + ṣaṭ →	pādaṣṣaṭ	'the foot six'

b. target \ trigger	t	d	n	ʃ	r
t,d	yes	yes	yes	no	no
n	mʃt	yes	yes	mʃ, ntʃ	mʃr
s	yes	rɔ	rɔ	yes	no

Stops (both oral and nasal) always trigger assimilation of the preceding segment, be it a fricative, a stop, or a nasal. On the other hand, the voiceless fricative /s/ triggers assimilation only when the preceding segment is also a fricative. When the preceding consonant is a stop, there is no assimilation.⁵ Another peculiarity of triggers concerns /r/, which never triggers assimilation.⁶

In spite of the apparent irregularities I will propose that retroflexion behaves exactly like the other types of coronal assimilation if we assume that the target has to be in the coda. If we do not incorporate the coda target condition, such rules as in (10) could be suggested. (10a) is the case when stops are triggers, whereas (10b) represents the fact that the fricative /ʃ/ is not as permissive as the other triggers. The fricative retroflex behaves as the trigger only when the target is the fricative dental /s/.

(10) Retroflex Assimilation



(when the trigger is /t/,/n/) (when the trigger is /s/)

We immediately note several problems with the above rules. First, we predict with no justification that these are two independent rules and that they can be manipulated separately. Second, we need to stipulate a condition on the target and the trigger that they have to share the feature [+cont] for the fricative trigger. I have argued in Cho (1989) against the so-called 'the principle of similarity,' which states that assimilation rules tend to apply when certain features are shared between the target and the trigger. Given that such a condition is not only undesirable on formal grounds but also empirically not supported, (10b) involves a stipulative complication.

The third and the most serious problem is; whereas all instances of spreading have been dealt with at the point in derivation where none of the default rules have been specified, for these rules we need a stage in which such default values as [-voice] and [-cont] have been filled in. In order to guarantee that

only dentals are the targets, we have to rely on a stage in which only the features that characterize the retroflex, lateral and palatal consonants are present and referred to as a set of spreading features.

I argue that all the surface peculiarities concerning the fricative trigger can be given a natural explanation by assuming independently motivated syllable structure. A syllable-based account (i.e. the coda-target condition) posits only one coronal assimilation which accounts for 4 different rules of (8) and (10). Nothing special has to be said about the nature of the target or the trigger with regard to retroflexion.

There are three sets of consequences for potential targets. One is the case in which a universal sonority scale (as shown in (11a)) predicts whether a sequence of two consonants should be tautosyllabic or heterosyllabic. Following Steriade (1982), I assume that the rule which forms onsets precedes the coda rule. For instance, an oral stop is always equal to or less sonorous than any consonant and has to syllabify as the onset, thereby triggering assimilation in all cases.

(11) Syllabification

a. Sonority

stops	fricatives	nasals	liquids	glides	
					→ (more sonorous)

b. Negative Condition on onsets

*[t _σ n	*[t _σ l	*[n _σ l
--------------------	--------------------	--------------------

c. Syllabification

s]	[ṣ	t]	[ṭ	s]	[ṭ	t]	[l	t]	[n
	[ṭṣ		[tr		[sr				

d. Three Arguments for Syllabification (Steriade 1982, Varma 1961)

- 1) Reduplication: ta-sthau
- 2) the Aorist /s/ deletion: /a-chid-s-ta/ → [achitta]
- 3) Doubling: /hasta/ → [hastta]

The second is the case in which syllabification is governed not by sonority but by a language-particular condition: certain homorganic clusters are not allowed as onset clusters as represented in (11b). The third is the case in which, due to prior application of neutralization, certain clusters (/n̄t̄/, /nr̄/ and /sr̄/) never arise, thereby bleeding the assimilation rule in question.

Let us now see in detail how the proposed coda-target condition renders Retroflex assimilation completely regular. Under the new account, /ṣ/ triggers assimilation to a fricative not because both the target and the trigger are continuants, but because, as shown in (11c) a sequence of two fricatives always syllabify as heterosyllabic, syllabifying the first fricative to the coda position. A sequence of oral stop and fricative, however, is always tautosyllabic since stops

are less sonorous than fricatives. Since *t* does not occupy the coda position, there is no assimilation in the *tʂ* cluster. In this account, one need not specify either the target or the trigger, other than that the target has to be in the coda; i.e. any retroflex consonant triggers assimilation only when the target is in the syllable coda position. (11c) represents syllabification facts of some relevant clusters. If we look at such cases as *sʂ*, *tʂ*, *sʂ*, *nd*, etc. in (10b), in which assimilation takes place, the first consonant is always equal to or more sonorous than the second consonant and has to syllabify as the coda of the preceding syllable.

The same explanation can be given for the special behavior of /r/. The potential target (the obstruent that precedes /r/) is never in the coda position since any obstruent is less sonorous than /r/, and syllabifies in the same syllable as /r/.⁷

Let us now look at the /s-t/ cluster in detail. According to Steriade there are two arguments for the /s/ + stop cluster to be heterosyllabic, even though there are word-initial /s/ + stop clusters. One is the fact that *s* does not participate in reduplication which involves copying of the root melodic core, as exemplified in *ta-sthau*. The other is the deletion of the Aorist suffix *s* which deletes when flanked by less sonorous consonants. As illustrated in an example like /a-chid-s-ta/ → [achitta], *s* cannot be syllabified with either the preceding or the following *t*. The third piece of evidence is a doubling rule which I analyze as the gemination of the first onset consonant. In the /s/+ stop cluster, it is not the *s* that doubles but the following stop as in /hasta/ → [hastta].

If syllabification takes place only in terms of the relative sonority strength of the two consonants, one wonders why there is assimilation in *tn* and *tl*, in which the nasal or the liquid is more sonorous than the stop, and both of the segments should be tautosyllabic. In these particular sequences, there is yet another independently needed onset constraint at work. Even though the sonority scale licenses such sequences as tautosyllabic, Sanskrit, like many other languages, does not allow two homorganic sequences as onset clusters, thereby prohibiting such clusters as *tn*, *tl*, *pm*, etc. Due to this negative condition, any homorganic clusters should be heterosyllabic. Given that *t* in *tn* and in *tl* occupies the coda position, we can explain why the nasal and the lateral features spread to it.

The third, and the last case that requires explanation is the case in which one expects assimilation based on syllabification but there is no assimilation. In the sequence *ns*, the sonority scale would force *n* to be syllabified as the coda of the preceding syllable. However, in internal sandhi there is a rule that derives a nasal glide known as anusvāra from a nasal stop whenever it precedes a continuant and this rule bleeds Retroflex Assimilation.

In external sandhi, there is always an intrusive stop /t/ between the nasal-

fricative sequences like $n\zeta$, $ns \rightarrow nt\zeta$, nts . Whitney (1889) observes that the insertion of the /t/ in such cases is a necessary operation. Schein and Steriade (1986) treat these sequences of nasal and stop as underlying clusters in the final position rather than as having an intrusive stop. Whichever analysis one might choose for the nasal-stop cluster in the final position, we can account for the reason why there is no assimilation.

After the sequence $n\zeta$ has developed into $nt\zeta$, we expect the syllabic division to be $nSt\zeta$ rather than $ntS\zeta$ due to the fact that the onset rule precedes the coda rule. First, t is not in the coda position and cannot undergo assimilation. As for the coda n , even though it occupies the coda position, the locality condition which requires the target and the trigger to be skeletally adjacent prohibits the retroflex feature from spreading from ζ to n crossing the skeletal position occupied by t .

It should be emphasized at this point that Palatalization and Lateralization behave in a completely regular fashion due to the fortuitous fact that all the potential targets happen to be in the coda position. On the other hand, Retroflexion appears to be irregular since some of the potential targets are in the onset. It is quite significant that syllable structure which is needed on independent grounds can be consistently applied as a condition in place assimilation. Now the parameters involved in coronal assimilation are shown in (12).

(12) Parameters for Coronal Spread

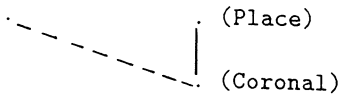
Site of Spreading: the Coronal Node

Target Specification: Coda target

Rule Order: Spread precedes all redundancy rules.

Locality Condition: skeletal adjacency

Directionality: none



4. I conclude that it is more than a coincidence that a potential target emerges as an actual target just in the case it occupies the coda position. Incorporating the coda-target condition can not only unify 4 otherwise unrelated rules (one for palatalization, one for lateralization, and two for retroflexion) as a single rule that spreads the CORONAL node, but it also helps to clarify the role of syllable structure in assimilation.

The coda target condition clearly shows that assimilation processes, though commonly attributed to phonetic explanations, are phonologically governed. Ohala (1988), among others, offered phonetic explanations for the common types of place assimilation. He claimed that place assimilation is not due to

the speaker's innovation but due to acoustic-auditory reasons; namely, the burst at release provides a more robust cue to place of articulation than the formant transitions that occur between two articulations. These phonetic explanations may provide some answers as to why real time changes work the way they do but these are not sufficient to explain how a particular synchronic grammar works. As a result, they do not have a direct bearing on the types of assimilation that actually occur and the conditions under which assimilation occurs. The phonetic explanations are valid only to the extent that they predict why the realization of the parameters are more likely to be one way rather than the other. That is, it can explain why Coda-Target is a more plausible value for the target-specification parameter than Onset-Target.

In the phonology, it is not directly relevant whether there is [release], or phonetic cues in the language or not. If the non-release (thus not providing relevant place cues) were a direct cause of place assimilation, we would not expect cases like Korean and Catalan where there are more than two consonants in the coda and the second consonant, though released, assimilates to the first, which is unreleased. Nor does it handle the complex case of Sanskrit retroflexion. I believe the coda condition is yet another instance showing that phonologization cannot be deduced from acoustic/ auditory organizations (Hyman 1976) and also that phonology is not natural (Anderson 1981).

Notes

* I would like to express my thanks to G. Guy, M. Inman, P. Kiparsky, A. Lahiri, W. Leben for comments and advice.

[1] Note that in Spanish [n] is the only nasal permitted word-finally due to a neutralization rule (Harris 1984).

[2] When *t* is followed by a palatal fricative *ś*, there is a mutual assimilation, so that the sequence of *t-ś* results in *c-ch* as in *vedavic chuurah* and *tac chrutvaa*.

[3] In external sandhi, *n* assimilates only to the coronal place of articulation whereas in internal sandhi it assimilates to all places of articulation. Schein and Steriade (1986) attribute the behavior of word-final *n* to the fact that the word-final *n* contains underlying clusters as in *-ns* (Acc. pl) and *-nt* (3pl).

[4] I assume that the reason /s/ does not assimilate to the lateral is due to Structure preservation. *[+cont, +lat] is not possible whereas [+son, +lat] is.

[5] In internal sandhi /s/ changes according to the environment. According to Whitney, the only environment in which /s/ remains unchanged is before /t/ and /th/.

[6] We should note that /r/ is a trigger for the ruki rule which retroflexes *s*. However, the ruki triggers, that is, *r*, *u*, *k*, *i* do not seem to be characterized by the features dominated by the Coronal Node.

[7] For some reason, the *nṭ* cluster is realized as *mṣṭ* rather than *nṭ*. Odden

(1978) proposes an *s*-epenthesis rule. Note that retroflex assimilation takes place even here because *s* is in the coda and realized as a retroflex fricative even though the nasal part is realized as a nasal glide known as *anusvāra*.

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