A Non-Linear Treatment of Grassmann's Law

A NON-LINEAR TREATMENT OF GRASSMANN'S LAW

Jonathan Kaye
UQAM

Jean Lowenstamm
UQAM

Our goal in this paper is to provide a principled explanation of the distribution of voiced aspirates in Sanskrit, a baffling problem of Indo- European linguistics, cf. Whitney (1896). In the framework of Chomsky & Halle (1968), henceforth SPE, any linguistic regularity can be mirrored in grammar by means of a rule. Only two things can go wrong with a rule: either it is hopelessly complex or it cannot be ordered in a satisfactory fashion with other rules of the language (or both). The impossibility of ordering the relevant rules of Sanskrit linearly has been noted by Zwicky (1965) and Kiparsky (1965), and has been used by Anderson (1970) to motivate a theory of local ordering. See Phelps & Brame (1973) and Sag (1974, 1976) for discussion. More recently, Borowsky & Mester (1983) have proposed an autosegmental account of the distribution of voiced aspirates, building on an insight due to W. S. Allen (1951). While we accept Borowsky and Mester's arguments to the effect that aspiration is to be represented suprasegmentally, our analysis rests on rather different theoretical premises and will differ from theirs in important respects. Our aim is thus twofold: 1) to provide a more explanatory account of the distribution of voiced aspirates in Sanskrit and 2) to provide evidence for the framework within which such an analysis is couched. Specifically, we will argue that the facts of Sanskrit can in large measure be derived, with a minimum of stipulation from various principles of UG. No reference to a rule component will be necessary. The issue of ordering thus becomes vacuous.

I. The relevant facts of Sanskrit.

In this section we discuss the factors governing the distribution of voicing in obstruents and how voicing or the absence thereof conditions the mobility of aspiration. We present representative Sanskrit verb paradigms. Discussion of the individual phenomena follows.

stem: duh- 'milk' (dugh-) strong: doh- weak: duh-

present indicative

	active			middle		
	sg.	dl.	pl.	sg.	dl.	pl.
1.	dohmi	duhvas	duhmas	duhe	duvahe	duhmahe
2.	dhoksi[B]	dugdhas	dugdha	dhukse[B]	duha:the	dhugdhve[C]
3.	dogdhi[A]	dugdhas[A]	duhanti	dugdhe	duha:te	duhate

imperfect

1.	adoham	aduhva	aduhma	aduhi	aduhvahi	aduhmahi
2.	adhok[B]	adugdham	adugdha[A]	adugdha:s	aduha:tha:m	adhugdhvam
3.	adhok[B]	adugdha:m	aduhan	adugdha	aduha:ta:m	aduhata

1. Devoicing.

A voiced obstruent, aspirated or unaspirated, devoices syllable-finally. Relevant examples in the paradigm are shown under [B]. Further examples are given in (1) below.

(1)
dugh + si ---> dhoksi
a + dugh ---> adhok
pad + su ---> patsu
pad ---> pat

2. Voicing assimilation.

On the surface consonant clusters agree in voicing, the value for the feature [voice] being that of the second member of the cluster. The cases discussed in 5. constitute a class of apparent exceptions. That their exceptionality is merely apparent will be demonstrated below.

(2)
yug + ta ---> yukta
marut + bhyas ---> marudbhyas

3. Devoicing with throwback of aspiration.

Aspiration is not compatible with voicelessness. Thus when a voiced aspirate loses its voicing per 1., aspiration appears on a root initial voiced obstruent. In the absence of such a segment, aspiration is lost altogether.

(3)
dugh + si ---> dhoksi
radh + syati ---> ratsyati

4. Throwback of aspiration sans Devoicing.

Syllable final devoicing is not the sole factor responsible for throwback of aspiration. Cases of throwback can be observed even though devoicing has been blocked per 2. See example [C] in the above paradigms.

(4) dugh + dhve ---> dhugdhve

5. Bartholomae's Law.

We saw that devoicing is a sufficient but not necessary condition for throwback, since throwback can take place in the absence of devoicing. Yet, the situation is further complicated by the existence of cases where neither devoicing nor throwback can be observed. Fortunately, such cases correspond exactly to exceptional cases of progressive voicing assimilation. Bartholomae's law is illustrated by the [A] examples.

(5) dogh + ti ---> dogdhi

The above example shows: 1) exceptional progressive assimilation, 2) absence of throwback of aspiration on the root initial voiced obstruent. The aspiration now appears on the formerly voiceless obstruent of suffix - ti.

Further clues as to the nature of the phenomena involved can be seen in studying the distribution of consonant types in Sanskrit roots. Sanskrit displays a number of constraints (assumed to date from the Indo-European period) regarding the cooccurrence of various consonants within a root. The following table gives the various consonant types found in Sanskrit roots. The table is organized as follows: the columns represent the consonant type of the second (right-most) consonant of the Sanskrit root. The consonant types which interest us here are (from left to right): voiced obstruents, voiceless obstruents, voiced aspirates and others (in particular resonants). The rows represent the consonant type of the initial consonant. The darkened cells represent combinations that are either totally lacking or represented by one or two exceptions which appear in the cell. Certain of the distributional gaps revealed by the table are worth noting.

2nd / 1st	voiced obst	voiceless obst	voiced asp.	other
voiced obst	gad	dyut, di:p, gup, guph	dagh, dadh, ba:dh, budh, dudh, bandh, dah, duh	dan, gam, dam
voicelss obst	tad′, kad, khad, pad, kurd	cak, tak, cat, tat, pat′, pat, path, kuth, tap		paj, tij, phan, kan, khar, kam
voiced asp	bhid	ghat′,bhat′		bhaj, bhan, dham, dhan
other	lag, lad, mad, rad, vad,ramb	vak, lok, rikh likh, rat, yat vat, math, rap	jogh, sagh, radh, vadh, jabh	yaj, raj, vaj, saj, jam

Table I

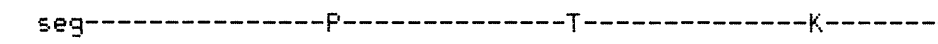
Sanskrit roots may not contain more than one voiced aspirate (*[bhudh]). A voiced aspirate is almost always to the right of a voiced obstruent within a root (?[bhid]). A voiced aspirate may not cooccur with a voiceless consonant within one root (*[bhut] *[tubh]). Interestingly, the only exceptions to the previous statement involve retroflex consonants (here represented as consonants followed by an apostrophe), ghat′, bhat′. This is surely no accident but we have no explanation for this fact. Finally, almost no Sanskrit roots have two voiced obstruents (?[bid]). An adequate analysis of Sanskrit aspiration should account for these distributional facts as well as the alternation cases discussed in the first section. In the following sections we will attempt to provide an explanation for the distributional properties of consonants in Sanskrit roots, as well as an account of Grassmann′s law and its associated phenomena.

II. The analysis

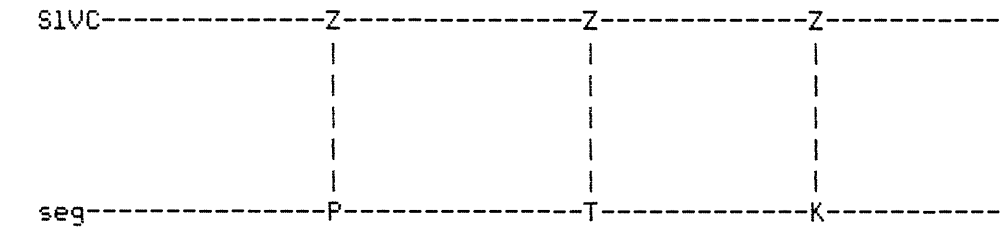
Following the lead of W.S. Allen (1951) and Borowsky & Mester (1983) we shall adopt the suggestion that aspiration is a prosody in Sanskrit. More precisely we assume that aspiration is to be represented on a separate tier and manifests certain autosegmental properties of association. We shall represent the prosody of aspiration by the symbol H which appears on the Expanded Glottis [ExGl] line of representation. In order to fully explain the representation of voiced aspirates in Sanskrit we must look at the representation of voiced obstruents. Given the standard assumptions regarding markedness in consonants, this series (the voiced stops) will be marked with respect to the feature Slack Vocal Cords [SlVC]. Given the theory of phonological representations outlined in Vergnaud

(1982), Kaye & Vergnaud (1984) and Kaye, Lowenstamm & Vergnaud (1984) the voiced obstruent series must be represented by an additional element on the line for which the series is marked. Concretely this means that voiceless stops may be represented as in (6a) while voiced stops are rendered as in (6b).

(6) a.



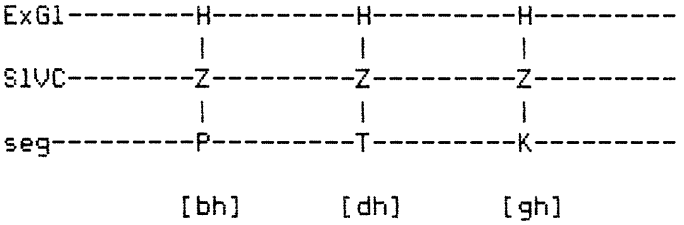
b.



We temporize here and use Z as the element on the SlVC line. What is essential here is that the additional markedness of the voiced obstruent series must be manifested in the additional complexity of its representation. By this theory b, d and g are complex in a way that p, t and k are not.

With this characterization of voiced obstruents in mind we can now represent the voiced aspirates of Sanskrit as in (7) below.

(7)



In this view, the series of voiced obstruents and voiced aspirates are complex while the voiceless obstruents are simple. Now it has been long pointed out by Sanskritists that only the simple series of voiceless obstruents can occupy syllable final position. Voiced stops and aspirates are devoiced and unaspirated in this context. This observation can extend, in fact, far beyond the Sanskrit facts. In the first place, neutralization of a voicing distinction in syllable final position is one of the most wide-spread of phonological phenomena. Secondly, other complex segments have been shown to have

similar or identical distributions. Glyne Piggott (personal communication) has made the observation that prenasalized consonants are limited to syllable onset position. If one assumes that the syllable coda position is recessive, the constraint against complex segments occupying this position reduces to something akin to the constraint against branching structures in recessive metrical positions. It is not our aim to present a complete theory of segmental dependency in this short article. We content ourselves with the observation that the distributional properties of Sanskrit aspirates are neither peculiar to Sanskrit nor to aspirates.

The second point that must be made concerning aspiration in Sanskrit is that it only "sees" elements on the SlVC line. In other words, aspiration does not freely associate to segmental elements such as p or k but rather links only through the mediation of the Z element of the SlVC line. Such a dependency between elements on two distinct lines is not without precedent. Consider the case of nine vowel systems involving the [ATR] feature (5 X 4 systems). Each [-ATR] vowel has a corresponding [+ATR] vowel save the low vowel a which has no [+ATR] equivalent in such systems. A reasonable way of expressing this extremely commonplace constraint is to require that the element of the ATR line must be linked to an element on the B/R (back/round) line in exactly the same way that aspiration in Sanskrit must be linked to a SlVC element. Since a is the only vowel with no element on the B/R line, this will be the only vowel of the system with no [+ATR] counterpart. Thus, the limitation on the associational properties of the aspirate element finds its counterpart in the distribution of the ATR element in vocalic systems.

The third point concerning Sanskrit phonological structures is that they are right-dominant. This point can best be seen by considering the cases of voicing assimilation discussed so far. In all clear cases of assimilation it is the segment to the right that establishes the voicing value for the entire cluster. Put another way, the right segment governs the cluster relative to voicing. This can be seen in the examples below.

(8) a. yug+ta ---> yukta 'joined
pad+su ---> patsu 'foot'

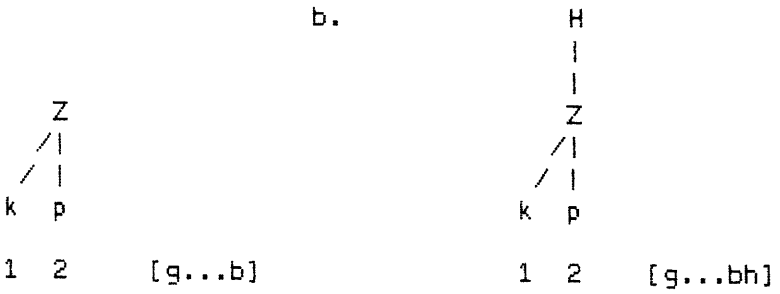
b. da(n)t+bhis ---> dadbhis 'tooth' (inst. pl)
marut+bhyas ---> marudbhyas 'wind' (abl. pl.)

The examples in (8a) show regressive voicing assimilation changing a voiced obstruent to a voiceless one. In (8b) the rightmost segment causes the consonant to its left to agree in voicing. The only apparent exception to the regressive nature of Sanskrit voicing assimilation is Bartholomae's law which will be discussed below. As a rule the dominant segment is found in the rightmost position.

The final point that needs to be made is that metrical structures involving aspiration (the H element) are accentual in nature. What this means is that the aspiration is only realized on the head of the particular structure in which it is found. In this sense it resembles an accentual tree where the accent is found only on the head of the given metrical structure and not on any of its recessive nodes. Thus a structure like (9a) involving the Z element will be interpreted as having both positions 1 and 2 marked for voicing (SlVC)

while the structure in (9b) will have aspiration appearing only on the second position, i.e. the head.

(9) a. b.



Given the description above regarding the prosodic properties of Sanskrit aspiration, it is now possible to offer a representation of Sanskrit diaspirate roots. Consider the following structures:

(10) Representations of roots.

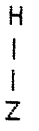
a. budh b. rudh c. bhan

The representation of a diaspirate root is given in (10a). There is a single hierarchical structure associated with the segmental melody put. The Z element of the SlVC line is associated with both consonantal positions. This element is linked to the aspiration element H. This representation is then interpreted in the way discussed above: voicing appears on both consonantal positions (p and t) and aspiration is manifested on the head (rightmost) element. The structure is accordingly interpreted as [budh].

In (10b,c) the roots contain only one aspirated segment. Thus, the only member of this prosodic structure is the head and so aspiration appears on the designated consonant (the final consonant in (10b) and the initial consonant in (10c)). Notice that the resonants r and n cannot be linked to the aspiration element. Although these are phonetically voiced elements they bear no element on the SlVC line. Such a designation is only available for segments that are marked for this feature. Resonants are of course unmarked for voicing and following the theory of phonological representations employed here, cannot be represented by an element on a line for which they are not marked. Thus, neither r nor n carry an element on the SlVC line and therefore are not visible to the aspiration element. Such representations for Sanskrit roots may equally supply an explanation for the distribution of the various consonant types found therein (cf. Table I above). If we assume that the prosodic structure combining the aspiration element with the slack vocal cord element is autosegmental in nature, i.e. floats at the level of lexical representation, then

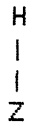
we may explain the absence[1] of roots of the form */p...bh/, */bh...p/, and */bh...b/, where bh is any voiced aspirate, b, any voiced stop and p, any voiceless stop. Consider putative roots of the form /pudh/ or /dhup/. Following our analysis these roots would have the representations as in (11) below.

(11) a.



p u t

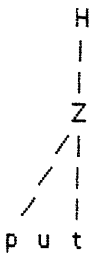
b.



t u p

Given the autosegmental nature of the H--Z complex it should associate to all appropriate segments in its domain. Now the initial and final p of (11a) and (11b) respectively is a segment that can accept the SlVC element and hence the aspiration element. There is no way under normal circumstances to prevent the association of this complex to all the appropriate segments in its domain. We derive then the structures in (12).

(12) a.



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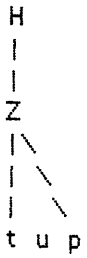
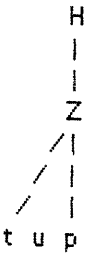


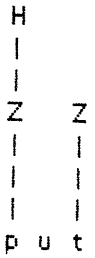
c.



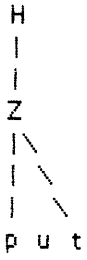
In (12a) the H--Z complex associates to the consonants in its domain. The resulting form is of course interpreted as /budh/. The same process applies to (12b) which is in reality (12c) since these structures are right-dominant as we have noted above. The stem in (12b,c) has the form /dubh/ in this analysis. It can now be seen that if the H--Z complex is allowed to associate freely to all the appropriate consonants in its lexical domain, then it will be impossible to derive structures of the form */pudh/ or */dhup/ in Sanskrit.

Let us now consider forms of the type */bhud/. In fact the same considerations discussed above will eliminate these forms. A putative stem of the type */bhud/ would have the form

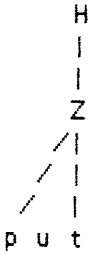
(13) a.



b.



c.

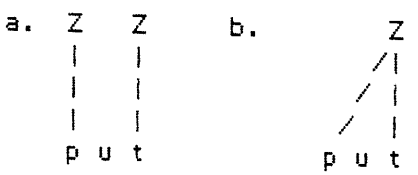


Starting from form (13a) we see that both segments have elements on the SlVC line. In such a case the OCP must apply. We assume here

that the effect of the OCP is to collapse the two identical elements to one as in (13b). The aspirate element H is still associated to the SIVC element Z. With the metrical property of right dominance already demonstrated for Sanskrit the structure in (13b) will be interpreted as (13c) with the final consonant being the head and accordingly receiving the aspiration. Thus, the above form would be realized as [budh] unless some special provision were made to block the effects of the processes discussed above.

Roots containing two (unaspirated) voiced obstruents are likewise excluded. The reasons for this are not entirely clear and our putative explanation will be somewhat tentative. Roots of this form would be represented as shown below.

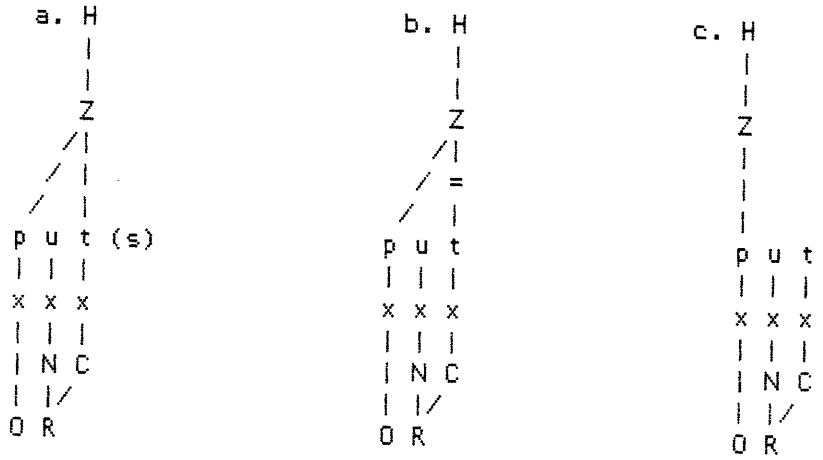
(14)



The form in (14b) reflects the application of the OCP. For some reason (14b) is ill formed. Not only are Sanskrit roots rarely if ever of this form,[2] but sequences of voiced obstruents are not found across morpheme boundaries. The inflectional suffixes of Sanskrit contain voiced and voiceless aspirates, and voiceless obstruents, but never a voiced obstruent. One conceivable reason for excluding sequences of voiceless obstruents would be that structures of the form (14b) are ill formed because a branching Z-structure must be complex, i.e. it must contain an additional element to be well formed. Why this should be so is not clear at the moment. Our only conclusion is that it is not coincidental that voiced obstruent sequences are excluded both from roots and from transmorphemic sequences.

Given the preliminaries of the Sanskrit analysis let us now proceed to its application to the various cases under study. Let us consider first the throwback cases, i.e. the cases where the aspiration is found on the stem- initial consonant in diaspirate roots. The first case is shown in (15) below.

(15) budh+s ---> bhut

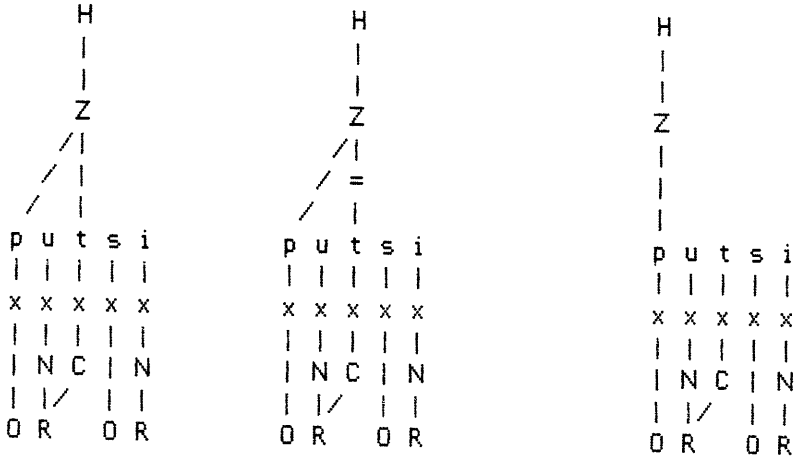


In these representations syllable structure is included below the

segmental melody. In the above example the root is followed by the inflexional suffix -s. No Sanskrit syllable may end with two consonants. Thus the final s is never incorporated into the syllabic structure. The root-final t occupies the coda position. This position being recessive the H---Z prosodic complex cannot remain associated to the final consonant. The association line is cut in (15b) and p is now in the head position of the prosodic structure H---Z (15c). The form is thus realized as [bhut], the correct output.

The second throwback case once again involves the aspirate consonant in a syllabically recessive position, this time in a non-final syllable.

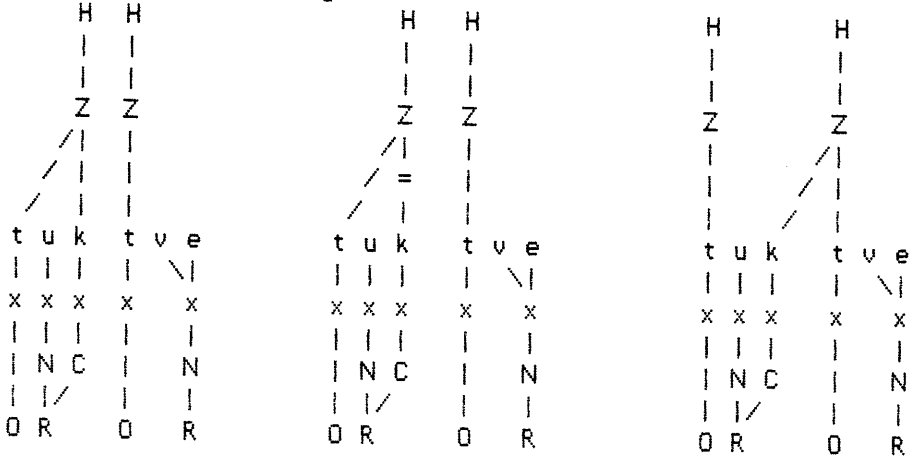
(16) budh+si ---> bhutsi



As before the head of the prosodic structure is found in a syllabically recessive position in this example. There is no possibility of extending the structure to the right since s cannot bear the SIVC element Z at the stage of Sanskrit we are considering here. In the resulting form the initial consonant is the only bearer of the H---Z complex and hence the aspiration falls on the initial consonant: [bhutsi].

In the final throwback case the suffix-initial consonant is a voiced aspirated obstruent. The derivation of the initial aspiration for this form is shown below.

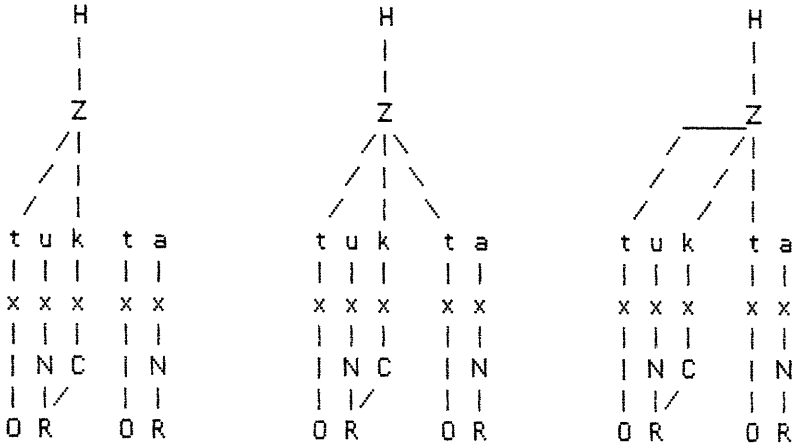
(17) dugh+dhve ---> dhugdhve



In this example there are two prosodic structures involving H---Z: the root dugh and the suffix dhve. As in the two previous examples the root-final consonant winds up in a recessive position from the point of view of syllabic structure. The association line is accordingly cut and the structure is limited to the initial position where aspiration ultimately appears. The second structure is that of the suffix. Given the recessive nature of the coda position, a prosodic tree cannot use this position as its head. This accounts for the delinking observed in the last three examples. There is however, no reason why the coda cannot occupy a recessive position in such a prosodic structure. Furthermore, it was assumed that the H---Z prosodic complex linked freely at the root level in order to account for the distribution of consonant types found therein. There is then every reason to suppose that the prosodic structure originating at the suffix links up with the now available consonantal position of the final root consonant k. This position is now recessive with respect to both syllable structure (the coda position) and the prosodic structure H---Z (which is right- dominant). This is the only case in which we expect to find a voiced obstruent in syllable-final position and this expectation is confirmed by the form [dhugdhve].

The one remaining case that remains to be dealt with is that of Bartholomae's law. This case involves apparent exceptional progressive assimilation, assimilation passing from the root-final consonant to the suffix initial consonant, and no accompanying throwback of aspiration to the root- initial consonant. All these facts follow quite simply from the account given above. It follows from the autosegmental nature of aspiration that if, for some reason, aspiration is thrown forward to a following consonant, it can never occur on the root-initial consonant as well. In such cases, there is only one H prosody which only shows up exactly once per prosodic structure. The relevant derivation is shown below.

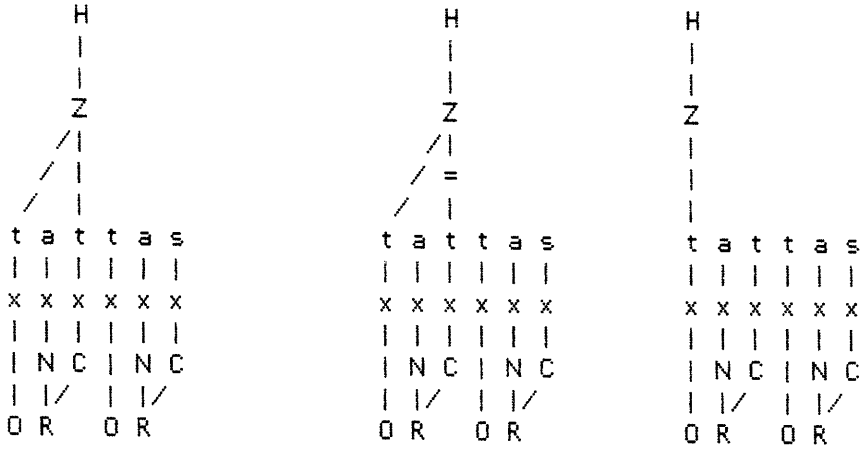
(18) dugh+ta ---> dugdha



The initial structure is ill-formed as it stands once syllable structure has been assigned. For the first time we encounter another possible repair strategy aside from delinking. The suffix-initial consonant can bear the Z element (unlike, say, -si) and this position is currently unoccupied (unlike -dhve). Thus, two strategies suggest themselves: delink, as in the earlier cases or, extend the H---Z

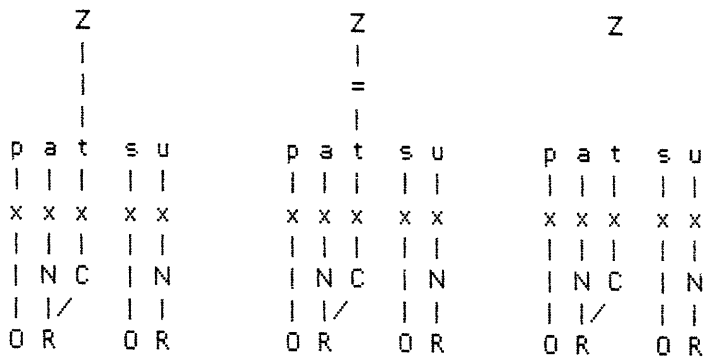
structure to an available consonant in a syllabically appropriate position. In fact, Sanskrit uses both strategies. In the case at hand the prosodic structure is extended to the suffix-initial consonant -t which occupies a non-recessive syllabic position, viz. the onset position, which can carry the Z element and which does not already have such an element. The suffix consonant now becomes the head of the H---Z structure which means that it is the site of the aspirate realization. The other two consonants involved in this structure, t and k are in recessive positions and only receive voicing. Thus we derive the form [dugdha] in which the aspiration appears on the right-most consonant of the form. Delinking may exceptionally apply in similar cases leading to a voiceless consonant cluster and aspiration appearing on the initial consonant. This derivation is given below.

(19) dadh+tas ---> dhattas



For reasons which remain obscure the root dadh- does not undergo Bartholomae's law. The initial ill-formed structure undergoes delinking with the initial consonant retaining the prosodic structure. Thus, one observes "regressive assimilation", the norm in Sanskrit, and the throwback of aspiration, exactly as in the cases of bhut and bhutsi. It is worth noting that the above analysis offers an account for Sanskrit assimilation as well as dealing with the aspiration cases. Cases of regressive voiceless assimilation are merely the application of the principle that complex segements may not occupy recessive positions.

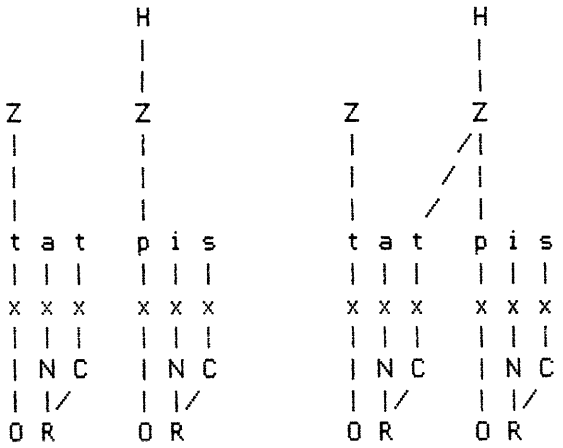
(20) pad+su ---> patsu



The Z element must disassociate from the coda position. Z unlike H--Z does not have the ability to reassociate once it has been delinked. The resulting consonant cluster is voiceless.

Consider now the case of regressive assimilation of voiced segments. The cases we have encountered to this point involve a voiced aspirate in the dominant (rightmost) position.

(21) dat+bhis ---> dadbhis



In the above example the H---Z complex spreads left ward to the available consonantal position. The root-final consonant is in a recessive position with respect to both the H---Z tree and its syllable structure. The facts of voicing assimilation are seen to follow from the same analysis that explains the aspiration facts.

In this paper we have attempted to show that a principled account may be found for the behaviour of Sanskrit voiced aspirate consonants. Our goal has been to find explanations for the range of phenomena associated with this class of consonants while keeping to a strict minimum the number of stipulations that are associated with this analysis. The analysis employs right-dominant metrical structures employing the form of segmental representation suggested in Vergnaud (1982). Voiced obstruents and, of course, voiced aspirates are complex segments. Their distribution is limited to syllabically dominant positions. The aspiration element H only sees elements on the SlVC line and accordingly is only associated freely to voiced obstruents. Aspiration like accent is only manifested on the head position of the structure in which it is found. As can be seen from the above analysis there is no rule ordering paradox; in fact there are no rules.

FOOTNOTES

[1] In fact there are some exceptions to this statement. We have found one root of the form /bh..b/ viz. bhi(n)d- 'to split'. In addition, voiced aspirates may cooccur in roots with voiceless obstruents just in case one or the other of the consonants is retroflex (cf. ghat', bhat').

[2] We have encountered one exception to this, gad 'to say'.

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