Root vowel syncope and reduplication in Sanskrit

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Introduction
In a well-known paper, Steriade (1988) argues that certain features of Sanskrit low root vowel syncope, perfect reduplication, and their interaction, give evidence for two conclusions about Universal Grammar: 1) syllables do not have onset constituents (C*V core syllables); and 2) the mechanism of reduplication is full copy of the stem and subsequent modification of the reduplicant. The general intentions here are the same, but different conclusions are reached: 1) what is crucial about the representation of syllable structure is not syllable constituency at the level of onset and rime, but adequate representation of nuclear structure; and 2) the idea that reduplication consists of copy plus truncation/modification is correct, but that it is incorrect to suppose that the entire stem is copied. Although there are differences with Steriade over the specific copying mechanism, there is agreement that reduplication is essentially copying with modification. Steriade's work is the starting point. The organization and explication of the key generalizations that a theory must account for are taken from her work, as well as several theoretical ideas.

1. Root vowel syncope
We begin with some of the verb forms associated with the root dves/dviś ‘hate’.

(1) Present Indicative

<table>
<thead>
<tr>
<th>(s)</th>
<th>(du)</th>
<th>(pl)</th>
<th>(s)</th>
<th>(du)</th>
<th>(pl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>dvēs-mi</td>
<td>dvēs-vās</td>
<td>dvēs-mās</td>
<td>dvēs-ē</td>
<td>dvēs-vāhe</td>
</tr>
<tr>
<td>2</td>
<td>dvēk-ṣi</td>
<td>dvēs-ṭhās</td>
<td>dvēs-ṭhā</td>
<td>dvēk-ṭē</td>
<td>dvēs-ṭhē</td>
</tr>
<tr>
<td>3</td>
<td>dvēs-ṭi</td>
<td>dvēs-ṭās</td>
<td>dvēs-ṭānti</td>
<td>dvēs-ṭē</td>
<td>dvēs-ṭē</td>
</tr>
</tbody>
</table>

Imperfect

| 1   | ā-dves-am | ā-dves-va | ā-dves-ma | ā-dves-i | ā-dves-vahi | ā-dves-mahi |
| 2   | ā-dvet | ā-dves-ṭaın | ā-dves-ṭa | ā-dves-ṭhās | ā-dves-ṭhām | ā-dves-dhvam |
| 3   | ā-dvet | ā-dves-ṭaın | ā-dves-ṭa | ā-dves-ṭaın | ā-dves-ṭaın | ā-dves-ṭaın |

Imperative

| 1   | dvēs-āṇi | dvēs-āva | dvēs-āma | dvēs-āi | dvēs-āvahi | dvēs-āmahāi |
| 2   | dvēd-ḍhī | dvēs-ṭām | dvēs-ṭā | dvēs-dvā | dvēs-ṭhām | dvēs-ṭhvām |
| 3   | dvēs-ṭu | dvēs-ṭaın | dvēs-ṭaın | dvēs-ṭaın | dvēs-ṭaın | dvēs-ṭaın |
The orthography here and in what follows is standard Sanskrit studies usage, except that I will sometimes use an IPA syllabicity mark underneath a nonvocalic sonorant to indicate that it is in the syllable nucleus. All the attention in this paper is on the sonorants, so little will be said about obstruent phonology and orthography. The root in (1) occurs in two forms, dveṣ (in boldface above) and dviṣ. There are some modifications of the final consonant when a consonant initial suffix is concatenated with the root, but these are regular Sanskrit morpheme juncture processes that are irrelevant to the issues at hand. Except for the singular active imperfect forms, dveṣ occurs in stressed positions and dviṣ in unstressed positions. Affixes in Sanskrit have inherent prosodic properties, producing complex stress patterns across paradigms. Presumably, the root in the singular active imperfect forms also bears stress at some level. The prosody of Sanskrit is such that only the leftmost stress survives as surface stress. The stressed prefix in the imperfect forms therefore obscures stress on the root. Many Sanskrit roots show a similar pattern, with alternation between a form which occurs in unstressed positions, called the zero-grade form in Indo-European studies, and a form which occurs in stressed positions, called the full-grade form.

The phonology of the dves/dvis variation is given in (2).

\[
\begin{align*}
\text{(full-grade)} & \quad \times \times \times \times \\
\text{(zero-grade)} & \quad \times \times \times \\
\end{align*}
\]

Sanskrit has various operations which eliminate diphthongs and vowel hiatus at the surface: ai → e, au → o, ia → ya, and ua → va. Within a root, underlying semi-vowels surface as glides in pre-a position. In Sanskrit, underlying u surfaces as the labiodental glide v when not nuclear. In the full-grade form in (2), normal diphthong reduction applies. The underlying vowel inventory in Sanskrit is \{a, i, u\}. Surface e and o are always derived from underlying ai and au and since they are always long, they are written without length marks (i.e. not as ē and ő). The zero-grade form in (2) is derived by syncope of the unstressed low vowel.

Long low vowels do not syncopate or shorten. This makes sense if the driving force of syncope is the elimination of an unstressed low vowel but the mechanism is timing slot deletion. Deleting only one of the timing slots associated with a low vowel does not cause the low vowel to delete. Low root vowel syncopation is not unique to Sanskrit. It is interesting that in the typologically different language Lushootseed, an indigenous North American language, a similar root reduction process applies. Urbanczyk (2001) says that syncope in Lushootseed is “best analyzed as an extreme case of unstressed vowel
reduction, with a strong preference for unstressed a to delete or reduce, and the high vowels i and u to retain full vowel status.”

Verb roots in Sanskrit are monosyllabic and, except for a few roots with long high vowels, contain a low vowel. Almost all roots with ai or au undergo zero-grade reduction and have paradigms analogous to (1). Examples follow:

(3) | full grade | 0-grade |
---|---|---|
| a. laih | leh | lih | ‘lick’ |
| b. ciut | cyot | cyut | ‘drip’ |
| c. baudh | bodh | budh | ‘know, wake’ |
| d. ais | eṣ | iṣ | ‘seek, desire’ |
| e. auc | oc | uc | ‘be pleased’ |
| f. ai | e | i | ‘go’ |

Sanskrit has underlying nasal and liquid (n, m, r, and l) syllable nuclei, although syllabic n and m surface as a. It is convenient to use the term semi-nucleus to denote a phoneme that can enter syllable structure either as a nucleus or as a consonant. In Sanskrit, all high vowels, nasals, and liquids are semi-nuclei. The low vowel is not, since it must syllabify as a nucleus. Although not as predictably as ai/au-roots, many other roots with a semi-nucleus adjacent to short a syncopate. Whether or not a root syncopates is not evident in its surface form. The root suap ‘sleep’, for example, is subject to syncope but the apparently similar root suaj ‘embrace’ is not. The root uas ‘shine’ syncopates, but the apparently homophonous root uas ‘clothe’ does not (at least in Classical Sanskrit). Some examples follow of roots that are subject to syncope:

(4) | full grade | zero-grade | nucleus of syncopated root |
---|---|---|---|
| a. dhar | dhar | dhṛ | ‘hold’ | post-a liquid |
| b. uan | van | va (vṇ) | ‘win’ | post-a nasal |
| c. suap | svap | sup | ‘sleep’ | pre-a semivowel |
| d. iaj | yaj | ij | ‘offer’ | pre-a semivowel |
| e. mrad | mrad | mṛd | ‘rub, crush’ | pre-a liquid |
| f. uraśc | vraśc | vṛśc | ‘cut up’ | pre-a liquid |

Steriade made the following important generalizations about the source of the derived nucleus in syncopated roots:

(5) a. Only a semi-nucleus which is adjacent to the vowel which syncopates can be promoted to be the nucleus of the syncopated root.

b. If a semi-nucleus immediately follows the vowel which syncopates, then it becomes the nucleus of the syncopated root, irrespective of the quality of the phoneme which precedes the vowel which syncopates.
These principles are illustrated in (6) by examples with various sonorants adjacent to the low vowel, either preceding it or following it.

(6)  

<table>
<thead>
<tr>
<th>root</th>
<th>full grade</th>
<th>syncopated</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>duais</td>
<td>dvaıs</td>
</tr>
<tr>
<td>b.</td>
<td>uan</td>
<td>van</td>
</tr>
<tr>
<td>c.</td>
<td>smai</td>
<td>sme</td>
</tr>
<tr>
<td>d.</td>
<td>siand</td>
<td>syánd</td>
</tr>
<tr>
<td>e.</td>
<td>mard</td>
<td>márd</td>
</tr>
<tr>
<td>f.</td>
<td>uardh</td>
<td>várđh</td>
</tr>
<tr>
<td>g.</td>
<td>´srâu</td>
<td>´sro</td>
</tr>
</tbody>
</table>

Semi-nuclei which follow the low vowel take precedence

Only a semi-nuclei adjacent to the low vowel can be the new syllable head

h. mrad | mrad | márd | *mrád | rub, crush’ |

Steriade drew important conclusions from these generalizations. One might be tempted to think that syncopation of suap, for example, as opposed to nonsyncopation of suaj, is controlled by some covert feature of the semi-vowel. In essence, the claim would be that u and v are distinct in lexical representations, with v fixed as a consonant. The two forms would be suap and svaj. But this cannot be the case for Sanskrit. If it were, we would expect to find syncopating roots of the form C1iavC2. If this root syncopated, v would be promoted to be the nucleus of the syncopated root. But this does not occur, as (5a) claims. Since applicability of syncope is not controlled by phoneme features, Steriade concluded there was nothing structural which could control the applicability of syncope and it had to be directly specified lexically, with some roots specified to undergo a-deletion. I will take issue with the conclusion that there is no structural trigger for syncope, but it is first worthwhile to go through the further implications that Steriade drew from this conclusion.

One of the early attempts to integrate insights into moraic structure with syllable structure posited structures like the one on the left in (7) for bimoraic syllables, with the two moras identified with syllabic constituents. The nucleus of the syllable was identified as the rightmost element of the initial mora. In effect, the initial mora was identified as a C*V core subsyllable. With this structure, low vowel syncope would produce the derivation shown in (7), which does not correspond to the facts of Sanskrit since the pre-a semi-nucleus is incorrectly
promoted to be the nucleus of the syncopated root. Steriade therefore concluded that this model of syllable structure is incorrect.

\[
\begin{align*}
\sigma & \quad \sigma \\
\mu & \quad \mu & \quad \mu \\
\times & \quad \times & \quad \times & \quad \times \\
\downarrow & \quad \downarrow & \quad \downarrow & \quad \downarrow \\
d & \quad u & \quad a & \quad i & \quad s \\
\rightarrow & \quad \rightarrow & \quad \rightarrow & \quad \rightarrow \\
\mu & \quad \mu & \quad \mu & \quad \mu \\
\times & \quad \times & \quad \times & \quad \times \\
\downarrow & \quad \downarrow & \quad \downarrow & \quad \downarrow \\
& d & u & i & s
\end{align*}
\]

(incorrectly)

In place of the structure in (7), Steriade proposed the structure in (8) in which pre-nuclear elements are outside the moraic structure entirely and the syllable nucleus is the leftmost element of the initial mora. As the derivation shows, this correctly predicts the Sanskrit facts.

\[
\begin{align*}
\sigma & \quad \sigma \\
\mu & \quad \mu & \quad \mu \\
\times & \quad \times & \quad \times & \quad \times \\
\downarrow & \quad \downarrow & \quad \downarrow & \quad \downarrow \\
d & \quad u & \quad a & \quad i & \quad s \\
\rightarrow & \quad \rightarrow & \quad \rightarrow & \quad \rightarrow \\
\mu & \quad \mu & \quad \mu & \quad \mu \\
\times & \quad \times & \quad \times & \quad \times \\
\downarrow & \quad \downarrow & \quad \downarrow & \quad \downarrow \\
& d & u & i & s
\end{align*}
\]

Although the structure in (8) correctly predicts the facts of Sanskrit zero-grade reduction, it is not the only possibility. A flaw in (8) is that it does not distinguish the diphthong \( ai \) from the vowel-consonant sequence \( ai \). Other theories of syllable structure can more adequately represent nuclear structure. The (partial) structure in (9a) is one possibility. It could also be that the identification of the nuclear elements is on a separate plane, parallel to the syllable tier (or tiers), but not a subpart of it, as in (9b). Kessler (1992) also suggests that syllable structure is split between parallel tiers.

\[
\begin{align*}
\sigma & \quad \sigma \\
\mu & \quad \mu & \quad \mu \\
\times & \quad \times & \quad \times & \quad \times & \quad \times & \quad \times \\
\downarrow & \quad \downarrow & \quad \downarrow & \quad \downarrow & \quad \downarrow & \quad \downarrow \\
d & \quad u & \quad a & \quad i & \quad s \\
\rightarrow & \quad \rightarrow & \quad \rightarrow & \quad \rightarrow & \quad \rightarrow \\
\sigma & \quad \sigma \\
\nu & \quad \nu \\
\times & \quad \times & \quad \times & \quad \times & \quad \times \\
\downarrow & \quad \downarrow & \quad \downarrow & \quad \downarrow & \quad \downarrow \\
d & \quad u & \quad a & \quad i & \quad s
\end{align*}
\]

Since it is more consistent with the theory of syllable structure proposed in Frampton (2001), I will adopt the parallel tier approach (9b). The details of a syllable constituent tier will turn out to be relatively unimportant for what follows. If (9b) is taken seriously, even (7) cannot be ruled out. If the nuclear tier plays a sufficiently strong role in the resyllabification which syncope initiates, and the nuclear structure of roots which are subject to syncope has the appropriate properties, moraic structure can be forced to conform itself to nuclear structure. Before we discuss the role of nuclear structure in low vowel syncope, we first examine the relation between low vowel syncope and perfect reduplication.
2. Perfect Reduplication

The perfect paradigm of the root *taud* `strike’ is given below:

(10) | active | middle |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>sg</td>
<td>du</td>
</tr>
<tr>
<td>tu-tód-a</td>
<td>tu-tud-i-vá</td>
</tr>
<tr>
<td>tu-tód-i-tha</td>
<td>tu-tud-ánhus</td>
</tr>
<tr>
<td>tu-tód-a</td>
<td>tu-tud-áts</td>
</tr>
</tbody>
</table>

When the root is stressed, the full grade form of the root *tad* (from *taud*) appears and when it is unstressed, low vowel syncope reduces the root to *tud*. Of particular interest is the fact that the vowel of the reduplicant is the same in both the full grade and syncopated forms. This is most interesting in the full grade, where reduplication appears to effect *taud* → *tu-taud*, with copying to the reduplicant skipping over the low vowel and copying the following vowel.

In general, 1) if a root syncopates and its syncopated form has a vocalic nucleus, then the vowel of the reduplicant is the vowel of the syncopated root; 2) if the root has a long vowel, then the vowel of the reduplicant is the vowel of the root; and otherwise, 3) the vowel of the reduplicant is *a*. A few examples illustrate this:

(11) | full grade | 0-grade | 1sg, active | 3pl, active |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>syncopated root has a vocalic nucleus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. suap ‘sleep’</td>
<td>sváp</td>
<td>sup</td>
<td>su-suáp-a</td>
<td>su-suáp-ús</td>
</tr>
<tr>
<td>b. miaks ‘be situated’</td>
<td>myáks</td>
<td>miks</td>
<td>mi-miáks-a</td>
<td>mi-miáks-ús</td>
</tr>
<tr>
<td>c. suaid ‘sweat’</td>
<td>svaid</td>
<td>svid</td>
<td>si-suáid-a</td>
<td>si-suáid-úš</td>
</tr>
<tr>
<td>root has a long vowel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. jív ‘live’</td>
<td>jív</td>
<td>jíjíva</td>
<td>jíjívás</td>
<td></td>
</tr>
<tr>
<td>syncopated root has a liquid or nasal nucleus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. uart ‘turn’</td>
<td>vart</td>
<td>vřt</td>
<td>vavárta</td>
<td>vavvřúš</td>
</tr>
<tr>
<td>e. marj ‘wipe’</td>
<td>marj</td>
<td>mřj-a</td>
<td>mamářja</td>
<td>mamářúš</td>
</tr>
<tr>
<td>root does not syncopate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. suaj ‘embrace’</td>
<td>svaj</td>
<td></td>
<td></td>
<td>sasvája</td>
</tr>
</tbody>
</table>

The 1sg active forms are the most interesting. The root is not subject to low vowel syncope because it is stressed. Nevertheless, the reduplication process appears to have access to the results of low vowel syncope. How else can reduplicative copying know that the high vowel should be copied from *suap*, but the low vowel should be copied from *suaj*? Recall that we have already
established that the possibility of syncopating the low vowel is not coded in phoneme features, but must be coded lexically. Steriade concluded from this that there is nothing in the representations of suap and suaj which allows them to be distinguished. We will shortly take issue with this and propose that although there is nothing in the phoneme features which regulates the possibility of low vowel syncope, the two forms have different syllable structures, nuclear structure in particular. On the one hand, this difference will account for the fact that one root syncopates and one does not. On the other, it controls the choice of reduplicant vowel. Before elaborating that proposal, we consider Steriade's solution to the problem.

Since the stressed root in the 1sg active case is not subject to low vowel syncope, but the unstressed reduplicant reflects the syncopated root, Steriade concluded that reduplication consists of copying the entire root, then applying low vowel syncope to the unstressed reduplicant. Further truncation of reduplicant material then achieves the desired reduplicant.

(12) Full Copy theory (Steriade, 1988)

\[
\begin{align*}
suaid & \\
1. suaid & \rightarrow suaid \quad \text{full copy} \\
2. svaid & \rightarrow svaid \quad \text{syllabification and low vowel syncope} \\
3. svaid & \rightarrow svaid \quad \text{coda removal} \\
4. si & \rightarrow svaid \quad \text{onset trimming}
\end{align*}
\]

The Full Copy Theory of Reduplication faces two problems, one with respect to its empirical adequacy for Sanskrit and the second with respect to its adequacy as a universal theory of reduplication.

First, if a root syncopates and the nucleus of the syncopated root is a liquid, the nucleus of the reduplicant syllable is incorrectly predicted to be that liquid.

(13) \[
\begin{align*}
uart & \\
1.uart & \rightarrow uart \quad \text{full copy} \\
2. vrt & \rightarrow vart \quad \text{syllabification and low vowel syncope} \\
3. vr & \rightarrow vart \quad \text{coda removal}
\end{align*}
\]

Because of certain features of Sanskrit phonology, the same problem does not arise in the case of syncopated roots whose nucleus is a nasal. In the nasal case, siand (syand/synd) for example, the reduplication process itself produces the perfect form sn-synd. But since syllabic nasals are realized at the surface as a, the desired sa-syad would in fact surface. There is no such rule for syllabic liquids, however, which do occur in Sanskrit surface forms. So the form produced in (13) would in fact appear at the surface, contrary to fact.
The second and more serious problem faced by the Full Copy analysis is its lack of generality. While the analysis of Sanskrit perfect reduplication is more or less plausible, and there may be some variant of it that circumvents the problem raised by (13), there are reduplication processes in other languages which are not plausibly analyzed as full copy and truncation. Washo, an indigenous language spoken in California, forms plurals as follows:

(14) \[
\begin{array}{ll}
\text{root} & \text{plural} \\
\text{a.} & \text{baloxat} & \text{baloxaxat} & \text{bows} \\
\text{b.} & \text{malosañ} & \text{malosasañ} & \text{stars} \\
\text{c.} & \text{?ewši?} & \text{?ešiši?} & \text{father’s brothers} \\
\text{d.} & \text{net’us} & \text{net’unt’us} & \text{old women} \\
\text{e.} & \text{mokgo} & \text{mogokgo} & \text{shoes}
\end{array}
\]

It is very easy (and I believe correct) to analyze this reduplication pattern using Steriade’s idea of copying coupled with truncation. But the idea that the initial copying operation is full copy must be abandoned. Copying starts after the penultimate vowel and ends after the final vowel. Below, copying to the left is assumed. A typical derivation is shown in (15a), with the material that is copied boldfaced. Full copy leads to requiring incoherent truncation, and truncation of both stem and reduplicant, in order to obtain the desired output:

(15) a. Copy (a designated substring) and truncate

\[
\begin{array}{l}
\text{nent’us} \\
\text{1. ne-nt’u-nt’us} & \text{copy} \\
\text{2. ne-\text{\textemdash}nt’u-nt’us} & \text{truncation reduplicant to CV}
\end{array}
\]

b. Full copy and truncate

\[
\begin{array}{l}
\text{nent’us} \\
\text{1. nent’us-nent’us} & \text{full copy} \\
\text{2. nent’u\textemdash-\textemdash nent’us} & \text{incoherent truncation}
\end{array}
\]

The computational mechanism employed by Washo is straightforward: a substring is singled out by reference to standard landmarks (in this case, the penultimate and final nuclei), the designated substring is then copied with modification to satisfy simple criteria. Frampton (2002) proposed that this is the universal computational mechanism for reduplication and applied it to study reduplication in a very wide variety of languages. After we reconsider Sanskrit syllable structure in the next section, a straightforward account of Sanskrit perfect reduplication will be given based on this mechanism.
3. Syllabification and reduplication: counterproposals

The motivation for the Full Copy Theory of reduplication comes from the conclusion that the applicability of syncope is not governed by structure. We first reconsider syllabification. It is possible to understand the structural basis of syncope in terms of the nuclear structure of roots. The paradigmatic case of a root that undergoes low vowel syncope in unstressed environments is a root with an ai or au nuclear diphthong. Syncope promotes the nonlow member of the diphthong to be the new syllable nucleus. There are instances of long nuclear liquids in Sanskrit and there have been proposals that Proto Indo-European had both long nuclear liquids and nasals. See Szemerényi (1996, p. 49) and the references cited there. If we extend this idea to vowel/sonorant diphthongs, which do not necessarily surface as such but are present at the level of morphophonology at which the content of the perfect reduplicant is determined, a structural basis for root syncope can be established. The inventory of possible diphthongs must be expanded from the pair \{ai, au\}, which is commonly assumed, to the falling (sonority) diphthongs \{ai, au, ar, al, an, am\} as well as the rising diphthongs \{ia, ua, ra, la, na, ma\}. All of the semi-nuclei can potentially be part of a diphthong. I will also assume that there is a diphthong markedness hierarchy, with falling diphthongs less marked than rising diphthongs. Syllabification (at the level in question) respects this hierarchy. The default is to syllabify a semi-nucleus that follows a low vowel into a falling diphthong, but to syllabify a semi-nucleus that precedes a low vowel as an onset.

Lexical exceptions to this default syllabification pattern are possible, and will be discussed shortly. Before doing that, however, the presence of diphthongs can be related to the applicability of low vowel syncope. Suppose that unstressed low root vowels are subject to syncope under the condition that only minimal resyllabification is needed to reconstitute well-formed syllable structure. The relevant notion of “minimal resyllabification”, of course, needs to be made precise. Sanskrit has a few roots of the form C₁aC₂ which syncopate when unstressed if there is a V-final prefix and a V-initial suffix to absorb the consonants, which must find a syllabic home after syncopation. The root pat, for example, forms pa-pát-a, but also pa-pt-úr, with syncope. If there is not a suitable environment to absorb the consonants, no syncope takes place. Since there is no V-final prefix to absorb the initial consonant, there is no syncope of pat-i-ta, in spite of the unstressed low root vowel. This is important, because it shows that the applicability of syncope can be sensitive to the potential of the product of syncope to readily resyllabify. If we suppose that “minimal syllabification” does not allow the formation of new nuclei, then syncopation depends in most cases on the presence of a diphthong, with syncope promoting the semi-nucleus in the diphthong to be the new nucleus.

If there were no lexical exceptions, we would expect all roots with a semi-nucleus following short a to syncopate and no roots with a semi-nucleus preceding short a, but no semi-nucleus following it, to syncopate. In fact, about
10% of the former class do not syncopate and about 35% of the later class do. I assume that default syllabification can be overridden by lexical specification. Some roots with a post-\(a\) semi-nucleus are specified as \(-\text{DIPH}\) and some roots with a pre-\(a\) semi-nucleus are specified as \(+\text{DIPH}\). In all, about 15% of the roots which have a semi-nucleus adjacent to short \(a\) are exceptional. They must be specified as such in the lexicon. The figures are from Steriade, based on Whitney's (1885) compendium of verb roots. In general, among roots with an \(a\)-adjacent sonorant, the smaller the sonority difference is the more likely it is that the pair syllabifies into a diphthong. This suggests that in addition to the primary diphthong markedness, under which falling sonority diphthongs are less marked than rising sonority diphthongs, there is a secondary diphthong markedness under which diphthongs with small sonority differences are less marked than diphthongs with larger sonority differences.

For roots with an \(a\)-adjacent sonorant, DIPH marking or lack thereof determines the root syllable structure. The root \(\text{suaj}\), for example, is unmarked for \(\pm\text{DIPH}\), but the root \(\text{suap}\) is marked \(+\text{DIPH}\). This results in syllabification with the nuclear structure shown below:

\[
\begin{array}{c}
\text{(16) a. } & \times \times \times \times \\
\text{b. } & \times \times \times \times \\
\text{s u a j} & \text{s u a p}
\end{array}
\]

Syncope is blocked in \(\text{suaj}\) for exactly the same reason that syncope was blocked in \(\text{pat-ita}\); the consonantal remnants of syncope in \(\text{suaj}\) cannot be absorbed without creating a new nucleus. If syncope allowed a new nucleus to be created, then the semi-vowel \(u\) could be recruited to head a new syllable.

No formal mechanism prevents a root of the form \(\text{duais}\) from being marked \(+\text{DIPH}\). This marking, however, is not learnable. The learning algorithm will not interpret the default case as something to be marked in the lexicon. Only exceptions induce lexical marking.

We now have an explanation for Steriade's generalizations (5) about the relation of the nucleus of the syncopated root to the nucleus of the presyncopated root. A root like \(\text{siand}\), for example, could potentially be specified as \(-\text{DIPH}\) and would not syncopate, producing \(\text{syand}\) in both stressed and unstressed environments. But if it is not marked \(-\text{DIPH}\), then diphthong markedness will ensure that it is syllabified with a falling diphthong and the pre-\(a\) semi-nucleus will not become the nucleus of the syncopated root. Since diphthongs necessarily consist of contiguous phonemes, the fact that only semi-nuclei that are adjacent to the nucleus in the presyncopated root can become the nucleus of the syncopated root is also explained.
3.1 Perfect reduplication

We now are in a position to understand Sanskrit reduplication. Assuming that the remarks made above about Washo reduplication are guiding principles, the first step (for us and for a child learning the Sanskrit reduplication patterns) is to determine what substring of the stem is copied. The rule is simple: *copy from the beginning of the word up to the first +high nucleus, if there is one, otherwise up to the first vocalic nucleus.* This determines what I call the *duplicant.* Then copy it, truncating it medially to produce a CV copy. This is illustrated for a number of examples below. Crucially, reduplication occurs prior to low vowel syncope.

For reasons of space, I omit discussion of two interesting and well-known, but secondary, reduplication phenomena. First, dissimilation regularly applies to the reduplicant under certain conditions (*ka-kam-* → *cã-kãm-* and *bhi-bhī-* → *bi-bhī-*), for example). Second, reduction of C*V to CV behaves anomalously if the initial onset is an s-obstruent cluster (*ska* reduces to *ka*, not *sa*, for example).

Among the roots in (17), only *suap* is marked for ±DIPH. It does not have a post-*a* semi-vowel, but it is marked +DIPH, so it syllabifies with a diphthong. The duplicant has been explicitly marked with “|” and “||” junctures inserted into the timing tier. The truncated material is also marked with inserted junctures. This has two virtues. First, it much more efficient computationally, since it avoids copying and subsequent deletion. The decision about what copied material to truncate is transformed into a decision about what not to copy. Second, if prosodic conditions are imposed on the duplicant, the position of junctures can be shifted in order to ensure satisfaction of the conditions. Sanskrit reduplication does not appear to use this mechanism, but it is crucial in various other languages.
3.2 Present, Aorist, and Desiderative reduplication

Sanskrit uses prefixal reduplication similar to perfect reduplication to construct a variety of other verb forms. For example, the desiderative stem \( śu-śoc-i-ṣa- \) (which receives a further tense/agreement suffix), is built from the root \( sauc \) ‘gleam’. The suffix \( -ṣa \) and the prefixal reduplication are associated with the desiderative semantics. The \( i \) which occurs before the desiderative suffix is epenthetic, used in many places in Sanskrit to link consonant final roots and consonant initial suffixes. In the desiderative, stress goes on the initial syllable and the root is unstressed, so it is subject to low vowel syncope in deriving the surface form. An aorist stem, \( śu-śoc-i- \) (which also receives a further agreement suffix) is formed from the same root. The \( -a \) suffix is a “stem vowel” which shows up in a wide range of verbal constructions. The prefixal \( a- \), which is always stressed, and the reduplication are characteristic of the aorist semantics. As in the desiderative, the unstressed root will be subject to low vowel syncope in the derivation of surface form. Finally, there are verb roots like \( hau \) ‘sacrifice’ that form a present stem \( hu-hau- \) (\( ju-hau- \) after dissimilation) which receives a tense/agreement suffix to form a variety of verb forms (present, imperfect, imperative, and optative). This stem is called the present stem.

For the two roots used illustratively above, the vowel of the reduplicant is the same as the vowel of the perfect reduplicant. With some exceptions noted below, the reduplicant vowel in desiderative, aorist, and present reduplication is the same as the vowel of the perfect reduplicant, provided that the vowel is a high vowel (i.e. \( i \) or \( u \)). If it is the low vowel \( a \), the vowel in the desiderative, aorist, and present reduplicants is \( i \). The simplest analysis is that the desiderative, aorist, and present reduplication processes use exactly the same reduplication rule as the process which builds the perfect stem, but that a further vowel raising operation applies to the reduplicant, raising \( a \) to \( i \). Further lengthening applies in the aorist, apparently involving weight dissimilation between the reduplicant and the following syllable.

The major exception is a fairly large subclass of the class of roots which have reduplicated present stems which are exceptions to the rule which raises low vowels in present stem reduplicants. The root \( uart \) ‘turn’, for example, has the perfect stem \( va-vart \) and the same present stem, not subject to reduplicant vowel raising. The desiderative stem is \( vi-vart-ṣa- \) and aorist stem is \( vi-vart-a- \), with vowel raising (and reduplicant lengthening in the desiderative), as expected.

3.3 Intensive reduplication

In order to exemplify intensive reduplication, recall from (1) above the present tense forms of the root \( dves/dvis \): \( dvés-mi \) (1sg active) and \( dvis-más \) (1pl active). Vowel syncope occurs in the 1pl form because the suffix is stressed. Alongside these are intensive/frequentative forms: \( dē-dves-mi \) and \( de-dvis-más \). Slightly below the surface, the present tense forms are \( dváis-mi \) and \( dvis-más \) and the intensive forms are \( dái-dvais-mi \) and \( dai-dvis-más \). One might be led from this to
conclude that the intensive prefix was independent of root syncope. This is not
the case. For the root svap/sup, the 1sg and 3pl present active intensive verb
forms are sā-svap-mi and so-sup-más. It follows that the INT morpheme must
combine with the stem after the TNS/AGR morpheme (or morphemes) has
combined with the stem, because have already applied before the reduplicant is
copied. It is quite plausible that a morpheme like INT with essentially adversial
semantics occurs high in the structure, above tense and agreement morphemes.
Note that this implies that it is incorrect to speak of the “intensive stem”, because
this suggests that the stem is formed before it is combined with the
tense/agreement suffixes. There is no intensive stem.

Some examples follow. The one vowel initial root (ij, syncopated yaj)
does not undergo intensive reduplication. Vowel initial roots, in general, do not
form intensives. I omit here a connecting -i- that occurs between a consonant
final reduplicant and a consonant initial root in some surface forms. Presumably,
since its use is extensive in Sanskrit morphology, language learners had no
difficulty in factoring out its presence in learning the reduplication patterns. I also
omit the tense/agreement suffix:

<table>
<thead>
<tr>
<th>root</th>
<th>intensive</th>
<th>gloss</th>
<th>root</th>
<th>intensive</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>tuais</td>
<td>tai-tvais-</td>
<td>‘be stirred up’</td>
<td>krand</td>
<td>kan-krand-</td>
<td>‘cry out’</td>
</tr>
<tr>
<td>mard</td>
<td>mar-mard-</td>
<td>‘crush’</td>
<td>krnd</td>
<td>kan-krnd-</td>
<td>‘cry out’</td>
</tr>
<tr>
<td>mṛd</td>
<td>mar-mṛd-</td>
<td>‘crush’</td>
<td>suap</td>
<td>sa:-suap-</td>
<td>‘sleep’</td>
</tr>
<tr>
<td>pat</td>
<td>pa:-pat-</td>
<td>‘fly’</td>
<td>sup</td>
<td>sau-sup-</td>
<td>‘sleep’</td>
</tr>
<tr>
<td>iaj</td>
<td>yā-ya:j-</td>
<td>‘offer’</td>
<td>kṛd</td>
<td>kai-kṛd-</td>
<td>‘play’</td>
</tr>
</tbody>
</table>

ij (none) ‘offer’

The intensive prefix is invariably of the form CαX, with X a sonorant coda. It is
reasonable to suppose that this was taken to be a phonotactic for intensive
reduplication.

The copying rule follows directly from the phonotactic: copy up to a
postnuclear sonorant, if there is one, otherwise up to the nucleus. The onset is
then simplified just as in perfect reduplication. If the reduplicant does not meet
the coda criterion of the phonotactic, the nucleus is lengthened to produce a coda.
If the nucleus is not a low vowel, replace it (and only it) by a low vowel. This
means that long nuclei must degeminate before replacement by a low vowel
(ī → ai, for example). Derivations of the forms above follow:
(19)\[\begin{array}{cccccc}
duplicant & truncation & copying & lengthening & a-nucleus \\
tvāis & [tvai]s & [tvai]s & tai-tvais & \\
mārd & [mar]d & [mar]d & mar-mārd & \\
pāṭ & [pa]t & [pa]t & pā-pāt & \\
yāj & [va]j & [va]j & yā-yāj & \\
krand & [kran]d & [kran]d & kan-krand & \\
krṇḍ & [krn]d & [krn]d & kan-krṇḍ & \\
sup & [su]p & [su]p & sū-sup & \\
krīḍ & [krī]d & [krī]d & kai-krīḍ & \\
\end{array}\]

Conclusions

The principle objective has been to support the theory of reduplication proposed in Frampton (2002). The core mechanism is partial copy with truncation. The fact that this approach extends successfully to Sanskrit lends support to the idea that this mechanism is the universal mechanism of reduplication.

In order to carry this out, it was necessary to find a structural basis for low vowel root syncope in Sanskrit. The basis that was proposed relies on the idea that syllable structure is distributed between parallel tiers. Some support is therefore given to the program initiated in Frampton (2001) of developing a thoroughly autosegmental theory of syllable structure which can replace the nested constituent models which, in my view, were inherited uncritically from syntax.

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Appendix

The point of this appendix is to show how resyllabification associated with low vowel syncope is analyzed in the theory of syllable structure proposed in Frampton (2001). That paper proposes the structure (20a), rather than either (20b) or (20c), which were discussed above as (7) and (8).

(20)\[\begin{array}{ccc}
a. \begin{array}{cccc}
\omega & \omega & \mu & \sigma \\
duais & x & x & x & x \\
\end{array} & b. \begin{array}{cccc}
\mu & \sigma \\
duais & x & x & x & x \\
\end{array} & c. \begin{array}{cccc}
\mu & \sigma \\
duais & x & x & x & x \\
\end{array} \\
\end{array}\]

There is no syllable constituent in (20a), although syllables can be recognized as pairs of overlapping ω-clusters. Syncopation in (20a) has a different effect than in (20b), although the same duai C V grouping appears in both. Syncopation splits (20a), as shown in (21). The second
syllable is hopelessly ill-formed, with a semi-vowel onset and a consonantal nucleus. The structure must be repaired. The repairs (22a) and (22b) are equally simple. One produces dvis and the other days.

If nuclear structure is considered, it is clear that the repair (22a) is far simpler than the repair (22b), because no reorganization of syllable structure is needed. The complete derivation is:

The derivation (23), in which resyllabification is simple association, is considerably simpler than the corresponding derivation (8) proposed by Steriade, which requires “mora splitting” in resyllabification.

Finally, note that the resyllabification involved in pa-pat-úr → paptúr, discussed at the beginning of Section 3, is equally simple, just straightforward autosegmental association.

References


