Attenuated spreading in Sanskrit retroflex harmony

Abstract

Drawing on a two-million-word corpus of Sanskrit, two previously unrecognized generalizations are documented and analyzed concerning the morpho-prosodic conditioning of retroflex spreading (nati). Both reveal harmony to be attenuated across root boundaries (i.e. between a prefix and root or between members of a compound), in the sense that while harmony applies across these boundaries, when it does so, it accesses a proper subset of the targets otherwise accessible. This attenuation is analyzed here through the ‘ganging up’ of phonotactics and output-output correspondence in serial HG. The article also simplifies the core analysis of the spreading rule, primarily through recognizing FlapOut, an articulatorily grounded constraint.

Sanskrit exhibits a consonant harmony process called nati by which retroflexion spreads progressively and at any distance from a retroflex continuant trigger to a coronal nasal target (e.g. 1a–b), assuming that no consonantal coronal intervenes to block it (1c). A trigger can occupy any morphological position, including a prefix (1d).

(1) (a) √ɣaːgʱav-ena → [ɣaːgʱav-ena] ‘by the descendant of Raghu’
(b) √µg-na- → [µg-ṇa-] ‘broken’
(c) √atʱ-ena → [atʱ-ena] ‘by the chariot’
(d) pʰa-√fī-ṇoc-ti → [pʰa-fī-ṇoc-ti] ‘incites’

Nati has drawn the attention of linguists for nearly three thousand years. Among generative phonologists, it has played significant roles in treatments of harmony, (non-)iterativity, feature geometry, autosegmentalism, and prosodic phonology (§1), and continues to inform new developments. Recently, for instance, Jardine (2014) identified nati as one of only two known segmental (as opposed to tonal) processes in the world’s languages with the potential to be ‘unbounded circumambient’, that is, sensitive to unbounded contexts on both sides of the target (see §4). Hansson (2010: 189ff) identifies several respects in which nati is unusual among consonant harmony systems, including the non-overlap between triggers and target, the coronal blocking of a coronal harmony, the progressive directionality, and the (occasional) phrasal domain. One might add that prefixes rarely initiate harmony cross-linguistically (Baković 2000, Hyman 2002, Krämer 2003, Kenstowicz 2009).

The present article has two goals. First, it simplifies previous analyses of the core facts of nati, primarily through incorporating into the analysis a phonetic property of retroflex stops, namely, ‘flapping out’ (i.e. releasing in a more anterior position). Sanskrit is argued to be normal typologically in that its retroflex stops flap out, while its retroflex continuants do not. This constraint explains a number of at first glance disparate properties of nati, including its trigger set, non-iterativity, progressive directionality, and some aspects of blocking.

Second, drawing on a two-million-word corpus of Vedic and Epic Sanskrit, this article revisits the primary data, identifying and analyzing two previously unrecognized (including
by the grammars) morphological conditions on *nati*. Both independently reveal root boundaries to attenuate spreading, in the sense that harmony accesses fewer targets if it crosses a boundary. In particular, first, cross-boundary harmony never affects immediately post-plosive targets, whereas stem-internal harmony almost always does so (§3). Second, cross-boundary harmony rarely accesses targets in pre-retroflex position, whereas stem-internal harmony always does so (§4).

Both cases are analyzed in Harmonic Grammar (HG) through the ‘ganging up’ of the relevant independently motivated markedness constraint (*Tï or the OCP) with an output-output correspondence constraint, IDENT_{OO}([retro]), which requires derived forms to match their bases’ retroflexion. As a brief illustration of this principle, stem-internal *nati* almost always affects post-plosive targets (e.g. [√õug-ṇa-] ‘broken’, [√tõp-ṇu-] ‘be pleased with’), revealing that a pro-harmony constraint, say, SHARE outweighs *Tï. *Nati* also normally applies across root boundaries (e.g. [pṇa-√hi-ṇu-] ‘incite’, [pāḷj-√aṅk-ṇa-ṇam] ‘of the beds’); thus, SHARE > IDENT_{OO}. But when both of these situations arise simultaneously, as when harmony must cross a root boundary to reach a post-plosive target, *nati* fails (e.g. [pī-√aṅp-ṇu-] ‘attain’, [pṇa-√b̅aṅṇa-] ‘crushed’). This generalization is captured if the summed weight of *Tï and IDENT_{OO} exceeds that of SHARE.

This analysis is argued to be superior to other conceivable approaches in §5. For example, an Optimality Theory (OT) analysis, whether classical or serial, would require a conjoined constraint, entailing both a loss of generalization and empirical problems concerning locality (§5.2). An OT analysis in terms of morphologically indexed constraints (e.g. SHARE_{stem}) is also argued to be untenable (§5.1). A version of the analysis proposed in this article set in classical rather than serial HG is possible but pathological, and thus not pursued (§5.3). Finally, a stratal OT analysis is possible, but not without additional constraints, multiple re-rankings between levels, and potentially dubious morphological assumptions (§5.4).

1 The language and corpus

The basic facts surrounding *nati* ([n@ti]; English pronunciation ['n@ti]) have been recounted numerous times since antiquity. Pāṇini (c. 500–350 BCE) treats them in a set of 39 rules in the last chapter of the last book of his grammar, the Aṣṭādhyāyī (§8.4.1–39; see Böhtlingk 1887: 461–72, Vasu 1898: 1651–70). *Nati* is also discussed in the Prātiṣākhyaśas, ancient treatises on Vedic pronunciation (Wackernagel 1896: 188, Allen 1951: 940).

The term *nati*, literally ‘bending, curvature’ (Allen 1953: 66), was not used by Pāṇini, but rather appears in the Prātiṣākhyaśas (Rk-Pr. 5.61, Vājasaneyi-Pr. 1.42). It refers to tongue retroflexion as an articulatory process. To refer to the retroflexes as a class, the ancient phoneticians used a different term, mūrdhanya ‘cerebral’, from mūrdhān, the relevant passive articulator. The term *nati* sometimes appears in print erroneously with an initial retroflex, but is properly dental-initial, as in the Prātiṣākhyaśas, coming from a zero-grade nominalization (< *nm-티) of the root √nam ‘bend’, the same root found in ‘namaste’ (nam-as=te), literally ‘[a] bow [to] thee’. It does not, as the spelling *ṇati would suggest, mean something like ‘ṇ-ification’. While *nati* can in principle refer to any process of retroflexion, it is used here,


The language names used in this article, while standard, deserve comment, since different authors employ them with different degrees of specificity. First, ‘Sanskrit’ here refers to all of Old Indic (also known as Old Indo-Aryan). It is not used here to refer only to Classical Sanskrit, as it sometimes is elsewhere. Sanskrit in this broad sense can in turn be divided at the coarsest into two periods, the older ‘Vedic’ (c. 1500–600 BCE) and the younger ‘Classical’ (c. 600– BCE), the latter more closely conforming to Pāṇini’s rules (Masica 1993: 50–5). ‘Classical’ thus construed subsumes the two Sanskrit epics.

When this article cites corpus counts, they derive from the texts enumerated in Figure 1, all downloaded from the Göttingen Register of Electronic Texts in Indian Languages.1 The texts, arranged roughly by chronology (the Rg-Veda being the oldest extant Sanskrit text), are labeled according to period and genre. Abbreviations are given in parentheses. For example, ‘10v 1b 5e’ would mean that the form is attested sixteen times total in the corpus, ten of which occur in the Vedas, one in the Brāhmaṇas, and five in the epics. The corpus includes over two million words in total, roughly one third Vedic and two thirds Epic. Since the corpus is not exhaustive, additional forms from dictionaries, grammars, and other texts are also cited when relevant, though not included in corpus statistics.

The consonant and vowel inventories of Sanskrit are shown in Figures 2 and 3, respectively (e.g. Cardona 2003). While this article employs the IPA for citing data (though not for names of texts, technical terms, etc.), the IPA can be easily converted back to the standard romanization using these tables. IPA transcriptions below depart from these tables only in

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1 [gretil.sub.uni-goettingen.de](http://gretil.sub.uni-goettingen.de), accessed May 2014.
Period | Genre | Text | Word Count
--- | --- | --- | ---
Vedic | Vedas | (v) Rg-Veda | 164,767
| | | Sāma-Veda | 19,019
| | | Atharva-Veda | 85,021
Brāhmaṇas | (b) (Madhyamādīna) Šatapatha | 127,255
| | | Pañcaviṃśa | 42,700
| | | Gopatha | 31,267
| | | (Bāśkala) Kaušitaki | 39,060
Early Upaniṣads | (u) Brhadāranyaka | 16,502
| | | Chāndogya | 13,968
Epic | (e) Mahābhārata | 1,258,457
| | | Rāmāyaṇa | 213,773
| | | | Total: 2,011,789

Figure 1: Sources and abbreviations covered in the corpus reports below. Each is given with its period, genre, and orthographic word count.

giving the short low vowel as [a], as it is normally transcribed, despite its schwa-like quality. For the handful of vowels for which the Vedic and Classical values differ, the Classical values can always be assumed, as is standard practice. The letter anusvāra (m), usually said to be a kind of placeless but moraic nasal coda (cf. Japanese), is omitted from the figure.

<table>
<thead>
<tr>
<th>Labial</th>
<th>Dental</th>
<th>Retroflex</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
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<tbody>
<tr>
<td>Plosive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p [p]</td>
<td>t [t]</td>
<td>ṭ [ṭ]</td>
<td>c [c]</td>
<td>k [k]</td>
<td></td>
</tr>
<tr>
<td>b [b]</td>
<td>d [d]</td>
<td>ḍ [ḍ]</td>
<td>j [j]</td>
<td>g [g]</td>
<td></td>
</tr>
<tr>
<td>Fricative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[f]*</td>
<td>s [s]</td>
<td>ś [ṣ]</td>
<td>[x]*</td>
<td>h [h]</td>
<td>h [ɦ]</td>
</tr>
<tr>
<td>Nasal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m [m]</td>
<td>n [n]</td>
<td>ṅ [ṅ]</td>
<td>n [n]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l [l]</td>
<td>ɻ* [ɻ]*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhotic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v [v]</td>
<td></td>
<td>r [ɾ]</td>
<td>y [j]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Sanskrit consonant inventory, with standard Indologists’ transcription in italics followed by IPA. Asterisked phones are specifically Vedic, [f] and [x] being variant pronunciations of h. The chart includes phones usually assumed to be allophonic, viz., [n], [ŋ], [h], [f], [x], [l], and [l̰].

The rhotic, a retroflex continuant and by far the most common trigger of nati, is transcribed, with its syllabic variants, as [ɾ] here, though it may have varied with tapped or trilled [ɾ]. Whitney (1889: §24, §52), for one, identifies it as untrilled, noting, among other
things, that ‘[n]o authority hints at a vibration as belonging to it’, as might be expected for a trill, given the general articulatory detail commanded by the ancient phoneticians. Indeed, at least two ancient prescriptions seem to forbid trilling (barbaratā), one calling it excessive contact (atisparśa) and the other indelicate (asauskumārya) (Allen 1951: 54). Other possible but not strong hints at the smoothness of the rhotic include its frequent glide-like alternations in syllabicity (not unlike English) as well as its frequent confusions with the lateral (ibid. §53). Furthermore, as §2.2 elaborates, the fact that the rhotic initiates a domain of progressive retroflex spreading indicates that it does not ‘flap out’ into a more anterior position on its release. Since retroflex stops and flaps typically flap out, while retroflex fricatives do not, this diagnostic also points to a smooth rhotic.2

As the caption to Figure 2 implies, dental /n/ vs. retroflex /ŋ/ is a phonemic contrast in Sanskrit (cf. e.g. [pama] ‘drinking’ vs. [paṇa] ‘stake in a game’). Nevertheless, its functional load is low, the vast majority (over 80%) of tokens of [ŋ] being due to nati.3

<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th>Central</th>
<th>Back</th>
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<tbody>
<tr>
<td>High</td>
<td>i [i]</td>
<td></td>
<td>u [u]</td>
</tr>
<tr>
<td></td>
<td>i [iː]</td>
<td></td>
<td>ū [uː]</td>
</tr>
<tr>
<td>Mid</td>
<td>e [eː] ([aː]*</td>
<td>o [oː] ([aː]*</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>a [a]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diphthong</td>
<td>ai [ai] ([aːi]*</td>
<td>au [au] ([aːu]*</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Sanskrit vowel and syllabic consonant inventory. As before, asterisked transcriptions are Vedic pronunciations. All items can be considered phonemic.

This article uses final hyphens in citing words only when they would be hyphenated in standard romanization. The lack of a hyphen does not imply that the word could stand alone as such. For example, the word nati itself could never occur as nati without an ending (e.g. nominative singular [nati-h]), but is normally cited as nati, not nati- or natih. Internal hyphens, which are often problematic, are supplied freely when convenient, but always when the morphology is relevant to the application of nati. As is also common practice in citing...

2While generally recognized to be retroflex by ancient and modern sources, some (but not all) ancient phonetic treatises suggest instead an alveolar place for the rhotic (Allen 1951: 54f). As Allen clarifies, even if it were phonetically alveolar (in some dialects), it is clearly functionally retroflex. See Cathcart (2012) on why an alveolar rhotic might pattern with the retroflexes phonologically.

3The present corpus includes 122,680 tokens of [ŋ]. Of these, 82.4% occur in a nati context, though this figure includes occasional false positives in which underlying /ŋ/ happens to occur in nati context and excludes occasional false negatives in which nati obtains across a word boundary.
2 Triggers, targets, blockers, and the importance of flapping out in their analysis

2.1 Preliminary data

_Nati_ is a progressive (left-to-right) consonant harmony. Its triggers are all and only the non-lateral retroflex continuants, \{\{õ õ õ õ õ\} (on the status of \{l l\} as (non-)triggers, which has not previously been discussed, see §2.3). Its lone target is the dental /n/, which becomes retroflex [ŋ]. Harmony obtains across an arbitrarily long string of segments so long as no blocker intervenes. Blockers (also called opaque segments) comprise the consonantal (i.e. excluding [j]) coronals. These basic properties are summarized in (2). The domain is typically the word (though occasionally larger or smaller). For the most part (though see §3), harmony is blind to morphology. For example, a rhotic in a prefix will target a visible nasal in a root, suffix, infix, or other prefix, a rhotic in a suffix will target subsequent suffixes, and so forth. Syllabic position is also irrelevant. _Nati_ applies only if the target immediately precedes a vowel, glide, or nasal; on this restriction, see §2.3.

(2) Directionality: progressive
Triggers: \{\{t \{t^h d \{d^h n^* s l l^*\}\}\\} Target: \n Outcome: \ŋ Blockers: consonantal coronals, i.e.
• dentals \{t \{t^h d \{d^h n^* s l l^*\}\}\}
• retroflexes \{\{õ õ õ õ õ\}\}
• palatals \{c c^h j j^* p^* c\}

*Unattested or ambiguous as blockers; see text.

As an illustration, consider the instrumental singular suffix /-e:na/ (see also e.g. Hansson 2010:179ff for a different presentation of the basic data). When attached to a stem lacking a trigger, it surfaces as such, as in (3). (The ‘vs. 0’ addendum to a corpus citation makes it explicit that no counterexample is found in the corpus; in general, however, patterns suggested by example sets are entirely regular unless otherwise noted.) When the stem contains an (unblocked) trigger, the suffix undergoes _nati_, as shown in (4).
As mentioned, harmony is blocked by an intervening coronal. This subsumes the dental, retroflex, and palatal series, with the one exception of the palatal glide /j/, which is always transparent (as in (4-b, g) above). Some blockers are exemplified in (5). Items (e–f) also reinforce that retroflex stops do not serve as triggers (see also (3) (c–d) above).

## Blockers

**3**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>kām-enā 'by desire'</td>
<td>v10 b3 e37 vs. 0</td>
</tr>
<tr>
<td>(b)</td>
<td>pad-enā 'by step'</td>
<td>v2 b5 vs. 0</td>
</tr>
<tr>
<td>(c)</td>
<td>baṇ-enā 'by arrow'</td>
<td>e66 vs. 0</td>
</tr>
<tr>
<td>(d)</td>
<td>mudhanā 'by the stupid (one)'</td>
<td>e6 vs. 0</td>
</tr>
<tr>
<td>(e)</td>
<td>gaṇ-enā 'by elephant'</td>
<td>v10 b3 e37 vs. 0</td>
</tr>
<tr>
<td>(f)</td>
<td>jōg-enā 'by means'</td>
<td>e37 vs. 0</td>
</tr>
<tr>
<td>(g)</td>
<td>jéna 'by which/whom'</td>
<td>v212 b62 u6 e769 vs. 0</td>
</tr>
<tr>
<td>(h)</td>
<td>guś-enā 'by cave'</td>
<td>e6 vs. 0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>nañ-enā 'by man'</td>
<td>e18 vs. 0</td>
</tr>
<tr>
<td>(b)</td>
<td>manuṣ-enā 'by human'</td>
<td>e20 vs. 0</td>
</tr>
<tr>
<td>(c)</td>
<td>ḍhām-enā 'by dharma'</td>
<td>b1 u1 e295 vs. 0</td>
</tr>
<tr>
<td>(d)</td>
<td>cīmm-enā 'by horn'</td>
<td>e4 vs. 0</td>
</tr>
<tr>
<td>(e)</td>
<td>qaṅga-enā 'by the Rāghava'</td>
<td>e28 vs. 0</td>
</tr>
<tr>
<td>(f)</td>
<td>viśkamb-enā 'by span'</td>
<td>e3 vs. 0</td>
</tr>
<tr>
<td>(g)</td>
<td>tijang-enā 'by tripartite'</td>
<td>e1 vs. 0</td>
</tr>
<tr>
<td>(h)</td>
<td>puṣpaug-enā 'by the heap of flowers'</td>
<td>e1 vs. 0</td>
</tr>
</tbody>
</table>

**4**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>nā-s-enā 'by man'</td>
<td>(e18 vs. 0)</td>
</tr>
<tr>
<td>(b)</td>
<td>manuṣ-s-enā 'by human'</td>
<td>(e20 vs. 0)</td>
</tr>
<tr>
<td>(c)</td>
<td>ḍhām-s-enā 'by dharma'</td>
<td>(b1 u1 e295 vs. 0)</td>
</tr>
<tr>
<td>(d)</td>
<td>cīmm-s-enā 'by horn'</td>
<td>(e4 vs. 0)</td>
</tr>
<tr>
<td>(e)</td>
<td>qaṅga-s-enā 'by the Śūdrā'</td>
<td>(e28 vs. 0)</td>
</tr>
<tr>
<td>(f)</td>
<td>viśkamb-s-enā 'by span'</td>
<td>(e3 vs. 0)</td>
</tr>
<tr>
<td>(g)</td>
<td>tijang-s-enā 'by tripartite'</td>
<td>(e1 vs. 0)</td>
</tr>
<tr>
<td>(h)</td>
<td>puṣpaug-s-enā 'by the heap of flowers'</td>
<td>(e1 vs. 0)</td>
</tr>
</tbody>
</table>

**5**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>ḍh-enā 'by chariot'</td>
<td>v63 b11 e111 vs. 0</td>
</tr>
<tr>
<td>(b)</td>
<td>paś-s-enā 'by the antelope'</td>
<td>(e18 vs. 0)</td>
</tr>
<tr>
<td>(c)</td>
<td>fiḍ-daj-enā 'by heart'</td>
<td>(v2 b6 u3 e30 vs. 0)</td>
</tr>
<tr>
<td>(d)</td>
<td>viṣal-enā 'by the wicked man'</td>
<td>(e1 vs. 0)</td>
</tr>
<tr>
<td>(e)</td>
<td>viṣa-enā 'by Virātā'</td>
<td>(e14 vs. 0)</td>
</tr>
<tr>
<td>(f)</td>
<td>qaṇḍ-enā 'by Garuḍa'</td>
<td>(e5 vs. 0)</td>
</tr>
<tr>
<td>(g)</td>
<td>qaṇj-enā 'by royal'</td>
<td>(e34 vs. 0)</td>
</tr>
<tr>
<td>(h)</td>
<td>maṇi-c-enā 'by the Mārīca'</td>
<td>(e4 vs. 0)</td>
</tr>
</tbody>
</table>

**6**

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<tr>
<th>Item</th>
<th>Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>kṣiṇ-ēnā 'by milk'</td>
<td>v1 e8 vs. 0</td>
</tr>
<tr>
<td>(b)</td>
<td>caṇi-enā 'by the body'</td>
<td>v1 b1 e33 vs. 0</td>
</tr>
</tbody>
</table>
Finally, the dental nasal cannot occur in blocking position because it itself undergoes harmony, becoming \[\tilde{n}\]. In such cases (as with underlying /\eta/), which is not a trigger), harmony does not spread beyond the undergoing /\tilde{n}/ to the next /\tilde{n}/; see (8). Thus, it is also possible, though not necessary, to consider dental and retroflex nasals to be blockers.

(7) (a) \textipa{põa\textashape {-}ê\textashape -êna} ‘by breath’ (v15 b57 u17 e11 vs. 0)  
(b) \textipa{ksa\textashape -n-êna} ‘by an instant’ (b1 e108 vs. 0)  
(c) \textipa{hi\textashape -\textashape n\textashape -j-êna} ‘by gold’ (v2 b3 e4 vs. 0)  
(d) \textipa{põ\textashape -ja\textashape -n\textashape -j-êna} ‘by introductory’ (b11 vs. 0)

2.2 Core analysis

The facts introduced to this point are now analyzed before turning to additional complications. A key and often overlooked component of their explanation, it is maintained here, concerns ‘flapping out’ (Ladefoged 1964), a property of retroflex stops (including nasals) by which the tongue tip moves forward during the closure phase of the segment, releasing into a more anterior position (ibid., Bhat 1973:47, Dave 1977, Simonsen et al. 2000, Dart 1991, Shalev et al. 1993, Butcher 1995, Krull et al. 1995, Steriade 1995:5f, Spajić et al. 1996, Dart and Nihalani 1999, Flemming 2003, Hamann 2003, Boersma and Hamann 2005, Arsenault 2012). As such, retroflex stops are contour segments, so to speak, and could be narrowly transcribed as such, e.g. narrow \([\text{>út}]\) for broad \([\text{ú}]\) (Boersma and Hamann 2005:21ff). The narrower transcription does not imply that the release of a retroflex stop is homophonous with that of a dental stop; it indicates only that the release enters an anterior (e.g. alveolar) configuration (Steriade 1995: 6).

The acoustic consequence of flapping out is that the F3 depression associated with retroflexion is realized more prominently in the VC than CV transition. Flapping out has been documented palatographically for retroflex stops of Australia, Scandinavia, and South Asia (including daughters of Sanskrit such as Hindi and Gujarati; op. cit.), and is further supported by their phonological behavior, particularly their better cueing by left-hand context (e.g. Steriade 1995, Hamann 2003). But flapping out does not apply to all retroflexes. As Boersma and Hamann (2005: 18) clarify, while it is a typical, perhaps universal, property of retroflex stops, it is not found in retroflex fricatives and affricates. The absence of flapping out among fricatives is likewise corroborated by their phonology, particularly their frequent interactions with following vowels (ibid.).

It is therefore assumed on both typological and internal grounds that the Sanskrit retroflex stops flap out, while the retroflex fricative does not. Internal grounds include the behavior of stops vs. fricatives in \textit{nati}, as explained presently, as well as their licensing requirements: Retroflexion is contrastive for stops only in post-vocalic position (with marginal exception due to onomatopoeia and dialect borrowing), while the retroflex fricative is more broadly distributed (e.g. \textipa{[sa\textashape t]} ‘six’ vs. \textipa{[s\tilde{a}\textashape t]} ‘being’). Thus, \textipa{[s]} is narrowly \textipa{[s]}, not \textipa{[\textashape s\textashape s\textashape s]}. Note that retroflex continuants also possess stronger internal cues to their anteriority, which could also support their broader licensing.

While the typology is less clear for retroflex rhotics, internal grounds support treating Sanskrit \textipa{[\textashape u]} like \textipa{[s]} in terms of flapping out. Aside from its comparably broad licensing (e.g. it
occurs word-initially, where it remains retroflex, as confirmed by nati), the fact that both [ɨ] and [s] serve as triggers for progressive retroflexion is itself prima facie evidence of their lack of flapping out, given that the consensus holds nati to be a spreading harmony (e.g. Flemming 1995b, Gafos 1999, Ni Chios´ain and Padgett 2001, Rose and Walker 2004, Hansson 2010, Jurgec 2011). That the mechanism of nati is strictly local spreading (i.e. gestural extension) as opposed to agreement across non-undergoing interveners is supported by the existence of blockers, progressive directionality, disjoint triggers and target, and the (occasional) phrasal domain (op. cit., especially Hansson 2010: 189ff). In order to initiate a progressive domain of retroflex spreading, the retroflex continuants cannot flap out. This asymmetry between stops and continuants is summarized in (8). 4 In what follows, retroflex stops will continue to be given their broad transcriptions, with the understanding that they flap out.

\[
\begin{array}{|c|c|c|c|}
\hline
\text{onset (V-to-C)} & \text{offset (C-to-V)} & \text{broad} & \text{narrow} \\
\hline
\text{retroflex continuants} & \text{posterior} & \text{posterior} & [s] & [s] \\
\text{retroflex stops} & \text{posterior} & \text{anterior} & [\tilde{\eta}] & [\tilde{\eta}] \\
\text{dentals} & \text{anterior} & \text{anterior} & [n] & [\tilde{n}] \\
\hline
\end{array}
\]

The constraint enforcing flapping out in stops is here called FlapOut. Loosely speaking, this constraint requires every retroflex coronal stop to have an anterior offset. Coronal is specified because non-coronal stops can link to [retroflex] on this analysis (as when retroflexion spreads through them), and non-coronal retroflexes such as [k] are not accompanied by flapping out. In terms of autosegmental spans, the constraint, as in (9), demands that every retroflex coronal stop coincide with the right edge of its span of retroflexion.

\[
\text{(9) FlapOut: Penalize every retroflex coronal stop that is non-final in its span of retroflexion.}
\]

One other caveat is that only released retroflex stops flap out. A cluster such as /\tilde{\eta} \tilde{\eta}/, for instance, is presumably realized as [\tilde{\eta} \tilde{\eta} t], not [\tilde{\eta} \tilde{\eta} \tilde{\eta}]. The latter, which contains a dental stop between two retroflex stops, can be ruled out by other constraints (much as, say, [kqk] would be). GEN also produces candidates in which such clusters share their [retroflex] feature. In such candidates, the no-line-crossing convention and (possibly GEN-encoded) NoGap, which forbids discontinuous spans (Kiparsky 1981, Archangeli and Pulleyblank 1994, Walker 2014), together ensure that the first part cannot flap out. As suggested by Hamann (2003) and Boersma and Hamann (2005), a constraint along the lines of FlapOut is potentially hardwired in GEN and, if so, unnecessary to include in CON. Here it is treated as an undominated constraint for expository purposes.

Next, a constraint is required to motivate the harmony, whose mechanism appears to be strictly local spreading as opposed to long-distance agreement with intervening non-undergoers (op. cit.). Several constraint-based approaches to spreading can be found in the literature, including Align, Spread, Specify, *A-Span, Agree, and ∀-Harmony; see Wilson (2003) and McCarthy (2009, 2011) for overviews and pathologies of these proposals.

\[4\text{As mentioned, non-triggering by retroflex laterals is treated in §2.3.}\]
Here, SHARE(retro) is employed, following McCarthy’s (ibid.) schema, as in (10).

(10) \textit{SHARE}([\text{retro}]) (abbreviated \textit{SHARE}): For every pair of adjacent segments, assign a penalty if they are not both linked to the same token of [retroflex].

Given the autosegmental setting, the spreading feature is often taken to be privative, as with [retroflex] here, agreeing with recent analyses of Sanskrit (e.g. Ní Chiosáin and Padgett 2001) and other languages (e.g. McCarthy 2009, 2011, Walker 2014). This assumption is not crucial here; if binary [anterior] or [TTCO] (Tongue Tip Constriction Orientation; Gafos 1999) were instead employed, the constraint definitions could be recalibrated. Also following McCarthy (ibid.), \textit{SHARE}([\text{retro}]) is taken to be violated by a pair of adjacent segments in which neither segment is linked to [retroflex].

A competing faithfulness constraint, \textit{IDENT}([\text{retro}]) (11), penalizes changing a segment’s anteriority. In the tableaux, this constraint is taken to be violated by /\text{n}/ \rightarrow [\text{n}] even though the latter, assuming it flaps out, retains an anterior release. At any rate, since \textit{IDENT} is not an active constraint here, this detail of formulation is irrelevant.

(11) \textit{IDENT}([\text{retro}]) (abbreviated \textit{IDENT}): Penalize a segment whose anteriority differs from its input correspondent.

The constraint-based framework employed here, for reasons to be clarified in §5, is serial Harmonic Grammar (SHG; Pater 2012, Mullin 2011, Kimper 2011), which is the same as Harmonic Serialism (McCarthy 2009, 2011) except set in Harmonic Grammar (HG; Legendre et al. 1990, Smolensky and Legendre 2006, Pater 2009b, Potts et al. 2010) rather than Optimality Theory (OT; Prince and Smolensky 1993/2004, McCarthy and Prince 1993). SHG is like classical OT and HG in that each language comes with a fixed ranking or weighting of constraints. Unlike classical OT and HG, however, only one operation (e.g. addition or deletion of an association line) is permitted per GEN/EVAL cycle, and the output of each evaluation is recycled as an input to a new evaluation until no more changes are optimizing, at which point the derivation converges. Furthermore, since it is serial HG rather than OT, constraints have real-valued nonnegative weights and the violation score of a candidate is the weighted sum of its violations, which are taken to be nonpositive integers. The candidate with the greatest harmony wins. On harmony in HS, as well as more general background on the theory, see McCarthy (2009, 2011) and references therein.

Tableau series (12) illustrates the derivation of [\text{\textipa{\text{\textalpha\text{\textalpha}}}}] ‘delight’ from (possible input) /\text{\textipa{\text{\textalpha\text{\textalpha}}}}/. Parentheses indicate spans of retroflexion, i.e., strings in which every segment is linked to the same token of [retroflex]. Retroflexion is redundantly marked on every segment within the span, using an underdot if the IPA lacks a symbol. Since only one operation is permitted per step, the span grows one segment at a time until it reaches target /\text{n}/, at which point it cannot spread any further without violating higher-weighted FLAPOUT. Reducing or deleting the span is never optimizing. In Step 1, candidate (c), which removes the retroflex span altogether by anteriorizing the rhotic, violates \textit{SHARE} three times, one for each pair of adjacent segments, following McCarthy’s definition and use of that constraint. When the most faithful candidate wins, as in Step 3, the derivation converges.
The simple weighting of FlapOut > Share, while not yet the full story, already captures several core features of nati. First, it captures the stop/continuant asymmetry in triggering without specifying it in the harmony apparatus, as reinforced by (13) with [mu:ŋʰ-ema] ‘by the fool’. Because retroflex stops flap out (not only in Sanskrit, but perhaps universally), they cannot trigger. As (13) also illustrates, this analysis predicts regressive retroflexion insofar as no blocker interferes (blocking is treated below). No harm comes from this prediction, for two reasons. First, if it were incorrect, one could add a constraint preventing leftward spreading such as Initial (feat) (McCarthy 2004, 2009: 9). But the prediction is not incorrect, at least not on language-internal grounds. Sanskrit orthography distinguishes retroflexion only in coronals. It follows that retroflexion in non-coronals is effectively hidden structure (granting also the impossibility of instrumental study) and free to follow from analytical and typological considerations (Allen 1951: 940ff, Steriade 1995: 51).
Second, the analysis predicts the directionality of *nati* without specifying it in the harmony apparatus. Consider /vamaa/ ‘monkey’ in (14). Retroflexion spreads onto the vowels surrounding /a/, but cannot affect the preceding /n/, given that [n] continued by retroflexion would violate FLAPOUT. Thus, the system embodies the prediction that retroflex spreading harmony targeting stops could only possibly be progressive, as in Sanskrit. Regressive retroflex spreading harmony is attested, as in Kinyarwanda (Walker and Mpiranya 2005, Walker et al. 2008), but its targets are continuants, not stops, consistent with this proposal. This proposal also does not make any predictions about retroflex harmony by correspondence as opposed to spreading (see Arsenault 2012). When multiple orders of operations are tied, only one path is illustrated.

(14)

<table>
<thead>
<tr>
<th>Step 1. vama(a)</th>
<th>FlapOut</th>
<th>Share</th>
<th>Ident</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. vama(ãa)</td>
<td>-21</td>
<td>-4</td>
<td>-1</td>
</tr>
<tr>
<td>b. vama(ãã)</td>
<td>-25</td>
<td>-5</td>
<td></td>
</tr>
<tr>
<td>c. vama(ãã)</td>
<td>-21</td>
<td>-4</td>
<td>-1</td>
</tr>
</tbody>
</table>

Third, as (15) illustrates (for [kṣan-ena] ‘by the instant’), the analysis captures the fact that harmony terminates when it reaches a target, rather than continuing on to yet
another target. In other words, the non-iterativity of harmony is derived from an independent property of the language rather than implemented as an *ad hoc* parameter or constraint.5

(15)

<table>
<thead>
<tr>
<th>Step 1. k(ʂ)an-ena</th>
<th>FlapOut</th>
<th>SHARE</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (kʂ)an-ena</td>
<td>-26</td>
<td>-5</td>
<td>-1</td>
</tr>
<tr>
<td>b. k(ʂ)an-ena</td>
<td>-26</td>
<td>-5</td>
<td>-1</td>
</tr>
<tr>
<td>c. k(ʂ)an-ena</td>
<td>-30</td>
<td>-6</td>
<td></td>
</tr>
</tbody>
</table>

Steps 2 and 3 omitted.

Step 4. (kʂan)e:na

| a. (kʂan)e:na | -15 | -3 |       |
| b. (kʂan)œ:na| -17 | -2 | -1   |

Fourth, harmony is asymmetric in the sense that an anterior continuant does not cause an unblocked retroflex nasal to become anterior (e.g. /sa-ɡaïa/ \(\rightarrow\) [sa-ɡaŋa], *[sa-ɡana] ‘along with troops’). This follows from the statement of SHARE, which favors the spreading of retroflexion, but not of anteriority. While the present ranking predicts *[saɡaŋa] for this input, the prevention of segments such as /s/ from undergoing harmony is treated in (18). The point here is that anterior continuants are not triggers like retroflex ones.

Fifth, and finally, FlapOut covers blocking by retroflex stops (e.g. [vi̍ŋaː-t-ena] ‘by Virāṭa’). Retroflex continuants (e.g. [kşiː-t-ena] ‘by milk’) are also handled appropriately, since the retroflex span is free to spread to /n/ regardless of the multiplicity of triggers. This leaves only blocking by palatals (except /j/) and dentals. The former can be motivated biokinematically (and hence potentially by GEN), in that a palatal articulation is incompatible (in Sanskrit, if not universally) with tongue tip retroflexion (Gafos 1999:213f, 223f; cf. Hamann 2003, Flemming 2003, Boersma and Hamann 2005). As Gafos (1999: 214) also emphasizes, this articulatory incompatibility naturally fails to extend to the palatal vocoid, which involves less arching of the tongue body.

At this point, then, FlapOut > SHARE remains incomplete concerning the core data only in that (a) it fails to restrict the targets to /n/ as opposed to the other anteriors, viz. /t th d dʰ s l l/, and (b), relatedly, it fails to capture blocking by anteriors, which are

---

5A common refrain of rule-based analyses of *nati* purports to derive its non-iterativity from the fact that a retroflex nasal, the outcome, does not otherwise serve as a trigger, without relating it to any phonetic property (cf. e.g. Johnson 1972, Howard 1973, Anderson 1974, Ringen 1976, Kiparsky 1985). On the present analysis, it is no coincidence that the retroflex nasal neither triggers nor propagates, as both are motivated by FlapOut. But the present analysis does not relate the (non)iterativity of a harmonic process to whether or not its trigger(s) and target(s) overlap. It predicts a harmony to be possible in which a segment undergoes and propagates the harmony without triggering it. Indeed, if *nati* is analyzed as strictly local spreading, then this prediction is borne out even by *nati*: A segment such as [k] undergoes and propagates without being a trigger. As a reviewer notes, other cases of non-triggers propagating harmony can be found in Baiyina Orochen (Kaun 2004) and Seto (Kiparsky and Pajusalu 2003).
thus far predicted to undergo en route to a target just like non-coronals. For example, the correct output for /õas-e:na/ is [õas-e:na] ‘by flavor’, in which /s/ both blocks and fails to undergo retroflexion. But the ranking so far generates *[õas-e:na], in which /s/ is both transparent to and undergoes retroflexion.

Following Ní Chiosáin and Padgett (1997: 36; also Ohala and Ohala 1993, Padgett 1995, Gafos 1999, Steriade 1995, 2009), place is generally less faithful for nasals than for other consonants, particularly obstruents. For one, nasals are more likely to undergo assimilation, all else being equal. Moreover, diachronically, a contrast between dental and retroflex is less robust for nasals than for plosives, as suggested by the daughters of Sanskrit that lost the /n ∼ ñ/ contrast while preserving phonemic retroflexion in the plosives (e.g. Bengali, Nepali, Hindi dialects; Masica 1993). A solution, then, is to rank SHARE below a faithfulness constraint that prevents retroflexion from spreading onto oral coronals, e.g. IDENT_{OrCor} in (16). This general strategy of Faith[specific] >> Harmony >> Faith[general] is not new here but employed by all prior constraint-based analyses of nati (see below) to implement the asymmetry between /n/ and other dentals.

(16) \text{IDENT}_{\text{[cor] \text{-} \text{nas}}}([\text{retro}]) (\text{abbreviated IDENT}_{\text{OrCor}}): \text{Penalize an oral coronal whose anteriority differs from its input correspondent.}

In essence, while this approach assumes that [retroflex] can link to any segment (except perhaps the palatals), its interaction with coronals, especially oral coronals, is afforded special faithfulness due to its greater perceptibility on them. Tongue tip orientation during non-coronals is less tightly regulated. Gafos (1999: 222) employs Faith(Tongue Tip Constriction Orientation, Obstruent) to this end, but this constraint fails to account for blocking by /l/ and for the transparency of non-coronal obstruents. The analysis of Ní Chiosáin and Padgett (1997: 36) is dispersion/contrast-based, evaluating paradigms as candidates (cf. Flemming 1995a). The approach here is more classical, and predicts blocking to be independent of the contrastive status of retroflexion in coronals. In Sanskrit, after all, all coronals block, but retroflexion is contrastive for only a subset of them. In particular, there is no anteriority contrast in the laterals in any period, but laterals block in all periods (as do the palatals, for which retroflexion is moot). While one could still maintain that laterals block because retroflexion is contrastive for some coronals in Sanskrit, or because retroflexion is a possible contrast for laterals typologically, invoking contrast at all is unnecessary. The greater perceptibility of retroflexion differences in coronals, especially oral coronals, can be projected onto faithfulness constraints (cf. Steriade 2009). While this explanation still invokes dispersion in some sense, it does not require evaluating paradigms as candidates.

Derivation (17) illustrates both blocking of harmony by an oral coronal and failure of the same oral coronal to undergo harmony. Derivation (18) shows that anticipatory harmony to a coronal continuant is also properly ruled out.
To summarize thus far, the ranking for basic nati, including its trigger and target sets, directionality, non-iterativity, retroflex-anterior asymmetry, and transparent vs. blocking segments, is depicted as a Hasse diagram in (19). As mentioned above, FlapOut might be part of GEN, and if so omitted here.

This analysis improves upon previous constraint-based analyses of nati (full OT analyses being offered in Ní Chiosáin and Padgett 1997, 2001 and Gafos 1999; cf. also sketches in Steriade 1995 and Jurgec 2011). First, the proposed pro-harmony constraint is the simplest, merely stating the feature that spreads. The constraint says nothing about the set of triggers, targets, or directionality; all of these properties fall out from interaction with other relatively simple and independently motivated constraints. Compare the pro-harmony constraints in (20)–(23), all of which include one or more features of the triggers and/or target (viz. continuancy and/or coronality), as well as directionality.

(17)

Step 1. (q)as-ena

<table>
<thead>
<tr>
<th></th>
<th>FlapOut</th>
<th>IDENT&lt;sub&gt;OrCor&lt;/sub&gt;</th>
<th>SHARE</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

Step 2. (q)a-se:na

<table>
<thead>
<tr>
<th></th>
<th>FlapOut</th>
<th>IDENT&lt;sub&gt;OrCor&lt;/sub&gt;</th>
<th>SHARE</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>-20</td>
<td></td>
<td>-4</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>-22</td>
<td></td>
<td>-1</td>
<td>-3</td>
</tr>
</tbody>
</table>

(18)

Step 1. sa-ga(η)a

<table>
<thead>
<tr>
<th></th>
<th>FlapOut</th>
<th>IDENT&lt;sub&gt;OrCor&lt;/sub&gt;</th>
<th>SHARE</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>-21</td>
<td></td>
<td>-4</td>
<td>-1</td>
</tr>
<tr>
<td>b.</td>
<td>-27</td>
<td>-1</td>
<td>-4</td>
<td>-1</td>
</tr>
</tbody>
</table>

Steps 2 and 3 omitted.

Step 4. s(agaη)a

<table>
<thead>
<tr>
<th></th>
<th>FlapOut</th>
<th>IDENT&lt;sub&gt;OrCor&lt;/sub&gt;</th>
<th>SHARE</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>-10</td>
<td></td>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>-12</td>
<td></td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

(20) **Tip Position:** ‘A nasal apical maintains the same tip position, raised or lowered, as a preceding continuant apical’ (Steriade 1995: 51)
(21) ALIGN-R([retroflex], C): ‘Align any [retroflex] feature contained in a [+continuant] segment $S_m$ to a consonant $S_n$, where $n > m$’ (Ní Chiosáin and Padgett 1997: 36)

(22) HARMONY(TTCO = [retroflex], trigger = [+continuant]) [in which TTCO refers to Tongue Tip Constriction Orientation and HARMONY is defined essentially as ALIGN-R] (Gafos 1999: 218–23)

(23) ALIGN-R(p-phrase, [-anterior], [+coronal]) (Jurgec 2011: 23)

In the present analysis, the interaction of SHARE and FLAPOUT captures several at first glance disparate properties of nati, including the restriction of triggers to continuants, the progressive directionality (given that the target is a stop), the blocking by retroflex stops, and the non-iterativity of spreading, in the sense that harmony cannot spread through the first eligible target to any following target.

The celebrated non-iterativity of nati (see e.g. Kiparsky 1985:113, Gafos 1999:213, Kaplan 2008:21, Hansson 2010:190) is here an artifact of the target being a stop. In other constraint-based analyses, non-iterativity is stipulated or left unanalyzed (see also footnote 5 on a common rule-based approach). It is stipulated through a dedicated, rankable constraint in Jurgec (2011: 23) and through alignment directly to the target (as opposed to a domain edge) in Ní Chiosáin and Padgett (1997: 36). As explained by Hansson (2010: 186–8), the analysis of Gafos (1999) fails to account for non-iterativity, and alignment-to-target analyses fail to properly handle blocking, at least given the vague formulation of target selection in (21). The analysis here not only covers non-iterativity, but requires it of spreading-driven retroflex harmonies targeting stops. A hypothetical version of Sanskrit with otherwise the same phonetics but iterative nati, or nati feeding another progressive retroflexion, could not exist. At the same time, if the target of retroflexion is a continuant, non-termination and feeding are predicted. Indeed, this prediction is borne out by Sanskrit: Consider ruki, another rule of progressive retroflexion, by which a rhotic, velar, or non-low vowel causes immediately following /s/ to become retroflex (Selkirk 1980, Beguš 2012). Ruki, as predicted, invariably feeds nati, as in /uṣ-ana/ → [uṣ-ana] ‘sprinkling’, in which the rhotic first triggers retroflexion in the sibilant, which in turn triggers retroflexion in the nasal (recall that [s] would otherwise block nati). This is possible because the target of ruki retroflexion is a continuant, unlike the target of nati retroflexion.

While this section has treated the basic properties of nati, including its triggers, targets, blockers, directionality, and non-iterativity, all of which are known in the phonological literature, some additional complications are documented and analyzed in §3–4.

2.3 Addenda concerning the basic rule

Two details concerning the basic rule are yet to be addressed. First, the triggers for nati are usually reported to be the retroflex continuants, which include {õ, ū, ṽ, ṭ}. But the Vedic inventory, as Figure 2 suggests, also includes laterals [ḷ] and [ḷʱ], presumably also retroflex continuants. They appear exclusively as allophones of /d/ and /dʱ/, respectively, in intervocalic position in certain Vedic texts. Judging by 45 diagnostic tokens in the present corpus, retroflex laterals never trigger nati.
Possible causes for this failure include the following. First, it could be synchronic opacity, with lateralization counterfeeding \textit{nati}. Second, it could be that the apparent opacity is not synchronous but a historical artifact. Under this scenario, at the time of composition, the stops would have been pronounced as stops. At some later point in the transmission of the text, lateralization would occur, but without retriggering \textit{nati}, either because \textit{nati} had lost productivity, or because the nasals’ anteriority was orthoepically fixed. Finally, it is possible that the class of triggers was synchronically not the retroflex continuants, but the central retroflex continuants, potentially with phonetic motivation. Given the laterals’ shallow origin in stops, for instance, perhaps they continued to flap out in articulation, in which case they could not trigger. In any case, given the rarity of these allophones and the irrelevance of this issue to the remainder of this article, these questions are left open.

Second, \textit{nati} is usually reported to apply only if the target immediately precedes a vowel, glide, or nasal, i.e., a non-liquid sonorant. As Schein and Steriade (1986: 720–2) motivate (also Hansson 2010: 183), failure before a liquid, fricative, or word boundary follows from general phonotactics independent of \textit{nati}, such as word-final neutralization. Only non-application before a plosive (e.g. /ca-t-a-n-ti/ → [ca-t-a-n-ti] ‘wander (3pl)’) requires further comment, as retroflex nasal-plosive clusters are otherwise permitted (e.g. /p\textsuperscript{h}a\textsuperscript{t}a/ → [p\textsuperscript{h}a\textsuperscript{t}a] ‘spring (pass. part.)’). On the present analysis, failure in [ca\textsuperscript{t}anti] is already handled by IDENT\textsubscript{OrCor}, which preserves [t] as such, outranking the imperative to spread (other run-of-the-mill constraints, such as CODA\textsubscript{COND} in McCarthy 2008, proscribe heterorganic *[nt]). On the other hand, IDENT\textsubscript{OrCor} alone erroneously predicts /t/ to be preserved as such in /p\textsuperscript{h}a\textsuperscript{t}a/. One solution is to introduce a faithfulness constraint dominating IDENT\textsubscript{OrCor} such as MAX([\textit{retro}]), which penalizes deleting a token of retroflexion (cf. also directional IDENT; Pater 1999, Rose and Walker 2004, 2011, Walker 2014). With MAX([\textit{retro}]) weighted highly (e.g. 8 here), as long as CODA\textsubscript{COND} > IDENT, [nt] is forced over [nt] for /\textit{nt}/.

### 3 Boundary attenuation I: post-plosive targets

One aspect of \textit{nati} often omitted from generative discussions is that while velars and labials are normally transparent, as illustrated in (4) above, they often block when immediately preceding the target nasal. For example, consider the verb stem [p\textit{t}-\\sqrt{\textit{ap}}-] ‘attain’ (from preverb [p\textit{t}\textsuperscript{a}] + root \sqrt{\textit{ap}}). \textit{Nati} applies without exception whenever the target nasal is post-vocalic, as in (24) and numerous similar examples. But when the nasal immediately follows the final [p] of the stem, as in (25), \textit{nati} always fails. This failure is not, moreover, a function of the [\textit{nu}]/[\textit{no}:] suffix (class five present stem formative), as (26) illustrates using the same preverb and suffix but vowel-final root.

\begin{align*}
(24) & \quad (a) \quad p\textit{t}-\sqrt{\textit{ap}}-\textit{a} \quad & \text{‘attaining’} & \quad (b1 \ e5 \ vs. \ 0) \\
& \quad (b) \quad p\textit{t}-\sqrt{\textit{ap}}-\textit{a} \texti{\textsuperscript{ji}} \quad & \text{‘to be attained’} & \quad (e2 \ vs. \ 0) \\
(25) & \quad (a) \quad p\textit{t}-\sqrt{\textit{ap}}-\textit{no:-ti} \quad & \text{‘attains (3s)’} & \quad (v1 \ b21 \ u1 \ e183 \ vs. \ 0) \\
& \quad (b) \quad p\textit{t}-\sqrt{\textit{ap}}-\textit{nu:jah} \quad & \text{‘should attain (2s optative)’} & \quad (u1 \ e14 \ vs. \ 0)
\end{align*}
(26) (a) \( p\text{m}-\sqrt{\text{fii}-\text{nc}}\text{-ti} \) ‘incites (3s)’ (b2 e1 vs. 0)
(b) \( p\text{m}-\sqrt{\text{fii}-\text{nu}}\text{-j\text{a}}\text{h} \) ‘should incite (2s optative)’ (e1 vs. 0)

The post-plosive blocking of \( \text{nati} \) in (25) no doubt reflects a more general phonotactic of Sanskrit. While /\text{n}/ and /\text{n}/ generally contrast (§1), the contrast is virtually confined to tau-tonomorphemic post-vocalic (occasionally post-sonorant) position (Steriade 1995). Retroflex nasals can be found in post-plosive position, but only due to assimilation. Putting aside \( \text{nati} \) contexts, if the plosive is coronal, the following coronal nasal must agree in place (e.g. \([\text{i}\text{\'atna}] \) ‘gift’, \([\text{a}\text{\'η\text{\'a}}\text{\'ia}] \) (proper name), \([\text{ja}\text{\'η\text{\'a}}] \) ‘sacrifice’); otherwise, the coronal nasal must be dental (e.g. \([\text{sv\'apna}] \) ‘sleep’, \([\text{a\'gni}] \) ‘fire’). No isolated lexemes like \(*[\text{sv\'apn}\text{\'a}]\) or \(*[\text{a\'gni}]\) are found. Thus, \( \text{T}\text{n} \) appears to be more marked than \( \text{T}\text{n} \).

The analysis from §2.2 can be easily amended by adding a highly ranked constraint forbidding post-plosive retroflexes, e.g. \(*\text{T}\text{n} \) in (27). While this constraint could likely be generalized further, e.g. to palatal and velar (but not labial) nasals, these details of formulation are unimportant here. Retroflex plosive-nasal clusters (e.g. \([\text{a\'\eta\'a}]\)) can be motivated by assimilatory constraints dominating \(*\text{T}\text{n} \), not shown. If \(*\text{T}\text{n} \) outweighs \( \text{Share} \), post-plosive \( \text{nati} \) is suppressed, as in (28).

(27) \(*\text{T}\text{n}: \text{Penalize a retroflex nasal immediately following a plosive.} \)

(28) \((\text{weights to be revised})\)

<table>
<thead>
<tr>
<th>Step 4. ((\text{p}1\sqrt{\text{a}p}\text{n}o\text{t}i))</th>
<th>( \text{H} )</th>
<th>( \text{\text{T}n} )</th>
<th>\text{Share}</th>
<th>\text{Ident}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ( \text{'a} ) ((\text{p}1\sqrt{\text{a}p}\text{n}o\text{t}i))</td>
<td>-20</td>
<td>-4</td>
<td>-4</td>
<td>-4</td>
</tr>
<tr>
<td>b. ((\text{p}1\sqrt{\text{a}p}\text{n}o\text{t}i))</td>
<td>-22</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
</tr>
</tbody>
</table>

Weighting (28) is incorrect, however, since \( \text{nati} \) does regularly target a post-plosive nasal target in some forms. The data in (29) cover all such forms in the corpus (see §1), sorted by descending frequency. Irrelevant affixation and compounding is now factored out in the entries, such that only the relevant root and affix, if any, are shown. For example, (d) \([\text{i\'eknas}] \) ‘inheritance’ includes counts for \([\text{i\'eknas}] \) in various case forms as well as prefixed \([\text{su}-\sqrt{\text{i\'ekn}a}\text{-\'a}] \) ‘well endowed (masc. nom. sg.)’ and suffixed \([\sqrt{\text{i\'eknas}}\text{\'uti}] \) ‘endowed (fem. nom. sg.).’ The ‘vs. 0’ annotation indicates that the lexeme never occurs in the corpus as \(*[\text{i\'eknas}] \), regardless of genre, period, or morphological context.

(29) (a) \( \sqrt{\text{g\'ib}^{\text{\'b}}}\text{-n}\text{\'V} \) ‘grasp (pres. stem)’ (v33 b15 vs. 0)
(b) \( \sqrt{\text{m}\text{\'n}}\text{-} \) ‘break (pass. part.)’ (v2 e40 vs. 0)
(c) \( \sqrt{\text{v\'k}-\text{\'n}}\text{-} \) ‘cut off (pass. part.)’ (v4 b7 u7 e2 vs. 0)
(d) \( \sqrt{\text{\'eknas}} \) ‘inheritance’ (v14 vs. 0)
(e) \( \sqrt{\text{t\'p}-\text{\'n}}\text{-} \) ‘be satisfied (pres. stem)’ (v7 vs. v1; AV 20.136.5)
(f) \( \sqrt{\text{t\'isk\'n}}\text{-} \) ‘sharp (cf. \( \sqrt{\text{t\'iks\'n}}, \text{id.}) \)’ (e5 vs. 0)
(g) \( \sqrt{\text{\'m}\text{\'n}}\text{-} \) ‘unite (pass. part.)’ (v1 vs. 0)
(h) \( \sqrt{\text{\'k\'n}}\text{-} \) ‘wound (pass. part.)’ (b1 vs. 0)
By contrast, all of the forms in the corpus in which an otherwise eligible post-plosive /n/ fails to undergo nati are given in (30).\(^6\) When the trigger is not explicitly shown, as in (c), assume that the ‘X-’ portion contains a visible trigger. For example, (c) (\(\sqrt{\text{a}}\)X-\(\sqrt{\text{g}}\)na ‘X-killer’ subsumes [\(\sqrt{\text{n}}\)\(\sqrt{\text{a}}\)-\(\sqrt{\text{g}}\)n\(\text{a}\)] ‘man-killer’, [\(\sqrt{\text{v}}\)\(\text{t}\)\(\text{a}\)-\(\sqrt{\text{g}}\)n\(\text{a}\)] ‘V\(\text{r}\)tra-killer’, and so forth, generalizing over irrelevant affixation and compounding as before. Similarly, when ‘preverb-’ is indicated in the gloss, all applicable trigger-containing preverbs (e.g. [\(\text{p}\)\(\text{a}\)]\(\text{d}\)-\(\sqrt{\text{a}}\)) are included.

(30) (a) \(\text{p}1\)-\(\sqrt{\text{a}}\)ap-n\(\text{V}\)- ‘attain (pres. stem)’ (v2 b62 u4 e510 vs. 0)  
(b) (\(\sqrt{\text{a}}\)X-\(\sqrt{\text{a}}\)gni ‘X-fire/Agni’ (v161 b195 u2 e104 vs. 0)  
(c) (\(\sqrt{\text{a}}\)X-\(\sqrt{\text{g}}\)na ‘X-killer’ (v27 b38 e379 vs. 0)  
(d) X-\(\sqrt{\text{b}}\)ag-na ‘preverb-break (pass. part.)’ (b1 e90 vs. 0)  
(e) d(a)u(h)-\(\sqrt{\text{sv}}\)\(\text{ap}\)-ja ‘bad sleep’ (v35 b1 e12 vs. 0)  
(f) X-\(\sqrt{\text{g}}\)na- ‘preverb-kill (3pl forms)’ (v5 b14 vs. 0)  
(g) \(\sqrt{\text{fi}}\)\(\text{a}\)-\(\sqrt{\text{kn}}\)ika ‘bay-colored’ (v2 vs. 0)  
(h) p\(\text{a}\)ja-ak-na ‘turned around’ (b2 vs. 0)  
(i) n\(\text{u}\)-\(\sqrt{\text{vi}}\)g-na ‘unshaken’ (e1 vs. 0)  
(j) \(\sqrt{\text{v}}\)i-\(\sqrt{\text{sk}}\)\(\text{a}\)-na ‘fix (pres. stem.)’ (v1 vs. 0)  
(k) \(\sqrt{\text{k}}\)\(\text{e}\)\(\text{r}\)-\(\sqrt{\text{n}}\)\(\text{o}\)ch ‘springing (gen. sg.)’ (v1 vs. 0)  
(l) \(\sqrt{\text{t}}\)\(\text{p}\)-n\(\text{V}\)- ‘be satisfied (pres. stem)’ (v1 vs. v7; see (29))

The difference between (29), in which nati applies to post-plosive targets, and (30), in which it does not, is that in all of the cases in (29), no root boundary intervenes between trigger and target, whereas in almost all of the cases in (30) (with a handful of exceptions to be addressed below), a root boundary intervenes. This root boundary criterion separates tokens into the two categories with almost perfect accuracy (100% hits and no misses for the first set; >99% hits and <1% misses for the second). Furthermore, it holds across genres and periods. On its lack of recognition in the previous literature, see the end of this section.

To be sure, some of the nati failures in (30) could be attributed to compounds failing to undergo nati by virtue of being compounds. In Classical Sanskrit, after all, nati often fails to apply across compound boundaries. In Vedic, however, in which nati usually applies across compound boundaries, it never does so when the target is post-plosive. Consider, for example, two derivatives of the root \(\sqrt{\text{Han}}\) ‘kill’, namely, \(\sqrt{\text{g}}\)n\(\text{a}\)/ ‘killer’ and \(\sqrt{\text{fi}}\)\(\text{a}\)/ ‘killing’, in compound-final position. When the first member of the compound contains a trigger, \(\sqrt{\text{fi}}\)\(\text{a}\)/ undergoes nati, while \(\sqrt{\text{g}}\)n\(\text{a}\)/ does not, as in (31).

(31) Cross-compound nati:
   (a) \(\sqrt{\text{v}}\)\(\text{t}\)\(\text{a}\)-\(\sqrt{\text{fi}}\)\(\text{a}\) ‘V\(\text{r}\)tra-killing’ (v16 b2 e7 vs. 0)  
   (b) \(\sqrt{\text{v}}\)\(\text{i}\)-\(\sqrt{\text{fi}}\)\(\text{a}\) ‘hero-killing’ (b1 e3 vs. 0)

(32) But not to a post-plosive target:

\(^6\)[\(\text{b}1\)\(\text{ag}\)\(\text{b}\)-na-] is also found in the corpus (twice in the S\(\text{a}\)ma-Veda) but omitted from this list since it is a misreading of the Devan\(\text{a}\)g\(\text{a}\)ri for [\(\text{b}1\)\(\text{ad}\)\(\text{b}\)-na-] ‘pale’, in which /n/ is not eligible for nati.
In any case, compounds are not the whole story. Even preverbs that otherwise normally trigger nati in their stems never affect a post-plosive target. This was already demonstrated in (24) through (26); some additional examples involving /põ/- are given in (33) and (34). Other trigger-containing prefixes (e.g. [paː]-, [duː-]) behave the same.

(33) /põ/- triggers nati in its base:
(a) /põ-√i:i-ŋo:-t/ ‘incited (3s)’ (e82 vs. 0)
(b) /põ-√mi:ŋ-az-ti/ ‘frustrates (3s)’ (b5 vs. 0)
(c) /põ-√ja:-ŋa/ ‘setting out’ (v5 b1 e21 vs. 0)

(34) But not if its target immediately follows a plosive:
(a) /p⊄-√ap-no:-t/ ‘attains (3s)’ (v1 b21 u1 e183 vs. 0)
(b) (abᵢ̃i-) /p⊄-√g₆n-an-ti/ ‘kill (3pl)’ (v2 b2 vs. 0)
(c) /p⊄-√b₆ag-na/ ‘broken’ (b1 e72 vs. 0)

To summarize thus far, first, non-coronal plosives are normally transparent to nati, as established in §2.1 and reinforced here. Coronals, for their part, always block. A non-coronal plosive also blocks iff (a) it immediately precedes the target and (b) the trigger and target straddle a root boundary. The latter configuration is found both when the trigger occupies a prefix and when the trigger occupies a preceding member of a compound.

Schematically, the new generalization can be summarized as in (35), where √ notates the left edge of a root. As the organization of (35) implies, nati failure in (c) can be analyzed by the ‘ganging up’ (e.g. Jäger and Rosenbach 2006, Kenstowicz 2009, Pater 2009b: 1008ff) of the two markedness constraints implied by (a) and (b) against SHARE. In other words, while neither a violation of (a) alone nor (b) alone is enough to prevent nati, when both (a) and (b) are violated, nati fails in just this ‘worst-of-the-worst’ case scenario.

(35) (a) Nati generally applies across √.
    (b) Nati generally applies to a post-plosive target.
    (c) Nati fails to apply to a post-plosive target when the span must also cross √.

Formally, ganging up can be analyzed using weighted constraints, as in HG (§2.2). This situation obtains when the weights of two weaker constraints sum to a value greater than that of the stronger constraint (i.e. $w_1 < w_3; w_2 < w_3; w_1 + w_2 > w_3$). In the present case, the stronger constraint is SHARE, and one of the two weaker constraints is *Tr. The other must penalize cross-√ harmony. The approach adopted here to do so (see §5 regarding other possibilities) is output-output correspondence (Benua 1995, 1997, Kenstowicz 1996, Ussishkin 1999, Steriade 2000, McCarthy 2005, Zuraw 2013, inter alios), in particular, IDENTOO([retro]) in (36). The base of correspondence of a prefixed form is its unprefixed
counterpart (as with Italian in Kenstowicz 1996). Members of compounds also stand in correspondence with their uncompounded bases. For example, [√fii-no:ti] is the free base corresponding with prefixed [(p1a-√fii-ŋ)o:-ti] ‘incites’. [(p1a-√fii-ŋ)o:-ti] therefore incurs three violations of IDENTOO, one for each segment that undergoes retroflexion.

(36) IDENTOO([retro]) (abbreviated IDENTOO): Assign a penalty for every segment that differs in anteriority from its correspondent in the base.

Derivation (37) shows a prefix triggering nati when *Tŋ is not at stake. Because SHARE outweighs *IDENTOO (and IDENT), harmonizing across √ is optimal. The convergence step, in which harmony does not spread past [ŋ] due to FLAPOUT (§2.2), is omitted.

(37) Base: [fiinotti]

<table>
<thead>
<tr>
<th>Step 1. p(t)a-√fii-no:-ti</th>
<th>SHARE</th>
<th>*Tŋ</th>
<th>IDENTOO</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (√f) (p1a) fii inotti</td>
<td>-36</td>
<td>-7</td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>b. (√) p(q) a fii inotti</td>
<td>-36</td>
<td>-7</td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>c. p(t)a √fii inotti</td>
<td>-40</td>
<td>-8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step 2 omitted.

Step 3. (p1a) √fii inotti

| a. (√f) (p1a) f ii inotti | -29 | -5 | -1 | -1 |
| b. (p1a) √fii inotti      | -30 | -6 |    |    |

Step 4 omitted.

Step 5. (p1a) √fii no:ti

| a. (√f) (p1a) f ii no:ti  | -25 | -3 | -3 | -1 |
| b. (p1a) √fii no:ti       | -26 | -4 | -2 |    |

Step 6 (convergence) omitted.

Derivation (38) shows nati accessing a post-plosive target when √ is not crossed. Because /√xe:knas/ (assuming a richness-of-the-base input without retroflexion) is a root, IDENTOO is not applicable. Figure (38) ignores the debuccalization of final /s/ to [h] if this word were pronounced in isolation.

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7 Any definition of base selection compatible with this state of affairs is sufficient here. For example, the base of free form i could be defined as the free form j such that j contains the maximal proper subset of the grammatical features of i and no conflicting features (Kager 1999: 281).
Finally, when the span crosses √ and reaches a potential post-plosive target, as in [p₁√/aːp-no-ti] ‘attains’ in (39), both *T₁ and IDENT₀₀ are violated, now collectively out-weighing SHARE. This gang effect prevents nati from reaching the target in Step 4. Vowel coalescence between preverb /p₁a/ and root /aːp/ is assumed by fiat.

This section will now conclude with some remarks on exceptions and on the lack of previous recognition of the rule described here. As a representative passage from a grammar, Whitney (1889: §195a) says only the following about post-plosive targets (Wackernagel 1896 says somewhat more, but the outlook for the present point is the same): “The immediate combination of n with a preceding guttural or labial seems in some cases to hinder the conversion to n: thus, vrtraghnā etc., kṣubhnātī, tṛpnoti (but in Veda tṛṇu), kṣepnū, suṣumnā.”

This description implies that post-plosive targets vary freely, as indeed phonologists mentioning this caveat have taken it (Steriade 1995: 52f, Hansson 2010: 182). It is the nature of grammars, after all, to list exceptions without tempering them with clear indications as to
the robustness of the rule. To address Whitney’s examples, \([\sqrt{\text{t\textipa{\text{-}a}}}-\sqrt{\text{g}^6\text{n\text{-}}}n\text{á}]}\) ‘\(\text{V\text{-}tra-killer}\)’ follows the rule proposed here. \([\sqrt{\text{k\text{-}s\text{ub}^6\text{-}}n\text{V}}\) ‘shake’ does not, but is entirely absent (with either \([n]\) or \([\text{ñ}]\)) from the present two-million-word corpus. \([\sqrt{\text{t\textipa{\text{-}p\text{-}}}n\text{V}}\) ‘be pleased’, in which \(N \in \{n, \text{ñ}\}\), occurs eight times and breaks the rule only once. In other words, Whitney foregrounds the exception, not the rule. \([\sqrt{\text{k\text{-}s\text{e\text{-}p\text{-}}}n\text{ú}]}\) ‘springing’ occurs once and is a genuine exception. \([\text{su}]-\sqrt{\text{\textipa{\text{-}um\text{-}}}n\text{V}}\) ‘gracious’ is not included in the lists above, which consider only post-plosive targets. Its counts here are ‘v5’ for \([n]\) and ‘v1 b1 e7’ for \([\text{ñ}]\).

\([\text{su}]-\sqrt{\text{\textipa{\text{-}um\text{-}}}n\text{V}}\) and two similar forms from the list of non-undergoers in (30), namely \([\text{vi}]-\sqrt{\text{\textipa{\text{-}k\text{ab}^6\text{-}}}na}\) ‘fix’ and \([d(a)u(h)\text{-}\sqrt{\text{svámp\text{-}ja}}]\) ‘bad sleep’, require further comment. In all three, the trigger \([s]\) ostensibly occupies the root, and none exhibits \(\text{nati}\) of a post-plosive target. While at first glance exceptions to the proposed generalization, in fact they follow from it. In every case, the trigger acquires its retroflexion from the prefix via \(\text{ruki}\) (§2.2). Thus, they correspond to non-prefixed forms without \(\text{nati}\), and the gang effect with \(\text{Ident}_{\text{OO}}\) applies in the prefixed forms, properly suppressing \(\text{nati}\).

Putting aside these three forms with \(\text{ruki}\) as explained, then, the rule, as stated above, is a near-perfect generalization. All 138 tokens with post-plosive \(\text{nati}\) have a domain of retroflexion that is root-initiated, and 1,648 of 1,650 (99.9%) of tokens with a failure of post-plosive \(\text{nati}\) have a domain of retroflexion would have to cross \(\sqrt{\text{\textipa{\text{-}}}}\). The only robust exceptions in this corpus are one token of \([\sqrt{\text{kse\text{-}p\text{-}}}n\text{ú}]}\) and one of \([\sqrt{\text{t\textipa{\text{-}p\text{-}}}n\text{V}}\) (against seven of \([\sqrt{\text{t\textipa{\text{-}p\text{-}}}n\text{V}}\)\), both mentioned by Whitney (1889).

4 Boundary attenuation II: clashing spans

As a further complication, \(\text{nati}\) also fails under certain predictable circumstances when a retroflex follows the target. For example, consider once again the preverb \([\text{p\textipa{\text{-}a\text{-}}}]\), now with the root \(\sqrt{\text{nac-}}\) ‘vanish’ (or ‘reach’). As §3 demonstrated, \([\text{p\textipa{\text{-}a\text{-}}}]\) triggers \(\text{nati}\) in a root or suffix. /\(\text{p\textipa{\text{-}a\text{-}}}\sqrt{\text{nac-}}\)/ is no exception, as (40) reinforces.

\begin{align*}
(40) & \quad (a) \quad \text{p\textipa{\text{-}a\text{-}}}\sqrt{\text{nac-ja-ti}} & \text{‘vanishes (3s)’} & (e53 \text{ vs. } 0) \\
& \quad (b) \quad \text{p\textipa{\text{-}a\text{-}}}\sqrt{\text{nac-ja-n-ti}} & \text{‘vanish (3pl)’} & (b2 e3 \text{ vs. } 0) \\
& \quad (c) \quad \text{p\textipa{\text{-}a\text{-}}}\sqrt{\text{nac-in-i:}} & \text{‘destroyer (fem.)’} & (e5 \text{ vs. } 0) \\
& \quad (d) \quad \text{p\textipa{\text{-}a\text{-}}}\sqrt{\text{nak}} & \text{‘reach (aorist)’} & (v4 b1 u1 \text{ vs. } 0) \\
& \quad (e) \quad \text{p\textipa{\text{-}a\text{-}}}\sqrt{\text{nac-aj-e-t}} & \text{‘destroy (3s caus. opt.)’} & (e2 \text{ vs. } 0) \\
& \quad (f) \quad \text{p\textipa{\text{-}a\text{-}}}\sqrt{\text{nac-a}} & \text{‘disappearance’} & (e17 \text{ vs. } 0)
\end{align*}

\(^8\)Once plosives and vowels are put aside, only two non-coronals remain that are normally licit in immediately pre-[n] position, namely, [n] and [ñ]. As \([\text{su}]-\sqrt{\text{\textipa{\text{-}um\text{-}}}n\text{V}}\) might suggest, \(\text{nati}\) applies optionally in this context when \(\text{nati}\) crosses \(\sqrt{\text{\textipa{\text{-}}}\). This optionality could be implemented by giving \(*\text{Nn}\), which penalizes [n] immediately following a sonorant consonant, less weight than \(*\text{Tn}\) in a probabilistic implementation of HG (Hayes and Wilson 2008, Pater 2009b). \(*\text{Tn} > *\text{Nn}\) can be motivated by the greater perceptibility of retroflexion following a sonorant as opposed to a plosive.
But when the final consonant of √nac- is realized as retroflex (owing to irrelevant mor-
phophonology), nati fails in the vast majority of instances, as shown in (41). Forms (b–c)
do not appear in the present corpus, but are cited as such in the sources given (‘MW’ abbrevi-
ating Monier-Williams 1899). In total, the corpus contains 320 instances of /pəa√nac-/. Of
them, 218 have a non-retroflex ending, and nati applies in 100% of those cases. The
remaining 102 have a retroflex ending, and nati fails in 91% of those cases.

(41) (a) (vi-)pəa√nāṣ-ṭa- ‘vanished (past pass. part.)’ (e91 vs. e9)
(b) pəa√nāṣ-ṭum ‘to vanish (inf.)’ (0 vs. 0; MW: 659)
(c) pəa√na-ṇ-k-ṣ-ja-ti ‘will vanish (3s fut.)’ (0 vs. 0; Allen 1951: 946)

Moreover, the pattern suggested by the above paradigm is general. Regardless of the
prefix and root involved, nati fails to cross √ when an unblocked retroflex follows the target
(‘unblocked’ meaning that no coronal intervenes; cf. [t] in [pəa√nēr-ṭa] ‘leader’). Additional
elements are given in (42). Diagnostic forms are infrequent because the requisite set-up is
quite specific, being a triggering prefix attached to a stem with an unblocked target followed
by an unblocked retroflex, which in Sanskrit is unlikely to be provided by a suffix. But
insofar as forms meeting these criteria are found, the generalization is supported.

(42) (a) pəa√nīt- ‘dance forth’ (v1 e32 vs. 0)
(b) pəaī√nīt- ‘dance around’ (v3 e1 vs. 0)
(c) pəa√nād- ‘roar’ (e1 vs. 0)
(d) pəa√naks- ‘approach’ (0 vs. 0; MW: 681)
(e) pəaī√naks- ‘encompass’ (0 vs. 0; Macdonell 1910: §47)

Aside from the nine exceptional (against 91 regular) tokens of [pəa√nāṣ-ṭa-] mentioned
in (41), the only other cases in the corpus in which a prefix triggers nati in a root domain
containing an unblocked retroflex are given in (43).9 These exceptions are discussed further
at the end of this section.

(43) (a) pəa√nē- ‘lead forth (fut./subj.)’ (v1 b1 e2 vs. 0)
(b) pəa√naqj-ah ‘waterways’ (e1 vs. 0)
(c) pəa√van-ēr-śu ‘slopes (loc. pl.)’ (v1 vs. 0)

That nati is suppressed by a following retroflex is already established in the literature
(Macdonell 1910: §47, Allen 1951: 945f, Hansson 2010: 184), though to my knowledge no
formal analysis of it has been put forth. Hansson (2010: 184) suggests that it might arise from
misperception, specifically, the hypocorrective misattribution of the source of the cues for
retroflexion on the nasal to the surrounding retroflexes. But given the data to be presented in
(44), this explanation cannot be correct: In other contexts, Sanskrit orthoepy/orthography
consistently records retroflexion on nasals in inter-retroflex position.

9Though it is not a verbal form, the Vedic compound [√svāt-√nāṇa] ‘sky-man’ (v17 b4 e4 vs. 0) is also an
exception to the analysis proposed in this section, perhaps owing to the adjacency of the target and trigger.
Other compounds, such as [√cikṣa-√nāṇu] ‘trainer, facilitator’ (v3 vs. 0), follow the generalization.
Previous discussions do not make explicit the fact that suppression is confined to a limited morphological context. Hansson (2010: 184), for one, reports only that “[w]hen there is also an /ʃ/ or /r/ later in the word, retroflexion fails to apply” (likewise Graf 2010, Jardine 2014). Indeed, Macdonell (1910), whom he cites, leaves this interpretation open. Allen (1951) claims that the suppressing retroflex may be at most one vowel away from the target (on which, see below), but omits any mention of morphological conditioning.

In particular, suppression of nati by a following retroflex occurs only when the span must cross √. Otherwise, nati applies regardless of whether a retroflex follows, as the examples in (44), among numerous others, illustrate. Such cases of non-suppression within the root-suffix complex vastly outnumber the cases of cross-√ suppression considered above.

(44) (a) √b formulaire-é-śu ‘Brahmins (loc. pl.)’ (v2 b1 e67 vs. 0)
(b) √g痢-ni-shy ‘grasp (2s imp.)’ (e15 vs. 0)
(c) √kér-mu-stá ‘do/make (2s imp.)’ (v26 b1 vs. 0)
(d) √př-ňa-k-ši ‘unite (2s)’ (v8 b2 vs. 0)
(e) √přnov-i-śu ‘breathers (loc. pl.)’ (e7 vs. 0)
(f) √puam-tr-śi ‘ancient rishi’ (e6 vs. 0)
(g) √ján-i-ś-tañ ‘rejoice (2pl aorist)’ (v1 vs. 0)
(h) a-√nam-i-ś-uh ‘rejoice (3pl aorist)’ (v1 vs. 0)

Descriptively, the new generalization can be summarized as in (45), whose structure mirrors (35) in §3. As (45) implies, a gang effect with IDENTOO is once again in evidence.

(45) (a) Nati generally applies across √.
(b) Nati generally applies to a target that precedes an unblocked retroflex.
(c) Nati fails to apply to a target that precedes an unblocked retroflex when the span must also cross √.

What remains to be treated is the markedness constraint implied by (b). Here, it is proposed that the failure of harmony in such cases reflects the OCP (Obligatory Contour Principle; Leben 1973, McCarthy 1986, Myers 1997). OCP([retro]) in (46) penalizes every point of contact between two spans of retroflexion. On this approach, [př-śi], for instance, fails to undergo nati because doing so would give ∗[(př-śi)(śi)]t, which violates both OCP and IDENTOO. (Other constraints in §2, namely, FLAPOUT, IDENTOrCor, and MAX([retro]), prevent fusing or deleting the autosegments.)

(46) OCP([retro]) (abbreviated OCP): Penalize adjacent domains of retroflexion.

The analysis of suppression then runs as follows. First, the fact that a prefix such as [př-] normally triggers harmony across √ continues to hold, as (47) illustrates.

10 The restriction of the following suppressor to retroflex continuants as opposed to retroflex consonants in general is also unmotivated and not assumed here.
(47) Base: [nacja-]

<table>
<thead>
<tr>
<th>Step 1. (p(\ddot{\text{a}})a\sqrt{nacja-})</th>
<th>(\mathcal{H})</th>
<th>SHARE</th>
<th>OCP</th>
<th>IDENT(_{OO})</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\text{[p\ddot{a}]}) (\sqrt{nacja-})</td>
<td>-31</td>
<td>-8</td>
<td>-6</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>b. (\text{p(\ddot{a})}) (\sqrt{nacja-})</td>
<td>-31</td>
<td>-6</td>
<td>-6</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>c. (\text{p(\ddot{a})}) (\sqrt{nacja-})</td>
<td>-35</td>
<td>-7</td>
<td>-5</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

Step 2 omitted.

Step 3. \(\text{p(\ddot{a})}\) \(\sqrt{nacja-}\)

<table>
<thead>
<tr>
<th>Step 3. (\text{p(\ddot{a})}) (\sqrt{nacja-})</th>
<th>(\mathcal{H})</th>
<th>SHARE</th>
<th>OCP</th>
<th>IDENT(_{OO})</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\text{p(\ddot{a})}) (\sqrt{nacja-})</td>
<td>-24</td>
<td>-4</td>
<td>-3</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>b. (\text{p(\ddot{a})}) (\sqrt{nacja-})</td>
<td>-25</td>
<td>-5</td>
<td>-5</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

Second, when no \(\sqrt{\text{intervenes, an OCP violation is tolerated, as in (48). Once again, candidates with fusion and deletion are ruled out by other constraints in }\S 2. (For simplicity, the sibilant is given as retroflex in the input, though it is due to \textit{ruki}.)

(48) Base: \(\emptyset\)

<table>
<thead>
<tr>
<th>Step 1. (\sqrt{(\ddot{a})an-i-(\dddot{s})-})</th>
<th>(\mathcal{H})</th>
<th>SHARE</th>
<th>OCP</th>
<th>IDENT(_{OO})</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\text{\sqrt{(\ddot{a})an(\dddot{s})-}})</td>
<td>-16</td>
<td>-3</td>
<td>-3</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>b. (\text{\sqrt{(\ddot{a})ni(\dddot{s})-}})</td>
<td>-16</td>
<td>-3</td>
<td>-3</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>c. (\text{\sqrt{(\ddot{a})ani(\dddot{s})-}})</td>
<td>-20</td>
<td>-4</td>
<td>-4</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

Step 2 omitted.

Step 3. \(\sqrt{((\ddot{a})n(\dddot{s})-}\)

<table>
<thead>
<tr>
<th>Step 3. (\sqrt{((\ddot{a})n(\dddot{s})-})</th>
<th>(\mathcal{H})</th>
<th>SHARE</th>
<th>OCP</th>
<th>IDENT(_{OO})</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\text{\sqrt{((\ddot{a})n(\dddot{s})-}})</td>
<td>-9</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>b. (\text{\sqrt{((\ddot{a})n(\dddot{s})-}})</td>
<td>-10</td>
<td>-2</td>
<td>-2</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

Finally, when \(\sqrt{\text{would interrupt harmony, harmony fails, thanks to OCP and IDENT}_{OO}\) collectively outweighing SHARE. In (49) Step 1, IDENT\(_{OO}\) ensures that retroflexion in the root spreads first. As Step 4, candidate (c) demonstrates, the second span of retroflexion cannot retreat across the vowel to rescue the OCP. Step 4 does not contain a candidate that involves both a retraction of retroflexion before \([\dddot{s}]\) and application of \textit{nati} to /n/, since only one change per step is possible.
Base: \([n(\text{aśt})a-]\)

<table>
<thead>
<tr>
<th>Step 1. (p(t)a-\sqrt{na(\text{aśt})a-})</th>
<th>(\mathbb{H})</th>
<th>SHARE</th>
<th>OCP</th>
<th>IDENT(_{OO})</th>
<th>IDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\text{ś}a) (p(t)a/\sqrt{n(\text{aśt})a-})</td>
<td>26</td>
<td>5</td>
<td>3</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>b. ((pÎ)a/\sqrt{na(\text{aśt})a-})</td>
<td>29</td>
<td>5</td>
<td>-1</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>c. (p(t)a/\sqrt{na(\text{aśt})a-})</td>
<td>29</td>
<td>5</td>
<td>-1</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>d. (p(t)a/\sqrt{na(\text{aśt})a-})</td>
<td>33</td>
<td>6</td>
<td>-1</td>
<td>-1</td>
<td></td>
</tr>
</tbody>
</table>

Steps 2–3 omitted.

Step 4. \((pÎ)a/\sqrt{na(\text{aśt})a-}\)

| a. \((pÎ)a/\sqrt{n(\text{aśt})a-}\) | 15    | 3     | -1  | -1           |       |
| b. \((pÎa/\sqrt{n(\text{aśt})a-}\)   | 17    | 2     | -1  | -1           | -1    |
| c. \((pÎa/\sqrt{na(\text{aśt})a-}\)   | 24    | 4     | -1  | -1           |       |

Beyond harmony, the activity of OCP([\text{retro}]) in Sanskrit is corroborated by reduplication. Consider the desiderative, which comprises a CV reduplicant prefix in which V is high as well as the suffix /\(-s/\) (Whitney 1889: §1.026ff). If the root is /\(-s/-initial and no retroflex follows, the root undergoes ruki conditioned by the prefix, as in [\(\text{sic}-\sqrt{\text{sa}:a-}\) ‘wish to gain’ (for \(\sqrt{\text{sa}:a}\)) and [\(\text{su}-\sqrt{\text{sup}-s-}\) ‘wish to sleep’ (for \(\sqrt{\text{swap}}\)]. But if the suffix undergoes ruki, ruki in the root is usually (though not always) suppressed, as in [\(\text{sic}-\sqrt{\text{sa:ek-ś-}}\) ‘wish to hang’ (for \(\sqrt{\text{sa:ek}}\)] and [\(\text{sic}-\sqrt{\text{si:ś-ś-}}\) ‘wish to flow’ (for \(\sqrt{\text{si:ś}}\)].

This section will now conclude with some remarks on the locality of \(\text{nati}\) suppression. First, all examples of suppression so far have involved a target in a root. Nevertheless, some of the forms used to exemplify suppression in previous research (Macdonell 1910: §47, Allen 1951: 945f, Hansson 2010: 184) have a somewhat different profile. These are enumerated in (50), in which ‘\(\_=\)’ indicates a compound boundary and ‘\(X\)’ contains an unblocked trigger.

\[
\begin{align*}
\text{(50)} & \quad \text{(a) } \sqrt{puõu-niś-\sqrt{\text{síd}^\text{b}}-} \text{ ‘all-giving’} \quad (v2 \text{ vs. } 0) \\
& \quad \text{(b) } \sqrt{X=ni\text{i}l-\sqrt{\text{nj}-}} \text{ ‘X-adornment’} \quad (v6 \text{ e1 vs. } 0) \\
& \quad \text{(c) } \text{paqi-ni-\sqrt{ṣṭ}^\text{a}-} \text{ ‘eminent’} \quad (e28 \text{ vs. } 0) \\
& \quad \text{(d) } \text{paqi-niṣ-\sqrt{\text{viṇa}}} \text{ ‘despondent’} \quad (e2 \text{ vs. } 0)
\end{align*}
\]

In all of the cases in (50), the suppressed target is in a prefix. The compounds in (a–b) are handled properly by this analysis if it is assumed that each member is evaluated separately by IDENT\(_{OO}\) (e.g. for (a), the bases would be \([puõu]\) and \([niś\sqrt{\text{síd}^\text{b}}-]\) with its prefix).\(^{11}\) Items (c–d) are cases of double prefixation in which the first prefix could triggers \(\text{nati}\) in the second, but fails, perhaps because a retroflex follows. However, these prefix pairs are likely ineligible.

\(^{11}\) \text{Nati} applies less reliably in compounds in general (§3 and footnote 9), though in this case an argument can still be made for suppression: The initial members of the compounds in (a–b) comprise [\(puõu]\), [\(sa:q\)], [\(candõ\)], and [\(va:q\)]. In every one of the 12 tokens in the Rg-Veda in which one of these initials attaches to a \(\sqrt{nV[\text{retro}]}\) base, \(\text{nati}\) fails. In every one of the eight tokens in which one of these initials attaches to any other \(\sqrt{nV}/-\) initial base, \(\text{nati}\) succeeds, a significant difference (Fisher’s exact test \(p < .0001\)).
for *nati* in the first place.\(^{12}\)

Second, one might wonder whether suppressing retroflexes are confined to roots, given that the examples of non-suppression mostly involve inflectional suffixes. This is not the case, as properly captured by the analysis. Prefixes suppress in (50), the suffix [-s] suppresses in (41), and in every other case in (41), the suppressing consonant, though ostensibly located in the root, acquires its retroflexion from a suffix.

Third, all examples of (successful) suppression in this section involve a morpheme-initial target. The analysis here predicts that suppression should also be possible for non-morpheme-initial targets. Forms confirming or disconfirming this prediction are rare, owing to the combined infrequencies of the requisite parts, namely, a triggering prefix, a root beginning with a vowel or non-coronal followed by a dental nasal, and a suffix containing an unblocked retroflex. One such case was cited in (43), namely, [pʰ-a-√vaŋ-ét-su]. Suppression fails in this case, but this single token is not particularly compelling, since other causes for the failure are conceivable (e.g. next paragraph).

A final question concerns whether the suppressing retroflex can be any distance from the target. All of the examples of suppression in this section involve a suppressor that is at most \(\tilde{V}_0\tilde{C}_0\) away from the target, where \(\tilde{V}\) is a short vowel. No case of suppression across a long vowel or multiple syllables was found. What’s more, all of the exceptions to suppression in (43) involve a target and suppressor straddling a long vowel. Since diagnostic data are sparse, it will be left unresolved here whether this generalization is principled or accidental. If it were principled, it could indicate that leftward spreading from retroflexes (across non-coronals) is not unchecked, as implied by §2.2, but rather limited to a single vocalic mora.

On the present approach, a constraint requiring a preceding vowel to license retroflexion (cf. RETRO/V in Steriade 1995) could dominate a constraint forbidding leftward spreading (e.g. INITIAL( feat) in McCarthy 2009) to achieve minimal leftward spreading.

Suppression also fails regardless of distance when the would-be suppressor is derived by external sandhi, apparently a case of post-lexical opacity. For example, /âː̆n̪ɪ-s/ ‘Āruni’ is realized as [âː̆n̪ɪ] when followed closely by a voiced-initial word, as in [âː̆n̪ɪ aːfia] ‘Āruni said’. While there remains more philological work to be done on suppression, this article is not the place to do so. This section has shown that *nati* suppression, previously unanalyzed, can be accommodated by the proposed account of *nati* by adding a single constraint, OCP([retro]).

### 5 Analytical comparisons

The analysis of *nati* proposed in this article relies on output-output correspondence in a serial HG framework. This section considers some alternative approaches.

---

\(^{12}\) *Nati* application across certain preverbs is unreliable in Epic Sanskrit. Tellingly, though only four tokens of /paːi-/ before /ni-/ or /nis-/ are attested without a following retroflex, all lack *nati*: [paːi-ni-√gʰnant], [paːi-nic-√cit(j)a(m)], and [paːi-nih-√cvasan].
5.1 Morphologically indexed constraints

As established in §3–4, harmony affects a post-plosive or pre-retroflex target unless it has to cross a root boundary (‘√’) to reach it. In the proposed analysis, IDENT OO tempers the benefit of spreading into the root domain. But consider an alternative approach by which prefixes are treated as weak triggers for harmony, in the sense that they access fewer targets than root triggers do. Root control is common in harmony systems (Clements 1980 et seq.), and affix-triggered harmony can be penalized directly (e.g. Kenstowicz 2009). However, the nati data in §3–4 cannot be characterized as affix weakness: A root trigger is comparably weak when its span crosses √, as seen in compounds (e.g. (31), (32), (50)). Thus, the descriptive generalization is not that affixes are weak triggers, but that spreading is weakened by √-level boundaries.13

Rather than treating affixes as weak, a related strategy would treat roots or stems as strong. Assume that ‘stem’ here refers to the root-suffix complex. The ranking SHAREstem ≫ *Tï ≫ SHARE could then conceivably implement the desired behavior of post-plosive targets, spreading retroflexion indiscriminately within stems (modulo FlapOut and coronal blocking) but leaving *Tï active for stem-crossing spans. The difficulty is in defining SHAREstem. Generic SHARE was defined in (10); a possible formulation of SHAREstem is given in (51), adding only the phrase ‘within a stem’.

(51) SHAREstem([retro]): For every pair of adjacent segments in a stem, assign a penalty if they are not both linked to the same token of [retroflex].

As tableau (52) illustrates, definition (51) is not viable. Candidate (a), not (b), should win. The problem is that once the span enters the stem, SHAREstem applies regardless of its source. Given also that [õe:kïas] needs to win, no HG solution is possible either, as confirmed with OT-Help 2.0 (Staubs et al. 2010).14

(52)

<table>
<thead>
<tr>
<th></th>
<th>p(õ)a-√a:p-no:-ti</th>
<th>SHAREstem</th>
<th>*Tï</th>
<th>SHARE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>(p1√a:p)no:ti</td>
<td>-4</td>
<td>-4</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>× (p1√a:p)ï:o:ti</td>
<td>-3</td>
<td>-1</td>
<td>-3</td>
</tr>
<tr>
<td>c.</td>
<td>p(õ)√a:pno:ti</td>
<td>-5</td>
<td>-7</td>
<td></td>
</tr>
</tbody>
</table>

A perhaps more promising approach involves SPREAD, as in (53) (Kaun 1994, Padgett 1995, Myers 1997, Walker 1998; cf. ∀-HARMONY in Walker 2014). SPREADstem (54) then assigns violations only to stem-internal spans. (Given the preceding paragraph, it would not

13 A morphological version of *DEPENDENT-HEAD (Mullin 2011) would be untenable here for this same reason, since it defines weakness according to properties of the head of the span (cf. also Walker 2005).

14 Attaching stem specificity to another part of the definition offers no solution. For example, the definition “for every pair of adjacent segments, assign a penalty if they are not both linked to the same token of [retroflex] whose span is contained in a stem” handles tableau (52) and [õe:kïas] properly but fails to capture nati across compounds, as in (31) and (57).
work for $\text{Spread}_{\text{stem}}$ merely to penalize unharmonized segments within stems.)

(53) **$\text{Spread}([\text{retro}])$:** For every token of [retroflexion], assign a violation to every segment to which it is not associated.

(54) **$\text{Spread}_{\text{stem}}([\text{retro}])$:** For every token of [retroflexion] whose span is contained in a stem, assign a violation to every segment to which it is not associated.

This definition ensures that $\text{Spread}_{\text{stem}}$ is effectively ‘turned off’ for any span that crosses $\sqrt{}$, as shown in (55) and (56). Candidates in which the span is removed altogether are ruled out by $\text{Max}([\text{retro}])$, not shown.

<table>
<thead>
<tr>
<th>$\sqrt{p(a)} \sqrt{\text{ap-no:-ti}}$</th>
<th>$\text{Spread}_{\text{stem}}$</th>
<th>$^*\text{T}_\eta$</th>
<th>$\text{Spread}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. $\sqrt{p(a)} \text{ap-no:-ti}$</td>
<td>$\text{Spread}_{\text{stem}}$</td>
<td>-4</td>
<td>$\text{Spread}$</td>
</tr>
<tr>
<td>b. $\text{p(a)} \text{ap-no:-ti}$</td>
<td></td>
<td>-1</td>
<td>-3</td>
</tr>
<tr>
<td>c. $\text{p(a)} \text{ap-no:-ti}$</td>
<td></td>
<td>-7</td>
<td>$\text{Spread}$</td>
</tr>
</tbody>
</table>

(56)

<table>
<thead>
<tr>
<th>$\sqrt{\sqrt{\text{teknas}}}$</th>
<th>$\text{Spread}_{\text{stem}}$</th>
<th>$^*\text{T}_\eta$</th>
<th>$\text{Spread}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. $\sqrt{\sqrt{\text{teknas}}}$</td>
<td>$\text{Spread}_{\text{stem}}$</td>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>b. $\sqrt{\text{teknas}}$</td>
<td></td>
<td>-3</td>
<td>$\text{Spread}$</td>
</tr>
<tr>
<td>c. $\sqrt{\text{teknas}}$</td>
<td></td>
<td>-5</td>
<td>$\text{Spread}$</td>
</tr>
</tbody>
</table>

Simple spreading across compounds (where $^*\text{T}_\eta$ and the OCP are not at issue) is also now handled properly, as in (57).

<table>
<thead>
<tr>
<th>$\sqrt{\text{vi}(\text{t}) \sqrt{\text{fiana}}}$</th>
<th>$\text{Spread}_{\text{stem}}$</th>
<th>$^*\text{T}_\eta$</th>
<th>$\text{Spread}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. $\sqrt{\text{vi}(\text{t}) \sqrt{\text{fiana}}}$</td>
<td>$\text{Spread}_{\text{stem}}$</td>
<td>-1</td>
<td>$\text{Spread}$</td>
</tr>
<tr>
<td>b. $\sqrt{\text{vi}(\text{t}) \sqrt{\text{fiana}}}$</td>
<td></td>
<td>-2</td>
<td>$\text{Spread}$</td>
</tr>
<tr>
<td>c. $\sqrt{\text{vi}(\text{t}) \sqrt{\text{fiana}}}$</td>
<td></td>
<td>-4</td>
<td>$\text{Spread}$</td>
</tr>
</tbody>
</table>

But this approach fails for compounds when $^*\text{T}_\eta$ or the OCP is at stake. Recall from (50) that a retroflex suppresses $\text{nati}$ across compounds, as in (58), in which $\text{[cand\text{a=ni}} \sqrt{\text{\text{\text{l}}} \text{\text{j}}} \text{]}$ should win. But because $\text{Spread}_{\text{stem}}$ loses all of its violations once the span extends beyond the stem, retroflexion erroneously spreads into the second part of the compound.
In short, the generalization is not that some triggers are inherently stronger than others, but that spreading is attenuated in bases, as implemented here by the additive weight of IDENT\textsubscript{OO}. Moreover, empirical viability aside, SPREAD (and likewise SHARE in non-serial OT/HG) is known to make pathological predictions (Wilson 2003, McCarthy 2004, 2009, 2011). For example, it predicts languages in which blockers or inaccessible segments are deleted, among several other unattested scenarios. As McCarthy (2009, 2011) argues, SHARE evaluated serially, as in this article, avoids these pathologies.

SPREAD\textsubscript{stem} (or SHARE\textsubscript{stem}) is even more pathological than its vanilla counterpart. For example, in the grammar illustrated by (59) and (60), retroflexion spreads minimally onto a prefix if one is present. If no prefix is present, it spreads maximally in the other direction. The simple ranking SPREAD\textsubscript{stem} \gg IDENT generates this apparently impossible language. Thus, morphological indexation is not viable on language-internal or typological grounds.

5.2 Constraint conjunction

The analyses in §3–4 relied on gang effects. To recapitulate the argument in §3, because SHARE > IDENT\textsubscript{OO}, harmony spreads across \(\sqrt{\cdot}\) into a base. Similarly, because SHARE > *T\textsubscript{ï}, harmony reaches a post-plosive target. But when IDENT\textsubscript{OO} and *T\textsubscript{ï} are both violated — as when harmony must cross \(\sqrt{\cdot}\) to reach a post-plosive target — harmony fails, thanks to the summed weight (IDENT\textsubscript{OO}+*T\textsubscript{ï}) > SHARE. The argument in §4 is analogous, substituting the OCP for *T\textsubscript{ï}. Such a gang effect cannot be implemented in classical OT. In short, [p\(\sqrt{\cdot}\)am\(\sqrt{\cdot}\)i\(\sqrt{\cdot}\)ti] entails SHARE \gg IDENT\textsubscript{OO} and [\(\sqrt{\cdot}\)ek\(\sqrt{\cdot}\)ahi] entails SHARE \gg *T\textsubscript{ï}.
But composite Share $\gg \{\text{IDENT}_{OO}, \ast T_\eta\}$ then incorrectly generates $[p_\eta/\text{apño:ti}]$.

A possible response in OT is to fuse $\text{IDENT}_{OO}([\text{retro}])$&$\ast T_\eta$ into a single, hybrid constraint local to some domain (Smolensky 1995). The domain cannot be the word: The constraint would then be violated (erroneously) even if the violations of $\text{IDENT}_{OO}$ and $\ast T_\eta$ (or the OCP) came from two unrelated loci of retroflexion in the word, as in compounds. It also cannot be the root, since targets often occupy suffixes. One potentially viable domain is the segment (see below regarding other possibilities), as in (61) and (62).

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Base: [a:pno:ti]} & \text{[ident}_{OO}\&\ast T_\eta]_{\text{seg}} & \text{SHARE} & \text{ident}_{OO}\&\ast T_\eta \\
p(a)-\sqrt{a:p}-\text{nö:ti} & & & \\
\hline
a. & (p_\eta/\text{ap})\text{nö:ti} & -4 & -2 \\
b. & (p_\eta/\text{ap}:\eta)\text{ö:ti} & -1 & -3 \quad -3 \quad -1 \\
c. & (p_\eta)/\text{apno:ti} & -6 & \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Base: [n(a\dot{u}ú)am]} & \text{[ident}_{OO}\&\text{OCP]}_{\text{seg}} & \text{SHARE} & \text{ident}_{OO}\&\text{OCP} \\
p(a)-\sqrt{naC-ta-m} & & & \\
\hline
a. & (p_\eta/a\dot{u})\sqrt{n(a\dot{u}ú)am} & -4 & \\
b. & (p_\eta\sqrt{\eta})a\dot{u}(\dot{u}ú)am & -4 & -2 \\
c. & (p_\eta)/\sqrt{na(\dot{u}ú)am} & -5 & -1 \\
d. & (p_\eta\sqrt{\eta})(a\dot{u})\dot{u}(\dot{u}ú)am & -1 & -3 \quad -1 \quad -1 \\
\hline
\end{array}
\]

Nevertheless, (62) only works under possibly dubious assumptions about locality under conjunction. In particular, the crucial OCP violation in (d) is taken to be local to the segment $[\eta]$ even though it is induced by the juncture of two spans, one of which does not contain $[\eta]$. ‘Local to the segment’ must therefore mean that the segment is merely part of a structure contributing to the violation, not that it comprises or contains it. But this interpretation raises further problems. For instance, it incorrectly predicts that an OCP violation on one side of a span should count as local to a segment on the opposite side of the span. Consider the phrase $[\sqrt{puõu} \sqrt{põijn} \dot{a}: ïa: ïa]$ ‘dear to many, for us’ (v1 vs. 0), in which retroflexion spreads from the compound to the enclitic /nas/ ‘us’. The desired winner, (a) in (63), violates the OCP thanks to the juncture in the compound.

\[15\text{An example is } [p_\eta\sqrt{\eta}a=\sqrt{g\eta}af=\sqrt{\eta}a\dot{h}a] \text{‘for the purpose (arthā) of seizing (grahaṇa) affection (?) (prāṇaṇa)’ (e1 vs. 0), in which the OCP violation in grahaṇarthāṇa is irrelevant for prāṇaṇa.}\]
Thus, locality would have to be defined in some other sense that remains to be explored. Changing the domain to the stem would not help; for one thing, the target in (63) is not part of the stem. Changing the domain to the span of retroflexion itself, if feature spans are permitted to be domains, would also not alleviate the error in (63). A workable definition of locality may still be possible, but this section has shown that it is not straightforward. At any rate, there are independent reasons to object to this approach. First, even if a solution is found for nati, the pathologies remain (Pater 2009a). For example, in the present case, even though indexing to a domain other than the word might work, the theory still permits indexation to the word, predicting an apparently impossible grammar.

Second, viability aside, the conjunction analysis is arguably less elegant than the HG analysis. Consider the respective constraint hierarchies in (64) and (65). Conjunction requires extra, complex constraints to accomplish what is handled by simple constraints alone in HG, albeit with weighting. Moreover, the complex constraints are formally redundant: Both contain IdentOO, and all four conjuncts have [retro] as a predicate. While these properties make sense for Sanskrit, in terms of pure formalism, they are coincidences: The theory could just as easily encode a language with these conjuncts indexed to unrelated features.

\[
\begin{align*}
\text{(63)} & \quad \text{Bases: } [(pu\dot{u})(pu\dot{ja}a)], \text{ [nas]} \\
& \quad \sqrt{pu\dot{u}u} - \sqrt{pu\dot{ja}a} \text{ nas} \\
& \quad \begin{array}{|c|c|c|c|}
\hline
\text{(IdentOO \& OCP)}_{seg} & \text{MAX} & \text{SHARE} & \text{IdentOO} \text{ OCP} \\
\hline
a. & \sqrt{(pu\dot{u})(pu\dot{ja}a: \eta)as} & -1 & -3 & -1 & -1 \\
b. & \sqrt{(pu\dot{u})u(pu\dot{ja}a: \eta)as} & & -4 & -2 & \\
c. & \times \sqrt{(pu\dot{u})(pu\dot{ja}a: \eta)nas} & & -4 & -1 & \\
d. & \sqrt{(pu\dot{u})u(pu\dot{ja}a: \eta)nas} & & -5 & -1 & \\
e. & \sqrt{(pu\dot{u}pu\dot{ja}a: \eta)as} & & -1 & -2 & -1 \\
\hline
\end{array}
\end{align*}
\]

In conclusion, a conjunction analysis may be possible under certain (as of yet unclear) assumptions about locality. It would not obviate the need for output-output correspondence (or some suitable replacement), but would provide an alternative implementation of ganging. However, even putting aside concerns about locality and typology, conjunction requires a more complex and redundant constraint set than serial HG does in this case.

5.3 Non-serial Harmonic Grammar

As mentioned in §5.1, serialism avoids a number of pathologies exhibited by pro-spreading constraints in classical OT/HG. Since the analysis here depends on gang effects (§3), serial HG rather than OT was employed. Serial HG was also favored over classical HG because the latter, while able to implement gang effects, is even more pathological than classical OT when it comes to harmony, predicting what might be called cut-off-point effects.
A classical HG cut-off-point pathology is illustrated by the grammar in (66) and (67). In this language, a blocker /ú/ is deleted to permit retroflexion to spread further in service of SHARE (already a pathology), but only if more than seven segments would otherwise remain unharmonized. The cut-off could not only be seven, but any number, as determined by the ratio of the weight of MAX to that of SHARE. Since harmony is myopic in serial HG, proceeding one segment at a time, cut-off-point pathologies of this type do not occur.

\[
\begin{array}{|c|c|c|c|}
\hline
(\text{st})\text{amamama} & \mathcal{H} & \text{FlapOut} & \text{Max} \\
\hline
\text{a. } (\text{st})\text{amamama} & -7.0 & 9 & 7.5 \\
\text{b. } (\text{st})\text{amamama} & -7.5 & & 1 \\
\text{c. } (\text{st})\text{amamama} & -9.0 & & 1 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|c|c|}
\hline
(\text{st})\text{amamamanam} & \mathcal{H} & \text{FlapOut} & \text{Max} \\
\hline
\text{a. } (\text{st})\text{amamamanam} & -7.5 & 9 & 7.5 \\
\text{b. } (\text{st})\text{amamamanam} & -8.0 & & 1 \\
\text{c. } (\text{st})\text{amamamanam} & -9.0 & & 1 \\
\hline
\end{array}
\]

5.4 Stratal OT

Finally, consider a cyclical version of OT that interleaves phonological evaluation with affixation and compounding. This approach is untenable if the ranking is fixed across cycles, since it cannot implement the patterns analyzed as gang effects in §3-4 (cf. §5.2). However, stratal OT (Kiparsky 2000, Bermúdez-Otero to appear), in which levels can have different rankings, is more promising. Assume two levels, Stem and Word, such that prefixes are integrated in the Word. In the Stem, SHARE \(\gg\) *T\(_n\), therefore nati affects a post-plosive target. In the Word, the ranking is reversed, *T\(_n\) \(\gg\) SHARE, such that a newly introduced trigger can no longer access a post-plosive target.

This ranking as it stands erroneously undoes the retroflexion of a post-plosive target that underwent nati in the Stem. Take /√ıe:knas/. In the Stem, it becomes \([√ıe:knas]\). But in the Word, nati is undone by now dominant *T\(_n\) leaving \([√ıe:knas]\]. Adding MAXLINK([retro]), which penalizes deleting an association line to [retro] (cf. Jurgec 2011), solves this problem, preserving [n] that arises in the Stem. MAX([retro]) (§2.3) alone would not work, as the span could retreat without deleting. The rankings are given in (68).

\[
\begin{array}{c}
\text{(68) Stem level: } \text{MAXLINK([retro]) } \gg \text{SHARE } \gg \text{*T\(_n\)} \\
\text{Word level: } \text{MAXLINK([retro]) } \gg \text{*T\(_n\) } \gg \text{SHARE}
\end{array}
\]

Next, the OCP effects in §4 would also require more than flipping SHARE and the OCP. Recall from (49) that \((p₄ₙ₃)-√n(₃₉-t)a-[\) wins over \(*[(p₄ₙ₃)-√ₙₙ(₃₉-t)a-,\) in the serial analysis

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because the latter would require two changes in one step. Thus, retroflexion cannot retreat across the vowel to save the OCP. In stratal OT, by contrast, *[(p₁ə-√η)a(ṣ-t)a-] is a viable contender. It could be ruled out by adding a constraint, say, LICENSE, that penalizes a retroflex consonant not immediately preceded by a retroflex vowel, as in (69). (LICENSE must be dominated by MAX, DEP, etc., not shown.)

(69) Stem level: LICENSE $\gg$ SHARE $\gg$ OCP
    Word level: LICENSE $\gg$ OCP $\gg$ SHARE

In sum, an analysis of the facts in §3-4 may be possible in stratal OT, though not without additional constraints. The serial HG analysis has the further virtue of requiring only a single, fixed ranking for the language, with arguable benefits for learnability and restrictiveness. Moreover, the stratal analysis requires potentially problematic assumptions about the morphology, since (often highly lexicalized) prefixation and compounding must follow (even inflectional) suffixation. With IDENTOO, a form such as [p₁ə√Hiïo:ti] stands in correspondence with [√Hiïo:ti] simply because the former contains the latter and both are free. It does not require prefixation to follow inflection anywhere in the grammar.

6 Conclusion

Sanskrit retroflex spreading is attenuated by root boundaries, such that stem-internal triggers access more targets than stem-external triggers. At least two independent processes demonstrate this attenuation. First, only stem-internal triggers access post-plosive targets. Second, only stem-internal triggers access pre-retroflex targets. These restrictions reveal the activity of two markedness constraints, *Tᵣ and the OCP. Permitted to gang with IDENTOO in serial HG, they implement the observed subset relation among triggers. Other possible approaches, including morphological indexation, constraint conjunction, and non-serial HG, were argued to be untenable or pathological. Beyond introducing and analyzing these domain conditions on nati, this article also presented a novel analysis of the basic rule that simplifies previous constraint-based analyses.

References


Jurgec, Peter. 2011. Icy targets. MS., Meertens Institute, Amsterdam.


Kaun, Abigail. 2004. The phonetic foundations of the rounding harmony typology. *Phoneti-
cally based phonology, ed. by Bruce Hayes, Robert Kirchner, and Donca Steriade, 87–116. Cambridge: Cambridge University Press.


McCarthy, John, and Alan Prince. 1993. Prosodic morphology I: Constraint interaction and satisfaction. MS, University of Massachusetts-Amherst and Rutgers University. Distributed as Rutgers Optimality Archive 482. Available at


Smolensky, Paul. 1995. On the internal structure of the constraint component Con of UG. Handout, University of Arizona, ROA-86.
Staub, Robert, Michael Becker, Christopher Potts, Patrick Pratt, John J. McCarthy, and Joe Pater. 2010. OT-Help 2.0. Software package. Amherst, MA: University of Massachusetts, Amherst.
Steriade, Donca. 2009. The phonology of perceptibility effects: The P-map and its consequences for constraint organization. The nature of the word: essays in honor of Paul


Zuraw, Kie. 2013. *MAP constraints*. MS., UCLA.