The Development of Diphthongs in Vedic Sanskrit

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Old Indic diphthongs underwent a chain shift whereby *e* and *o* monophthongized (aḭ > ē) and *ai* and *au* shortened, filling the gap (āḭ > aḭ). While it is clear that these changes were complete by the end of the Vedic period, it has been unclear when during (or before) that period they occurred. Based on the avoidance of superheavy syllables in metrical cadences, which is corroborated here, I argue that both shifts took place during the compositional period of the R̥gveda. That is, they had not yet begun when the oldest material was composed, but were largely complete by later material, including book 10.

In Old Indic metrics, syllable weight is conventionally treated as a binary opposition between heavy (*guru*) and light (*laghu*). Nevertheless, as Hoenigswald (1989) and Kobayashi (2001: 94–96) observe, the R̥gvedic (RV) poets preferentially avoid placing overlong (also known as superheavy or trimoraic) syllables in metrical cadences, making for a third grade of weight that is metrically relevant, albeit not categorically regulated.[1] A superheavy syllable has a rime of the shape VXC_1, where VX indicates a long vowel, diphthong, or short vowel plus consonant, and C_1 indicates at least one consonant. The cadence here refers to the final four or five (see §1) positions of the line, excluding the ultima, which is metrically indifferent. In Vedic and elsewhere, the cadence is the strictest part of the line. To be sure, superheavies are not hard to find in cadences, but heavies are significantly less likely to be superheavies in the cadence than elsewhere in the line. Hoenigswald (1988, 1989, 1991) connects this avoidance to other evidence for superheavy markedness in Vedic and adduces comparative support.[2]

This article corroborates superheavy avoidance in cadences, going beyond Hoenigswald and Kobayashi by using statistical models that control for possible confounds such as word boundary distribution. Aside from drawing additional support for cadential avoidance in the general case, the article pursues three new directions. First, it examines whether different types of superheavies are treated differently, finding, for one, that ultraheavies (VXC_2) are avoided even more stringently than VXC superheavies. Second, it exploits avoidance as a diagnostic to determine whether particular sound changes had occurred at the time of composition of the text. Finally, it considers implications of these results for the proposed stratifications of the RV.

Old Indic has four diphthongs, transcribed *e*, *o*, *ai*, and *au*. All are metrically heavy, including *e* and *o*, which are usually transcribed without macrons because they lack short counterparts. Uncontroversially, the original (say, early Vedic or pre-Vedic) pronunciations were *e* [aḭ], *o* [aṷ], *ai* [āḭ], and *au* [āṷ] (Wackernagel 1896: 35–41; Whitney 1889: 12; Allen 1953: 62–64). This is clear from both external (comparative) and internal evidence, such as sandhi (e.g., *a* plus *i* yields *e*). Nevertheless, the received values of the vowels for both San-

1. See also Ryan 2011, 2019 on rich weight distinctions in meter.

2. For example, non-thematic, full-grade forms such as *dógdhi* are avoided. Further, epenthesis can be triggered by superheavy avoidance, as in *uvócitha* vs. *vivyáktha*. Sievers' law vocalizes a glide when it would otherwise yield a superheavy. In sandhi, hiatus (e.g., *sá ít*) is more likely to be maintained when crasis (*séd*) would yield a superheavy, that is, before a consonant-initial following word. Hoenigswald (1991) treats the cadential avoidance of superheavies in ancient Greek.

skrit and Vedic are *e* [ē], *o* [ō], *ai* [ai̯], and *au* [au̯]. These latter realizations, which remain standard to date, were set forth in even the earliest phonetic descriptions, the Prātiśākhyas.[3] These outcomes entail two sound changes, as in Figure 1. First, *e* and *o* flatten, eventually to monophthongs. Second, the cores (low vowel components) of *ai* and *au* shorten. Flattening of some degree must precede shortening, lest the pairs merge.

Transcription	Pre-Vedic	Orthoepy	
e	ai̯	ē	1. flattening
o	au̯	ō	
ai	āi̯	ai̯	2. shortening
au	āu̯	au̯	

Fig. 1. Starting (“pre-Vedic”) and ending (“orthoepy”) points of the chain shift

The question remains as to when the changes occurred. Their completion by the time of the Prātiśākhyas, as well as their confirmation by Greek loans (ca. 300 BCE; Wackernagel 1896: 35), merely supply a terminus ante quem: the changes must have been complete by the end of the Vedic period. In principle, they could have occurred any time within that period, or even before it (after Proto-Indo-Iranian).[4] This article proposes that the changes took place at a relatively early date, but not so early as to predate the Vedic corpus, namely, midway through the compositional period of the RV. Based on superheavy avoidance in cadences, *ai* and *au* are shown to transition from trimoraic to bimoraic within the RV. Meanwhile, *e* and *o* must have at least partially flattened by the later strata of the RV. That is, *e* (and *o*, mutatis mutandis) might have flattened either fully, to the monophthong [ē], or partially, to a minor diphthong such as [ei̯] or [ae̯]. Either way, it would not have retained its original value as a major diphthong [ai̯].

1. SUPERHEAVY AVOIDANCE IN THE RV

The sharp drop in the incidence of superheavies from the pre-cadence to the cadence is depicted for the RV in Figure 2. The figure is divided into three panels for three metrical line (*pāda*) types, namely, dimeter (8-syllable) and trimeter (11- or 12-syllable), hereafter simply 8, 11, and 12. Lines of other lengths, which are infrequent in the RV, are excluded, as are lines in special meters,[5] lines from the Vālakhilya, and repeated lines after the first instance. The remaining 31,766 lines compose the normal meter corpus used in this article.

3. The Ṛk-Prātiśākhya, for one, establishes the monophthongal qualities of *e* and *o* (Allen 1953: 63–64). Allen suggests that the Pāṇinīya-Śikṣā can be read as prescribing incomplete flattening of *e* and *o*. At any rate, regardless of whether *e* and *o* had fully flattened by the end of the Vedic period, they had flattened enough to permit the shortening of *ai* and *au*, which is the important point here.

4. Wackernagel (1896: 39) dismisses the argument that the changes must be of post-RV provenance because otherwise, the argument goes, the sandhi in the RV would be opaque (as would later *pluta* forms, such as *agnā3i* for *agne*). If late Vedic and Sanskrit composers can handle opacity, Wackernagel reasons, so could early Vedic composers. Furthermore, Wackernagel (ibid.), Whitney (1889: 12), and Allen (1953: 64) note that while the tradition labels *e* and *o sandhyakṣara* (sandhi vowel, translated “diphthong”), this classification is based on their behavior in sandhi, not their phonetic realization.

5. Special meters include the trochaic *gāyatrī*, uneven lyric, epic *anuṣṭubh*, *Bhārgavī*, *Gautamī*, and *Virāṭsthānā* (Arnold 1905: 211–16, 228–43). Lines were also excluded for having a marked cadence of other than heavy-light-heavy-X for 11 or light-heavy-light-X for 8 or 12.

Figure 2 shows the percentage of heavies that are superheavy in each position.[6] Cadences are indicated by solid circles and pre-cadences by empty circles. To a first approximation, the cadence is the final four positions of the line, ignoring the weight of the ultima. In 12, however, the cadence extends to the fifth position from the end, that is, 12-8, as is clear from Figure 2 as well as from the general strictness of 12-8, which is filled by a heavy 97% of the time, consistent with 12 being a hypercatalectic 11. Turning to 8, position 8-4, while conventionally regarded as part of the opening, patterns more like the cadence in terms of superheavy avoidance. Thus, for purposes of this article, 8-4 is taken to be cadential.

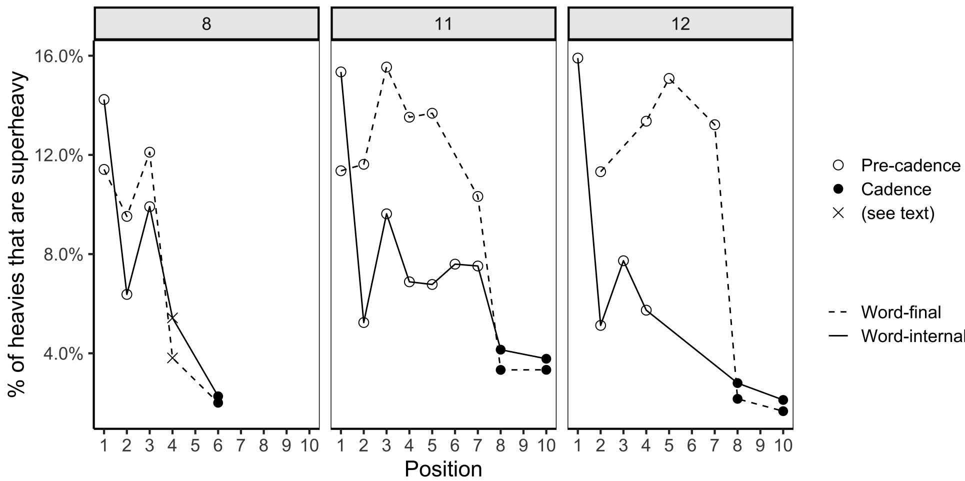

Fig. 2. Cadential suppression of superheavies in three RV metrical types. Line-final and majority-light positions are excluded

Figure 2 includes separate lines for word-final and word-internal syllables to address a confound not broached by the cited research, namely, the possibility that superheavies might be underrepresented in cadences because word boundaries are underrepresented in cadences. As the figure clarifies, although a word-final syllable is more likely to be superheavy than a word-medial syllable (as suggested by the higher dashed lines), superheavy avoidance is approximately equally strong for word-final and word-medial syllables. It is therefore not an artifact of the underrepresentation of word-final syllables in cadences.

In total, in the normal meter corpus of the RV, superheavies account for 14.3% of heavies in pre-cadences as just defined and 5.7% of heavies in cadences (Fisher's exact test $p <$ .0001). Moving beyond previous findings, Figure 3(a) demonstrates that within the superheavies, different syllable types exhibit different degrees of avoidance, such that the heavier the superheavy, the more it is avoided in cadences. VV refers to a long vowel, *e*, or *o*; V to a short vowel; C to a consonant; *ai* to *ai* or *au*; *e* to *e* or *o*; and "Ultra" to an ultraheavy, that is, VXC_2. The bar heights in Figure 3 are not affected by the baseline frequencies of rime types. Ultraheavies, for instance, are rare in general, but their rarity is irrelevant to the results

6. Syllables ending in *īr* or *ūr* are excluded (Hoenigswald 1989: 559 and Kobayashi 2001: 95; cf. Wackernagel 1896: 22–31).

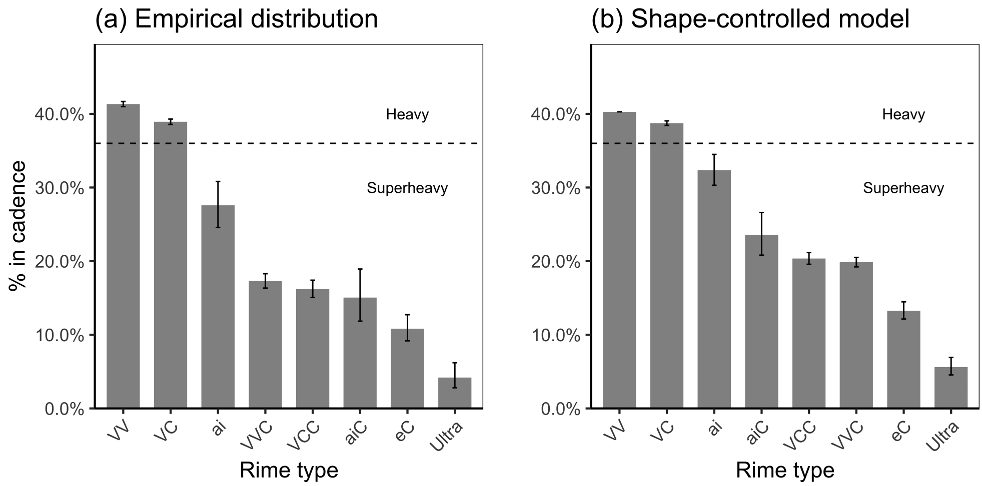

Fig. 3. The percentage of syllables of each type that occur in cadences as opposed to pre-cadences in the RV. Heavier types are increasingly avoided in cadences. Plot (a) is the empirical distribution while (b) shows percentages (converted from log-odds) generated by a mixed-effects model with word shape as a random effect

shown in the figure, which show only that the ultraheavies that do occur are skewed more strongly towards pre-cadences than other heavy types.

Before discussing the substance of these results, a shortcoming of Figure 3(a) should be addressed, namely, that it does not control for word boundaries, leaving open the possibility that the trend is an artifact of word shape distribution. To wit, there is a positive correlation in Vedic between the heaviness of a syllable (as syllabified in context) and the likelihood that the syllable is word-final. Given that word-final syllables are underrepresented cadence-internally,[7] this correlation alone could in principle motivate the results in Figure 3 without any appeal to superheavy avoidance. A further possible confound is that only certain word shapes are metrifiable in cadences. For example, the penult of an all-heavy trisyllable (HHH) cannot normally be cadential. Imagine that such a penult were more likely to be superheavy than other heavies. Word shape constraints would then contribute to the paucity of superheavies in cadences. In short, in order to conclude that a syllable type (such as VVC) is avoided in cadences because of its overweight, one must control for other possible explanations, unrelated to weight, for its infrequency in cadences.

One approach to controlling for such confounds is to consider only word types that are metrifiable in both cadences and pre-cadences, and further to consider only a fixed position (e.g., word-final) of such types (cf. Devine and Stephens 1994: e.g., 74–79). For example, is the ultima of a heavy-light-heavy word (HLH) more likely to be superheavy in the cadence than in the pre-cadence? Restricting the data in this manner has two drawbacks. First, it severely reduces the quantity of data brought to bear on the question. In this case, 97% of heavies in the corpus would be disregarded. As such, any findings are of limited use, as their

7. Several factors contribute to the relative infrequency of word-final syllables within cadences. These include metrical factors (e.g., caesurae falling outside of the cadence), syntactic considerations (e.g., second-position clitics being usually outside of the cadence), and discourse tendencies (e.g., Behaghel's law, which has the potential to inflate the incidence of longer words at the ends of constituents).

generalizability is dubious. Second, metrifiability in cadences is not all-or-nothing, but gradient. Word shapes vary widely in their cadential biases. For example, monosyllables, though metrifiable in cadences, are for various reasons biased toward pre-cadences.

A solution to all these problems is a model that takes all heavies in the corpus into account while also controlling for word shape and position in the word by correcting for any cadential biases attributable to those factors. One such model is a mixed-effects logistic regression (Baayen et al. 2008; Sonderegger et al. 2018) with random effects for word shape (Ryan 2011). A word shape is a heavy-light template with the position of the syllable datum indicated (e.g., HLX for the ultima of an HLH word). Every heavy syllable in the corpus is coded for its cadential status (true or false), word shape, and rime type (eight levels). A logistic model is then set up to predict cadential status from rime type and word shape, schematically, "Cadence ~ Rime Type + (1|Word Shape)." In fitting this model, each rime type and each word shape is weighted according to its propensity to appear in cadences. For example, HXH (in which X is heavy, since only heavies are considered) has a lower weight than HLX. As another example, rime type ultraheavy has a lower weight than VCC. Because the model employs both shape and rime as factors, it is less prone to attribute cadential biases to rime that can be explained by shape. For instance, superheavies in the frame HXH have almost no effect on the rime type weights, since the cadential status of a heavy in HXH is predictable without considering X's rime type. The notation "(1|Word Shape)" indicates that word shape is coded as a random effect, such that each shape gets its own intercept, as is appropriate for an identifier sampled from a large set of unordered labels (Baayen 2008: 241–302; Baayen et al. 2008). Controlling for word shape in this fashion not only corrects for word context, but also for the lower incidence of boundaries within cadences, since word shape encodes boundary adjacency.

Figure 3(b) shows the results of such a model for rime type (word shape intercepts are not shown). The resulting percentages resemble those in Figure 3(a), suggesting that word shape distribution, while a potential confound, is not a serious confound in practice. Nevertheless, going forward, the models in this article are shape-controlled, as the method is more rigorous.

Returning to the substance of Figure 3, as both versions of the figure reveal, ultraheavies are avoided in cadences even more stringently than superheavies. Furthermore, *ai* patterns as intermediate between heavy and superheavy, as evident both from category "ai" and from "aiC," the latter being expected to be ultraheavy if *ai* were itself superheavy. This intermediacy could in principle reflect either or both of the following. First, *ai* might be intermediately long in the RV, that is, [a·i̯]. (This explanation requires superheavy avoidance to be sensitive to submoraic duration.) Second, *ai* might be superheavy [āi̯] in some parts of the RV but bimoraic [ai̯] in others, yielding a middling average. To test the second hypothesis, the corpus must be stratified, to which I now turn.

2. THE WEIGHT OF *ai* AND THE STRATIFICATION OF THE RV

As discussed above, *ai* shortened from [āi̯] to [ai̯] sometime during or before the Vedic period. Superheavy avoidance in the RV yielded a result whose interpretation is not straightforward, namely, that *ai* is aggregately lighter than [āi̯] but heavier than [ai̯]. This section de-aggregates the RV, demonstrating that shortening was not in evidence in early strata but was complete by later strata, explaining the intermediate result in the composite text.

I consider three stratifications, based on Arnold (1905: 269–88 et passim), Oldenberg (1888: 191–270, and 1909–12: passim), and Witzel (1995: 309–12, and 1997: 262–64), respectively (see also Jamison and Brereton 2014: 10–13 for an overview).[8] In every case, I apply the same exclusions as in §1, such as repeated *pāda*s and the Vālakhilya. Arnold identifies five chronological strata, namely, archaic, strophic, normal, cretic, and popular, in that order. Oldenberg posits six layers in the assembly of the RV, the sixth and latest (putting aside the Vālakhilya) being what he identifies as appendices (Anhänge), a relatively small number of arguably late additions spread across the books of the RV. Oldenberg's first five strata, in every case excluding the appendices, are (1) books 2–7, (2) 1.51–191 and 8.1–66, (3) 1.1–50 and 8.67–103, (4) book 9 (minus 9.68), and (5) book 10 (plus 9.68). To be sure, Oldenberg does not suggest that his six strata (five plus appendices) represent a linguistic periodization of the text. They reflect, rather, the order in which the RV was arguably assembled, which may or may not correlate with linguistic innovation. That said, he observes that book 10 and the appendices appear to be younger on linguistic grounds. Witzel endorses Oldenberg's assembly strata but identifies a somewhat different set of appendices.

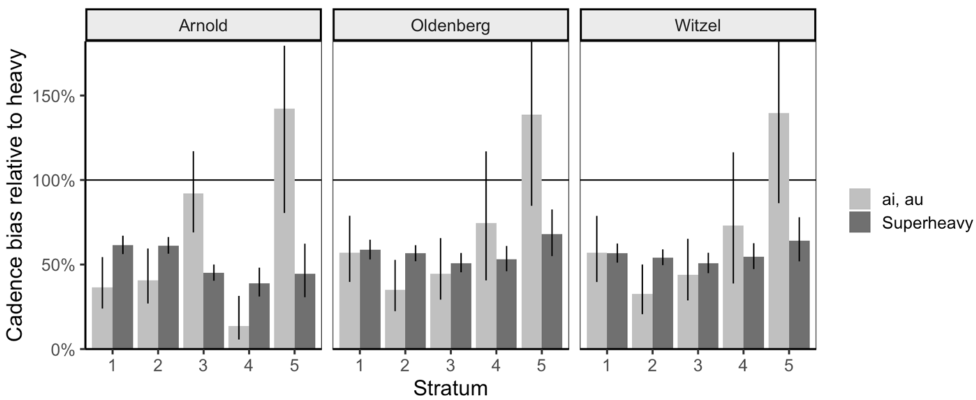

Fig. 4. Cadential avoidance of {*ai*, *au*} vs. other superheavies under three stratifications of the RV. A lower bar indicates greater avoidance in cadences. Overlap with the midline indicates no avoidance in cadences

In Figure 4, strata are numbered accordingly for each author. Oldenberg's and Witzel's results exclude the appendices identified by each of those authors, respectively. For consistency across strata, results are based exclusively on 8-syllable *pāda*s.[9] Within each stratum, a mixed effects model is run as in §1. The coefficients are then normalized so that the horizontal rule at 100% in the figure always represents the intercept for heavies, to which one can compare {*ai*, *au*} and superheavies (excluding *ai* and *au*). The lower the bar, the more the syllable type is avoided in cadences. A bar near (or whose error bar crosses over) the 100% baseline is treated metrically as a bimoraic syllable.

Crucially, superheavy avoidance as a general phenomenon is a constant across all strata. While it fluctuates slightly from one to the next, it is always a highly significant effect, in the vicinity of 50% of the baseline. By contrast, *ai* and *au* undergo a marked change. In the earliest strata of each scheme, *ai* and *au* are on par with or even heavier than other super-

8. In computing the statistics for the figures in this section, I benefited from files containing stratal labels prepared by Dieter Gunkel and Salvatore Scarlata.

9. Different strata have different relative frequencies of 8-, 11-, and 12-syllable meters, which could conceivably distort the results if there are systematic differences among the metrical types with respect to superheavy avoidance.

heavies.[10] By the latest stratum of each scheme, they are indistinguishable from bimoraic syllables in terms of weight. Note also that Oldenberg's observation about linguistic periodization appears to be supported: there is little change here in his first few assembly strata, while the final stratum (book 10) stands out the most.

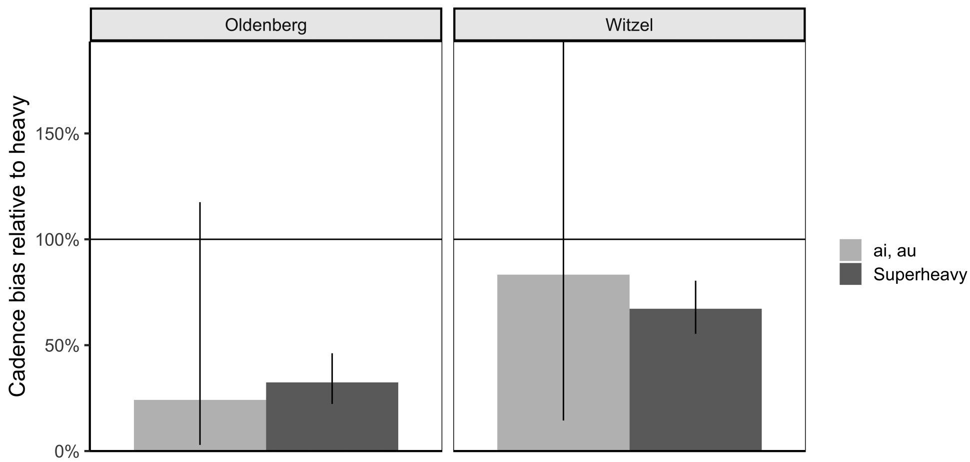

Fig. 5. Cadential avoidance of {*ai*, *au*} vs. other superheavies, as in Fig. 4, except now for appendices to the RV as identified by Oldenberg (1888, 1909–12) and Witzel (1995)

Figure 5 shows results just for the appendices, which were excluded from Figure 4. Judging by these results, Witzel's appendices seem to be better supported than Oldenberg's, in that the former are more consistent with being the culmination of the trend evident in Figure 4. Nevertheless, the appendix subcorpora are small, making for the large error bars observed in Figure 5. With such large errors, one cannot draw firm conclusions. Moreover, Oldenberg's and Witzel's appendices overlap. Counting only appendices that apply to the normal dimeter corpus employed in this section, Oldenberg identifies 1,354 *pāda*s and Witzel 1,931, with 618 *pāda*s shared by both authors' lists.

In sum, *ai* and *au* shifted from [āi̯] and [āu̯] to [ai̯] and [au̯] during the compositional period of the RV. This progression is evident from all the stratifications in Figure 4, though the course of its development is clearest from Oldenberg's and Witzel's stratifications: it has not yet begun in books 2 through 8, is mixed in book 9, and is complete by book 10. The middling result for book 9 might reflect the heterogeneous composition of that book, its soma hymns being extracted from various sources. It is worth noting also that the present results are based solely on 8-syllable *pāda*s (excluding epic *anuṣṭubh*, trochaic *gāyatrī*, etc.), which might aggregately reflect a different degree of conservatism or innovation than other metrical types. In Arnold's strata, the change has not yet begun in archaic, strophic, or cretic, is underway in normal, and is complete by popular. The present results favor Oldenberg's and Witzel's strata over Arnold's, or at least suggest that Arnold's normal stratum is heterogeneous, such that much of it postdates his cretic.

10. The latter is not unexpected phonologically for [āi̯] and [āu̯]. Although they are like other superheavies in being trimoraic, they are also more sonorous, which can correlate with extra weight cross-linguistically (Gordon 2002: 53; Ryan 2019: 10–12). Moreover, a large portion of the other superheavies are VVC, which can be subject to (perhaps gradient) closed-syllable shortening.

3. CONCLUSION

This article revisits and confirms the notion that the Vedic poets preferentially avoid locating superheavy syllables in metrical cadences. Indeed, the notion is extended here, as it is demonstrated that ultraheavies are even more avoided than superheavies. Using controlled models, it is argued that this avoidance cannot be ascribed to word shape or boundary distribution to the disregard of overweight.

Once superheavy avoidance is established in the general case, it can be exploited to probe whether certain sound changes occurred by the time of composition of the target corpus. The Old Indic diphthongs, for their part, are known to have undergone a chain shift sometime between Pre-Vedic and the Prātiśākhyas, though a more precise chronology has been difficult to secure. The evidence examined here suggests that *ai* and *au* had long cores (āi̯ and āu̯) in books 1–8 of the RV but were already shortened (to ai̯ and au̯) by book 10. Book 9 is intermediate, perhaps mixing material from both stages. Moreover, once *ai* and *au* are bimoraic, *e* and *o* can no longer have their original values [ai̯] and [au̯], lest a merger occur. This means that *e* and *o* had flattened by book 10 at the latest, at least partially, if not completely (ē and ō).

In similar fashion, this method can be used to investigate other aspects of phonetic restoration that are not discernible from the transmitted orthography/orthoepy, effectively looking under the hood of the received forms of texts to unveil more of the rich phonetic sensibilities of their composers.

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