

The Phonetics of the Independent Svarita in Vedic^{*}

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1. Introduction

Although from the beginning of Indo-European studies the Vedic accentual system has been thoroughly investigated and its importance for the reconstruction of Proto Indo-European accent long recognized, the phonetics of Vedic accent have received much less attention. The aim of this paper is to help fill this gap, building on previous work from various grammatical sources, from antiquity to modern times (including the descriptions in Pāṇini, the Prātiśākhya, and the treatments in Haug 1873:21–107, Whitney 1879:27–32, *AiG* I:281–97, Macdonell 1910:76–82, and Allen 1953:87–94). I will focus on the phonetics of the “independent svarita,” which in my opinion has been the least satisfactorily described accent in Vedic accentology. I will first propose a new terminological distinction between pitch accents on particular syllables and a “global” pitch trajectory that spans several syllables and constitutes the phonological accent in Vedic. This crucial step will allow me to define the phonetic differences between elements of different pitch accents in Vedic. Based primarily on data from the Sāmaveda, I will propose a new explanation for the phonetics of the independent svarita. Essentially, I will argue that the independent svarita is in all respects identical to the udātta with the same pitch targets, the only difference being in timing—the independent svarita is a shorter version of the udātta. This new explanation not only brings new insights into the phonetics of Vedic accents, but also has the potential to explain other peculiarities of the accentual system, especially in the domain of accentual sandhi.

The structure of the paper is as follows: in §2 I present well-known facts about the phonetics of Vedic accent and propose a new terminological distinction. In §3 I discuss previous accounts of the phonetics of the independent svarita. In §4 I point to new evidence and propose a new explanation for the independent

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svarita. I conclude by suggesting how my account may help explain other phenomena of the Vedic accentual system.

2. Background and terminological clarification

As Haug (1873:4–5) already pointed out, there are three main sources of information about the Vedic accentual system: (a) the system of accent notation in the Saṃhitās and the Padapāṭha transmission of the texts, (b) the actual (still living) tradition of oral recitation of the texts, and (c) various commentaries and grammatical works, the most prominent of which are the Prātiśākhya (i.e., collections of works on the phonetics of recitation of Vedic hymns) and the grammar of the Vedic language by Pāṇini. This paper will focus primarily on accent marking in the Saṃhitās, which provides the most information for the phonetic reconstruction of Vedic accents. Where necessary, I will also include information about the accent from the Prātiśākhya and Pāṇini.

Accent marking in the Saṃhitās is not completely unified. Macdonell (1910: 78–80; 1916:448–53), following Haug (1873:21–107) and others, identifies four major traditions of Vedic accent marking: (i) that of the Rigveda, Atharvaveda, Taittirīya Saṃhitā, Taittirīya Brāhmaṇa, Taittirīya Āraṇyaka, and Vājasaneyi Saṃhitā;¹ (ii) that of the Maitrāyaṇī Saṃhitā, the Kāṭhaka Saṃhitā, and the Kāṭhaka Āraṇyaka; (iii) that of the Sāmaveda; and (iv) that of the Śatapathabrāhmaṇa.² The Śatapathabrāhmaṇa is the youngest of the systems. Since the accentual system in the ŚB has undergone major changes and the accent marking is not completely transparent,³ I will exclude it from the discussion.

Several facts regarding the phonetics of Vedic accent are well established and agreed upon based on these data. The three major comprehensive descriptions of the Vedic accent in which the core agreements are collected are Haug, *AiG* I, and Macdonell, all cited above. The summary of the well-known facts below is based on these works.

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- 1 In fact, Haug (1873:24–35) points to the fact that the accent marking of the Rigveda and the Atharvaveda differs slightly from that of the Taittirīya Saṃhitā and Vājasaneyi Saṃhitā. However, the differences are minor and affect only the accent marking of accentual sandhi, so the two types will be considered as one.
 - 2 The following abbreviations will be used throughout the text: RV = Rigveda, AV = Atharvaveda, SV = Sāmaveda, TS = Taittirīya Saṃhitā, TB = Taittirīya Brāhmaṇa, TA = Taittirīya Āraṇyaka, VS = Vājasaneyi Saṃhitā, MS = Maitrāyaṇī Saṃhitā, Kā. = Kāṭhaka, ŚB = Śatapathabrāhmaṇa.
 - 3 For a thorough study of the accentual system of the Śatapathabrāhmaṇa, see Cardona 1993.

Vedic is generally assumed to be a pitch accent language: each prosodic word usually bears one pitch accent.⁴ There are two types of pitch accents that a prosodic word can host, which are usually characterized as rising or falling, or in the Indic grammatical tradition, udātta and svarita, respectively. The exact realization of the pitch varies slightly across the traditions: in the Rigveda, for example, its phonetic realization differs slightly from that in the Sāmaveda (Macdonell 1910:77). However, the following general features of accent are common to all traditions.

The accented syllable is usually called the udātta. It is the syllable that continues the PIE accented syllable and that corresponds to the Greek acute, e.g., gen. sg. Gk. ποδός, Ved. *padás* ‘foot’. The udātta is characterized by a rising pitch. It is usually preceded by the anudāttatara, which is the syllable with the lowest pitch in the prosodic word. After the udātta comes the svarita, which is usually characterized as a falling pitch. The main point on which the various traditions differ is on which syllable the pitch hits its highest point. In the Rigvedic tradition the pitch reaches its highest point in the svarita syllable (Macdonell 1910:77) before falling back to the neutral level. In the Sāmavedic tradition, by contrast, the highest pitch is reached on the udātta syllable.

Historically, the pitch trajectory with the highest realization on the udātta syllable is likely to be the original one. The Rigvedic tradition represents a later innovation, although this innovation must have occurred quite early, as was pointed out by Macdonell (1910:77). It is very common for the high pitch to be realized with a delay (cf. Silverman and Pierrehumbert 1990, Xu 2001:26–7), and this is exactly what is happening in the Rigvedic tradition.

Schematically, we can represent the pitch (f₀) in the following figures. Note that the pitch trajectory is completely hypothetical and is not based on any measurements, but rather on descriptions from the literature. Figure 1 illustrates the Rigvedic pitch in which the peak is on the svarita syllable, which in transcriptions is usually marked as *V̄V̄*. Figure 2 illustrates the pitch in other traditions, in which the pitch peak is reached on the udātta syllable.

4 As is well known, there are some exceptions to this rule: a prosodic word can have two accents or no accent at all. Some compounds and the infinitives in *-tavai* can have two accents, e.g., *āpa-bhartāvai* ‘to take away’ (Macdonell 1910:81). Both accents within a word are marked identically and to my knowledge no difference in marking between the two exists in any of the traditions of accent marking. Prosodic words can also bear no accents: beside clitics, verbs in main clauses as well as nouns in the vocative case, except in pada-initial position, bear no accent (loc. cit.).

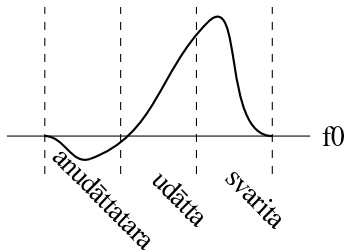


Fig. 1. Pitch accents of anudāttatara, udāṭṭa, and svarita with the highest pitch on the svarita

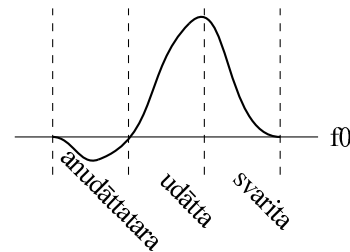


Fig. 2. Pitch accents of anudāttatara, udāṭṭa, and svarita with the highest pitch on the udāṭṭa

As I have already mentioned, there are two possible pitch accent trajectories that a prosodic word can have. The two illustrated above involve the udāṭṭa and show the usual trajectory; it continues the position of the PIE accent. However, later in the development of Vedic, another type of pitch accent arose which is usually called the independent svarita (in transcriptions usually marked as $V\check{V}$). The exact phonetics of this type are, however, less clear and this paper aims to answer this question.

Before we turn to discussion of the independent svarita and its treatments in the literature, it is important to make a terminological distinction that will help avoid the confusion that can occur in literature on Vedic accent. We saw that there are two types of pitch accents: for the moment let us call them Type 1 (rising) and Type 2 (falling). Type 1 consists of three syllables: anudāttatara, udāṭṭa, and svarita (see Figures 1 and 2 above). We do not yet know what Type 2 consists of. The confusion in the literature arises because the Type 1 pitch accent is often referred to simply as udāṭṭa, whereas Type 2 is referred to as independent svarita. But we saw above that udāṭṭa also refers to the particular syllable which is (the central) part of the Type 1 pitch accent. To avoid this confusion, I propose to make a distinction between the *accents* called “udāṭṭa” and “independent svarita,” and anudāttatara, udāṭṭa, and svarita *syllables*. For particular syllables within these two types, however, I propose that we refer to them as the UDĀṬṬA SYLLABLE, the SVARITA SYLLABLE, and the ANUDĀTTATARA SYLLABLE.

To exemplify: Figures 1 and 2 above thus represent the udāṭṭa accent (or simply the udāṭṭa), which consists of an anudāttatara syllable, an udāṭṭa syllable, and a svarita syllable, in that order. The pitch is lower than neutral on the anudāttatara syllable, is raised on the udāṭṭa syllable, and, in the Rīgvedic tradition, rises to the highest point and falls to the neutral position in the svarita syllable.

ble. This seemingly obvious terminological distinction will be crucial in establishing the exact phonetics of the independent svarita.

The question now arises: what is the source of our detailed knowledge of the phonetics of the udātta outlined above? The first revealing information on the phonetic nature of the udātta accent comes from the terminology used by grammarians. The three constitutive syllables of the udātta accent are described as udātta, which means ‘raised, high, elevated’; anudātta, which means ‘not raised’; and anudāttatara, which means ‘more unraised’. The latter is also characterized as “sannatara,” meaning ‘more sunken down, more depressed’ (Macdonell 1910: 79). The term svarita, on the other hand, is less revealing: it means ‘sounded’ and is derived from the root $\sqrt{\text{svār}}$ ‘to sound’ (e.g., Ved. *svārati* ‘sounds’) from PIE **suer-* with the same meaning (*LIV*²:613).

The second source of information comes from the accent marking systems. The anudāttatara syllable is usually marked by a vertical stroke below the character (akṣara) in the RV, AV, TS, TB, TA, VS, MS, and Kā.,⁵ indicating that the pitch sinks down and reaches its lowest point. In the Sāmaveda the anudāttatara syllable is marked by a numeral 3 above the character, again indicating the lowest point of the pitch (3 represents the lowest pitch, 1 the highest, and 2 the medial pitch). The udātta syllable is not marked at all in the RV, AV, TS, TB, TA, and VS. This indicates that the pitch of the udātta syllable in these traditions is medial, in the transition from the lower pitch of the anudāttatara syllable to the highest pitch of the svarita syllable. In the Sāmaveda, MS, and Kā., however, the highest pitch falls on the udātta syllable, which is reflected in the accent marking: in the SV the udātta syllable is marked with the numeral 1 above the character, and in the MS and Kā. with a vertical stroke above the character (cf. Haug 1873:30, 35–42; Macdonell 1910:79).

The greatest degree of variation between the various traditions is found in the marking of the svarita syllable. The svarita syllable following the udātta syllable is marked with a vertical stroke above the character in those traditions in which the highest pitch is realized on the svarita syllable: the RV, AV, TS, TB, TA, and VS. In the SV the svarita syllable is marked with the numeral 2 indicating the medial level of the pitch. In the MS it is marked by a horizontal stroke in the middle of the character, and in the Kā. the svarita syllable is marked by a dot

5 In some manuscripts of the Kāṭhaka Saṃhitā and in the Kāṭhaka Āraṇyaka the anudāttatara is marked by a vertical stroke below the character. In those manuscripts the dependent svarita is marked by a dot below the character (Witzel 2004:xxiv).

below the character. The horizontal stroke in the middle of the character in the MS in particular points to the svarita's middle pitch level.

All the characteristics described above refer to the udātta accent. Let us now turn our attention to the independent svarita. This accent type arises when the udātta syllable is lost. In other words, the loss of vowels under certain conditions turns the udātta accent into the independent svarita accent if the lost syllable would have been an udātta syllable.

The main source of the independent svarita in Vedic is syncope. Syncope targets the short high vowels *i* and *u* before *y* and *v*, respectively, which are followed by a vowel. The independent svarita arises when the syncopated high vowels *í* and *ú* constitute the udātta syllable. In other words, the udātta syllable is then lost and the result is the independent svarita. The independent svarita that results in such a way is also called the “jātyasvarita” by the Indian grammarians.

Example (a) illustrates this development. The three syllables in **rathiyàm* are the anudāttatara, the udātta, and the svarita, and they correspond exactly to the syllables in Figure 2. When the medial syllable is lost, the independent svarita accent arises. This is marked on the original dependent svarita syllable:

(a) **rathiyàm* > *rathyàm*

Another source of the independent svarita arises from external sandhi. Word-final long or short high vowels *-ī* or *-ū* lose their syllabicity before the initial vowel of the following word in external sandhi. This too can result in an independent svarita.⁶ This version of the development is called “kṣaipra svarita” by Indian grammarians. Consider example (b):

(b)	<u>Padapāṭha</u>	<u>Samhitā</u>
	RV 1.105.1a	<i>apsú antár</i> <i>apsv àntár</i>

There are two other sources of independent svarita, but in both cases the independent svarita is the result of developments in external sandhi and does not follow from the loss of the original udātta syllable. One of these happens in what native grammarians call “praśliṣṭa sandhi.” Here the independent svarita arises when a short final *-i* with the udātta syllable pitch is followed by a short initial *i-* that is unaccented, e.g., RV 5.1.12d *divīva* (for *diví iva*). Another type of external sandhi in which the independent svarita arises is called “abhinihita sandhi.” In

6 If word-final *-ī* and *-ū* are of the praghya type, they retain syllabicity and no independent svarita arises. For a recent treatment of praghya sandhi, see Malzahn 2001.

this case, word-final *-ó* (from *-ó* or *-áh*) and *-é* with an underlying udātta syllable pitch before unaccented short initial *a-* yield either *-ó a-*, *-é a-* with the udātta accent or *-ò '-*, *-è '-* with the svarita accent and loss of the initial *a-*. The two outcomes of abhinihita sandhi are collected in example (c):

(c)	<u>Padapāṭha</u>	<u>Samhitā</u>
RV 5.30.5d	<i>apáh ajayat</i>	<i>apó ajayad</i>
RV 3.33.6c	<i>deváh anayat</i>	<i>devò 'nayad</i>

While the first two sources of independent svarita discussed above are straightforward, the latter two are rather unexpected and have not yet received a satisfactory explanation. To limit the length of this paper, I will focus only on the independent svarita accent that arose through syncope. On the basis of these two developments I will propose a new explanation for the phonetics of independent svarita. Determining its phonetic nature will, in turn, be the first step in explaining the two peculiar developments in which the independent svarita arises from external sandhi. The explanation for these developments, however, will be given elsewhere.

3. Previous treatments

Previous accounts of the exact phonetics of the independent svarita are quite sparse. The first treatment goes back to the Indian grammarians. Pāṇini describes it briefly in 1.2.31 and 1.2.32. The svarita is defined as a “combined pitch” of which the first half is high, i.e., in his terms, the udātta, and the second half low, i.e., the anudātta (Joshi and Roodbergen 1993:52–6). This corresponds well to the phonetic nature of the svarita syllable as represented in Figures 1 and 2. However, as will be shown below, it does not efficiently describe the svarita syllable of the independent svarita accent.

As previously noted, the most comprehensive study of Vedic accent remains that of Haug (1873:72–84), which is the source for most later reconstructions of Vedic accentual phonetics, including this paper. Haug devotes an extensive chapter (Chap. 2b) to the svarita in which he discusses most of the treatments of the svarita in Pāṇini, the Prātiśākhya, and the manuscripts. He acknowledges that the definitions of the svarita in various sources do not always agree (1873:73), but some common patterns emerge in the descriptions: the svarita is assumed to be a combined high-low falling tone. The exact phonetics, however, are not always clear from the descriptions.

Whitney too acknowledges the difficulties in establishing the nature of the svarita by calling it “a term of doubtful meaning” (1879:27). He comes close to my explanation in his description by stating that the independent svarita is “the result of combination of an acute vowel and a following grave vowel into one syllable. It is also uniformly defined as a compound in pitch, a union of higher and lower tone within the limits of a single syllable.”⁷ However, as we will see below, the independent svarita is not only a combination of high and low, but most likely a combination of low-high-low.

Macdonell (1910:77) describes only the dependent svarita and does not discuss the independent svarita separately. He describes the svarita as a “falling accent of dependent nature” and goes on to say that the svarita “would thus have something of the nature of a circumflex in the Rigveda.”⁸

AiG I (290) similarly assumes the svarita to be a falling tone that starts at the height of the preceding udātta. It mentions Pāṇini’s description of the svarita as a combination of udātta and anudātta (i.e., from high pitch to low pitch, and therefore falling). However, it goes one step further and points to some facts crucial for establishing the phonetics of the independent svarita (291). It is noted that although Pāṇini’s description does not distinguish between independent and dependent svarita, some manuscripts mark the two differently. Furthermore, it posits that the independent svarita has a greater proportion of high pitch than its dependent counterpart (291). And finally, it points to the fact that in the Sāmaveda the independent svarita at the beginning of a word is marked with the numerals 1 and 2 above the character, which indicates its high nature (291). As I will show below, these observations will be crucial in establishing the phonetic nature of the independent svarita.

The treatment of the svarita in Allen 1953:87–94 mostly follows the treatments discussed above. Allen even provides some graphic approximation of the various accents. He represents the svarita as a falling tone, but assumes that the udātta has a middle (level) tone. This is adequate for the Rigveda, but cannot be the correct representation for other accentual traditions, where the udātta clearly has the highest pitch.

7 Whitney (1879:27) continues, stating that the svarita “is thus identical in physical character with the Greek and Latin circumflex, and fully entitled to be called by the same name.”

8 Macdonell (1910:77) further notes that the rise of pitch in the Rigvedic tradition is “slight (corresponding to the initial rise of the Udātta from Anudāttatara to Anudātta level), while the fall corresponds to the total rise of the Udātta.”

4. A new explanation

The distinction between the pitch accent on particular syllables and a “global” pitch trajectory as illustrated in Figures 1 and 2 now allows us to observe that the main difference between the udātta and the independent svarita is duration: the former is one syllable longer than the latter. The most obvious evidence to support this assertion comes from the sources of the independent svarita: it arises when the udātta syllable is syncopated. When the short *i* or *u* is lost, we get the independent svarita accent: **rathiyàm* > *rathyàm* (a).

The question now arises whether the pitch trajectory changes in the shorter timespan of the independent svarita or whether it remains the same as the udātta, with duration as the only difference between the two. I will argue below that several pieces of evidence point to the latter option, i.e., that the pitch trajectory remains the same because the pitch targets remain the same, except that the pitch trajectory is steeper, as it has to reach the same targets over a shorter period of time. There exists some indirect evidence that supports my proposal in the general practices of accent marking, but the direct evidence comes from the accent marking in the Sāmaveda.

The independent svarita accent in the RV and AV is marked in exactly the same manner as the udātta accent, except that the udātta syllable is lacking. The independent svarita is thus marked with a stroke below the character on the anudāttatara syllable and a vertical stroke above the character on the immediately following svarita syllable. This indicates that the independent svarita accent is one syllable shorter, but the general pitch trajectory remains the same.

The fact that the independent svarita accent features a steeper and more prominent pitch trajectory is indirectly reflected in the accent markings of the MS. The independent svarita is marked differently from the dependent svarita syllable of the udātta accent, with a curve below the character or with a combined horizontal line and double curve below the character if the udātta immediately follows (Macdonell 1910:79, Haug 1873:27–32). Likewise, the Kā. tradition marks the two differently: the independent svarita is marked by a curve or a hook (if an udātta immediately follows) below the syllable (Macdonell 1910:79).

That this special marking most likely represents the “strength” (as Haug [1873:38–42] calls it) or steepness of the pitch, as I will argue, is most evident from the accent markings of the SV. We saw above that pitch there is characterized by numerals, 1 being the highest and 3 the lowest. The independent svarita, however, is marked differently from the dependent svarita. The syllable before the independent svarita (anudāttatara) is marked by the numeral 3 and a sign for

ka. The svarita syllable of the independent svarita is marked by the numeral 2 and the sign for *ra*. The marking most likely represents the “strength” of the pitch articulation, whereby *ka* probably stands for *karṣaṇa* ‘pulling to and from, dragging’ and *ra* for *rekha*, the ‘line’ that represents the finger movement in recitation (as was pointed out in Haug 1873:38–42).

The accent marking peculiarities discussed above reveal a great deal of phonetic information about the independent svarita. However, the crucial piece of evidence that points directly to the fact that the independent svarita has to reach the same pitch targets as the udātta accent comes from the Sāmavedic marking of the independent svarita at the beginning of the line if an unaccented syllable follows. Here, the independent svarita is marked by the numeral 1 and the signs 2 and *ka* above the character. It is likely that, at the beginning of the line, the lowest pitch of the anudāttatara syllable is not realized completely, which is reflected in the absence of marking of the lowest pitch, i.e., no numeral 3 above the character. Because the lowest pitch is not marked, this gives room for marking the next pitch in the trajectory: the highest pitch, which is marked by the numeral 1, just as in the udātta accent. This numeral 1 above the character in the independent svarita accent line-initially points directly to the fact that the independent svarita too reaches the highest pitch target, equivalent to the one in udātta, before falling back to the neutral pitch level.

The reconstructed phonetics of the independent svarita accent are thus illustrated in Figure 3:

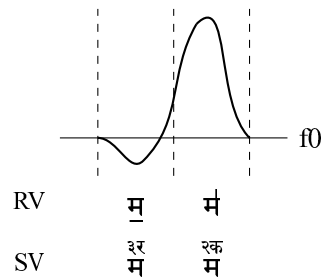


Fig. 3. Reconstructed pitch accent of the independent svarita
with corresponding marking of the pitches in the RV and SV line-internally

This figure shows that the independent svarita has exactly the same pitch targets as the udātta, but the timespan is shorter and therefore the “global” pitch trajectory is steeper than that of the udātta. The question remains: when exactly does the pitch accent start to rise from the anudāttatara syllable to the peak on the svarita syllable? It is most likely interpolated between the two syllables, as illustrated in

example (c). If we look at the svarita syllable in isolation, we also observe an important difference: in the udātta accent the svarita syllable is falling from high to low pitch, whereas in the independent svarita it has to rise from the anudāttatara's lowest pitch to the highest target and fall back to the low pitch. In other words, the dependent svarita syllable of the udātta accent is a falling (or in the Rigvedic tradition slightly rising and falling) pitch, whereas the independent svarita is a rising-falling pitch accent.⁹ Note that the realization of the anudāttatara is also slightly altered, as the pitch has to start rising earlier, which explains the different marking of the anudāttatara in the independent svarita (*3ra*) as opposed to the udātta (*3*) in the SV.

This new explanation, that the only difference between the udātta and the independent svarita in Vedic is that the pitch in the latter is steeper, has the potential to explain several other peculiar facts about Vedic accent. Some of them have already been mentioned: this study is the starting point for explaining the peculiar accentual sandhi in which the independent svarita arises on two short high vowels when the first one bears the udātta in praśliṣṭa and in all cases in abhinihita sandhi. There are also other peculiar developments, especially in accentual sandhi in Vedic, that are phonetically reflected in the accent markings and to which this paper can bring insights. These are, however, topics for another study.

References

- AiG I* = Jacob Wackernagel. 1896. *Lautlehre*. Vol. 1 of *Altindische Grammatik*. Göttingen: Vandenhoeck & Ruprecht.
- Allen, W. Sidney. 1953. *Phonetics in Ancient India*. Oxford: Oxford University Press.
- Cardona, George. 1993. The bhāṣika Accentuation System. *Studien zur Indologie und Iranistik* 18.1–40.
- Haug, Martin. 1873. *Ueber das Wesen und Werth des vedischen Accents*. Munich: Verlag der K. Akademie in Commission bei G. Franz.
- Joshi, S. D., and J. A. F. Roodbergen. 1993. *The "Aṣṭādhyāyī" of Pāṇini: Translation with Explanatory Notes in English*. New Delhi: Sahitya Akademi.
- LIV*² = Helmut Rix (ed.). 2001. *Lexikon der indogermanischen Verben*². Wiesbaden: Reichert.
- Macdonell, Arthur A. 1910. *Vedic Grammar*. Strassburg: Trübner.
- . 1916. *Vedic Grammar for Students*. Oxford: Clarendon.

9 In this respect, the description of the svarita as “the circumflex” (Whitney 1879:27; Macdonell 1910:77) would be appropriate, but only for the independent svarita and not the dependent svarita.

- Malzahn, Melanie. 2001. Sandhiphänomene im Rigveda als Reflexe von Archaismen und Dialektismen. Ph.D. diss., University of Vienna.
- Silverman, Kim E. A., and Janet B. Pierrehumbert. 1990. The Timing of Prenuclear High Accents in English. In John Kingston and Mary E. Beckman (eds.), *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech*, 72–106. Cambridge: Cambridge University Press.
- Whitney, William D. 1879. *A Sanskrit Grammar*. Leipzig: Breitkopf und Härtel.
- Witzel, Michael (ed.). 2004. *Kaṭha Āraṇyaka: Critical Edition with a Translation into German and an Introduction* (Harvard Oriental Series 65). Cambridge, MA: Department of Sanskrit and Indian Studies, Harvard University.
- Xu, Yi. 2001. Fundamental Frequency Peak Delay in Mandarin. *Phonetica* 58.26–52.