Akṣara the Basic Unit of Time Measure in Ancient India

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Abstract

In this paper after a brief review of ancient Indian time units, the ingenious method of Indian astronomers for calibrating the small time unit of *vighaṭikā* (24 seconds) phonetically by the recitation of a Sanskrit verse in the *līlākhelā* meter with sixty *gurvakṣaras*, is experimentally verified by sixty independent sample recitations. This is followed by exploring the concept of congruence of *akṣara* count and time periods such as the month and the year in Vedic texts. This leads to the symbolic equivalence of the *bṛhatī* meter of 36 syllables to the Year and several other numerical synchronies between phenomenal time and *akṣara*. The 1000 *bṛhatī* verses of the *prātaranuvāka* nocturnal performance in the *atirātra* ritual is the traceable most ancient origin and inspiration for gauging and estimating lapse of time by recognizing audible syllable as a time measure. To verify this, apart from text based theoretical estimates, real time information from a famous *śrauta* expert on his *prātaranuvāka* performance is presented. It is further demonstrated empirically that the rate of 3600 *gurvakṣara* per *ghaṭikā* of *siddhānta* astronomy is closely correlated with the speed of present day traditional chanting of the *Ṛgveda*, the fidelity of which has remained stable over millennia.

Key words: *Bṛhatī-chandas*, *Gurvakṣara*, *Līlākhelā*, Oral calibration, *Prātaranuvāka*, Time unit, Vedic recitation, *Vighaṭikā*, Water-clock.

1 Introduction

A large number of time measures with a variety of nomenclature and conversion values are mentioned in ancient Indian texts. In a recent publication Hayashi (2017) has presented a detailed review of time units in ancient and medieval India. He has discussed almost all important texts numbering sixty. There are some extremely small measures such as *aṇu* and *truṭi* as well as some very large time measures such as *yuga*, and *kalpa*. It would be clear that for practical purposes *muhūrta*, *nāḍikā* (*ghaṭikā*), *ahorātra*, *pakṣa*, *tithi*, *māsa*, *ayana*, *ṛtu*, *varṣa* with their simple multiples should have been in vogue. The smallest measures *samaya*, *truṭī*, *paramāṇu* must have been proposed by philosophers and mathematicians to imaginatively indicate that Time is continuous with no gaps in between.

Texts describing instruments for measurement of time within an *ahorātra* provide evidences to two types of devices; the gnomon (*śaṅku*) and the water clock (*jalayantra*). A detailed description of such devices found in Sanskrit texts with relevant historical background and available photographs has been presented by Sarma (1994, 2001) (Figure 1). Several of his investigations on the water clock and time determination in medieval India with insightful discussions are available in his monograph *The*

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Archaic and the Exotic (2008). Further recently Sarma (2018) has presented a detailed exposition on how the Jaina text *Jyotiṣkaraṇḍakam* by Pādalipta Sūri (c 100 CE) describes time measurement using the water clock and the steelyard.

2 Jalayantra

Two major types of water clocks, with some minor variants, were popular in ancient India. The *nālikāyantra*, perhaps the more ancient device, consisted of a tall jar or a pot with an outflow orifice at the bottom. The device when filled up with water at sunrise (*prātaḥ*) would get emptied at the next sunrise representing 60 *nāḍikā*. Assuming that on the equinoctial day, sun at midday (*madhyāhna*) and sunset (*sāyaṁ*) were observed, two more time markings could have been done on the device. Measuring finer intervals in such a device would be complex since the relation between time elapsed from sunrise to the water level is not necessarily linear. For example, if a cylindrical vessel of uniform cross section empties in one *ahorātra* of 60 *nāḍikā* (30 *muhūrta*), the time elapsed from sunrise to the point when the water is at mid-height will not be 15 but will be $(15/\sqrt{2})$ or between 10 and 11 *muhūrta*. However, by trial and error one may be able to mark two more graduations when sun is halfway between horizon and zenith and when sun is between midday and sunset.

The other device, namely the *ghaṭikāyantra* is the sinking-bowl type of water clock. This appears to have been popular among astronomers, administrators and priests who had to specify time periods within a day in advance to conduct the rituals during prescribed intervals. In the *ghaṭikāyantra*, the bowl would sink 60 times in one *ahorātra* or once in a *ghaṭikā* same as *nāḍikā* that is half *muhūrta*. The shape and dimensions of this bowl are mentioned in a few texts. This must have been arrived at by experimentation and continuous refinements. Based on available textual information, Kulkarni (1986) verified analytically, applying the laws of Mechanics, that the spherical pot mentioned in the *Arthaśāstra* when filled fully, would take nearly 24 minutes or one *ghaṭī* to discharge one *pala* of water.[1]

Whichever device was in use, there must have been an independent way to calibrate the unit of *muhūrta* or of *ghaṭī* or some part thereof. Only after such verification the water clock could get marked for measuring and announcing time routinely for administrative purposes. This was well known to ancient Indian scientific thinkers who proposed several smaller natural markers of time; *akṣara* (syllable), *nimeṣa* (eye wink), *prāṇa* or *asu* (breath or pulse rate). It is easy to note that these parameters are dependent on the subject selected for observation and hence vary from person to person. Whichever fundamental unit one may prefer, the accuracy of dividing *ahorātra* into 30 or 60 equal parts would depend on the accuracy of equating a convenient longer time unit on the device to the equivalent number of *akṣara*, or *nimeṣa* or *prāṇa*. In the medieval texts several equalities for time units are available, sometimes with same name but with different equations. Fortunately, all authors belonging to widely differing time periods and regions, are in agreement that *ahorātra* should be taken as 30 *muhūrta* as in the Vedas, and reckon it as 60 *nāḍi*(*kā*) or *ghaṭi*(*kā*). This must have helped standardization of time measure with *akṣara* as the fundamental unit all over India. Before we consider *akṣara* in detail, a brief reality check on the other units would be useful.

3 *Nimeṣa*, *Asu*, *Prāṇa*

Nimeṣa refers to the time taken for one eye-wink or blink. This word appears in the *Ṛgveda* and in several other Vedic texts. Notably the *Maitrāyaṇīya-āraṇyaka* (c 1800 BCE) which declares sun as the generatrix of Time (*sūryo yoniḥ kālasya*), mentions *nimeṣa* as a time unit, but does not quantify the term.[2] Blinking of eyes is a normal activity for all humans, but can be voluntary or involuntary. The rate of blink is sure to vary since continuous voluntary blinking fatigues the muscles. The natural clock with reference to which the experimental value had to be obtained was the position of the sun in the sky divided into two, three or four observably equal spatial intervals. The *Viṣṇupurāṇa* and the *Samarāṅgaṇa-sūtradhāra* of King Bhoja (1055 CE) report 1 *muhūrta* = 13500 *nimeṣa*. The famous astronomical text *Siddhānta-śiromaṇi* of 12th

[1] सुवर्णमाषकाश्चत्वारश्चतुरङ्गुलायामाः कुम्भच्छिद्रमाढकमम्भसो वा नालिका ॥ *KAS* (22.35).

[2] अथान्यत्राप्युक्तमत्रं वा अस्य सर्वस्य योनिः, कालश्चान्नस्य, सूर्यो योनिः कालस्य । तस्यैतद्रूपं यत्रिमेषादिकालात् सम्भृतं द्वादशात्मकं वत्सरम् । एतस्याग्नेयमर्धम्, अर्धं वारुणम् । *MAU* (6.14).

Figure 1 (a) Copper bowl water clock sinking in half *ghaṭi* from Uva Province, Sri Lanka in the Pitt Rivers Museum of Ethnology, Oxford. (photo by S. R. Sarma); (b) Coconut shell water clock sinking in one *ghaṭi*. Government Museum, Chennai. (photo by S. Ramaratnam)
Source: Sarma S. R. *A Descriptive Catalogue of Indian Astronomical Instruments*, 2019, pp. 3821–26. ***Reproduced with permission***.

century also reports the same value. Quite interestingly all the above four texts state two smaller units of time *kāṣṭhā* and *kalā* before *muhūrta* in the same way as 1 *kāṣṭhā* = 15 *nimeṣa*; 1 *kalā* = 30 *kāṣṭha* and 1 *muhūrta* = 30 *kalā*. Several other texts also refer to the *nimeṣa*, but this parameter must have been difficult to count in practice, particularly for fixing parts of a *muhūrta*. This limitation seems to have been circumvented by accepting *nimeṣa* to be equivalent to *laghvakṣara* time. The other basic unit *asu* is the breath rate and *prāṇa* the pulse rate. But the two words are often used with varying meanings in different contexts. The *Śatapatha-brāhmaṇa* (*ŚB* 12.3) divides *muhūrta* into four smaller units namely, *kṣipra*, *etarhi*, *idānīm* and *prāṇa* each being 15 times the next one in the same order.[3] The pulse rate as per modern measurements is about 70 per minute. This gives approximately 3360 heart beats per *muhūrta*. This value is quite close to 3375 *idānīm* for one *muhūrta* of *ŚB*. It is to be noted that the same word *idānī* of the *Taittirīya Brāhmaṇa* (*TB*) and of the *ŚB* carry different values. Also, the *prāṇa* unit of *ŚB* in the present context is not the heart beat. On the other hand the rate of breathing of normal humans is around 15 per minute. This leads to 720 *asu* (breaths) per *muhūrta* leading to 21600 breaths per *ahorātra*, which count is reported in several texts. Some texts such as the *Siddhānta-śekhara* (10th cent.) denote *asu* as *prāṇa* and report 21600 *prāṇa* for one *ahorātra*, as in the *Sūrya-siddhānta*. *Nimeṣa*, *asu* and/or *prāṇa* were not imaginary units, but were based on experiments. However, they were not robust for arriving at a scale that can be impersonally applied for measuring *ghaṭī* or *muhūrta* repetitively like a short rope or stick (*śulba*/*daṇḍa*) that was used repetitively in length measurements.

4 Akṣara

It can be easily gathered from the review of Hayashi (2017) or otherwise, that *muhūrta* was the older unit inherited from the Vedas but half-*muhūrta* or the *nāḍikā*/*ghaṭikā*, was perhaps more convenient for day to day work. A further interesting shift is in the recognition of *akṣara* as more practical than *nimeṣa*/*prāṇa*, although the two units are not independent of each other. The most ancient traceable text to mention *akṣara* or syllable as a unit of time is Lagadha's *Vedāṅga-jyotiṣa* (*LVJ*). Both the Ṛgvedic and the Yajurvedic recensions (Sastry and Sarma 1985) mention the length of *ahorātra* as 30 *muhūrta* equivalent to 60 *nāḍikā*, as in the works of Āryabhaṭa, Varāhamihira and others. However, the relation between the *akṣara* and the *nāḍikā* of *LVJ* is different from the equation stated

[3]दश च वै सहस्राण्यष्टौ च शतानि संवत्सरस्य मुहूर्ताः। यावन्तो मुहूर्तास्तावन्ति पञ्चदशकृत्वः क्षिप्राणि। यावन्ति क्षिप्राणि तावन्ति पञ्चदशकृत्व एतर्हीणि। यावन्त्येतर्हीणि तावन्ति पञ्चदशकृत्व इदानीनि। यावन्तीदानीनि तावन्तः पञ्चदशकृत्वः प्राणाः। यावन्तः प्राणास्तावन्तोऽक्तनाः। यावन्तोऽक्तनास्तावन्तो निमेषाः। यावन्तो निमेषास्तावन्तो लोमगर्ताः। यावन्तो लोमगर्तास्तावन्ति स्वेदायनानि। यावन्ति स्वेदायनानि तावन्त एते स्तोका वर्षन्ति॥ *ŚB* (12.3.2.5).

by later astronomers. In the *LVJ* the two units are related as 1 *nāḍika*= 6231 *akṣara*, which is different from 1 *nāḍikā* = 3600 *gurvakṣara* of the *siddhānta* texts. Even though Sastry and Sarma (1985) mention that the *akṣara* of *LVJ* is equal to one *gurvakṣara* of two *mātrā* time duration there is no statement in the original text to that effect. Here it is to be noted that the word *akṣara* normally translated as 'syllable' carries different shades of meaning in technical subjects. In the present context it should be interpreted as the time taken to produce audible sound of one syllable of a particular type. Unless specified clearly, *akṣara* can be one of the four types; *hrasva* (short), *laghu* (light), *guru* (heavy), *dīrgha* (long). The time taken by a *hrasva* and a *laghu* and similarly by a *guru* and a *dīrgha* syllable need not be exactly equal. In Sanskrit prosody it is by definition the long and heavy syllables take twice the time relative to the short and light ones that are assigned one *mātrā* measure. The word *mātrā* (measure) is inherited from the antecedent oral tradition wherein the *Prātiśākhya* texts describe and fix the Vedas in minute details of *chandas*, *akṣara*, *svara*, and *mātrā*. In classical literature the *mātrā* is by definition not divisible, unlike in the Vedic tradition where *mātrā* is divided into at least four fractions. Without further digression, it suffices to point out that the *akṣara* of *LVJ* might be referring to a particular definition of Vedic *syllable* as a time unit which need not closely match with the syllabic time of classical Sanskrit prosody (Tripathi 2008).

There are also references to *laghvakṣara* (light or short syllable) as in the *Purāṇa*,[4] which equate *nimeṣa* and *laghvakṣara* leading to 13500 short syllables per *muhūrta*. *Suśruta Saṁhitā* also equates *nimeṣa* and *laghvakṣara*, but present day texts lead to 9045 syllables per *muhūrta*.[5] This seems to be based on the misreading of the word *triṁśat* as *viṁśat* in later day manuscripts which has formed the basis for present day printed versions. If we take the original reading as *triṁśat*, (30 *kalā* per *muhūrta*) we get the same value of 13500 *laghvakṣara* per *muhūrta* as in other texts. There is also mention of *vikṛtākṣara* (distorted syllable) in the *Parāśara Tantra* (Iyengar 2013) as quoted by Bhaṭṭotpala that equates 16000 *vikṛtākṣara* to one *muhūrta*.

5 Gurvakṣara Scale

Definition of time in terms of different *akṣara* type points to the wide spread practice of estimating elapsed time using oral recitation of some texts. This should not be surprising since the learning of the Vedas has remained an oral tradition to this day. But the time covered naturally depends on the internal structure of the syllabic compositions and the speed of oral reproduction. Indian astronomers in their search for accuracy in the use of the water clock must have experimented with different texts to finally arrive at the attractive result that 60 *gurvakṣara* sound-string would need one *vināḍī* or *vighaṭī*. Sixty of such *vināḍī* make up one *nāḍikā* or *ghaṭikā* equal to the time needed for the bowl type water clock to sink once. While the *Soma-*, *Brahma-siddhānta* (Dvivedi 1912) and the *Vṛddhavasiṣṭha-siddhānta* (Dvivedi 1917) know the above relation of 60 *gurvakṣara* being equal to one *vināḍī*, it is the *Pañcasiddhāntikā* (*PS*) that standardizes this for calibration of the water clock. Varāhamihira (c 530 CE) the author of this text gives in the 14th Chapter, a verse of 60 *gurvakṣara* that can be used as an objective audible scale for measuring longer time by simply repeating it the required number of times. The relevant text and the translation by Sastry and Sarma (1993) are as follows;

द्युनिशिविनिःसृततोयादिष्टच्छिद्रेण षष्टिभागो यः ।
सा नाडी (स्वमथो) वा श्वासाशीतिः शतं पुंसः ॥ ३१ ॥
कुम्भार्धाकारं ताम्रं पात्रं कार्यं मूले छिद्रं
स्वच्छे तोये कुण्डे न्यस्तं तस्मिन् पूर्णे नाडी स्यात् ।
मूलाल्पत्वाद्वेधो वा षष्टिर्योज्या चाह्ना रात्र्या वर्णाः
षष्टिर्वक्राः श्लोको यत्तत् षष्ट्या वा सा स्यात् ॥ ३२॥
(VM)

One-sixtieth of the time taken by water to flow out through a desired hole during a nychthemeron is defined as the duration of a *nāḍī*. Or it is the time of 180 breaths of a man. ||31||

Construct a copper vessel resembling one-half of a spherical pot and pierce a hole at its bottom. Put it in pure water in a basin. The time in which the vessel is filled up is the duration of a *nāḍī*. The hole at the bottom of the vessel should be so small that on account of its small

[4]निमेषकालतुल्यं हि विद्याल्लघ्वक्षरं च यत् ॥ काष्ठा निमेषा दश पञ्च चैव त्रिंशच्च काष्ठा गणयेत्कलां तु। त्रिंशत्कलाश्चापि भवेन्मुहूर्त्तस्तै स्त्रिंशता रात्र्यहनी समे ते॥ *Brahmāṇḍa Purāṇa* (I. 29.5–6).

[5]तत्र लघ्वक्षरोच्चारणमात्रोऽक्षिनिमेषः, पञ्चदशाक्षिनिमेषाः काष्ठा, त्रिंशत्काष्ठाः कला, विंशतिकलो मुहूर्तः कलादशभागश्च, त्रिंशन्मुहूर्तमहोरात्रं, पञ्चदशाहोरात्राणि पक्षः। स च द्विविधः शुक्लः कृष्णश्च। तौ मासः। *Suśruta Saṁhitā* (6.5).

> size, the vessel may sink into water exactly sixty times during nychthemeron. Or, it is the time in which one may recite 60 times a verse composed of 60 long syllables (as verse 32 itself is). ||32||

The above verse 32 (denoted as VM) has fifteen *gurvakṣaras* in each foot in the meter *līlākhelā* (also called *kāmakrīḍā* or *sāraṅgikā*) belonging to the class of *atiśakvarī chandas*. Varāhamihira in *PS* reviews five older astronomical texts (*Pauliśa*, *Romaka*, *Vasiṣṭha*, *Sūrya* and *Paitāmaha siddhānta*) but in Chapter 14 there is no attribution to other authors for the above verse on the water clock. Before we verify the accuracy of VM, it is noted that there is another verse in the same meter in the commentary by Bhāskara-I (7th cent.) on the *kālakriyāpāda* of Āryabhaṭa (5th cent.). This verse with its correct version (B-I) as in the manuscript *ghaṭīyantra-ghaṭanā-vidhi* along with two more in the same meter has been unearthed by Sarma (2001).[6] The verse given by Bhāskara for calibrating the *vināḍī* is:

> मा कान्ते पक्षस्यान्ते पर्याकाशे देशे स्वाप्सीः
> कान्तं वक्त्रं वृत्तं पूर्णं चन्द्रं मत्वा रात्रौ चेत् ।
> क्षुत्क्षामः प्राटंश्चेतश्चेतो राहुः क्रूरः प्राद्यात्
> तस्माद्धान्ते हर्म्यस्यान्ते शय्यैकान्ते कर्तव्या ॥(B-I)

In the previous section different *akṣara* types and their measures were mentioned. In the absence of a clear definition of the syllabic time it would be reasonable to say that about 13500–16000 short syllables per *muhūrta* was the prevalent understanding before the astronomers introduced their refinement. The above approximates to 7375 long/heavy syllables per *muhūrta* as per the conventional understanding that *laghu* and *guru* are for one and two *mātrā* duration respectively. This evidence of measuring *muhūrta* in terms of *akṣara* counting in the early *purāṇas* and other texts originating before the common era naturally points to Vedic oral tradition as the progenitor of the concept of *akṣara-kāla* or syllabic-time. This point will be further discussed and demonstrated to be so in the present study.

Astronomers before and after Āryabhaṭa being aware of the prevalent use of *akṣara* count as a time measuring artifice, standardized one *vināḍī* (*vighaṭi*) to the audible scale of 60 *gurvakṣaras* embedded by verses in a particular meter known as *līlākhelā*, with 15 long/heavy syllables per quarter. The speed of recitation is said to be neither too fast nor too slow but in medium pace as pointed out by Bhāskara.[7] This must have existed as a culturally inherited trait followed in the medieval schools aptly called *ghaṭikāsthāna*, where a *ghaṭīyantra* the sinking type water clock was also operated probably by the students. Existence of such a school with a time measuring device is well attested in the inscription dated 1058 CE at Nagai, in Gulbarga District. This record mentions about the school, the number of teachers and students and the donation made for the upkeep of the institution including payment for the *ghaṭikā-praharī*, whose work was to announce the passage of each *ghaṭikā* by beating a gong.[8]

6 An Experiment

An interesting question arising out of the above prescription is, how accurate are the verses for representing one *vighaṭikā* that is equal to 24 seconds in current parlance? To understand this issue we conducted an experiment with the help of 30 volunteers drawn from in and around Bangalore. The group included persons knowledgeable in Sanskrit as well as some who could not understand the language, but had the tradition of reciting Sanskrit texts in their families for religious and spiritual practices. The members were requested to recite audibly the verse (B-I) in private at medium pace, as is normal for them, and submit the audio tracks. After a lapse of several months the verse (VM) from the *Pañcasiddhāntikā* was tested in similar fashion by another group that included a few members

[6] Sarma, S. R. (2018, p. 165). Two more verses in the same meter from the above manuscript follow:
मार्ताण्डस्तारानाथः क्षोणीसूनुः सूनुश्चेन्दोः
वागीशो दैत्याचार्यः छायापुत्रो राहुः केतुः।
नक्षत्रैरश्विन्याद्यैस्तारायुक्तैश्चाभिः सर्वे
कुर्यासुः कल्याणं वो नित्यारोग्यं लक्ष्मीमायुः॥12॥
लोकक्षेमायासीन्मत्स्यः कूर्मः क्रोडः पुंसिंहो
यो ह्रस्वाकारो रामो रामः कृष्णो बुद्धः कल्की।
एवं नानारूपं नानाकारं नाना नामानं
योगिध्येयं देवं देवानां वन्देऽहं गोविन्दम्॥13॥

[7] गुर्वक्षरेषु मध्यमवृत्तिग्रहणम्। " गुर्वक्षराणि षष्टिः" इत्यत्र मध्यमायां वृत्तौ षष्टिः गुर्वक्षराणि विनाडिकाकाल इति वक्तव्यम् । अन्यथा हि तिसृषु अपि वृत्तिषु अविशेषेण ग्रहणं प्राप्नोति । तद्यथा – द्रुतायां वृत्तौ षष्टिः गुर्वक्षराण्यल्पेन कालेन पठ्यन्ते, विलम्बितायां महता कालेन इति, मध्यमायां पुनर्न अल्पेन, न महता कालेन । तत्तर्हि मध्यमवृत्तिग्रहणं कर्तव्यम् । कथमनुच्यमानमवगम्यते, लोकप्रसिद्धेः। तद्यथा – लोके अनिर्दिष्टेषु कार्येषु मध्यमप्राप्तिः॥ Commentary of Bhāskara-I on the *Āryabhaṭīya*.

[8] The Inscriptions of Nagai, published in *Hyderabad Archaeological Series*, No. 8. Calcutta, 1928, p.16.

from the former group. The time taken for recitation was extracted from the sample audio tracks. The results obtained for both the verses are shown below in seconds.

Time samples for B-I: 23.28, 23.13, 22.23, 23.76, 22.4, 23.68, 25.2, 23.22, 24.15, 26.65, 23.42, 22.1, 24.72, 25.59, 24.47, 23.94, 25.91, 22.62, 25.04, 25.74, 23.06, 24.02, 23.31, 24.23, 23.19, 24.13, 24.15, 23.29, 24.31, 23.3.

Time samples for VM: 22.61, 21.45, 24.62, 23.81, 23.16, 25.51, 22.52, 21.98, 21.35, 23.55, 25.83, 24.86, 23.05, 23.12, 23.84, 23.48, 24.86, 23.07, 23.57, 25.04, 21.95, 25.18, 23.17, 23.5, 23.74, 24.24, 23.81, 24.29, 22.68, 23.76.

The average time in seconds taken for B-I is 23.94 with standard deviation of 1.1 seconds. The average time for the VM verse is 23.59 seconds, the standard deviation being 1.12 seconds. The sample variation in both the cases is about 5%. Verse B-I is easier to recite with lesser number of conjunct syllables and hence seems to be more accurate than VM.

7 Vedic Prelude

Vedic texts characterize *kāla* (Time) in a variety of ways. While some of these are abstract and philosophical, others are about *time* as related to the sun, the moon and the stars. The latter is the *mūrta-kāla* (concrete or phenomenal time) such as year, month, day, night etc. *Maitrāyaṇiya Āraṇyaka Upaniṣad* (MAU) extols *Time* as *Brahman*, with and without form.[9] Time with form, that is nameable time divisions, starts with Sun. The *ahorātra* (day-night) based on counting sunrises is the most natural time unit, so much so the *MAU* declares sun to be the origin/generator of time.[10] This and such other evidences indicate that with the help of the sun and the moon, longer periods such as *pakṣa*, *māsa*, *ṛtu*, *ayana*, *saṃvatsara* were conceptualized and used. It is no exaggeration to say that Vedic sacrifices, rites and rituals couched in legends of meters as deities show a deep sense of preoccupation with time measures, short and long, synchronized with numbers and syllables.

[9] द्वे वाव ब्रह्मणो रूपे कालश्चाकालश्च ॥ *MAU* (6.15).

[10] See footnote 2.

8 Prajāpati's Choice of 15 and 30

The concept of *māsa*, the time interval from full moon to full moon and from *amāvāsyā* to *amāvāsyā* is central to Vedic culture. It is easy to note that sunrise to sunrise is one *ahorātra* and hence this can be counted in integral numbers. But the *māsa* measure of sunset or sunrise as related with moon will not be a round number but will be between 29 and 30. The naming of both the *pūrṇamāsa* and the *amāvāsyā* as the Fifteenth that is *pañcadaśī* in the *Taittirīya Brāhmaṇa* (*TB* 1.5.10) is due to the idea of *pakṣa* synchronizing with the number 15. The *Śatapatha Brāhmaṇa* provides the heuristics for selecting the numbers 15 and 30 through a legend connected with *Prajāpati* one of his forms being the Year. After creation of the cosmos the joints of *Prajāpati* became slack at the meeting of day and night and at full moon and at *amāvāsya*. His joints at the syzygy were fixed by conducting the *darśa-pūrṇamāsa* rites.[11] The text further works out by recursion how the 360 days and 360 nights, that make up the year of 720 (*ahas* + *rātri*), can be factored into integers starting from 2 and increasing by unity at every step up to 24.

The number 720 is divided by 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 16, 18, 20 to get 360, 240, 180, 144, 120, 90, 80, 72, 60, 48, 45, 40, 36. The text says, for each of these possibilities, *Prajāpati* could not envelop (*sa naiva vyāpnot*).[12] When divided by 7, 11, 13, 14, 17, 19, 21, 22, and 23 *Prajāpati* could not manifest himself (*na vyabhavat*).[13] Then, He sat there in that 15 boxed figure. Since he settled in the Fifteen, there are 15 forms (for moon) in the waxing and 15 forms in the waning fortnight.[14] Twenty-four is the number of *ardhamāsa* (half-months) in a year.[15] In similar-

[11] प्रजापतेर्ह वै प्रजाः ससृजानस्य पर्वाणि विसस्रंसुः। स वै संवत्सर एव प्रजापतिः तस्यैतानि पर्वाण्यहोरात्रयोः सन्धी पौर्णमासी चामावास्या चर्तुमुखानि ॥ स विस्रस्तैः पर्वभिः न शशाक संहातुम्। तमेतैर्हविर्यज्ञैर्देवा अभिषज्यन्नग्निहोत्रेणैवाहोरात्रयोः सन्धी तत्पर्वाभिषज्यंस्तत्समदधुः पौर्णमासेन चैवामावास्येन च । पौर्णमासीं चामावास्यां च तत्पर्वाभिषज्यंस्तत्समदधुः। चातुर्मास्यैरेवर्तुमुखानि तत्पर्वाभिषज्यंस्तत्समदधुः॥ *ŚB* (1.6.3).

[12] स द्वेधात्मानं व्यौहत् षष्टिश्च त्रीणि च शतान्यन्यतरस्येष्टका अभवन्नेवमन्यतरस्य स न व्याप्नोत्। त्रीनात्मनोऽकुरुत। तिस्रस्तिस्रोऽशीतय एकैकस्येष्टका अभवन्त्स नैव व्याप्नोत्। [..] विंशतिमात्मनोऽकुरुत षड्विंशदिष्टकान्त्स नैव व्याप्नोत् ॥ *ŚB* (10.4.2; 2–14).

[13] न सप्तधा व्यभवत्। [..] नैकविंशतिधा व्यभवन्न द्वाविंशतिधा न त्रयोविंशतिधा॥ *ŚB* (10.4.2; 8-16).

[14] चतुर्विंशतिमात्मनोऽकुरुत त्रिंशदिष्टकान्त्सोऽत्रातिष्ठत पञ्चदशे व्यूहे तद्यत्पञ्चदशे व्यूहेऽतिष्ठत। तस्मात् पञ्चदशापूर्यमाणस्य रूपाणि पञ्चदशापक्षीयमाणस्य ॥ *ŚB* (10.4.2; 17).

[15] अथ यच्चतुर्विंशतिमात्मनोऽकुरुत, तस्माच्चतुर्विंशत्यर्धमासः संवत्सरः । *ŚB*

ity with the *śukla*- and the *kṛṣṇa-pakṣa* (bright- and dark-fortnight) being presided over by the number 15, the day and the night in an *ahorātra* are equated with 15 *muhūrta* of time.

This choice of taking *ahorātra* as equal to 30 *muhūrta* must be more ancient than the Brāhmaṇa texts. The word *muhūrta* occurs twice (*RV* III.33.5 & III.53.8) in the *Ṛgveda*, but from the context of the hymns it is not clear whether the word stands for one-thirtieth of *ahorātra* or is used in the sense of vague time. However, there are three instances where the number 30 is invoked referring to *Uṣas* (twilight) or Sun specifically illuminating and crossing 30 divisions every day.[16] In the first instance (*RV* I.123.8) it is 30 *yojana* which is generally taken as a distance measure. In the other two cases (*RV* VI. 59.6 & X. 189.3) the larger context of the *sūkta* (hymn) is about time as *aharahaḥ* (day by day) and hence Sāyaṇācārya's interpretation of 30 *dhāma* and 30 *pada* as equivalent to 30 *muhūrta* of time should be acceptable. This convention of taking parts of time and space to be numerically congruent is preserved in the *Parāśaratantra* where it is asserted *kāla-kṣetrayoḥ sāmyam*.[17] This principle is reflected in (*RV* V. 76.3) where the day is divided into five parts. Starting from sunrise these intervals are named *prātaḥ*, *saṅgava*, *madhyāhna*, *aparāhna* and *sāyaṁ*. Each of these intervals dependent on the position (*kṣetra*) of sun in the sky are notionally three *muhūrta* long, as attested in the *Viṣṇu Purāṇa*.[18] The *Taittirīya Brāhmaṇa* (*TB*) fine tunes this time division to introduce individual names for the 15 day and 15 night *muhūrta* for the dark and bright fortnights[19] separately and also mentions that each such *muhūrta* (48 minutes) is made of 15 further parts called *muhūrta-of-muhūrta*[20] also called *prati-muhūrta*. If such a small division as the *pratimuhūrta* (3 minutes 12 seconds) were to be important, what artifice might have been used to estimate the *muhūrta* measure in Vedic times? While there is no direct answer for this question in the sacred texts, it can be verified that *akṣara* count had significant role in stating, estimating and keeping vigil through specific time intervals.

9 Akṣara Congruence

The two prominent meanings of the word *akṣara* are i) imperishable, ii) syllable. Without going further into etymology, nuances and definitions of the word, we note that there is a hoary tradition of preserving the counts of the chapters, subdivisions, hymns, verses, words and the syllables of Vedic texts (Vaidya 1930). In some of the sacrificial rites the sacred formulas ritualistically state the number of syllables a particular hymn or a set of hymns contain. These statements are like recognizing equivalence between the number of *akṣara* and some important character and distinctive property of the deity that is invoked through the laudatory hymn. A typical example is about statements that enunciate connections between *samvatsara* as *Prajāpati* and the number of *akṣara* in a hymn or the number of stanzas in a ritual. Here we cite only a few such cases to illustrate the germination and growth of the idea of linking phenomenal time measure with syllable counts. The *Taittirīya Saṃhitā* refers to 15 *Sāmidhenī* verses that together make up 360 syllables to obtain the year of 360 days.[21] *Aitareya Brāhmaṇa* (3.41) synchronizes 360 hymns with the length of the year counted as 360 *ahorātra* in the *ukthya* sacrifice:[22]

> This *ukthyā* sacrifice has fifteen *stotras* and fifteen *śastras*. These make, if taken together, one

(10.4.2; 18).

[16] अनवद्याःत्रिंशतं योजनान्येकैका क्रतुं परि यन्ति सद्यः। *RV* (I.123.8 b).
हित्वी शिरो जिह्वया वावदद्यरत्रिंशत्पदा न्यक्रमीत् । *RV* (VI. 59.6 b).
त्रिंशद्धाम विराजति वाक्पतङ्गाय धीयते। प्रति वस्तोरह द्युभिः॥ *RV* (X.189.3).

[17] Quoted by Bhaṭṭotpala in his commentary on the *Bṛhatsamhitā*. Ref: *Parāśaratantra* (Iyengar 2013).

[18] रेखाप्रभृत्यथादित्ये त्रिमुहूर्तगते रवौ।
प्रातः स्मृतस्ततः कालो भागश्चाह्नः स पञ्चमः ॥
तस्मात् प्रातस्तनात्कालात् त्रिमुहूर्तस्तु सङ्गवः।
मध्याह्नस्त्रिमुहूर्तस्तु तस्मात्कालात्तु सङ्गवात् ॥
तस्मान्माध्याह्निकात्कालात् अपराह्न इति स्मृतः।
त्रय एव मुहूर्तास्तु कालभागः स्मृतो बुधैः ॥
आपराह्णे व्यतीते तु कालः सायाह्न एव च।
दशपञ्च मुहूर्तं वै मुहूर्तास्त्रय एव च ॥ VP (2.8.61-64).

[19] चित्रः केतुः प्रभानाभान्त् सभ्भान्। [..]।
आभूर्वाभूः प्रभूः शम्भूर्भुवः। *TB* (3.10.1.1-3).

[20] इदानीं तदानीमेतर्हि क्षिप्रमजिरम् ।
आशुर्निमेषः फणो द्रवन्नतिद्रवन् ।
त्वरंस्त्वरमाण आशुराशीयाञ्जवः। *TB* (3.10.1.4).
इदानीं तदानीमिति । एष एव तत् ।
एषह्येव ते मुहूर्तानां मुहूर्ताः ॥ *TB* (3.10.9.9).

[21] पञ्चदश सामिधेनीरन्वाह पञ्चदश वा अर्धमासस्य रात्रयः।
अर्धमासशः संवत्सर आप्यते तासां त्रीणि च शतानि
षष्टिश्चाक्षराणि तावतीः संवत्सरस्य रात्रयः।
अक्षरश एव संवत्सरमाप्नोति। *TS* (2.5.8).

[22] This is the summary as per the Mysore Palace Edition of the *Ṛgveda*, MPRV, Vol. 31 pp. 858–62.

> month of thirty days. By performing this sacrifice they commence the year as divided into months. This *ukthyā* sacrifice has 360 *stotriya* verses as many as the year has days. By performing this sacrifice, they commence the year as divided into days.

A special character stated for the year is the number 36 made of 12 full moons, 12 *aṣṭakā* (half-moon in the dark fortnight) and 12 new moons. This is said to be homologous to the *bṛhatī* meter that consists of 36 syllables.[23] Such concepts built around the number 36, 360, 3600, 36000 and the *bṛhatī* meter appear in several Vedic texts. The *Aitareya Āraṇyaka* represents 100 years each of 360 days, in terms of 1000 *bṛhatī* verses each of 36 *akṣara*.[24] Since the total number of days and the total number of syllables are both equal to 36,000, apparently here one day is matched with one syllable. But there are instances where the match is made differently; the constant component being *bṛhatī* the 36-*akṣara* and its simple multiples.

We have seen above how the numbers 15 and 30 were arrived at in *ŚB* (10.4). The text in similar fashion continues to state the number of *muhūrta* in a year as 10,800. Along with the year, seasons, months, fortnights, day and nights, *muhūrta* is also a form or limb of *Prajāpati*. In the construction of the sacred Vedic altar described in minute detail in the *ŚB*, the 10,800 *muhūrta* are represented by that many *lokaṁpṛṇā* bricks which fill the small space in between the specially consecrated bricks which represent longer time elements. In addition to such a theoretical equivalence between Prajāpati as Time (year and its parts) and Prajāpati as Space (*mahāvedi* and other altars) one more equation in terms of the syllables of the three Vedas is stated. As per *ŚB* the *Ṛgveda* has 432,000 *akṣaras*; the *Yajurveda* and the *Sāmaveda* have 288,000 and 144,000 *akṣaras* respectively.[25] These together, adding to 864,000 syllables, too form the body of *Prajāpati*. This number is 80 times 10,800 the number of *muhūrta* in a year. Thus, an *akṣara* is smaller in its esoteric magnitude than the *muhūrta*. Following such an argument the text discerns congruence between one *muhūrta* and 80 Vedic syllables. This is not still an equation suggested or speculated for the real time *muhūrta*. *ŚB* mentions about Prajāpati's 1000-year sacrifice and asks the performer to imagine scaling up all the parameters of the sacred altar by 1000. Here, the *muhūrta* and the corresponding syllable relation remain same at 80 *akṣara*. But the total *lokampṛṇa* space filling bricks become one crore eight lakh (1,08,00,000) hair pits, on the body of the self-similar *Great Prajāpati*, that are stated to be equal to the number of stars seen in the sky.[26] We need not digress on the doctrines and theories of the Vedic *Brāhmaṇa* texts. It suffices to point out that an underlying axiomatic relation between time and the Vedic chants forms the doctrinal basis for maintaining temporal sequencing and work flow discipline in the rituals carried out in real time.

Though *muhūrta* was given prominence as a division of the day, it was not the smallest such Vedic measure. *TB* defines *prati-muhūrta* that divides *ahorātra* into 450 parts. As per the *ŚB* legend about Prajāpati and the number 15, *muhūrta* was divided further by fifteens several times. In the 12th *kāṇḍa* of *ŚB* this division goes up to 50625 parts of *ahorātra*. The *Śāṅkhāyana Śrautasūtra* a later text is an exception to the above rule of sequential division into 15 parts. This text divides *muhūrta* into 10 *nimeṣa* which is further divided into 10 *dhvaṁsī*. The commonality among the different Vedic texts is in the *ahorātra* divided into 30 equal *muhūrta* parts and an effort to visualize close affinity among day, night, month and year with the number 36 of the *bṛhati* meter.

10 Real Time

Leaving aside ideological musings about very long and very small time periods, division of the *ahorātra* should have been a practical necessity in the conduct of the sac-

[23] यद्वेव संवत्सरमभिसम्पद्यते तद्बृहतीमभिसम्पद्यते
बृहती हि संवत्सरो द्वादश पौर्णमास्यो द्वादशाष्टका
द्वादशामावास्यास्तत्षड्विंशत् षड्विंशदक्षरा बृहती..॥ *ŚB* (6.4.2.10).
द्वादशपौर्णमास्यः। द्वादशाष्टकाः। द्वादशामावास्याः।
एषा वाव सा देवाक्षरा बृहती ॥ *TB* (1.5.12.2).

[24] तद्वा इदं बृहतीसहस्रं सम्पन्नं तस्य वा एतस्य बृहतीसहस्रस्य संपन्नस्य षड्विंशतमक्षराणां सहस्राणि भवन्ति तावन्ति शतसंवत्सरस्याह्नां सहस्राणि भवन्ति। *Aitareya Araṇyaka* (2.2.4).

[25] स ऋचो व्यौहद्बादश बृहतीसहस्राण्येतावत्यो हर्चो याः प्रजापतिसृष्टाः तास्त्रिंशत्तमे व्यूहे पङ्क्तिष्वतिष्ठन्त ता यत्त्रिंशत्तमे व्यूहेऽतिष्ठन्त तस्मात्त्रिंशन्मासस्य रात्रयोऽथ यत्पङ्क्तिषु तस्मात्पाङ्क्तः प्रजापतिस्ता अष्टाशतं शतानि पङ्क्तयोऽभवन् ॥ अथेतरौ वेदौ व्यौहत् द्वादशैव बृहतीसहस्राण्यष्टौ यजुषां चत्वारि साम्नामेतावद्भैतयोर्वेदयोर्यत्प्रजापतिसृष्टं तौ त्रिंशत्तमे व्यूहे पङ्क्तिष्वतिष्ठेताम् । तौ यत्त्रिंशत्तमे व्यूहेऽतिष्ठेतां तस्मात्त्रिंशन्मासस्य रात्रयः। अथ यत्पङ्क्तिषु तस्मात्पाङ्क्तः प्रजापतिस्ता अष्टाशतमेव शतानि पङ्क्तयोऽभवन्॥ *ŚB* (10.4.2.23-24).

[26] तस्य तपस्तेपानस्य एभ्यो लोमगर्तेभ्य ऊर्ध्वानि ज्योतींष्यायंस्तद्यानि तानि ज्योतींष्येतानि तानि नक्षत्राणि। यावन्त्येतानि नक्षत्राणि तावन्तो लोमगर्ता, यावन्तो लोमगर्तास्तावन्तः सहस्रसंवत्सरस्य मुहूर्ताः॥ *ŚB* (10.4.4.2).

rifices that were of various durations, from one day to one year and even longer. We have already seen that *RV* (V.76.3) attests five divisions of the day. These five divisions are elaborated qualitatively further in *TB* (1.5.3). Such a description with demarcation is not explicitly available for the night even though all the 15 day and 15 night *muhūrta* of the dark and bright fortnight are named separately in *TB* (3.10.1). However, allegorical explanation of how the night rites are to be carried out during the *Atirātra* sacrifice, which is a one-day *soma-yāga* already cited in *RV* (VII.103.7), is available in the *Aitareya Brāhmaṇa* (16.5). This starts with the legend of Indra clearing away *asurās* through the night with the help of the seven *chandas* (meters), that are defined in terms of the number of syllables contained in the hymns. This night ritual is carried out by the ordained group of priests in three cycles (*paryāya*) each comprising four *camasa-gaṇa*. The text reads:

> तान्वै प्रथमेनैव पर्यायेण पूर्वरात्रादनुदन्त मध्यमेन मध्यरात्रादुत्तमेनापररात्रात्।

Here, there is clear mention of three-part division of the night each of which was taken to be of equal duration. Sāyaṇācarya the renowned representative of the practicing sacrificial tradition explains that each division of the night is meant to be of ten *ghaṭikā* (five *muhūrta*).[27] The time unit *ghaṭikā* is not met in Vedic texts, but widely used in the medieval period as measured by a water clock. Hence we can infer that Sāyaṇācarya'a commentary refers to actual practice among *yājñika* groups during his time. Vedic rituals continue to be performed in India to this day and it should not be surprising to find modern time keeping methods in vogue. How equality of time periods was kept up in the most ancient period is not known but mention of *paryāya* indicates chanting, oblations and ritual acts that should have been nearly identical in the three cycles and carried out at the same speed. Section (16.6) of the above *Brāhmaṇa* text describes in detail the hymns to be sung in the three cycles on the night of the *Atirātra-yāga* which is a type of *Agniṣṭoma* sacrifice. But this does not make any direct or indirect statement about *akṣara* and the purported time divisions. However, the immediate next Chapter 17 of the text prescribes the *Aśvinaśastra* hymns to be chanted covering a part of the night till sunrise. These lauds are made up of all the meters such that the recitation consists effectively 1000 *bṛhatī* verses. This is a modification of the standard *prātaranuvāka* composed of 1000 *bṛhati* verses which is chanted in the night during the *somayāga* and several other Vedic sacrifices. A brief review of this leads to interesting new results on the measure of Vedic *akṣara* in real time, going beyond hymnal congruencies.

11 The *Prātaranuvāka*

The *Aitareya Brāhmaṇa* and the *Aitareya Āraṇyaka* expound the legends, doctrines and theories connected with the *prātaranuvāka*. Several Vedic *Brāhmaṇa* and *Śrauta* texts also describe in detail the composition and chanting of the *prātaranuvāka* during different Vedic sacrificial sessions. An in depth study of this set of Vedic hymns has been carried out by Gonda (1981) in his monograph *The Vedic Morning Litany*, by collecting and comparing differing details as stated in several ancient texts. For our purpose it is sufficient to determine as closely as possible the starting time and ending time of this important nocturnal recitation.

The earliest reference to the *prātaranuvāka* is in the *Taittirīya Saṁhitā* (*TS*) where it is enjoined that this should be completed before other voices are heard, indirectly meaning the chant should end by early morning before sunrise.[28] The same text in another place mentions that the chant should commence in the deep of the night.[29] Both the commentators of *TS* namely, Bhaṭṭa Bhāskara and Sayaṇācārya take the phrase *mahati rātryai*, for the beginning of the chant, as the vague middle part of the night. This is elaborated in the *Aitareya Brāhmaṇa* (7.5) with the injunction *mahati rātryā anūcyaḥ* repeated four times. The commentary of Sāyaṇācārya leaves no doubt about the approximate beginning and ending time of this litany.[30] The chant had to start after midnight when large part of the night was remaining and should end before the birds started chirping early in the morn-

[27] क्रमेण निराकरणप्रकारं दर्शयति – दशदश घटिका एकैको भाग इत्येवं रात्रेस्त्रयो भागाश्चत्वारश्चमसगणा एकः पर्याय इत्येवं द्वादशानां चमसगणानां त्रयः पर्याया:, तैः क्रमेण रात्रिभागत्रयादसुरानपानुदन्त॥ Sāyaṇa Bhāṣya on the *Aitareya Brāhmaṇa* (16.5).

[28] पुरा वाचः प्रवदितोः प्रातरनुवाकमुपाकरोति
यावत्येव वाक् तामवरुन्धे। *TS* (6.4.3).

[29] यदि सोमौ संसुतौ स्याताम् महति रात्रियै प्रातरनुवाकमुपाकुर्यात् । *TS* (7.5.5).

[30] रात्रेः साम्बन्धिनि शेषे महत्यवतिष्ठमाने सति
प्रातरनुवाकाख्य ऋक्समूहो वक्तव्यः॥ *Sāyaṇa Bhāṣya of AB* (7.5).

ing. The *Sūtra* texts that give the procedural details also say that the chant starts in the *mahārātri* part of the night such that the 1000 verses could be completed (before sunrise).[31] What is *mahārātri*; is it a particular marker like *madhyarātri* the boundary that divides the night into two equal parts? From the different texts, commentaries and introductory essays in the MPRV (1950) by practitioners of the *Śrauta* tradition, we can gather that in Vedic parlance this means some time after midnight but not too far away. The *Śabdakalpadruma* (Deva 1822) quotes an anonymous *Tantra*, stating that *mahārātri* starts two *muhūrta* after midnight.[32] Even though the speed and time limits mentioned in the Vedic texts are qualitative and at best intuitive, the *prātaranuvāka* is a rare instance where the texts, in letter and spirit, exhibit tendency for synchronization with time shorter than *ahorātra* by actual real time chanting. This is not the same as the axiomatic *akṣara* congruence with lunar and solar cycles in longer than *ahorātra* time scales such as the month and the year. Since the *bṛhatī-sahasra* is a long litany with a specified number of *akṣara* it would be interesting to find what might have been the duration of the chant even though the texts provide only vague starting and ending times. If we take the night (sunset to sunrise) to be of 15 *muhūrta*, the chanting had to start ½ to 1 *muhūrta* after midnight and end ½ to 1 *muhūrta* before sunrise. This essentially means the time taken for chanting would have been 5½ to 6½ or on average 6 *muhūrta*, at the rate of 6000 *akṣara* per *muhūrta*. This number, it may be noted, is based on the equinoctial night of 15 *muhūrtas*. But, in summer due to shorter nights the 1000 verses perhaps got completed in about 5 *muhūrtas* whereas in winter nights the rendering might have got extended. This conjecture, leads to a recitation speed of around 7000 to 6000 *akṣara* per *muhūrta* that is at best theoretical. However, in practice this may vary as the processes of the rituals, though not the Ṛgvedic hymns, differ in schools that branched off long before present.

It is known that the *Ṛgveda* (*śākalya* branch) text has been maintained accurately all over the country for several millennia. For maintaining the fidelity of the traditional chanting a variety of techniques are adopted the theory of which is described in the ancillary *prātiśākhya* texts. As discussed previously the concept of *akṣara* as a countable discrete entity in a hymn is central to Vedic rituals and practices. However, the *traisvarya* (tri-tonal) and even the *ekasvarya* (mono tone) *Ṛgveda* chanting is a continuous process in time and hence marking *akṣara* boundary, for counting purposes, is a matter of definition. The traditional *anukramaṇi* texts have preserved the meters of all the hymns with the stipulated number of *akṣara*. This is the only unambiguous definition we get for counting syllables in continuous recitations or records of the *Ṛgveda*.

Even though versification was the fashion among the *siddhānta* astronomers, the syllabic time in classical poetry remains notional and hence syllable counts can be based on orthography. But, the time of the astronomers being real their 60 *gurvakṣara* audio scale had to be made phonetically accurate by selecting a particular meter, among many possibilities, such that 3600 syllables span half-*muhūrta*. For arriving at such specific refinement there must have been some precedence for quantifying a part of the day or night by a long count of *akṣara*. The readily traceable source for such an effort is the importance given in the Vedas for the meter *bṛhatī* of thirty-six *akṣara* for representing time intervals. This cannot be treated as a fortuitous coincidence since the astronomical half-*muhūrta* of 3600 *akṣara* is numerically congruent, in true Vedic style, with 100 *bṛhatī* verses. Nevertheless, such comparison remains qualitative. Hence for getting a better picture of the influence of the Vedic tradition on measuring time with the *gurvakṣara* scale we have collected information on present day chanting of *Ṛgveda* by orthodox Veda specialists.

12 *Prātaranuvāka* of the *Kauṣītakins*

Śrauta practices are preserved in India by followers of the Veda who perform *soma-yāga* and such other rituals occasionally apart from regular *gṛhya* rites. Śri Itti Raveendran Nambūdiri, (Head of the *Veda Śrauta Gurukulam* of Edappal, Kerala) is a venerated scholar renowned for his lifelong devotion to Vedic tradition and his expertise on Vedic practices. He has participated and conducted several *Atirātra* as per the *Kauṣītaki* School. We contacted him to know about the details of *prataranuvāka* as re-

[31] अथ महारात्रे महाव्रताय प्रातरनुवाकमुपाकुर्वन्ति।
यथा परिसहस्रमनुब्रूयात्। *Śāṅkhāyana Śrauta Sūtra* (17.7).

[32] महारात्रिः - अर्द्धरात्रात् परं मुहूर्त्तद्वयम् ।
यथा, " अर्द्धरात्रात् परं यच्च मुहूर्त्तद्वयमुच्यते।
सा महारात्रिरुदिता तद्दत्तमक्षयं भवेत्॥"
इति तन्त्रम् ॥ *Śabdakalpadruma*, vol.5.

cited by him in long Vedic rites. He readily explained the procedure and mentioned that his recitals started in the night at 3 a.m. and got completed sometime after 4 a.m. We gathered that the chanting from start to end would need one hour and fifteen/twenty minutes. The chanting is enjoined to be done always in *ekasvara* (single tone), in medium pace maintaining medium loudness. When queried about the number of *bṛhatī* verses as mentioned in the *Aitareya Brāhmaṇa*, he was quite clear that he follows the *Kauṣītaki Vidhi* inherited from his teachers and not any printed book. He agreed to share all the *Ṛgveda* hymns that appear in the *prātaranuvāka* that consists of three subsets: *āgneyaṁ*, *uṣasyaṁ* and *āśvinaṁ*. He sent a written document noting down the *maṇḍala* and the *sūkta* so that we could identify all the 348 hymns and their canonical meters in the *Ṛgveda*. The number of *akṣara* in the litany as per the *Kauṣītaki* School adds up to 12,396. This gives the speed of chanting of *prātaranuvāka* to be 7500–7900 *akṣara* per *muhūrta*.

13 Recorded Ṛgveda

The other data collected comprises of audio records of *Śākalya-saṁhitā Ṛgveda traisvarya* (tri-tonal) *saṁhitā pāṭha* that maintains continuity within a *sūkta*, from Mysore[33] and Vārāṇasī.[34] The chanters are professionals trained since their younger days, in the age old oral tradition, inheriting the knowhow of their teachers. Thirty-eight *sūkta* distributed over different *maṇḍala* that consist of varying number of verses are selected for noting the durations of the chant. The *akṣara* (syllable) count and time taken for each *sūkta* of this sample data is presented in the Appendix. In Figure 2 for a quick appreciation of the results, the time taken for each *sūkta* is plotted against the syllable count. From the table in the Appendix, the mean and standard deviation of the chanting speed can be computed. It is found that the southern chant (Mysore) speed is on average 7296 *akṣara* per *muhūrta*, whereas for the northern chant (Vārāṇasī) the average speed is 14457 *akṣara* per *muhūrta*. In both the cases the standard deviation is about 10% of the average value.

[33] *Ṛgveda* audio record of S. S. Sharma and S. K. Bhatta. Published by Sri Ranga Digital Software Technologies, (Pvt.) Ltd. Mysore, 2012.

[34] *Ṛgveda* audio record of Vishvanatha Sharma from Vārāṇasī, Private Collection.

14 Discussion

Several interesting results emerge out of the above study. Firstly, the average recitation rate of 7296 *akṣara* per *muhūrta*, of the Mysore school in medium pace, is in magnitude close to the 7200 *gurvakṣara* rate of *siddhānta* astronomers that was the basis for time measurement in India till modern times. This is not a chance result nor a subjective opinion but what can be verified objectively. This close quantitative match, beyond reasonable doubt, leads us to infer that the oral tradition of Vedic learning and chanting, by design or by its very nature, was getting synchronized with numbers 15, 30 and 36 and their simple multiples, as time measures related with *day*/*night*, *ahorātra*, *pakṣa*, *māsa*, and *saṁvatsara*.

The result of 14457 *akṣara* per *muhūrta* of the Vārāṇasī tradition is twice of its southern counterpart, the difference being less than 1%. This is easily explainable since in the Vedic and in the music tradition, three speeds *vilamba*, *madhyama* and *druta*; each twice faster than the previous one, are recognized. If recitation of a particular fixed text material in the *madhyama* (medium) speed takes one *muhūrta*, the same will take two *muhūrta* in the *vilamaba* (slow) speed, whereas in the *druta* (fast) speed only half *muhūrta* would be sufficient to complete the recitation. Bhāskara-I, the commentator on the *Āryabhaṭīya* elaborates the importance (see footnote 7) of the speed being in the medium pace (*madhyama vṛtti*) for the calibration of one *vighaṭikā* by 60 *gurvakṣara* of the verse B-I, already experimentally verified for its accuracy in the present study. Bhāskara's comment quite well points to the Vedic origins of the *akṣara* count method of time measurement that was only fine-tuned by the astronomers using classical Sanskrit prosody.

Tracing the *akṣara* concept backwards takes one to the Vedic *Brāhmaṇa* texts, which propose congruencies between a variety of *akṣara* counts and time periods and spatial designs of the altars. Jan Gonda (1984) cites more examples of this type of syllable congruence or homologation. The congruency relations are neither figurative nor realistic in present day parlance, but indicate gradual growth of an idea following an urge to understand or characterize abstract time in terms of active rituals that use hymns already available to the followers of the Vedas. This represents a stage in the evolution of mathematical concepts in India wherein the mystical unitary

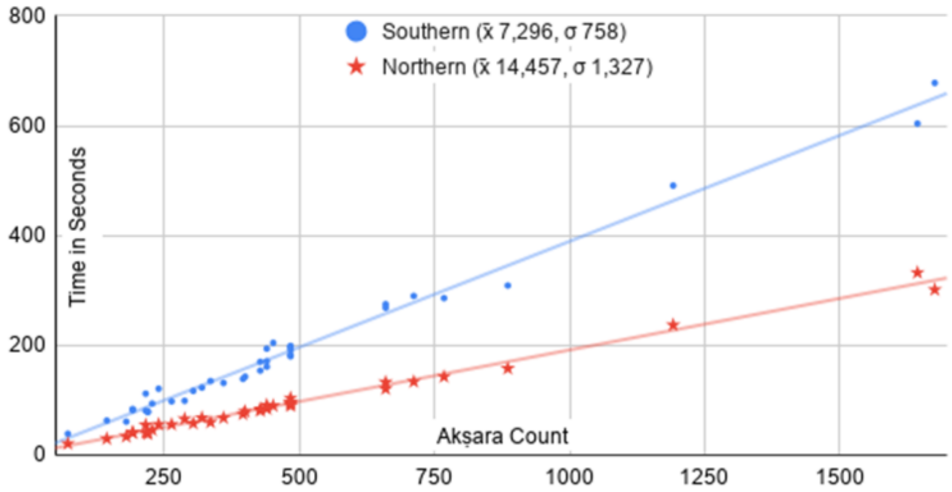

Figure 2 *Ṛgveda* chant time in seconds *vs Akṣara* count.

vision of the cosmos of the Vedic seers was transforming into tangible realities for the community through numbers and similarity relations, particularly in rectifying the year, months and still smaller intervals of time.

The principle of correspondence of *akṣara* in sacred hymns to abstract and concrete objects was not limited to time divisions only. The *Aitareya Brāhmaṇa* (5.3) refers to this as a general principle called *rūpasamṛddhi* (fullness-of-form). This principle appears to be the motive force behind some ritualistic actions striving for accuracy in minute details tending towards rigour of a mathematical kind. *Akṣara*, no doubt played a very important role in handling phenomenal time, but it involves discretization in the sense of counting by integer numbers. Going beyond such integral *akṣara*, Vedic texts in many places exhibit deeper analytical ideas about the *akṣara-kāla* itself being further divisible, as many times as one wishes, so much so *time* in reality is extolled to be continuous with no breaks. The *Taittirīya Āraṇyaka* (I. 2.4–5) in the very beginning describes that time is due to sun and that it is continuous like a river flow and is irreversible. Previously, we have referred to the *Sāmidhenī* verses and their perceived syllabic congruence with the year. The *Śatapatha Brāhmaṇa* enjoins that these hymns should be recited continuously without breaks because *ahorātra* flows continuously uninterrupted.[35] This continuity of time that is linked with the continuity in the observable movement of Sun might be leading to congruencies of a different kind. This aspect needs further investigation.

15 Summary and Conclusion

Any physical measuring instrument needs to be calibrated by independent methods to maintain its accuracy. Indian astronomers of the various *siddhānta* texts recognized the necessity to calibrate the water clock that was used to measure time by a bowl sinking exactly 60 times from sunrise to sunrise. It was important to measure one *ghaṭikā* that is (1/60th) of an *ahorātra* by independent means so that the bowl could be fine-tuned properly. An ingenious method of calibrating using an audible oral scale of one *vighaṭikā* was developed in the form of a Sanskrit verse in the *līlākhela* meter composed of 60 *gurvakṣaras*. Sixty repetitions of this verse in medium speed would indicate passage of one *ghaṭikā* equivalent to 24 minutes in modern parlance. In the present study the accuracy of this scale has been verified and shown to be very good. It is noted that the time value of this *gurvakṣara* in the particular meter gets fixed phonetically as equal to 0.4 seconds. Such a practice of recitation to estimate passage of time is traceable to the Vedic oral tradition, wherein many ritualistic texts describe congruence relations between *akṣara* and time. We find that in the legend of Indra crossing over the night with the help of the seven *chandas*, followed by the

[35] ...तानीमानि संवत्सरस्याहोरात्राणि सन्ततान्यव्यवच्छिन्नानि परिप्लवन्ते ॥ *ŚB* (I.3.5.16).

starting and ending time prescriptions for the *prātaranuvāka* chanting of 1000 verses, adding to 36,000 *akṣara* (Vedic syllables) there is evidence to the ancient practice of estimating passage of night-time by Vedic recitation at medium pace.

Quite interestingly the theoretical estimate from the books and the actual speed in real performances, although approximations, match well with the classical count of 7200 *gurvakṣara* per *muhūrta* of the astronomers. The *prātaranuvāka* was not always recited with pitch accents. The count of verses to be chanted perhaps varied among the different branches of the Vedic schools. Without the three pitch accents an oral performance would be a mix of only *laghu* and *guru* syllables almost like in classical poetry. This is borne out by the personal information provided by Iṭṭi Raveendran Nambūthiri. In such a chant the time measure of an arbitrary *akṣara* would be less than that of the astronomical *gurvakṣara*. But with the Vedic pitch accents included as in the Mysore record, the basic *akṣara* magnitude approaches that of the *gurvakṣara* time of Āryabhaṭa, Varāhamihira, Bhāskara and others. The Vārāṇasī performance rendered at twice the speed corroborates this observation.

The above analysis and discussion makes a case for recognizing the night-time recitation of the *prātaranuvāka* in different Vedic schools as the precursor for a variety of *akṣara* time units appearing in the works of Lagadha, Parāśara, Suśruta, Vṛddha-Garga, the *Brahmāṇḍa Purāṇa* and other texts. The very diversity in the definition of the basic *akṣara* and its time value is a clear indication of the intellectual tradition in India striving to standardize the vague time-keeping methods inherited from antecedent sources. This eventually was achieved with the calibration of the *vighaṭikā* by the medium pace recitation of a verse with sixty *gurvakṣara* which only could have led to the final design of the sinking bowl type water clock.

16 Acknowledgement

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Abbreviations

KAS – Kautilīya Artha Śāstra
VM – Varāhamihira
B-I – Bhāskara I
MAU – Maitrāyṇīya Āraṇyaka Upaniṣad
ŚB – Śatapatha Brāhmaṇa
TB – Taittirīya Brāhmaṇa
AB – Aitareya Brāhmaṇa
RV – Ṛgveda
LVJ – Lāgdha Vedāṅga Jyotiṣa
VP – Viṣṇu Purāṇa
TS – Taittirīya Saṃhitā

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Appendix

Sample analysis of 38 RV *Sūktas* with their *Akṣara* count as per ascribed meters.

Columns 4 and 5 show the chanting time taken in seconds. The last two columns show the resulting rate of chanting of *akṣara* per *muhūrta*. 1 *muhūrta* = 2880 seconds.

No	Sūkta	Number of *akṣara*	Chant time seconds		*Akṣara* per *muhūrta*	
			Southern	Northern	Southern	Northern
1	1.1	216	112	55	5,554	11,311
2	1.3.(10-12)	72	39	21	5,317	9,874
3	1.9	240	121	56	5,712	12,343
4	1.72	440	194	91	6,532	13,925
5	1.164.(15-52)	1676	678	301.5	7,119	16,010
6	1.165	660	275	133	6,912	14,292
7	1.166	712	290	134	7,071	15,303
8	1.167	484	199	93	7,005	14,988
9	1.180	440	171	85	7,411	14,908
10	2.1	768	286	143	7,734	15,467
11	2.7	144	63	30	6,583	13,824
12	2.32	336	135	60	7,168	16,128
13	2.33	660	268.5	121	7,079	15,709
14	3.35	484	180	96	7,744	14,520
15	4.6	484	197	104	7,076	13,403
16	4.7	428	170	81	7,251	15,218
17	4.8	192	84	41	6,583	13,487
18	4.9	192	82	41	6,743	13,487
19	4.10	228	94	46	6,986	14,275
20	4.33	484	192	96	7,260	14,520
21	4.34	484	183	90	7,617	15,488
22	4.35	396	139	75	8,205	15,206
23	4.36	428	154	84	8,004	14,674
24	4.37	304	117	58	7,483	15,095
25	4.38	440	161	85.5	7,871	14,821
26	5.74	320	123	68	7,493	13,553
27	5.75	360	131.5	68	7,884	15,247
28	5.76	220	79	39.5	8,020	16,041
29	5.77	220	79	40	8,020	15,840
30	5.78	288	99	66	8,378	12,567
31	5.79	400	143	79.5	8,056	14,491
32	6.13	264	98	56	7,758	13,577
33	6.14	216	81	41	7,680	15,173
34	6.15	886	309	158	8,258	16,150
35	6.16	1192	491	237	6,992	14,485
36	6.61	452	204.5	90	6,366	14,464
37	10.85	1644	604	332.5	7,839	14,240
38	10.164	180	61	34	8,498	15,247

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