

Vedic Perspectives on Acoustics

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Abstract

Sound plays a major role in various aspects of life. The field of acoustics deals with generation, transmission and reception of sound. Sound in modern scientific terms refers to the pressure waves in air received by human beings in the audible range of generally 20 cycles/sec to 20000 cycles/sec. However the infra- and ultra-sound refers to the frequencies below and above the audible range respectively. Acoustics has also received a very high importance in Vedas and Vedic literature. The classical literature of Hinduism or Sanatana Dharma is rooted in Vedas. It is known that the Vedas are collection of mantras. In Vedas and Vedic literature several terms such as Nāda and Shabda are used. These terms cannot be translated directly as sound as they refer to vibrations including both physical and spiritual aspects. However the Nāda and Shabda include the human auditory range sound. In particular human speech, vocal and instrumental music as they lie within the audio range have been discussed significantly in Vedas and Vedic literature. This paper presents Vedic perspectives on acoustics. The Vedic four-fold model for generation of speech is discussed with applications general sound. The acoustical aspects of speech, music, language, literature and spirituality are discussed. Also the paper includes discussions of Vedic view in relation to views of modern acoustics.

This paper is based on the presentations at the Workshop on Exploring Vedic Sciences (in November 2009) at the Center of Indic Studies, University of Massachusetts at Dartmouth, USA and at the International Music Conference and Festival (in January 2011) organized by Indiranagar Sangeeta Sabha, Bengaluru, India. The presentation at the International Music Conference is available on a DVD with the author.

Introduction

Veda refers to the body of knowledge that deals with physical, psychological and spiritual aspects of life and cosmos. The word Veda etymologically relate to the verbal root 'Vid' meaning 'to know'. However it is interesting to note that the Vedas also refers to 'mantras', which means 'chants that convey knowledge'. The Vedic chants have acoustical characteristics such as phonetics, tonal quality, length measure, effort etc. These Vedic chants are orally transmitted with precision from master to disciples over thousands of years. It is well known that the precision in the oral transmission of chants, music and speech cannot be surpassed through writing. Thus acoustics of human speech is very important. Also it is well known that the faculty of speech is revered as Goddess of Speech (Vagdevi). The mantra from the Yajurveda says:

Devīm Vacamajanayanta Devaha, Tam Viśvarūpah Paśavo Vadanti
Sa No Manderśamūrjam duhana dhenurvagasmānupaśtutaitu

The meaning of this mantra could be summarized as *"Creator Lord Brahma and other devata brought forth Vagdevi (Goddess of Speech) to manifest communication. All beings use their abilities to communicate through Vagdevi. May Vagdevi like an all-desire fulfilling cow bless us with food, strength and faculty of speech?"*

It is quite difficult to precisely define and describe the origin of language and human speech. However it is known that Vedic chants and music in India has existed from very ancient times. Sir C.V. Raman in his article titled "The acoustical knowledge of ancient Hindus" [1], says that:

"It would form a fascinating chapter of history to try and trace the gradual development of musical instruments and musical knowledge, from the rhythmic chanting of the Rig-Veda in the ancient home of the Aryan race to the Indian music of the present day".

Importance of Acoustics:

In modern times the importance of acoustics is very well known. The field of acoustics deals with generation, propagation and reception of sound. The importance of the field of acoustics can be seen as shown in the figure 1 which shows the role of acoustics in arts, life sciences, earth sciences and engineering. It is interesting to note that acoustics has high importance in Vedas and Vedic literature, which are the classical source literature for Sanatana Dharma also popularly known as Hinduism. The Vedas and Vedic literature, which is voluminous as shown in figure 2, deals with all aspects of life including sciences and arts.

‘नादाधीनमतीजगत्’ SOUND IS UNIVERSAL
 SĀRANGA DEVA (SANGITA RATNAKARA)



FIGURE 1: Lindsay's Wheel of Acoustics

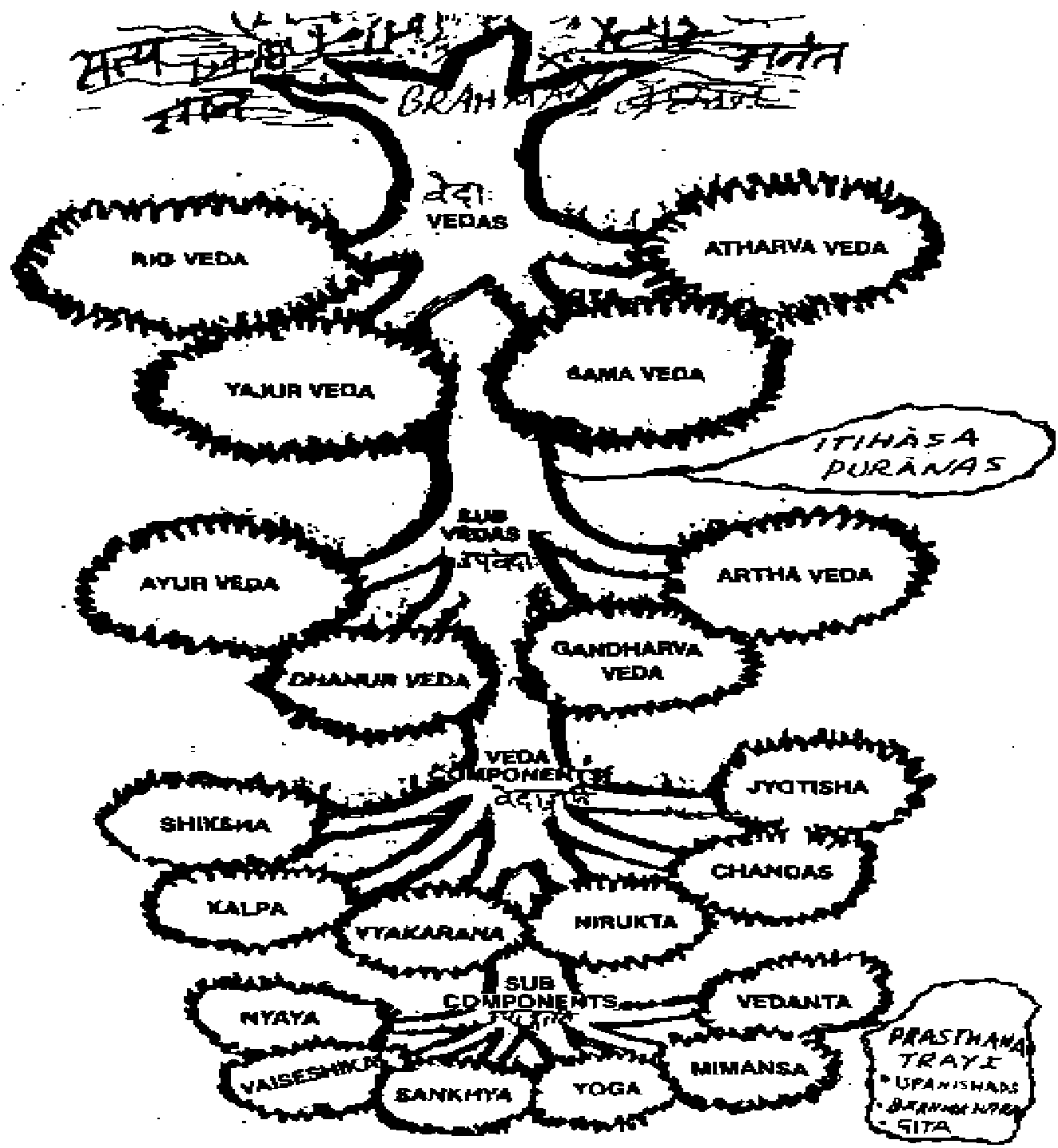


FIGURE 2: Inverted Tree representing Vedic Literature

For example, in reference to figure 2, Gandharva Veda deals with music and fine arts and Chandas deals with science of prosody and its knowledge aids in melodious pronunciation of mantras. It is well known that the four main Vedas (Rik, Yajus, Sama and Atharva) are collections of mantras, which have been orally transmitted through the ages. The proper recitation of mantras requires proper knowledge of acoustics for their recitation. It is interesting to note that UNESCO has also recognized the tradition of the oral transmission of Veda mantras as below.

"Expressed in the Vedic language, which is derived from classical Sanskrit, the verses of the Vedas were traditionally chanted during sacred rituals and recited daily in Vedic communities. The value of this tradition lies not only in the rich content of its oral literature but also in the ingenious techniques employed by the Brahmin priests in preserving the texts intact over thousands of years. To ensure that the sound of each word remains unaltered, practitioners are taught from childhood complex recitation techniques that are based on tonal accents, a unique manner of pronouncing each letter and specific speech combinations."
UNESCO Proclamation 2003 (Intangible Cultural Heritage – ICH)

The precision in oral transmission from teacher to student is directly related to acoustics. The six acoustical factors involved in precise Vedic chanting as per taittirīya upaniśat are pronunciation of letters (Varṇaha), their pitch (Svarha), the timing or duration (matrā), the force (balam), melodious articulation (sāma) and combined sound effects (santānaha).

Although sound is generated by varieties of sources in nature, the sound produced by human beings is of chief importance because of its role in communication. In Vedas and Vedic literature, the term nāda and śabda are referred to indicate both audible and inaudible sounds. This can be referred as **Sound Field**. The production of sound from human beings as speech and music are part of the nāda and śabda. However it is important to remember that the Vedic terms nāda and śabda cannot be translated as sound in the audible range (of 20 Hz to 20000 Hz). The various manifestations of sound in the world that are generated and propagated become part of the sound field. The sound field as nāda and śabda has received utmost importance in Vedic literature. śāranga deva, the author of sangīta ratnākara, a treatise on classical Indian music says:

nādena vyjyate varṇaha padam varṇāt padadvacaha
vacasa vyvaharoyam Nādadhīnamato jagat

which means *"the alphabets have manifested from the naada (sound field). the words are made up from alphabets and from the words speech come out. Worldly transactions are carried out through the speech, and thus, the world is dependent on nāda"*. In a similar way, in the words of a yogī-seer śrīranga sadguru, *"Just as from seed comes naturally sprout, branch, leaf, flower, unripe*

fruit and full fruit like wise starting from spiritual light as seed, the nāda, the svara and aksharas have developed into the various aspects of knowledge” [4]. The sound field as śabda and nāda takes us to the origins of the universe. The Amrita Bindu upanishat [5], one of the minor upanishat, the following verse says:

Dve brahmani veditavyae śabda brahma paramcayat
śabda brahmani niśnātaha param brahmādhi gacchati

This means, “Two Brahman to realize namely: śabda and Param Brahman. *One who has realized and is well versed in śabda Brahman will realize Param Brahman*”. Thus it is seen that the knowledge of sound field as śabda and nāda is a prerequisite to the spiritual fulfillment of realization of Param Brahman. Also the sound field as the revered nāda Brahman in addition to its being all-pervasive in the world is also source of Bliss. Sāranga deva gives it utmost importance in Vedic literature. Sāranga deva, the author of sangīta ratnākara [6] says:

caitanyam sarva bhūtanam vivritam jagadatmanā
Nāda brahma tadānandam advitīyamupāśmahe

Which means “*we worship the nāda Brahman second to none which is blissful and is in all beings as consciousness has manifested itself as universe.*”

The scriptures also refer to two types of nāda namely anāhata and āhata. The anāhata refers to self-existing sound field without any vibratory cause and is experienced only in spiritually focused deepest states of yoga. The āhata refers to the sound field produced vibratory cause. The discussion in this paper deals with produced sound field namely āhata naada.

Although sound (āhata nāda) is generated by both human beings as well as non-human sources in nature, the ones produced by and the ones that affect human beings manifest as speech, music, literature and spirituality (yoga) as shown in figure 3.

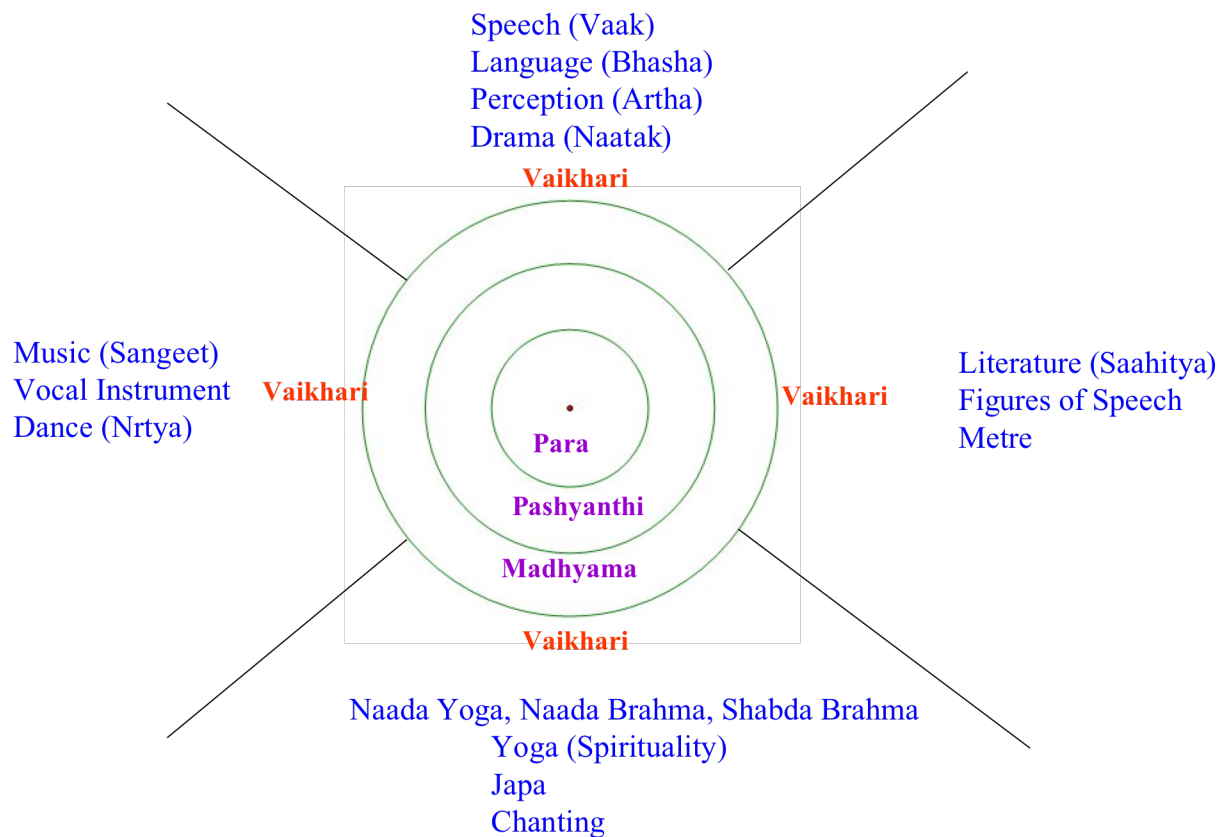


FIGURE 3: Vedic four-fold model of speech

In Vedic literature, major emphasis is given for the human speech. The production of speech is seen as a four-fold process of sound generation namely para, pashyanti, madhyama and vaikhari. After a brief discussion of modern view of speech production, the Vedic view is discussed.

Speech Production - a Modern View

A question of scientific importance is about the origin of sound. This question to begin with can be addressed in reference to human speech. There is a large amount of scientific literature on human speech and music [2, 3]. In a paper by Honda [2] four processes are recognized in production of speech. They are:

- (a) Language processing, in which the content of an utterance is converted into phonemic symbols in the brain's language center;
- (b) Generation of motor commands to the vocal organs in the brain's motor center;

- (c) Articulatory movement for the production of speech by the vocal organs based on these motor commands;
- (d) Emission of air sent from the lungs in the form of speech.

It is seen from the above description that the emphasis is on neurological and physiological basis. It is the intention of this paper to look into the importance of speech sounds and their production from Vedic view.

Four Stages of Speech Sounds – Vedic view

An important hymn from Taittirīya Brāhmaṇa [7, 8] says:

catavāri vak parimitā padāni tāni vidur brāhmaṇa ye maṇiśīṇaha
guhā trīṇi nihitā nengayanti turīyam vāco manuśyāha vadanti

Which means *"speech or word has four stages, which are known by brahmana who has control over mind is well versed in this field. The first three stages are concealed in the cave within while only the fourth stage comes out as utterances by human beings"*. According to a view of philosophers of grammar [8] the four stages are referred as (a) parā (b) paśyantī (c) madhyamā (d) vaikharī

Also in addition scriptures refer to dhvani [9] which would mean as voice and is related to speech sounds. The author Saranga Deva in sangīta ratnākara [6] says:

ātmā vivakśamānaoyam manaha prerayate, manaha
dehastham vahnimahanti sa prerayati mārutam
brahma granthisthitaha soetha krāmatūrdhvapathe caran
nābhihritkantasyiśeśvāvirbhāvayati dhvanim

Which means, *"The human being impels the mind and the mind activates the internal power source in the body which in turn stimulates the vital force. The vital force stationed around the root of the navel, rising upwards gradually through the heart, and the cerebrum and the cavity of the mouth as it (the vital force) passes through them to manifest as dhvani."*

In this process also we can see clearly the four stages for production of sound or dhvani as: (a) the person's impelling of the mind; (b) the mind activating the vital force and getting ready to move; (c) the vital force moving and rising up through the navel, heart, throat, cerebrum and mouth cavity; (d) dhvani produced and traveling to receiver.

Parā, paśyantī, madhyamā and vaikhari

It is to be noted that in Vedic view the origin of the verbal speech in human beings is traced to the location of the moolaadhaara cakra, which is placed in the coccygeal triangle where the spinal cord ends. This energy center or cakra is of primary importance as it supports the entire body organization [10]. An important verse from the prapancasāra tantra text says:

mūlādhārāt prathamamudito yastu bhāvah parākhyaha
paścāt paśyantyatha hridayago buddhiyungmadhyamākhyaha
vaktrae vaikharyatha rurudishorasya jantoh sushumna
baddhastasmādbhavati pavana prerito vama sanghaha

Which means " *the parā form of speech itself was unmanifest to begin with, then it manifested to become pashyantee as it moved up with vital force to the region of umbilicus or navel area. (Also simultaneously, the information at knowledge level is being converted into speech form). The paśyantī form formed at the location of navel region rises up along with the vital force to the location of heart to become madhyamaa along with the integration of the intellect to transform knowledge into speech form. Then from madhyamā form at the heart it rises along with the vital force to the location of throat and mouth to manifest as vaikhari speech or verbal speech heard by the listener. Thus the articulated speech that contains alphabets (and words) have manifested through the movement of vital force through the central energy carrying channel termed as sushumnā along the central axis of the spinal cord*". Thus in the above verse the whole process of four-fold level generation of speech is well described from Vedic view.

There is a verse from a classical Hindu text, which specifically gives the locations in terms of cakras to the four-fold level of speech in physiological terms in the human body similar to that as the previous verse. The verse says:

Parā vaṅgmūlacakrasthā paśyantī nabhisamsthitā
Hridgā tu madhyamā jneyā vaikhari kanthadeśagā

Which means " *In the four-fold speech, the parā level speech manifests at the mūlādhāra cakra (coccygeal triangle), the paśyantī at the manipūraka cakra (navel region), madhyamā at the anāhata cakra (cardiac or heart region) and the vaikhari at the viśuddhi cakra (at the cavity of the throat)*". It is seen that similar description is given in the bhāgavata purāna [11] in the verse 11-12-17. The various charkas that are referred in the above verse are shown in figure 4.

chakras

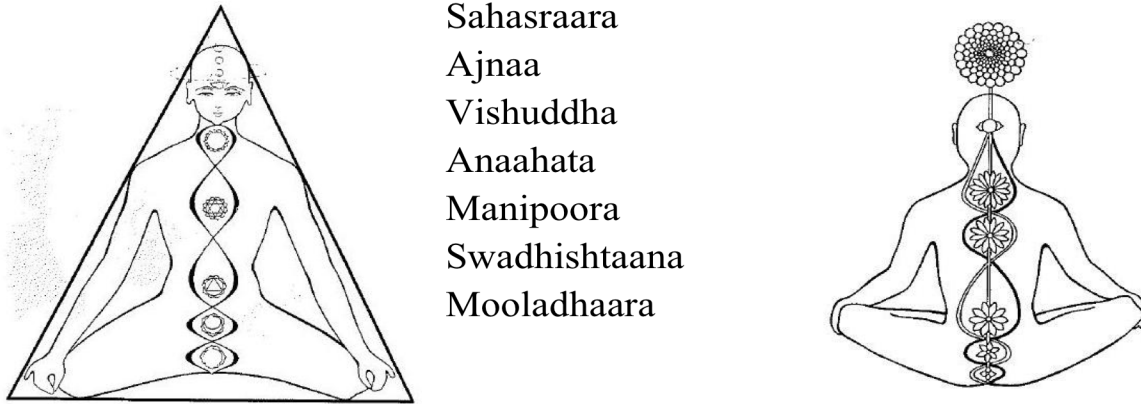


FIGURE 4: Location of Chakras

In another verse, the psychological process of speech formation is given as:

vaikharī śabda niśpattihi madhyamā smṛiti gocharā
dyotikārthasya pasyantī sūksmā brahmaiva kevalam

Which means, "In the four-fold levels of speech, the *vaikharī* form is the gross manifestation of words. The *madhyamā* form is at the memory level, the *pasyantī* form is at the level where the motive is seen and the *parā* form is at the subtle unmanifest as Brahman."

The above three important verses clearly shows that the Vedic view integrates both the physiological and psychological process involving the human body in explaining the four-fold speech (or sound field) formation through (a) *parā* (b) *pasyantī* (c) *madhyamā* (d) *vaikharī* levels.

The *vaikharī* level is the production of words and sentences. This level is physically energized by the vital force (in the form of exhalation and inhalation) at the throat and mouth. Prior to this is the *madhyamā* level, which is drawing from memory (refers to vocabulary and evens) and physically is energized by the vital force at the heart or cardiac region. Prior to this is the *pasyantī* level where

the purpose of speech is seen by the speaker and physically is energized by the vital force at the region of navel area or region of umbilicus. Prior to this is the subtlest and unmanifest parā level and physically exists as the potential energy form at the base of the spine or the coccygeal triangle. It is interesting to observe that in production of speech and music, not just the contributions of the efforts of the mouth but of the whole body is involved.

Relevance of the Vedic four-fold model of speech

A comparison of the modern acoustical view and the Vedic view of the production of the speech is considered. It is seen that the modern view considers the role of brain, lungs, and vocal organs such as throat and mouth. However the Vedic view through four-fold levels integrates both the physiological and the psychological aspects. The physiological aspects in Vedic view goes to the base of the spinal cord as the source of physical energy which drives the vital force to rise up and activate the various components such as lungs, heart, throat and the mouth. The psychological aspects do bring the role of brain through memory and seeing the motive of speech. The Vedic view seems to be more comprehensive. In addition the Vedic view of speech as a divine energy is important for the human beings in their spiritual developments. It is clearly seen that the production of speech involves not just the lungs and mouth but the whole body. It is for this reason that recitation of mantras and singing of music is seen as explicit spiritual practices as it affects not only the whole body but also the mind.

The Vedic four-fold level speech production can be applied to any type of sound production. As an example, when one blows a conch-shell, the sound produced by shell (heard by the listener) is vaikhari. Prior to that the blowing of vibrating air-pulses to the conch-shell is the madhyamā level. Prior to that of blowing, the person blowing the conch-shell had decided to blow for a particular purpose which is seen by the person and is at the paśyantī level. Prior to that is the capability or potential of the person to blow a conch-shell, which is at unmanifest level is referred as parā. This Vedic four-fold approach for speech production can be adapted to any production of the sound either through direct music or through an instrument.

Acoustical aspects of Music

An important role of Vaikhari, which is the fully manifested sound field, is music. It is well known that music transcends the barriers of language. In the words of yogi-seer Sriranga Sadguru, "*Music should become the bridge that takes the listeners from sensual level to the spiritual level of Atman.*" The music is universally based on seven notes which are directly related to the accents that are used in the Vedic chants. In Sanskrit the term svara denotes a note.

Svaras refer to accents in Vedic mantras, notes in music and vowels in language.

The svaras in music refer to the basic seven notes found in the seven sounds produced from animals in nature. They are Sa from a peacock, Ri from a bull, Ga from a goat, Ma from a curlew, Pa from a cuckoo, Dha from a horse and Ni from an elephant. A raaga is an acoustic presentation using various svaras to depict an emotion or a mood. The various moods are broadly classified in to nine moods namely Shringaara (amorous), Veera (heroic), Karuna (pathetic), Haasya (comic), Adbhava (marvelous), Raudra (ferocious), Bhayanaka (frightening), Bheebhatsa (odious), and Shaanta (peace). The essential effect of the various moods produced by musicians on the listeners is called rasa. Thus it seen that the acoustical aspects of music has effects on listeners through the tonal configuration namely raaga and total experience namely rasa [12]. The author Suvarnalata Rao in [12] says " *The different connotations of rasa could be viewed as having significance on three different levels - the physical, the psychological and the metaphysical. In the physical sense, it is used to denote juice or essence. For instance, when one states that the fruit is full of rasa, it means that it is full of juice. In the psychological sense, it implies flavor or taste, where the active participation of psyche plays a definite role, while on the metaphysical level it describes the experience that one undergoes when aroused by an artistic expression. The perceiver enjoys an experience, which is exalted from the particular to the universal plane by bringing about a complete effacement of the experiencer's ego and its total identification with that artistic creation. It is this supra-mundane experience described in Upanishads that assumes significance in Indian aesthetics*".

The two types of music are essentially vocal and instrumental. As vocal music comes powerfully through a melodious voice, the instrumental music produced through a well designed and tuned instrument can also be very powerful. Substantial scientific and engineering knowledge and skills are required to build a good instrument. In Indian instrumental music there are hundreds of instruments from ancient times. It is well known that the instruments namely veena (a string instrument) is held by Goddess Saraswati and bamboo flute is held by Lord Krishna as shown in figures 5 and 6.



FIGURE 5: Goddess Sarawati

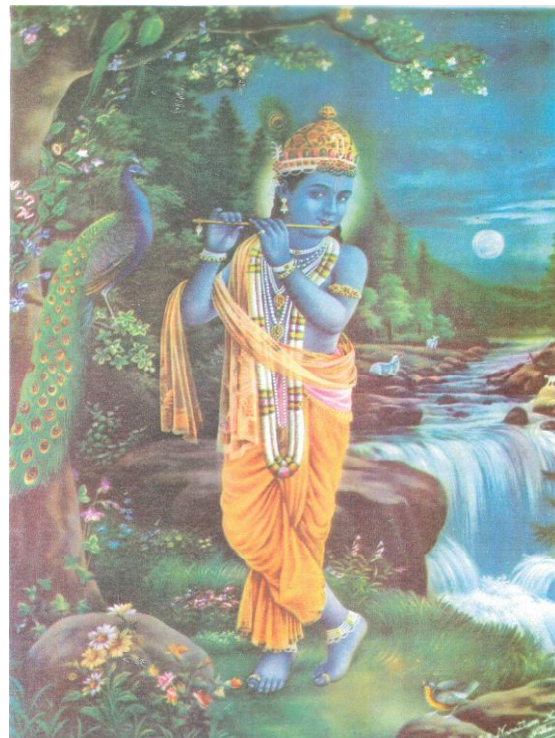


Figure 6: Lord Krishna

The divine energy within a human being, which energizes human speech and music, is Goddess Saraswati in the form of deity. She is also referred as Vagdevi or Goddess of speech. The instrument veena she is holding is a string

instrument, which has 24 frets. The number 24 also refers to the 24 syllables of the celebrated Gayatri Mantra. In addition the instrument veena also is a representation of the human spinal cord, which also has 24 cartilages. This representation is shown in figure 7. Also it is noted in the yoga and tantra texts that the locations of various seed-sounds (beeja-aksharas) is at various charkas.

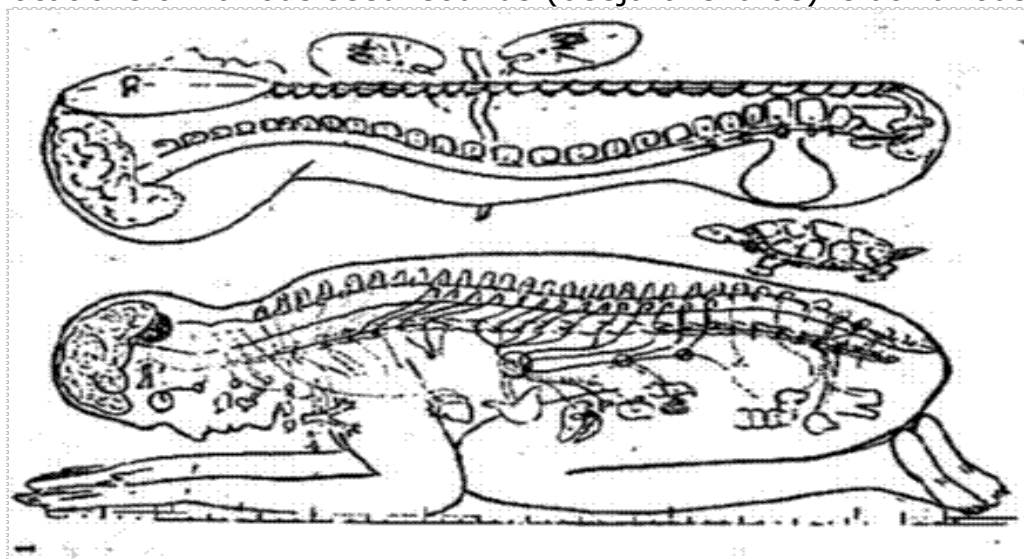


FIGURE 7: Spinal cord as a representation of veena

The flute, which is held by Lord Krishna, is known for ecstatic music and its spiritual impact on listeners. The epic Bhagavata describes in detail the impact of music played by Lord Krishna on the flute. In this context also the holes in the flute represent the location of the various chakras. The measurements of frequencies of various notes produced from a bamboo flute are shown in figure 8. Also the experimental ratios obtained from a bamboo flute compares well with the well-known Pythagorean scale as shown in figure 9.

MEASUREMENTS OF TONES FROM A BAMBOO FLUTE [A5]

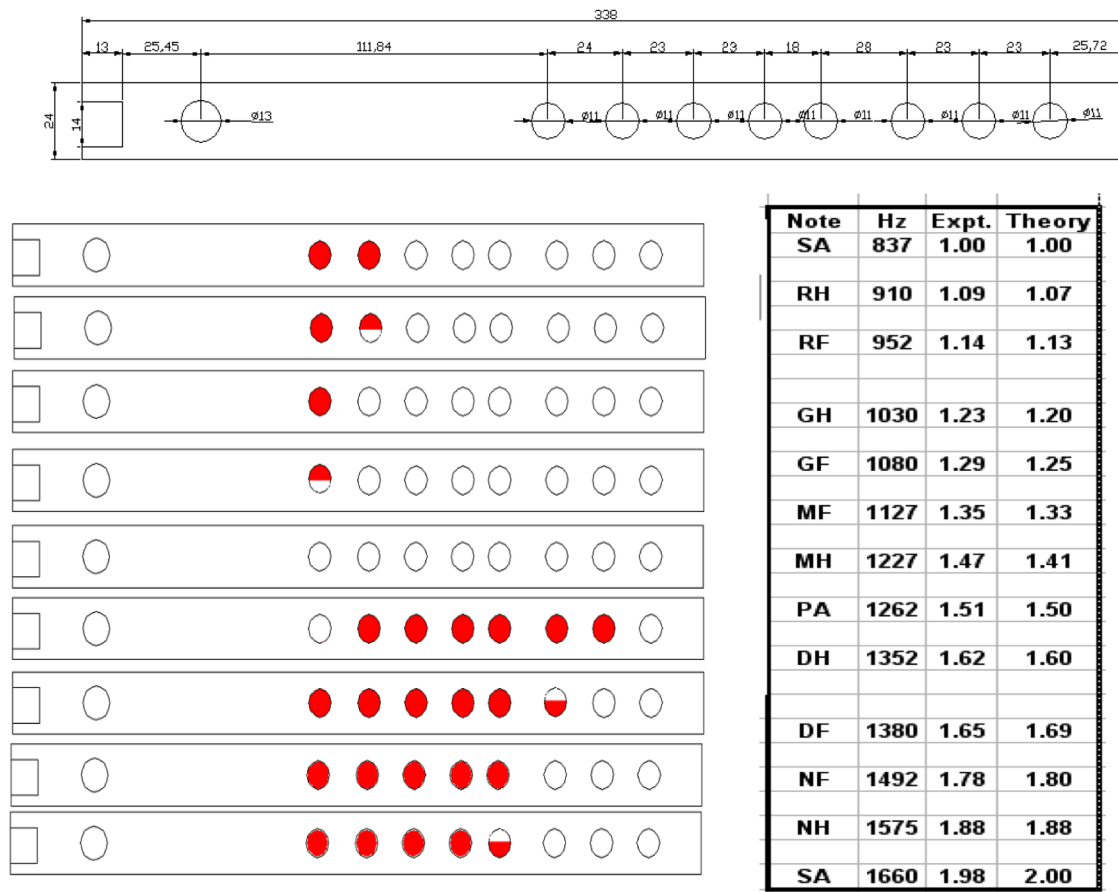


FIGURE 8

NOTE	RATIO [EXPT]	NOTE	RATIO [PYTHOGOREAN]
SA	1.00	C	1.00
RF	1.14	D	1.13
GF	1.29	E	1.25
MF	1.35	F	1.33
PA	1.51	G	1.50
DF	1.65	A	1.66
NH	1.88	B	1.88
SA	2.00	C	2.00

FIGURE 9

Another interesting feature of the Indian percussion instruments namely mridanga and tabla is that the rhythmic sounds produced from them have melody. This is because their natural modes have harmonic relationships. The figure 10 shows the modes and their harmonic relationship. It is well known in musical science that the melody is due to harmonic relationship. It is for this reason that the sounds of mridanga and tabla are not only rhythmic but also melodic.

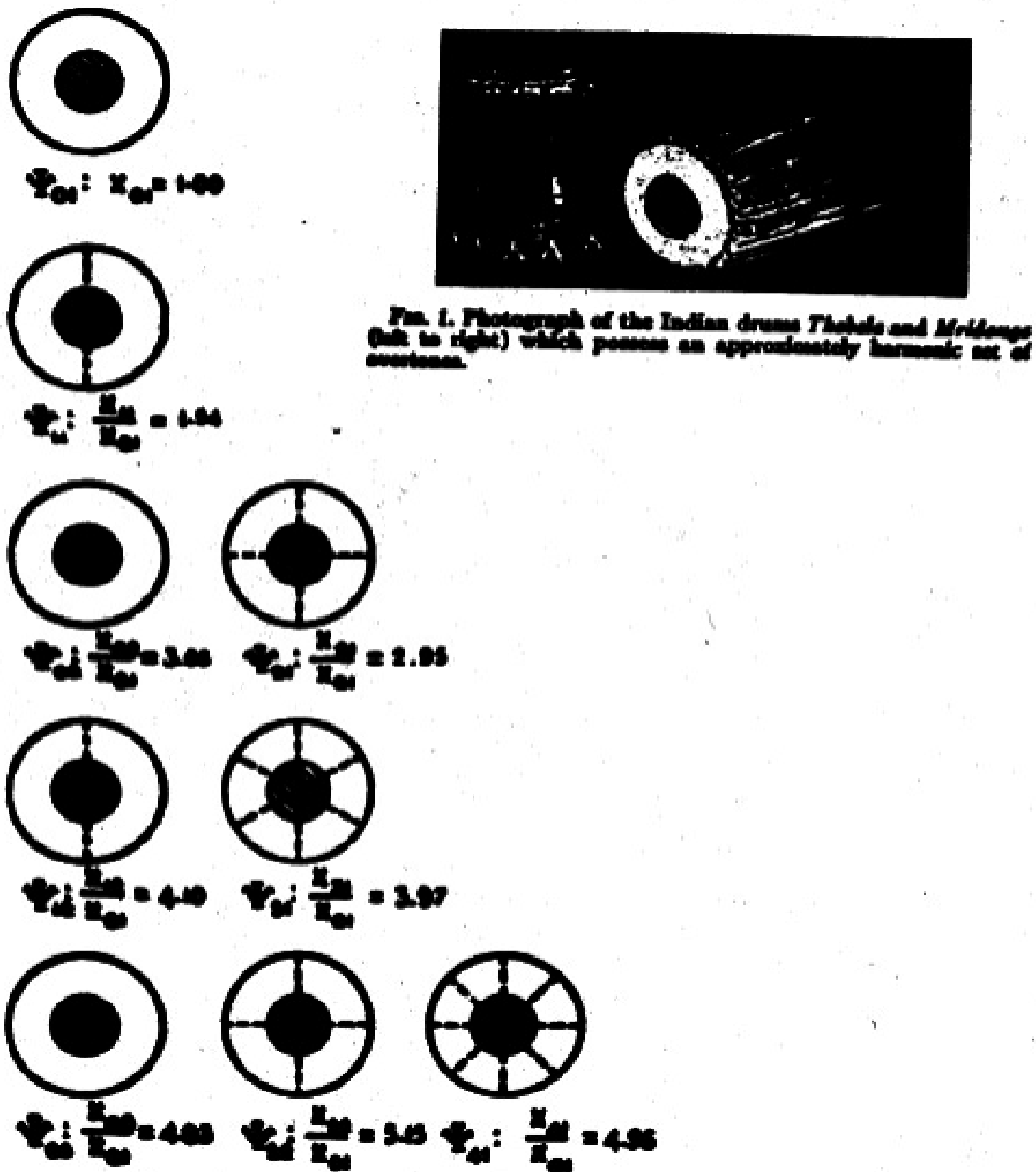


FIGURE 10: First five harmonic modes of Mridanga

In addition to musical instruments, there are additional instruments such as conch-shell, bell, cymbals, and singing bowls etc., which produce sounds that have special effects. They are used in Hindu worship practices to enhance the spiritual experience. For example, the sound from a conch-shell has a very sharp resonance, which results in a tonal sound. It is known that tonal sounds help in focusing of the mind.

The figure 11 shows the sharp resonance and the dominating first resonance frequency, which indicates the dominating tonal quality of the sound.

important in writing poems. The Sanskrit language in which most of the Vedic and classical Indian literature is written has several acoustical features. The distinctive phonetic quality of Sanskrit is reflected in poetry as well as prose. Some of the acoustical aspects of Sanskrit are:

- (a) The sandhi (joining of two words) has a significant effect on the pronunciation, which in turn has acoustical impact for both speaker as well as listeners. (example: Ratha + Utsava = Rathotsava)
- (b) The sound corresponding to an alphabet does not change.
- (c) The derived words from a verbal root have some acoustic similarity with the sound of the verbal root (example: the root vid (to know) becomes vidwan (scholar), vidyarthi (student), vidwat (scholarship), etc.
- (d) The pronunciation of soft aspirant alphabets, hard aspirant alphabets and nasals requires different efforts from the speaker and this affects the speaker and likewise the listeners are also affected. (for example: one need to pronounce the sound of "BA" softly whereas for producing sound of "BHA", an exhalation force is required)
- (e) The large number of alphabets makes it possible to pronounce many complex sounds from the written scripts.

It is well known that the scripts of plays become alive due to the acoustical aspects. The various emotions and their acoustical counterparts are very important in the performances.

Role of acoustics in spirituality and philosophy

Acoustics plays a major role in spiritual aspects of life. As stated earlier, shabda and naada Brahman refer to the Supreme Being. The five elements of universe namely earth, water, fire, air and space and their properties are referred in Vedic literature. The association of the corresponding properties to the element is important in reference to human perception. Several upanishads and scriptures have dealt with this topic [13]. The order of increasing subtlety of five elements is based on the decreasing number of properties or qualities required to characterize that element. In Vaisheshika sutras of Kanaada rishi [13], it is given as:

- 1) Earth possesses smell, taste, form and touch
- 2) Water possesses taste, form and touch
- 3) Fire possesses form and touch

4) Air possesses touch

The fifth element, termed Aakash (space) cannot be qualified by these four qualities namely touch, form, taste and smell. This leads to the observation that the space only be characterized or qualified by sound. However, sound is an additional characteristic to qualify all the other four elements namely air, fire, water and earth. In other words, sound as vibration travels through all these four elements and produce different effects, which characterize the corresponding element.

The term space or akasha does not refer to emptiness. The term akasha refers to the substance or element that is spread in all corporeal space meaning that the space capable of containing other elements and bodies [14, 15]. It is important to note that the scriptures say that the sound is not the property of air, but air is a carrier of sound waves. This can be further explained using the well-known bell-jar experiment. In this experiment when the air is taken out of the jar to create a vacuum, the listener can see the ringing of the bell, which means that the bell surface is vibrating and only the vibrations are not carried further because the air is absent. Changes in air such as turbulence, temperature variations etc. affect the propagation of sound waves. This means that the air is the efficient cause of sound but not the material cause, because the efficient cause can destroy the property just as the potter's wheel can influence the pot but not the clay [16]. This means that sound and space are always together. In the event of an impact the sound generated will propagate through the help of the media such as air, water and earth. Given the existence of space everywhere, it can be inferred that the sound also exists potentially everywhere.

Mantras are used extensively in various spiritual practices. There are three types of practices namely loud chanting, voiceless chanting and mental chanting. The reason that one should practice in this order is that through loud chanting, one gets the right way of pronunciation and also experiences the acoustical effects. In the course of time the practitioner will internalize the chanting to the mental level. There are also the mystical beeja-aksharas (seed-sounds) used to focus on various deities. The acoustical aspects of these seed-sounds are very important. The spiritual importance of sound of OM is well known and has been discussed in several Upanishads. Proper collective recitation of chants and OM results in positive feelings in congregations.

Concluding remarks

The Vedic four-fold approach to speech sound production provides a deep insight to understanding many phenomena. There are on going efforts to analogically view the creation of the universe through this Vedic four-fold view of

production of sound field as (a) parā (b) paśyantī (c) madhyamā (d) vaikhari [17]. Another way of observation is from manifest stage to unmanifest stage that is to say from vaikhari to parā. The interesting feature of the vaikhari, madhyamā, paśyantī and parā (VMPP) model is that one can direct the efforts to understand the life and nature starting from vaikharee and proceed towards paraa. It is like going from sound to deep silence. The important point to be noted is that there is continuous energy link through vital force from parā to vaikhari. This means that going in the reverse direction, one should be able to start from vaikhari and proceed towards the parā, which is spiritually at a very deep level.

Although vaikhari is the last quarter but one can experience vaikhari as it is in manifested form. It encompasses life in many of its expressions such as speech, music, literature and spirituality [18]. We know that speech directly relates human transactions. Music is the human artistic expression [19]. The literature such as poetry plays come into life through sound. The spirituality expresses through rituals. Mantras are used in meditation practices [20, 21].

It is known in the spiritual literature that the importance of many types of yoga are based on the sound field such as mantra yoga, nāda yoga, japa yoga, svara yoga [22,23] etc. Thus further work is needed in both theoretical and practical understanding and applications of the sound field [14]. The four-fold Vedic model for sound field would be helpful for further studies in the field of acoustics [24].

The field of acoustics impacts in many aspects of human life. In its desirable form, sound is essential as speech and music. Especially in the form of music and mantras, sound plays a major role in improving human life [25]. Much work is further needed on the effect of music and mantras from neuroscience point of view. The sound in its undesirable form as noise results in several negative effects on quality of human life. Thus it is important to create an acoustical environment that is conducive to sublime enjoyment of life and achieve spiritual progress.

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