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Ayurveda

THE AYUR-VEDIC UNDERSTANDING OF MODERN PHYSIOLOGY OF HEARING

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ABSTRACT Hearing or audition is a prime aspect of every individual's life and forms one of the major sources for all knowledge perceived and analysed by a living being, following the visual source. According to Modern Medicine, sound having the form of wave enters the external ear and on reaching the tympanic membrane its acoustic energy is converted to mechanical vibrations of the ossicular chain which in turn cause oscillatory movements in the inner ear fluids transforming the mechanical energy into electro-chemical energy carried by the Auditory nerve through the Neural Pathway to reach the Auditory Cortex where the sound is processed to finally produce the decoded information called heard sound. Various theories have been propagated to understand the frequency and intensity coding function of the cochlea and each of these have been categorized into the place theories and periodicity theories, while the process of understanding is still on. There have also been efforts by Grammatists around the globe to understand the process of sound perception as it plays a pivotal role in Phonetics, Linguistics and Communication. The theory of linguistics revolves around the phenomenon of *lemma* or in the words of *Bhartrihari 'sphota'* which is considered as the source of all sound produced and heard. Philosophers too to the surprise of many have a keen interest in this subject as to them sound is a vital energy having immense power to transform both mind and matter, a subject less understood by human intellect. Sound is said to have 4 forms namely *Vaikhari, Madhyama, Pashyanti* and *Para Vak* (form of speech).This paper is a compendium of the understanding of Hearing in the narrations of Ayurveda and Vedanta in par with the current understanding of contemporary medical science. Thus it presents a Medical, Grammatical and Philosophical bird's view of the magical phenomenon called "Hearing".

KEYWORDS : Hearing, Audition, Linguistics, *Sphota, Vaikhari, Madhyama, Pashyanti*

INTRODUCTION

Hearing or audition is a prime aspect of every individual's life and forms one of the major sources for all knowledge perceived and analysed by a living being, following the visual source. There has been extensive research by scientists/ doctors on the biophysical and biochemical understanding of how sound is heard. According to Modern Medicine, sound having the form of wave enters the external (outer) ear and on reaching the tympanic membrane its acoustic energy is converted to mechanical vibrations of the ossicular chain which in turn cause oscillatory movements in the inner ear fluids transforming the mechanical energy into electro-chemical energy carried by the Auditory nerve through the Cochlear Nucleus, Superior Olivary Nucleus, Lateral Meniscus, Inferior Colliculus and Medical Geniculate Body to reach the Auditory Cortex where the sound is processed to finally produce the decoded information called heard sound. Various theories have been propagated to understand the frequency and intensity coding function of the cochlea and each of these have been categorized into the place theories and periodicity theories, while the process of understanding is still on. There have also been efforts by Grammatists around the globe to understand the process of sound perception as it plays a pivotal role in Phonetics, Linguistics and Communication. The theory of linguistics revolves around the phenomenon of *lemma* or in the words of *Bhartrihari 'sphota'* which is considered as the source of all sound produced and heard. Philosophers too to the surprise of many have a keen interest in this subject as to them sound is a vital energy having immense power to transform both mind and matter, a subject less understood by human intellect.

AIM & OBJECTIVE

To compile and analyze the different references on perception of sound from Medical, Grammatical and Theosophical texts (mainly of Indian origin).

MATERIALS & METHODS

Different texts, audio and video lectures and articles were visited and compiled to reach to a meta-analysis on the subject of hearing.

MODERN PHYSIOLOGY OF HEARING

The Auditory System comprising of the External (outer) ear, Middle ear, Internal (inner) ear and Central Auditory nervous system functions to convert acoustic events/ stimuli into perceived sound. Conduction of sound in the body happens in 2 mediums- air and bone.

Air Conduction: Sound waves from the environment are absorbed and reflected by the listener's body, head and pinnae and arrive at the tympanic membrane (ear drum) through the external auditory canal. Here the acoustic energy is transformed into mechanical energy by the tympanic membrane by setting the ossicular chain into vibration. The tension of the tympanic membrane is important here as a flaccid membrane will not transmit vibrations efficiently reducing the quality of sound heard. The vibrations of the ossicular chain are transferred to the inner ear fluids (mainly the perilymph), via the elastic membrane at oval window, which get set into an oscillatory motion from the scala vestibule to the scala tympani through the helicotrema and backwards. This oscillatory movement creates a travelling wave motion along the basilar membrane of the cochlea. Basilar membrane houses the Organ of corti including the outer and inner hear cells, the ones that produce the electro-chemical impulses that are carried further by the Auditory nerve (cochlear element of vestibulo-cochlear nerve; CN VIII). The nerve signals then progress in the Eighth Cranial Nerve through the Cochlear Nucleus, Superior Olivary Nucleus and Lateral Meniscus, Inferior Colliculus and Medial Geniculate Body to finally arrive at the Auditory Cortex. This neural pathway of sound is usually remembered in Medical School by the pnemonic ECOLI-MA.

Bone Conduction: The current theory for bone conduction proposes that 4 major mechanisms are responsible for acoustic conduction via bone- 2 Inertia Mechanisms (at Middle and Internal Ear) and 2 Compression mechanisms (at External and Internal Ear).

To summarize, hearing by bone conduction is a combination of mainly 2 phenomena:

1] The relative motion of the ossicles in response to vibrations in the head.
2] Compression waves in the inner chamber of cochlea caused by vibrations transmitted from the skull.

Special Mechanisms:

The Outer ear has a special function of 'Selective Amplification of

Sound' by virtue of which it selectively enhances the sounds that are important to human behavior and speech/ communication. The Middle ear brings about 'Acousto- mechanic transduction', 'Impedance matching (by 3 major mechanisms- Area ratio transformation, Ossicular chain lever action and Catenary lever action)' and 'Acoustic Reflex'. Acoustic Reflex is a protective phenomena wherein when a high pressure sound wave approaches the ear canal a neuro- reflex mechanism causes the tensor tympani and stapedius muscles in the middle ear to contract which in turn cause the tympanic membrane to be pulled in and the stapes to be rotated away from its axis of action thereby reducing the energy transmitted through the middle ear. This reflex achieves an attenuation of upto 15- 20dB. The Inner ear has special phenomena including 'Cochlear Me chanisms (that encompass all the Place and Periodicity Theories)', Electric potentials (including Summating potential, Cochlear microphonic and Compound action potential)' and 'Hair cell action'. Cochlea is attributed with the function of coding (signaling specifically for right perception by cortex) the frequency and intensity of sound which are explained since the 60's by different theories including the Travelling wave theory, Resonance theory (both- Place theories), Telephone theory, Volley theory (both- Periodicity theories) and so on. In a nutshell the place theories say that the frequency of a sound wave is coded in the cochlea at the site/ place the basilar membrane vibrates the strongest. While the periodicity theories propose that the frequency is coded by the temporal (from 'tempo'- speed of a music rhythm) pattern of an acoustic wave, that is , by the number of neural impulses fired by the Auditory nerve in response to the acoustic stimulus. The Auditory nerve fibres fire impulses in response to the neurotransmitters secreted by the inner hair cells distributed in the basilar membrane, in response to an acoustic stimulus, and the potential generated by this firing is called Compound Action Pootential (CAP). The Central auditory nervous system specializes in the primary response to sound, in co-incidence detection, spatial sound perception, processing information of sound onset and duration and semantic decoding of sound.

AYUR-VEDIC UNDERSTANDING OF HEARING

The prime factor in the understanding of the modern physiology of hearing in terms of *Ayur- Veda* is the Vedic understanding of what a wave is.

Any wave needs a substratum, which is formed by *Akasha Mahabhuta* (The principle element of ether whose function is to provide space/ strata). And any movement in the universe happens only by *Vayu* (The principle element of air with the principal function of "movement"). Thereby, the propogation of waves through their respective mediums is brought about by *Vayu*. This is one reason why the perception obtained by any sense organ is considered to be a perception of touch, as skin the primary site of *Vayu Mahabhuta* and touch its primary function. The awareness of the sense organ(Sanskrit- *indriya*) reaches out to its object (*indriyartha*) and when there is contact (touch) between them then the perceived sensation is carried to the *manas* (psyche) and ultimately to *buddhi* for obtaining its scrutiny, which in turn brings about the sense (organ) perceived knowledge. Therefore without contact i.e without touch there is no sense perception. Be it sense of hearing, seeing, smelling or tasting. In each of these cases there is a substratum through which the perceived sensation travels to reach its target sense organ. This substratum is constituted by *Akasha Mahabhuta*. The movement of the sensation (which is usually in waves) is brought about by *Vayu*.

Even in the sensation of hearing, the *Karna Srotas* forms the substratum (*Akasha mahabuta*) for the sound waves while external *vayu* brings about the propogation of waves. Once the waves touch the tympanic membrane (termed by contemporary scholars as *karna patala*) the waves get transmitted through a bony medium, the ossicles. In Ayurveda bones are understood/ known as *asthi dhatu* and *asthi* is the seat of *Vata Dosha*. Importantly, the *Mahabhuta* constitution of *asthi* is *Akasha Mahabhuta* (along with *Vayu* as per some). So again the equation remains undisturbed which is that the substratum is *Akasha*. Vibration of the tympanic membrane causes the ossicles to oscillate which is to be understood undoubtedly as the action of *Vayu* [stimulated by the *vayu* on the outerside of the tympanic membrane]. The ossicles finally cause the oval window to vibrate which in turn passes on the vibrations to the fluid called perilymph present in the bony organ cochlea of the internal ear. The space in which the perilymph flows is a hollow spiral canal, thereby innately has *Akasha*. Now, the waves move through a fluid medium to finally reach the Organ of Corti in the Basillar membrane of the membranous cochlea. From here the waves are converted into electric nerve impulses which are carried to the Auditory cortex (Broadmann's area 41, 42 and area 22 partly) of the brain through the Auditory pathway. Throughout this journey the same equation continues, every substratum being a form of *Akasha* and the forward movement being brought about by *Vayu* (now in the form of *Prana Vata*, constitutionally present in the sense organs of the human body). Even the electric impulses generated by the generation of action potential in the cells of Organ of Corti are nothing but the functional form of *Vayu*.

Here the role of the fluid medium perilymph, and even endolymph indirectly, is to serve as a speed breaker to control the momentum of the waves. *Jala Mahabhuta* (The principle element of water having the function of unctuating*)* moves downwards and is *Guru* (heavy) compared to *Vayu* hence it curtails the fast moving *vayu* to transform it into a frequency more homely for the forthcoming anatomical structures in the path of the Sound wave.

In *Darshanas* (Doctrines of Philosophy; *darshana*- seeing, in sanskrit*)* we find few theories explaining the functioning of the sense of hearing, namely:

1] *Veechi Taranga Nyaya*- The sound (waves) spread like the waves created when a stone hits a water surface.
2] *Kadamba Mukula Nyaya*- Sound (waves) moves in a rhythmic pattern like that of the unfolding of petals when a bud blossoms into a flower.

In Indian Grammar Texts we find a reference of the doctrine of *Sphota* [*Sphota Vada*]. The word *sphota* literally means "bursting open". The word *sphota* had been first used by *Acharya Patanjali* in his works referring to it as the 'bursting out of an idea in the mind into a verbal expression'. However the term *sphota vada* was first and most importantly, in history, used by *Bhartrihari* in his text '*Vakyapadeeyam'*. He explains the concept of *Sphota* to occur in 3 types and in 3 stages. The 3 types are: *Varna sphota, Pada Sphota* and *Vakya Sphota*. The first referring to the expression of a syllable, the second to the expression of a word and the third to that of a sentence. The 3 stages in which *Bhartrihari* conceptualizes his theory of linguistics are:

I] In Speaker

1] *Pashyanti*- Blossoming of the idea in speaker's mind
2] *Madhyama*- Formation of phrase/s compassing the idea, in the mind
3] *Vaikhari*- The utterance of words by the speaker, articulation of speech

II] In Listener:

1] *Vaikhari*: Hearing/ knowing through the sense organ ear
2] *Madhyama*: Processing the heard sound in the mind
3] *Pashyanti*: Understanding the intent and emotional content of the speech

The *Vaikhari* sound uttered by the speaker is rightly heard in terms of syllables and its gross meaning is understood(this is at the *Madhyama* level). Finally the listener understands the rationale of the speaker (this is at the *Pashyanti* level). The different stages of *sphota* in a speaker are also related to the 3 types of energy (considered attributes of the Divine Mother Goddess) namely *Iccha Shakti (Pashyanti), Jnana Shakti (Madhyama)* and *Kriya Shakti (Vaikhari).*

Each of these levels of sound corresponds to the different levels of consciousness :

1] *Vaikhari* exists in the purview of conscious mind at the level of *Jagrut* (state of consciousness when awake or Physical Consciousness)
2] *Madhyama* is functional in the subconscious mind at the level of *Svapna* (state of consciousness during dreams i.e stage of sleep when dreams set in or Mental Consciousness)
3] *Pashyanti* is the domain of the unconscious mind at the level of *Sushupti* (state of consciousness during dreamless sleep or Intellectual Consciousness)
4] *Para* lies in the realm of the superconscious mind at the level of *Turiya* (Higher state of consciousness achieved at the Ultimatum of Yoga Sadhana i.e Transcendental Consciousness)

According to another school of thought *para* is opined to originate at the *mooladhara chakra* (energy centre at the origin of spinal cord),

pasyanti is formed in *nabhi* (navel region), *madhymaa* in *hrudaya* (precordial/ physical heart region) and *vaikahri* at *kantha* (throat).

Para is nothing but the *Shabda Brahman* or *Sphota*, the source of all the other 3 forms of speech. In Creation, Subtle is always the source of Gross, hence the above. *Vaikhari* is called as *Laukika Bhasha* whereas the higher forms of speech are called as *Alaukika Bhasha*.

Sphota is revered as the 'Pranava (commonly known as Omkar)' and considered the *upadana karana* (proximate/ material cause) of *Jagat* (Creation). According to Dr. V. Ramabrahmam, *Atman (soul; individual)* is one which continuously moves (*'yasya gamanam satatam tat atma'*- which moves incessantly is *atma)* and he moves on to call it a bio-oscillator which continuously emits energy pulses, at a frequency of 10^{-1}sec, from its inherent consciousness through mind. He interprets these energy pulses as *Chit Tattva* (principle of consciousness) described in the *Vedanta* (conclusive texts of the Vedas). A close parallel of *Sphota* in western psycholinguistics is *'lemma'* which is defined as an abstract conceptual form of a word that has been selected mentally for utterance. They say *lemma* represents a specific meaning while it does not have any specific sounds attached to it.

DISCUSSION

Contemporary researches have proven that the perception of sound is not limited to identifying tone and intensity of the sound. The sound reaching the cortex undergoes a transmission at the thalamus which is a conduit to the cortical areas of sound perception. The medial geniculate body (MGB) of thalamus is the information bottleneck for neural representations of sounds being sent to auditory cortex and it actively shapes them enabling an individual to experience sound not just in terms of identifying the syllables in a word but also comprehending the subject of spoken words, the identity and gender of the speaker as well as the emotional content of the speech. Another interesting fact revealed is that properties of individual neurons of the auditory pathway and their synaptic connections do not represent a fixed structure in the central nervous system. They are affected by immediate surroundings, experience, selective attention, learning, and emotional states of a person and they are continuously modified throughout the lifetime. Unlike the single-way traffic in sensory perception through other senses, in the ear there is a reverse wave produced to every sound wave that reaches the inner ear. This phenomenal phenomenon is called Otoacoustic emission or cochlear echo. Dr. Alfred Tomatis, a French Otolaryngologist better known as the Einstein of Hearing, whose extensive research on Acoustics today is a branch of Medicine called Audio- Psycho- Phonology, presented few core principles of which one says- "Communication is a process which begins in-utero. The unborn child hears as early as fourth month after conception". Another core principle of his says that sound is a nutrient and that we can either charge or dis-charge our nervous system by the sound we take in through air or bone conduction. Retrospecting with the Vedantic view, the basilar membrane can serve as a function specific sensor only with the presence of *Chit Tattva* (principle of consciousness) in it, which leads us to why in old age where death is approximating an individual, in turn meaning his/ her *Chit tattva* is gradually retiring, he/ she developes deafness clinically called Sensory Neural Hearing Loss (SNHL). The frequency of the bio-oscillator *Atman* given as 10^{-1} sec ($1/10^{th}$ of a sec or 10 cycles per sec) magically seems to match with the frequency of psycho-neural oscillations called alpha waves (frequency is 8- 14Hz; 1Hz= 1cycle/sec)detected by EEG as found by the German scientist Hans Berger and rightly inferred by Dr.V.Ramabrahmam. The *Veechi Taranga Nyaya* and *Kadamba Mukula Nyaya* suggests the ancients knew that sound has a form of wave which moves by propulsion of wave particles. In Western psycholinguistics too, lexicalization is considered as a two-stage process wherein the first stage deals with semantics and syntax leading to the abstract notion of a word that contains meaning while the second-stage deals with phonology where information of how the word should be uttered. The product of the first-stage is termed as *lemma* and that of second-stage is called lexeme.

CONCLUSION

Sound is not just an acoustic event but an energy that can transmute itself in end number of ways to give myriad information and interpretations. Similarly, hearing is not just a mechanical process but a highly complex science in itself involving even neuro-development. Even mental monologue and dialogue is a form of sound as per *Vedanta* falling under the phenomenon of *Madhyama Vak* (form of speech). Determination and intuition too are a acoustic energy pertaining to *Pashyanti Vak.* Hence for us, 'Auditory Biology determines the perception of Sound' is replaced by 'Sound has the power to determine our Biology(including Auditory Biology)'. To prove it better we have the whole branch of "Epigenetics", the Neo-Darwinian branch of Biology which says that that genes and DNA do not control our Biology but instead DNA is controlled by signals from outside the cell, including energetic messages emanating from our Positive and Negative Thoughts. Dr. Alfred Tomatis' principles tell us that the story of Abhimanyu in the Indian epic Mahabharata is not a myth (in the words of Dr. Devdutt Patnaik- 'Myth= *mithya* (false)'). They also give us the scientific background of Music Therapy. The *Upanishads* teach that depending on just *Vaikhari* (verbally spoken and heard form of sound), makes one prone to more errors. Moving towards the subtler forms of sound is the need of the wise. Thus, lets seek to exist more and more in "*pashyanti (*meaning to see*) vak"* and become better "Seers" of our science AYURVEDA and benefit the mankind all the more better.

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