# SRUTI: THE SCALIC FOUNDATION

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A foundational aspect of every musical system is that of the scale. Each system resolves the problem characteristically, and often uniquely, by asking and answering questions from time to time within the matrix of its history, cultural and traditional values, musical needs, aesthetic conventions etc. Indian music has evolved a theory of the scale in terms of a unitary and basic concept called the *sruti*, through at least two millennia. This theory is both adequate and unique. Its conceptual bases are far-reaching in their scope, function and influence; yet it is unfortunately little understood or appreciated on an international plane where it is even often misreprsented. This is largely due to the fact that a systematic attempt to provide for its representation and discussion on international forums has yet to be made in our country where ethno-musicology and comparative musicology are now in their infancy. A further disadvantage is that until very recently, the problems of musical scales and intervals have been obscured by an exclusive preponderance of a bias for mathematical theory or interpretation which is not very relevant in a musicological, psycho-acoustic or psycho-physiological context.

Thus the frequency ratios of the *srutis* of Indian music are of little significance *per se*. They reveal nothing of the conceptual foundations of our theory of scale or interval. They obscure the real functions of this unitary concept in deriving, explaining and predicting empirical facts or usages, as any systematic, scientific theory should. If the scale is relevant and important to musical system, and if its building unit is relevant and important to the scale, then the relevance or importance of the *sruti* can hardly be exaggerated. Sound textual evidence clearly suggests that such an adequate theory was formulated in India in a framework remarkably free from the cramping hand of Space or the corroding touch of Time. Such textual evidence is rather fragmetary and diffuse. It is the purpose of this short paper to present some of the highlights of this ancient theory through an eclectic ratiocination and to indicate its enduring applicability. The approach is of necessity brief and casual; the scope of the paper is essentially suggestion. A more systematic and extensive treatment may be found elsewhere.[1]

## Scalic Models

"Scales are made in the process of endeavouring to make music"[2] rather than the reverse. A scale is also a schematic organization of the tonal materials employed in a pitch series and is thus an ordered and comprehensive arrangement of the intervals occurring in a musical system. A scale thus involves the concepts of, but is not synonymous with, tonality, modality and key. The birth of a scale is contingent on the perception of pitch relations as a succession of intervals. A relevant psycho-physiological factor is the inherent activity of the central nervous system in man to organize sensory perceptions, with its analogue of symbolic transoformation in semantics and philosophy. The psycho-acoustical factors contributing to the construction of a musical scale are (1) the breadth of pitch, ie., variability of frequency within small limits without perceptible differences in pitch; (2) interval quality i.e., the variability in the intervallic quantity while the character of the interval remains unchanged; (3) absolute limits of pitch discrimination and practicable limits of interval discrimination; (4) laws of habituation involving mechanisation of behavioral or affective response and (5) laws of association involving response to formation of types. The function of the scale is aesthetic because it is the epitomy of the psychologically, physiologically and aesthetically discriminable intervals in the audible range and "the organization of them into familiar patterns used in music for aesthetic purposes."[3]

The construction of a musical scale proceeds through the operation of one or more of the principles of natural design, phenomenology, psychic, acoustic or aesthetic distance, or through extramusical principles such as mathematical, religious, spiritual or superstitious, or even physical factors involved in the construction of musical instruments. Natural design relates to the overtone pattern, while phenomenology relates to natural occurrences such as animal cries; the principle of distance relates to the need or otherwise for tempering; extramusical contributory factors or theories such as the *tridosa* of the organism, affective association or coloration, zodiacal association, supersitious numerical association, philosophical theories etc., are evident in the shaping of musical scales in India, China, Persia and Egypt.

Musical scales were evolved, historically, on theoretical or pragmatic criteria. Those of Persia, Arabia and Greece have a pragmatic bias while those of India, Greater India, China and Japan have a more or less theoretical orientation. The Arabians and Persians have evolved their musical scales through instrumental technology relating it to division and subdivision of intervals. The Greeks have employed the principles of (a) mathematical or just intonation by correlating the simplicity of numerical ratios to aesthetic quality, (b) the cyclic projection of consonantal intervals such as the pure fifth in what is called the Pythagorean intonation. A slight variation of this technique obviating or minimizing the divergences or noncoincidence of intervals in higher registers is the cycle of blown fifths used in many early musical systems such as those of Java, Siam, Burma, Peru, Melanesia, Brazil and a few African tribes,[4] (c) the progression of tetrachords (*of systemateleion*) overlapping in a common interval by conjunction (*synaphe*) or by disjunction through separation by a tone (*diazeuxis*). This was developed by Aristoxenus into a Greater Perfect System and a Lesser Perfect System by symmetry and variation of intervals

in the two tetrachords[5]. These three principles give rise to the diatonic, chromatic and enharmonic scales.[6]

**The Scalic Unit**

At an emprical level, a musical scale is evolved by the selection of a nucleal interval, usually from phenomenological material and by its more or less systematic extension in one or both directions. This technique may be designated *karsana*. It is evident in the lower scalic forms of ethnomusic. Lach, for example, has shown how the historical scales may be derived from the primitive cry or *Urschrei* through the processes of portamento, glissando etc.[7] Ethnomusic reveals the derivation of a tetrachord range through a preference for a descending fourth, and rarely by an ascending fifth. Parry has shown the operation of the principle of extension in the derivation of the tetrachords of Greek music.[8] Phenomenological events such as animal cries, bird songs, primitive cries, child-songs etc. suggest a phylogenetic origin of such extension while intermediate linguistic forms such as the recitation, parlando etc., reveal its more or less conscious operation. The *udatta* triad, the *arcika-gathika* etc. system of recitation, the *yajurvedic* heptachord encompassing *abhinihita* to *tatha-bhavya*[9-10] and the *samavedic* hepachord encompassing *krusta* to *atisvarya, sastha or antya* [11-13] as well as the extension in recitative techniques of the various vedic schools[14] etc. clearly reveal the *karsana* principle in ancient India.

A common feature of the more developed musical system is the subdivision of such nucleal interval. Arabian music and Persian music of the 13th century A.D., have experimented with a 18-note scale, [15] and later with 24 subdivisions in the scale (through the bifurcation of each of the twelve *nim pardah*[16] and of 22 degrees.[17] Chinese music, for example, divides its scale into 18, 53, 60 or even 360 degrees.[18]

**Sruti: Origin and Conceptual Evolution**

Indian musical theory has postulated the *sruti* as the scalic unit in *laukika* (secular) music since at least two thousand years. Like several other technical terms in our musical theory, the term *sruti* is also a borrowal from a vedic context. The general connotation of the word (*lit.* that which is heard) has been crystallised from a solution of ascribed attributes into a technical entity with definite, prescribed or conferred functions and scope. Its foundational role in the scale and therefore its authority in the world of music was emphasized by analogy with *Sruti* (scripture) which is prescribed to be foundational and authority for the word. The term is also used in the sense of pitch in vedic literature: प्रयोक्तुरीहागुणसन्निपाते वर्णोभवन् गुणविशेषप्रयोगात् । एकश्रुतीः कर्मणाप्नोति बहवी । [19] (*eka sruti*-one pitch). अनुदात्तः परः शेषः स उदात्तश्रुतिः । [20] उदात्तश्रुतितो यान्त्येकं द्वे वा बहूनि वा । [21] The *Naradiya Siksa* employs the term with at least four distinct meanings in the sense of pitch (*dhvani*) शतेषु पवित्रेषु नीचादुच्चार्यते श्रुतिः । [22] in the sense of interval (*svara*): पूर्ण नाम स्वरश्रुतिपूरणात् छन्दः पादाक्षर संयोगात् पूर्णमित्युच्यते। [23] नाविरते श्रुति कुर्यात् स्वरयोर्नापि चान्तरे[24] in the sense of intervallic displacement: श्रुतिस्थाने विशेयपेग (?-नेष्वशेषेण?) श्रुतिवत् स्वरतो भवेत् [25] and finally implying their subtle (and presumably minute) nature[26]. However, the word has been employed in the sense of a minute discriminable pitch

difference by Saunaka: मात्रासंसर्गादवरे पृथक् श्रुती [27] which Uvata expands with his commentary: पृथक् श्रूयेते इत्यर्थः। एवं श्रुतिविशेषो भवति। Panini also employs the word in the sense of a small (differentiable) pitch; एक श्रुति दूरात् सम्बुद्धौ [28] and Patanjali explains; *ekasrutih saptamah.*

However, the *sruti* is used in *Naradiya Siksa* almost exclusively in the sense of five techniques of intervallic extension, displacement or embellishment under the name of *dipta, ayata, karupa, mrdu* and *madhya.*[29] Yajnavalkya also mentions the *sruti* varieties probably in the same sense: वीणावादनतत्त्वज्ञ : श्रुतिजतिविशादः। तालज्ञश्चाप्रयासेन मोक्षमार्गं नियच्छति ॥[30] Bharata [31] and Abhinavagupta in his commentary on the former[32] both mention these five *sruti* names in much the same meaning. One final usage in *Naradiya Siksa* is suggestive: उच्चनीचस्य मध्ये साधारणमिति श्रुतिः These concepts of definite pitch, interval, just differentiated interval, tonal extension, displacement or embellishment, a common location between two musical entities etc., formed the conceptual source material which was adopted and adapted in a musicological context to delineate the *sruti* as the fundamental scalic element.

**The Sruti Experiment: Methodology**

Our ancient theorists have offered experimental devices for the determination and exact understanding of the *srutis*. This is done with varying degrees of objectivity. Two stringed instruments are tuned in unison exactly to prescribed conditions. One of them is kept unchanged throughout the experiment to serve as a control or basis of comparison while the notes in the other are progressively and systematically diminished so that in each step, each of consonantal note pair is so far reduced as to merge into the next lower note on the control instrument. The number of intervals obtained in each case is totalled and found to be equal to 22. The method offered by Bharata (and by Matanga who largely follows him) suffers in objectivity because it assumes a prior knowledge of two contemporary scales, the *sadjagrama* and the *madhyamagrama* in the experimenter, which at this distance of time can at best be only inferred. Further, the method is *a post-eriori* because it *defines* the intervals obtained by such collective dimunition as *dvi-,tri-*, and *catuhsruti,* so that each individual *sruti* is not separately obtained.[34-35] Again, the Bharatiya experiment apparently assumes that its results are reproducible in any pitch range at which the instruments would be tuned to the *sadjagrama*. Abhinavagupta's genius has offered a far more scientific methodology by (a) independently defining the *srtui* through its attributes; (b) avoiding dependence on prior knowledge of *madhyamagrama;* (c) improving the comparative technique through his expansion of the *vikalpa*, '*va*' for augmentation and dimunition in the original text (d) clarifying the meaning of *pramana* in the original text by refuting misinterpretations; (e) improving the technique of dimunitive tuning; (f) defining the unison tuning unambiguously and (g) extending the dimunition to every note at every stage[36]. However, he is committed by his examplar to relate the *sruti* to the *grama* and therefore suffers in objectivity to this extent. However, it is Sarngadeva who offers a purely reproducible method, independent of any prior assumptions as to current usages. His definition of the *sruti* is largely inspired by Abhinavagupta but the experiment is entirely *a priori*, for he defines the intervals through the *sruti* and relates the *sruti* to the completely fixed and enduring concept of the register (*sthayi*). He applies successive dimunition to each interval and points out that at the second dimunition *gandhara* and *nisada* merge

into *risabha* and *dhaivata;* at the fifth, *risabhasadja* and *dhaivata-pancama* pairs coincide while at the ninth, *sadja-nisada, pancama-madhyama* and *madhyama-gandhara* pairs in the two instruments coincide, so that each note in these pairs has two, three and four *srutis* respectively, thus totalling twentytwo. The crux of the method lies in the following: (1) defining the pitch range at which the results are reproducible; (2) defining *sadja, risabha, gandhara* etc. at the 4th, 7th, 9th etc. *srutis*. Thus, that pitch range of *mandratamadhavana* at which the various notes can be located at these prescribed positions and where twentytwo such positions are obtainable, is the appropriate pitch range and these interval are the *srutis*. (3) A third aspect of the method is the introduction of the principle of *rakti* to delimit the number ofintervallic dimunitions. (4) The expanse of this range of 22 *srutis* is *defined* as the *sthayi*. (5) Every stage of dimunition is retained for repeated comparison. The implications and analysis of these methods are beyond the scope of this short paper but are studied by me at length elsewhere.[37]

**Sruti: Attributes and Acoustical Basis**

The *sruti* concept in Indian music is multidimensional and projects into several fields. Therefore it would serve little purpose in attempting a brief, inclusive definition. The purpose of this paper, on the other hand, is to resolve the concept into its various attributes and roots so that its functions may be derived or explained. To study a the evolution of these attributes and roots in a historical perspective would be productive but limitations of this paper preclude such a treatment. The textual sources of such a study are collated—and collimated—by Matanga and Abhinavagupta and may be regarded as mutually inclusive rather than otherwise.[38] Therefore an eclectic study would suffice here.

Thus the *sruti* is a just differentiable interval in pitch — a *dhvanivai-laksanya:* प्राक्तनस्य ध्वनेर्वैलक्षण्यं यावता हीनेनाधिकेन या तीव्रमन्दात्मना रूपेण लक्ष्यते सा श्रुतितिरिति यावत् । यद्यपि परमाणुतोऽप्युत्कर्षापकर्षो वा भवेद् ध्वनोर्विशेषस्थापि नासौ गृहीतुं पार्यते । अत एव यत्रोत्कर्षापकर्षौ न (! कौ) चिद् ध्वनीनां ग्राह्येते तत्रैकाश्रुतिरिति, यदाह परमाचार्यः 'एकश्रुतिर्दूरात् सम्बुद्धौ'[39] Visvavasu describes the *sruti* similarly: श्रवणेन्द्रियग्राह्यत्वाद् ध्वनिरेव श्रुतिर्भवेत् ।[40]
So also Catura (? Tumburu?): उच्चैस्तरो ध्वनी रूक्षो विज्ञेयो वातजो बुधैः।[41] And Matanga: श्रुतीनां ध्वनिविशेषाणां ग्रानन्त्यं . . . . । [42] Sarngadeva has made this explicit by relating the *sruti* with contiguity (*dhvanyantarasruti*); and continuity (*nairantarya*) by interpreting *sravanendriya grahyata* and *uccaistara* as pitch discrimination. If this is read in conjunction with Kohala's definition of *svarā:* ध्वनी रक्तः स्वरः स्मृतः [44] an important inference becomes admissible *viz.*, that of all the *srutis* some acquire expressiveness as *svara* through *rakti* (mental coloration, appeal etc.) while others, in between two such *srutis* do not. This is the division of the *srutis* into *svaragata* and *antaragata* by Visvavasu.[40] It is very explicitly stated by Abhinavagupta again while commenting on Bharata's ordered relations of musical notes : जातिभिः श्रुतिभिश्चैव स्वरा ग्रामत्वमागताः[45]—that *dhvani* may or may not have *rakti*, that it is a pitch, a point or level of sound and that *sruti* is the interval between two such pitches: रक्तोऽरक्तो वा ध्वनिः, ध्वनिः स्थानं, तदन्तरालं च श्रुतिः, कर्मधिकरणव्युत्पत्त्याश्रयात् । [46] He again clearly states that there is the absence

(or distortion) of *svaratva* in such intermediate or *antaragata sruti*: वैस्वर्यं स्वरत्वेन विहितेषु अन्तरालश्रुतिविशेषेषु ध्वनि (वि) संवादनाद् भवतीति सर्वत्राभ्यूह्यम् । [47]

The attributes of continuity and contiguity are clearly logical necessities, for it is universally recognized that the tonal phenomenon is a space-time continuum. Aristoxenus was perhaps the first occidental musicologist to assume a linear continuity of tone. In India, it is time and again acknowledged that musical sound is continuous. Matanga asserts that despite the two fold division into *antaragata* and *svaragata, sruti* is indeed only one: सा चैकापि द्विधा ज्ञेया स्वरान्तरविभागत:[48] Matanga uses a *purna-upamana* with *sruti* and *Sruti* with vedantic overtones which inspired Sarangadeva to worship *nada* as Brahman because both are continuous, infinite, latent or potential and yet can appear as discontinuous finite and manifest. Abhinavagupta also endorses this view because he cites Matrgupta as saying: पुनर्नाद एक एवाद्य रञ्जित: [49]

Now, *rakti* is an attribute which manifests through *anuranana* — co-vibration or resonance. This is clear enough from the acouscal observation that a monotonic frequency becomes a musical note when it is enriched by other vibrations forming an overtone pattern and the degree of *rakti* is directly proportional to the number and favourable distribution of these overtones. Thus the *svaragata sruti* obtains expression through *anuranana* while the *antaragata sruti* has little or none of this attribute. However, *anuranana* is also sometimes interpreted in terms of a temporal sequence: that the initial, pure monotonic vibration of the body existing in a minute but finite life (*ranana*) is followed by sympathetic vibration, *anuranana*.[50]

This leads to the temporal atributes of the *sruti*: Abhinavagupta unequivocally admits the attributes of *kaala, kala*, breadth, duration and pitch: प्रमाणेति वदन् न कालकला श्रुतिनापि नादांशो न चायुर्न स्थानं न करणमिति दर्शयति । [51] *Kaala* and *kala* here mean the time lag between production of a tone and its perception; duration (*ayuh*) is the minimum period of existence for it to be perceived, breadth (*nadamsa*) is the minimum frequency incerement required for its perception. *Pramana* means the interval of the *sruti Sthana* is pitch. Nanyadeva transmutes the concept of the five *srutijati*-s into a very productive and systematic theory of the *sruti* to explain scalic phenomena. This will be discussed in the next section. It suffices to mention here that he derives the 22 *srutis* out of these five through differentiation in terms of *kaala, kala* and *pramana*: पञ्चैता: कलाकालप्रमाणेन विभेदिता द्वाविंशतिरिति विख्याता: । [52]

It is extremely interesting to note that these attributes of the *sruti* have sound accoustical and psychological bases, for every one of these finds corroboration in the researches carried out in these fields. Thus psycho-accoustic and physiological correlates of the *sruti* as implied in its etymology श्रवणात् श्रुतिसंज्ञिता।: [53] श्रु श्रवणे चास्य धातो: क्तिन्प्रत्ययसमुद्भव: । श्रुतिशब्द: प्रसाध्योऽयं शब्दज्ञेर्भावसाधन: ।[54] श्रुति: श्रूयत इत्येवं ध्वनिरेषोऽभिधीयते । श्रृणोते: कर्मविहिते प्रत्यये क्तिनि जायते । [55] are corroborated in modern work in these areas [56]. Again, pitch discrimination as implied in *sravandri yagrahyata* may be resolved into intensity, time interval or lag, and breadth. These find realization in recent acoustical findings. Thus Culver concludes, on the basis of his own researches: 'However, in order to be audible, the sound must represent a certain minimum amount of power; that is the sound must have a certain intensity and this minimum depends on the frequency. The ear is most

sensitive in the region of 2,500 c.p.s.; for both lower and higher frequencies, the sensitivity falls off rapidly'.[57] On time interval and frequency interval, he says: 'Another aspect of pitch perception which is coming to have increased significance concerns the minimum time required for the ear to recognize a definite pitch .. it would appear that the pitch perception time is more or less independent of the frequency, being the order of 1/20 sec. Not only can the ear catalogue a note as to pitch in a remarkably short interval, but it can also recognize a sound as such when only two vibrations are made .. However, to recognize the characteristics of a note, anywhere from 2 to 20 oscillations are necessary.[58] The findings of Dashiell,[59] Woodworth,[60] Fletcher[61] and Seashore[62] are concordant on the generality of these attributes of the *sruti*. While agreeing with the above results on duration, Revesz adds that it depends also on the progress of the stimulus.[63] Glen Haydon further adds that "Duration is, thus one of the four intrinsic orders of tones; it is of particular significance in relation to the rhythmic structure of music."[64] This duration has been called *maana* by Kumbhakarna in the 15th century A.D.[65].

*Nairantarya* is an attribute of a tonal element which is yet to receive experimental interpretation, though it is generally conceded that the tonal phenomenon is a continuum. Thus, for example Seashore asserts" .. it (pitch) denotes highness or lowness in the tonal continuum along which we locate the musical scale."[66] However, since sound is a spatiotemporal event projecting into the physical, physiological and psychological dimensions, absolute continuity cannot be attributed on empirical, epistemological or psychological grounds because consciousness is itself generally regarded as a sequence of contiguous but discrete bursts. But the philosophy of Indian music considers sound and therefore the *sruti* as a continuous phenomenon. A pragmatic discreteness of tone perception has been systematically studied. It has been found that *dhvani vailāksanya* — to use Abhinavagupta's expression, — or pitch discrimination may be measured in terms of just noticeable differences in pitch. Such differential perception, expressed as the number of such differences is a function of the intensity, range, pitch level and complexity and is fairly independent of training, intelligence or age. The work of Culver,[67] Revesz,[68] Glen Haydon,[69] Seashore, Shower and Biddulph,[70] and Fletcher[71], may be mentioned in this connection. An important effect of extrapolating a pitch or interval to a distant range is the lack of exact congruence. This problem is familiar in every instance of tuning in homophonic or polyphonic music and manifests itself in the form of the schisma, diesis, commas of Pythagoras and Didymus etc. I have called this effect *vaditva bhagnata parinama* in relevance to melodic systems with restricted pitch range such as Indian music which employs a three register range. Our musical theory has recognized such discrepancies and makes adequate allowance. Thus Pundarika Vitthala states: न्यूनाधिकैकगतिका मन्द्रतारस्वरा यदि। न रागहानिका: सर्वे स्पष्टता मध्यसप्तके।[72] and Somanatha: पूर्ववदपराच्च रवात् पगपैस्तत्रोचितै: समात् क्रमत:। श्रुत्यैकयाधिकत्वं न्यूनत्वं वा न दोषाय।। [73]

Finally two other attributes of the *sruti* may be mentioned. These are essentially postulates; they are unique to Indian musical theory and are highly productive with far-reaching results. These are the concepts of *uradhva spara* (vertical recurrence; *lit.* upward touching) of a *samskara* (experiential residue). *Urdhvasparsa* stems directly from *nairantarya* (continuity). Thus the *srutis* are not regarded as discrete, self-contained and

independent entities but as the locus traced by the *sruti* moving vertically in a tonal continuum. The *svaras* are regarded as those regions of the continuum where there is manifestation, illumination or expression. Such vertical recurrence of a *sruti* may be considered as occurring at three levels: at every successive position, at the distance of 3, 2 or 4 *srutis*, at the 9th or 13th *sruti* and at 22 *srutis*. *Samskara* is a concept borrowed from the philosophical systems. It is the residuum of the quality or attributes of experence of a prior existence progressively and cumulatively acquired, according to the *vedanta*. According to the *sautrantika* buddhist, *samskara* is the fifth *skandha*, i.e., a principle of pure-experience, nonmaterial and nonactivising. It is the subtlest state of experimental residue into which the material (or formal), conscious, affective and conceptual states progressively bequeath their essential attributes. The *nyayavaisesika* system postulates *samskara* as one of the 24 attributes (*guna*) residing in *dravya*. It is of three kinds; the *vega* resides in concrete objects, *sthitisthapakatva* (or elasticity) resides in *ksiti* while the *bhavana* resides in the individual soul being para-sensory and being responsible for recall and recognition. Familiar illustrations of *samskara* are the *pancikarana* of the primordial elements in which each transfers its essence to the next, thus progressively causing increasing gross manifestation, and the progressive *samskarapradana* of each syllable in a word into the next so that finally the meaning becomes manifest, and the extension of this residue donation to words to form sentence etc. These are classical examples and need not be elaborated. Their relevance here is the adaptation of this philosophic technique into a musicological instrument. Both the concepts are postulated by Abhinavagupta.

**The Sruti as a Scalic Foundation**

Since the *sruti* is the basis of the *svara* in our musical theory, it has to explain the empirical facts of the *svara* and therefore of the scale. This may be now briefly examined.

*Svara* is derived from *svri*, *svar*, *rajr* variously meaning sound, illumination, (hear-) warming etc. Various theories of the origin of *svara* from *sruti* are discussed by Abhinavagupta.[74] His own view is that *sruti* is only of the nature of *ranana* and when this acquires resonance which confers continuity, smoothness and *rakti*, it becomes *svara*. He refers to the pitch-theory of *svara* that *sruti* itself becomes *svara* by *ucca-nica bhava* in sequence. Here he offers a very tenable reason as to why *svaras* caused by different *srutis* at different levels still possess the same effect of *anantarya, ruksata, snigdhata, anuranana* and *madhurya;* that *karanabheda* does not necessarily culminate in *karyabheda*. It is thus that ध्वनी रक्तः स्वरः स्मृतः[44] has to be interpreted; the theoretical provision for this is in the *svaragata* and *antaragata srutt*, only the former possessing the *raktidharma*.

The *antaragata sruti* confers depth or range on the *svara*: श्रूयमाणास्तु गृह्यन्ते गम्भीरा इव [75] Sarngadeva also refers to this when he asserts that the first three *srutis* are also the causes of *sadja* etc.[76]. That is why Abhinavagupta points out that *risabha*, for example, is not at the third *sruti* but is *trisruti*.[77] That is why at the range of a definite number of *Srutis* ततः स्वरे तत्कृतश्च संख्यानियमः [77] *svara* acquires a qualitative and quantitative exactitude: *pramana*.

Next, the concept of *svasamvedyata* of the *svara* is unique to Indian music. This is the property by virtue of which an entity is understood only through itself, a philosophical concept usually associated with Brahman. Abhinavagupta endorses this view from a host of earlier theorists like Visakhila, Matrgupta and Bhatta Tauta who are all agreed that the *svara* is uniquely apprehended as itself at its final *sruti*.[77] The explanation of Matrgupta in this respect is very able and adequate हीयमाने स्वरे श्रोतुः स्वसंवेद्योऽणुशः क्रमः। श्रूयमाणः पुननंदि एक एवाद्य रंजितः ।। [78] This is accomplished by each *sruti* donating its *samvkara* progressively to the next. This *samskara* is compounded of *kaala, kala, pramana, ayuh, sthana, nadamsa* and the other attributes discussed above. As a consequence, any *sruti* possesses a character not only of itself but of all its predecessors also, just as a person possesses not only environmental and hereditary characteristics but also the *samskara* of previous births. So the quality and quantity of each *sruti* is different, though by a minute increment, from its predecessor. When the accumulated *samskara* is large enough to confer individuality it becomes a *svara*. This is a continuous process and occurs collectively in terms of *svaras* themselves so that not only a given *svara* in the scale but every *svara* in the tonal continuum becomes *svasamvedya*.[78] It is indeed remarkable that such a plausible theory was enunciated a thousand years ago to explain which modern psychoacoustic uses such ideas as the Two Component Theory of Revesz[79], tone colour, brightness, pitch level etc.

Such *samskarapradana* — क्रमिकश्रुतिजनितसंस्कारविशेष [77] — was accomplished by *urdhvasparsa* and *niskasa*. Thus *sadja* the first, full and standard interval of reference, may be regarded as achieving its *sadjatva* when its first *sruti* donates its attributive residue to the second, the second to the third and the third to the fourth, thus progressively spanning the interval (thus diminishing its extent) and progressively increasing the *samskara* content, till it acquires self-illumination,self-description aad self-expression at the 4th *sruti*. More precisely, a single *sruti* may be regarded as occupying each successive position, carrying with it the residue of attributes it acquired at each existence as a *result of the specificity* of its distance in the continuum from the origin. The nature of these positions is such by definition that when only two or three are occupied, *dvisruti* and *trisruti* intervals are not produced because enough *samskara* is not acquired for *svasamvedyata*. However, *sadja* obtains vertical recurrence exactly at its own interval by such continuous progression, now manifesting another important attribute. This is called *niskasa* or progressive elimination. By shedding its last *sruti* which is directly responsible for its *svasamvedyata*, it now acquires a new personality through vertical recurrence of *svasamvedyata* itself, at the 7th *sruti*. This is the *trisruti* interval of *risabha*. This recurrence — now of 3 *srutis* — is repeated again with the shedding of another *sruti*, giving a *dvisruti* interval at the 9th *sruti* when there is again a *urdhvasparsa* of *svasamvedyata*, giving the *gandhara*. By carrying out this one step farther, only one *sruti* remains. (Note that this progressive extension is the *karsana* principle). We cannot carry out this process below two *srutis* because *svaratva* is lost due to *sthanasankarya* and *svarasankarya*, nor beyond four *srutis* because it requires too much musical effort and results in a dischord (*dvaisvarya*) चतुःश्रुतेर्हि नोर्ध्वमस्ति, द्विश्रुतेर्नाधरमिति। [80] Thus the *svaras* are only three ultimately: तेन परमार्थतः त्रय एव स्वराः--सरिगाः पधनयः[80] This is the origin of the trichord, the universal basis of scale construction. This also explains the contention of Bharta and Vena that *srutis* are ultimately only of 9 kinds

(each is different because of *samskara pradana*) and is of fundamental significance because the scale is ultimately constructed by the vertical recurrence of these very 9 *srutis* at the distance of a fifth through the disjunctive. The above recurrence may be designated *savisesa urdhvasparsa* because of its differentiating character. However, when this is carried out even beyond *gandhara* to its limit of one *sruti, svaratva* is no longer possible and therefore this is also eliminated. Now the *catuhsruti sruti* interval starts all over again, but from the 9th *sruti* and recurrs completely again in all its original character. This is the *madhyama* which, because of congruent recurrence bears the greatest resemblance with *sadja* but differs from it, only because of its recurrence at a different level. This is the disjunctive, the instrument of scalic extension. Now the interval is bound on either side with an identical interval with the greatest congruence and is a selfsufficient, selfcontained, miniature scale. This is the tetrachord, possessing a total of 13 *srutis*, 9 of which are the result of *savisesa urdhvasparsa* while the last 4 are due to *nirvisesa urdhvasparsa.*

These two intervals of 9 and 13 *srutis* are of basic importance because *urdhvasparsa* is repeated again at these two intervals. When this occurs at the distance of the entire tetrachord, i.e., at a fifth, for each note another exactly similar tetrachord is obtained with identical, exact and complete symmetry. When the disjunctive, i.e., the *madhyama*, very appropriately named for this reason, recurs at a fifth, only *sadja* is now obtained and the octave is completed. Thus the trichord, tetrachord and octave may be directly derived from this theory of *samskara urdhvasparsa* and *niskasa.* Now, the octave may be regarded as composed of a trichord and a tetrachord or of two trichords separated by a disjunctive. Recurrence may therefore occur at the distance of a trichord or a tetrachord. Such *urdhvasparsa* is called *samvaditva* in Indian music. Thus we may have pairs of notes at the end of a trichord or of a tetrachord i.e., at the 9th or the 13th *sruti* from the first. Each of these pairs would have great mutual similarity and slight difference for the reasons mentioned above and because of *samasruikatva* and would possess *conjugability* (through rotability of the interval) which, besides the above interval, complete the three criteria of consonance in Indian musical theory. However, it is more precise to regard the *samvadi* as a single note obtained by the above attributes than as a pair. We have the sanction of Abhinavagupta and his teacher for this उपाध्यायास्त्वाहुः– श्रन्तरमिति-स्वरूपं नान्तराल, तेन नवश्रुतिकं यस्य स्वरूपं स्वऽस्य, यस्य च त्रयोदशश्रुतिकत्वं स्वरूपं,तौ स्वरौ परस्परसंवादिनौ[82] The *madhyama bhava* is different from the *pancama bhava* because in the former only *savisesa urhvasparsa* is involved while in the latter *nirvissa urdhvasparsa* is also present It may also be noted that the completion of the scale has resulted in 9+13=9+4+9=22 *srutis*, which is the span of the scale. It may also be recalled here that the 22 *srutis* were experimentally demonstrated in a perfectly logical manner: while the *srutis* are developed and realized by the synthetic principle of progressive extension, they are demonstrated by the opposite, analytical principle of progressive dimunition.

Thus adjacent notes are obtained by adjacent recurrence through *savisesa urdhvasparsa.* If the recurrence is the most proximate, *vivaditva* or dissonance results; if at the interval of 3 or 4 *srutis*, or their total, *anuvaditva* is obtained; if at the interval of all these, i.e., a trichord, *madhyama samvaditva* results; if *nirvisesa urdhvasparsa* also joins in, recurrence at a tetrachord results in *pancama samvaditva.* Now, finally, if the *sruti* causing

*svasamvedyata* recurs at the total of these, i.e., at 22 *srutis*, only self-reproduction is possible because every other tonal possibility is now exhausted in the scale. Thus the note recurrs by partaking of itself. This is called the *vadi* which is therefore defined as यो यस्य यदांशं स्पृशति स तदा तस्य वादी ।[82] in a text ascribed to his rival theorists by Abhinavagupta अपरे तत्सिद्धये "यो यदांशं सृपृशती" ति पठन्ति।[81] *Apare* here stands for Sankuka and Kirtidhara for, the recension which offers this text is ascribed to them by Ramakrishna Kavi[83] The significance of the words *amsam* and *sprati* may be noted. It is clear that the *sthayis* or different registers may be derived by such successive vertical recurrence at 22 *srutis*.

The unique position of the *madhyama* in the scale is thus derived from the *nivisesa urdhvasparsa* of *sadia* which is nowhere else duplicated in the scale. This special character and disjunctiveness makes it as important as the tonic itself. This theoretical importance was honoured in practice also because it was the backbone of the scale. Hence the theoretical prescription in ancient India that it was *avinasi*.

The role of the *sruti vikrti* may now be briefly studied. This concept is again unique to Indian music. Perhaps ours is the only system in which the *suddha svaras* are defined as the lowest of all possible denominations of that *svara* and as a standard or origin so that variation is possible only by upward displacement. The *suddha svaras* of the ancient Indian musical scale are fixed by definition by the well-known allocation of 4, 3, 2, 4, 4, 3 and 2 *srutis* to *sadja, risabha* etc. respectively. This must be recognized as a *theoretical*, not pedagogical or empirical standard. Failure to do so has caused much confusion and misunderstanding. Theoretically, this is the most logical standard, irrespective of geography or history in India, because it can perform all the functions required of a theoretical standard such as the organisation of tonal materials in practice from acoustical, aesthetic and physiological points of view, comparison, derivation or prediction of modal material etc. *Svaravikrti* was and is regarded as the upward displacement, of a *svara* from its theoretical *suddha* position by one or two *srutis*. *Sadja madhyama* and *pancama* were, however, allowed a *downward* displacement of one *sruti* each in *sadjasadharana, madhyamasadharana* and in *madhyamagrama* respectively. This *svarasadharana* admitted of such downward displacement largely to avoid two continuous *trisruti* intervals in the scale, probably — and justly— because they were considered to be weak and their adjacence would tend to weaken the character of the scale. This is also probably why the *gandharagrama* was discarded.

It may be noted *en passant* that the 17th *sruti* distinguished the two *gramas* which served to provide the important and indispensable tritone and to theoretically derive the *suddha* and *vikrta* notes of practice through cyclic rotation of tonic (*murchana*). The *murchana* is the derivation of new keys by shifting the origin from the tonic to the appropriate *svara* such that the mutual *sruti* intervals are maintained unchanged. *Tanas* or gapped scales may be regarded as *murchanas* in which one or two (or more) *svaras* are eliminated because the *sruti* responsible for the *svasamvedyata* of the appropriate *svara* is not employed. Using the *sruti* concept, both kinds of *vikrti* could be derived, *viz.*, in relation to the just precedent note or in relation to the tonic. The tonic *sadja* and its *nirvisesa urdhvasparsa, madhyama* were clearly recognized to be of fundamental importance as the two *gramas* were named after them. The disappearance of the *grama* system from

practice has necessitated minor changes in *svara vikrti*. The *sadharana* technique is no longer needed. The use of 4 *sruti* and 6 *sruti* intervals is now established in Karnataka music. However these may still be regarded as dichords 2+3, 3+3 or 4+2 *sruti* intervals and the *ati-prayatna* forbidden in early theory is now an accomplished fact in theory and practice. The downward displacement of sa, ma, and pa is now replaced by a scheme of invariant location of sa and pa while ma can be *vikrta* by upward displacement. But now the limit of such upward displacement for ri and dha (which in the *gramas* could not be displaced at all) hi has been raised to 3 *srutis*. However, these are only secondary theoretical principles which do not affect the substance of the above theory. Finally it also explains why these two intervals are mutually equivalent but not the *pancama*.

Thus all the important scalic phenomena and facts may be derived or explained in terms of the simple theory of *samskara, urdhvasparsa* and *niskasa*. For a more detailed and systematic treatment, attention may be invited to my work elsewhere. I believe that the need or importance of such a synoptic theory to explain the foundations of our musical system can hardly be exaggerated. The essentials of such a theory were formulated by our ancient musicologists. This paper aims at reconstructing such a theory on the basis of the fragmentary textual evidence available. Only the evidence from Abhinavagupta, the foremost leader of such theory, will be cited here for want of space and time.

तत्र प्रयत्नवशात् कस्मिंश्चिदमिहते स्थाने जातेऽभिघातजात् शब्दात् शब्दान्तरेऽनुस्वानात्मनि स्वरे तदध्यवहितस्थानाभिघातो यदि स्यात् संकीर्येताम् । पूर्वापरेस्वरे स्थानगतो यथा तत्र संकीर्णभावस्तथा स्वरगतोऽपि तद्विभागलाभार्थं मध्ये वर्जनीयस्थानभागोऽन्यत्र स्वर इति द्विश्रुतिकस्य संपत्तिः। स्थानद्वयेन व्यवधौ त्रिश्रुतिकस्य, त्रयेण चतुःश्रुतिकस्य, ततः परं चतुरादि व्यवधानेऽतिप्रयत्नवशाद् द्वैस्वर्यमिति पञ्चश्रुतिकादेरसंभवः । तत एव श्रुतिद्वयोत्कर्षो द्विश्रुतिकयोरेव गन्योक्तः । एकश्रुत्युत्कर्षस्तु नोक्तः स्थानसाङ्कर्येण स्वरसाङ्कर्यप्र संगादिति ह्युक्तम् । चतुःश्रुतिस्त्रिश्रुतिरिति क्रमेणान (? न्व) र्थश्रुतिरेव। ततोऽपि चतुःश्रुतिस्त्रिश्रुतिरिति षड्जप्रधानत्वात् षड्जग्रामः सरिगमपधनि, मपधन्यादि मध्यमग्रामः। चतुःश्रुतिस्त्रिद्विश्रुतिरिति। तथा हिएकस्मिन्नेवोरसि ऊर्ध्वाधरतया, सप्तस्वराः तथा हि चतुःश्रुतिकात् पूर्णादाद्यात्, तदगृतरूपादेकैकं निष्कासं प्रक्रमेण पुनश्च प्रकृतिभूतपूर्वरूपस्पर्शश्चत्वार : सरिगमा : । तथैवस्थाने ऊर्ध्वस्पर्शे पधनिसाः, केवलं षड्जेन द्वितीयं स्थानं स्पृश्यत एव। मन्द्रस्पर्शवतः (? ति) स्थानं स्वराणामृत् एवं कण्ठस्थाने शिरसि च । तेषु सर्वथा तादूप्यसंक्रमणाव त्वंशादिव्यपदेश ए संवादत्वं वक्ष्यते । तेन परमार्थतः त्रवएन स्वराः—सरि गाः पधनयः मध्यमस्तु ध्रुवकस्थानीयो मध्यमत्वादेव । [80]

An alternative, or perhaps a supplementary, theory was suggested by Nanyadeva and developed by Sarangadeva. The five *srutis dipta, ayata* etc., which were adapted from a vedic context were further expanded in scope with the attributes mentioned above and were regarded as giving rise to many other particular *srutis* so that these latter totalled 22. Thus the *srutis* are ultimately only five. The distribution of these over the *svaras* in the scale reveals a scheme which admits of several important inferences. These may be regarded as a scalic theory. The number, sequence extent and location of these *srutis* are the basic attributes which determine the interval, *svasamvedyata, samvaditva* etc. of the *asvara*. The *svara* construc-

tion from these *sruti jatis* may be analyzed down to the following principles; (1) the *samskara* of a single *sruti* is not enough for *svaratva;* (2) A single *sruti jati* cannot donate *samskara* more than once. The only exception to this is in the *karuna* at the 17th *sruti,* which serves to distinguish the two *gramas,* i.e., a *sruti jati* cannot occupy two adjacent positions; (3) no *svara* can contain all five *sruti jatis,* (4) all five *sruti jatis* occur in a regular sequence only at the beginning on the scale. From these premises and the above attributes, the *svara* and scale may be satisfactorily explained.[84]

**Sruti: Some Misconceptions**

Some misconceptions of the *sruti* prevailing in modern musicological studies may be briefly mentioned. Thus there is an overwhelming bias for expressing *sruti* values through mathematical techniques; among the more prominent of these may be mentioned the system of ascribed equations (2 *srutis*=16/15; 3 *srutis*=10/9; 4 *srutis*=9/8), Bosanquet's method of cyclic order and class, and of equal temperament. At the outset it must be pointed out that frequency ratios or string length ratios etc. are only empirical aids and do not contribute anything to theory. They also do not explain any of the *svara* or scalic facts or phenomena. The havoc wrought by this method is evident in that to about 250 frequency values already proposed for 22 *srutis* by different scholars more are being added. The system of ascribed equations is a failure because these ratios are not ascribed to intervals required by textual authority but to others which obviously do not have these *sruti* values. Even the ascribed values differ from calculated values. This method repudiates theory, practice and logic. Bosanquet's method is also unacceptable because it involves (a) methodological errors; (b) derivation by ascending cyclic fifths; (c) techniques and needs for remedying errors of equal temperament unknown in Indian music; (d) derivation of only the chromatic scale and not 22 *srutis*; (e) uses ascribed numerical equation; (f) the use of major third as an instrument of cyclic rotation. The system of equal temperament assumes a physical equality or equivalence of all the *srutis* which is nowhere implicitly or explicitly provided for in our musical theory at any time. Moreover, such equality may be repudiated unequivocally. Even if equivalence is a criterion, there are at least three other equivalences: psychic, aesthetic and musicological, which are more relevant and more important. The values obtained for different intervals here differ widely from their actual ones.

Two musicological theories of the *srutis* must be pointed out to be very untenable. One is that the 22 *srutis* can be derived by the quintan cycle. Firstly this requires a range of 13 registers which is beyond sensory perception. It also involves an intolerable amount of clash of intervals (*vaditvabhagnataparinama*). It gives only *svara* intervals and not *srutis.* The fundamental attributes of a *sruti* and a *svara* are completely ignored by this system. The extrapolation of intervals in the higher pitch ranges to the experimental octave necessitated in this method involves loss in tone quality and brightness; it is also unfounded in theory.

Another theory seeks to identify the *sruti* concept with shades of a *svara* employed in different melodic contexts. It tacitly assumes that the 22 *srutis* are actually 22 *svara sthanas,* that *sadja* is at the first *sruti* and that everyone of the *srutis* shall be found used in some *raga* or another; if not, it has no place in the scale. Such mistaken ascription clearly arises out of an equation of the tonal inflexion due to *gamaka* or contextual usage with

*sruti*. This theory cannot be supported because *gamaka* is applicable only to *svaras*; *gamakas* are of infinite subtle variation and this finds usage in *raga*, by no means in only 22 ways. A single note assumes slightly different and often intangible, indefinable shades due to *gamaka* in different contexts by different artists in different *ragas*. If these are to be called *srutis* each *svarasthana* will then have a large number of *srutis*, not a definite fixed one, which will be obsolete or will radically change with time and with aesthetic requirements or conventions. All these cannot be designated as *srutis*. Folk music employs several intervals never used in art music. Furthermore, these shades can find neither a fixed position, nor consonantal or other relations in the scale. Illusory notes, medial shades, augmented or diminished *svaras* — all these must be explained through the extensivity of *svara* and not through the *sruti* concept. The shades obtained by *gamaka* are by vibrato, accent, swing, oscillation, glissando, portamento etc, which is always relative to two tonal limits in a range and are never definable with respect to position or extent. Often certain shades are obtained through illusory notes, association, signification, implication etc. Many of these have no independent existence. It thus violates many fundamental requirements or rules of theory.

The discrepancy that arises between theory and the modern Indian key-board instruments by the assumption of mutual equivalence of *srutis* has been shown elsewhere.[85]

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43. Sarngadeva, *op. cit.* I, iii, 12.
44. Kohala, ?, *cit.* Matanga, *op. cit.* p. 12.
45. Bharata, *op. cit.* xvii, 5, p. 409.
46. Abhinavagupta, *op. ci;.* xvii, 129 pros , p. 398.
47. *Idem.* on Bharata, *op cit.* xvii, 129 prose, p. 398.
48. Matanga, *op. cit.* p. 4.
49. Matrgupta, ?, *extr.* Abhinavagupta, *op. cit.* vol. iv, p. 21.
50. *e.g.*, Abhinavagupta, *op. cit.* vol. iv, pp. 12—13; Kallinatha, *Sangita Kalanidhi, comm.* Saragadeva, *op. cit.* vol. i, p. 67.
51. Abhinavagupta, *op. cit.* p. 22.
52. Nanyadeva, *Bharatabhasya*, iii 92, p. 95.
53. Dattila, *Dattilam*, 1, p. 2.
54. Matanga, *op. cit.* 26, 27 prose, 4.
55. Nanyadeva, *op. cit.* III, v, 82.
56. *e.g.*, Lloyd, LL.S., *Acoustics* in *Groves Dictionary of Music and Musicians*, vol. i, p. 32; Troland, Leonard T., *J. Acoust. Soc., Amer.* (1930), I, 301, *extr.* Ilyod, *op. cit. loc. cit.;* Seashore, Carl E., *Psychology of Music*, pp. 53—54 etc.
57. Culver Charles A., *Musical Acoustics*, p. 33.
58. *Ibid.* pp. 47—48.
59. Dashiell, John F., *Fundamentals of General Psychology*, p. 45.
60. Woodworth, Robert S., *Experimental Psychology*, pp. 298—339.
61. Fletcher, Harvey S., *Speech and Hearing*, pp. 152ff.
62. Seashore, Carl E., *op. cit.* pp. 61-62.
63. Revesz, G., *op. cit.*, p. 7.
64. Glen Haydon, *op. cit.*, p. 40.
65. Kumbhakarpa, *Sangitaraja*, vol. i, *Srutiprakarana*, p. 358.
*cf.* also review of *Sangeeta Ratnakara* by B.C. Deva,in the. *Bull. Decc. Coll.* Poona. Vol. 14, particularly p. 312.
66. Seashore, Carl E., *op. cit.* p. 53.
67. Culver, Charles A., *op. cit.* pp. 32—33, 47—48.
68. Revesz, G., *op. cit.* pp. 32—33, 47—48.
69. Revesz G., *op. cit.* pp. 7, 9—10.
70. Shower, E. G. and Buddulpha, R., *Different Pitch Sensitivity of the Ear.* in the *J. Acoust. Soc. Amer* II, (1931). pp. 330—371.

71. Fletcher, Harvey S., *op .cit.* p. 178; *J. Acoust. Soc. Amer.* vol. 6 (1934), p. 59; vol. 13, (1941), pp. 84, 87.

72. Pundarika Vitthala, *Ragamala*, 17.

73. Somanatha, *Ragavibodha*, ii, 34, p. 68.

74. Abhinavagupta, *op. cit.* pp. 11—12.

75. Visakhila, *cit.* Abhinavagupta, *op. cit.*, p. 17.

76. Sarngadeva, *op. cit.* I, iii, 25—27.

77. Abhinavagupta, *op. cit.* p. 16—17.

78. For a detailed discussion and textual basis *vide* Sathyanarayana, R., *op. cit.* 220, 235, 261, 303—346, 378—394 etc.

79. Revesz, *op. cit.* pp. 59—76.

80. Abhinavagupta, *op. cit.* pp. 13—14.

81. *Ibid.* p. 16.

82. Bharata, *op. cit.* xxviii, 22 prose. Variant from the exemplar '*Ma*'. p. 15.

83. Ramakrishna Kavi, (ed. Bharata, *op. cit.* Vol. ii, Introduction p. ix.

84. For a more comprehensive study of the *sruti jati, vide* Sathyanarayana R., *op. cit.* pp. 372—402.

85. Sathayanarayana, R., *op. cit.* pp. 450—454.