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The Construction, Reconstruction, and Deconstruction of Shruti

SUVARNALATA RAO AND WIM VAN DER MEER

Intonation, and in particular the concept of shruti, has perhaps received more scholarly attention than any other topic in Indian art music. After the Nātyaśāstra, the first work to discuss shrutis extensively, virtually all treatises on music have elaborated, criticized or commented upon this issue. Shruti is intimately linked to the fundamental concept of svara. Whereas svara is a musical note or scale degree, shruti is a more subtle division of the octave. From early times, an octave was said to contain twenty-two shrutis, and as we shall see, the relation between shruti and svara has been a major source of confusion. It has not been uncommon to refer to shrutis as microtones or quarter tones, but with twenty-two shrutis to divide over seven svara in an octave, this clearly presents a mathematical problem.\(^1\)

Up to the time of Ahobala, the first scholar in India to deal with pitch in terms of string lengths (in the second half of the seventeenth century), most of the discussions about micro-intervals have been ambiguous, for want of exact pitch measurements.\(^2\) The well-known experiment with the two vinas, in which Bharata demonstrates the twenty-two shrutis, was carried out exclusively by ear. Even when an actual analysis was attempted, especially by some of the theoreticians of the nineteenth and twentieth centuries, it was usually aimed at supporting the theory of musical scales as propounded by the ancient Sanskrit authors. Although the awareness of a discrepancy between ancient theory and contemporary practice had been growing at least from Rāmāmāya’s time (1550), it was only in the second half of the twentieth century that theories of intonation based on empirical research emerged.\(^3\) Nonetheless, a comprehensive model of contemporary intonation practice has yet to be developed. Empirical research generally goes just far enough to ascertain that the old theories cannot be applied to present-day music, an allegation which still meets with much emotional resistance from both musicians and musicologists.

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\(^1\) In a paper by S.M. Tagore there is an extensive discussion about the propriety of using the term quarter tone. See Tagore 1965: 354-8.

\(^2\) Pandith 1984: 378. The author gives the precise measurements in a tabular form. It should also be noted that Śāṅgadeva (thirteenth century) had already described the position of the frets on the vina, thus enabling us to get some notion of the intervals used.

This chapter traces the historical development of the concept of shruti. A special attempt has been made to review developments during the last century, including an account of recent research based on the actual analysis of music.

THE CONSTRUCTION OF SHRUTI

ANCIENT PERIOD

The term shruti is derived from the Sanskrit root śru, to hear. Hence, shruti literally means that which is heard. In Sanskrit literature, this applies to all works which are considered to have been divinely revealed. It applies therefore to the Mantra and Brahmana portions of the Vedas and also to the Upanishads.4

In musicology shruti has a more specific meaning and the discussion of shruti is invariably associated with Bharata’s Nātyaśāstra, a work on theatre dating approximately from the second century AD. It is to be noted that in the Nātyaśāstra we do not find a clear definition of shruti. This may suggest that the term had already been established before Bharata’s time. In Nārada’s Nāradīyaśikṣā, parts of which are older than the Nātyaśāstra, five types of shrutis are enumerated, implying that shruti must originally have referred to variations of the Samavedic notes.5 There are grounds to assume that this variation had more to do with timbre or tonal quality than with pitch.6 In this work, an important observation is made about the vexing nature of shrutis: “As foot-marks of fish and birds do not remain in water and sky, similarly the shrutis are known by their timbre (dhvaniśeṣa) and not by their size”.7

Yet it is in the monumental treatise of Bharata that the theory of shruti is fully expanded. In chapter six he first mentions the seven musical notes—ṣadja, ṛṣabha, gāndhāra, madhyama, pañcama, dhaivata and niśāda (often referred to as Sa, Re, Ga, Ma, Pa, Dha, Ni respectively).8 In chapter twenty, the term shruti is mentioned in connection with musical scales (grāma).9 Significantly, Bharata discusses shruti in connection with instrumental music. He lists shruti as one of the capabilities of the vina while refraining from mentioning it in relation to the human voice.10

Bharata uses the unit of shruti to define the interrelation of two notes in terms of consonance and dissonance. He considers two notes to be samvādi (consonant) if there are nine or thirteen shrutis between them, intervals which have invariably been equated with the perfect fourth and fifth. If the interval is of two or twenty shrutis, on the other hand, the notes are considered vivādi or dissonant. Notes are termed as anuvādi or assonant (neither consonant nor dissonant) if they have any other interval sizes between them.11 After stating that there are twenty-two shrutis in each scale (grāma), Bharata gives the following arrangement for the ṣadja-grāma and madhyama-grāma:

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5Nārada 1983: 1, 7, 9-16.
7Ranade 2000: 37.
9Ibid., 20, 5.
10Ibid., 28, 13-15.
11Ibid., 28, 22-3.
sadja-grāma    Sa  3  Re  2  Ga  4  Ma  4  Pa  3  Dha  2  Ni  4  Sa
madhyama-grāma Sa  3  Re  2  Ga  4  Ma  3  Pa  4  Dha  2  Ni  4  Sa

Thus, a change of only one shruti is needed to make the two grāma identical. As observed
by S.A.K. Durga, Bharata seems to have followed the methodology of Sankhya philosophy in
his treatment of shrutis and svara. Without bringing in mathematical formulations, Bharata
validates his theory of twenty-two shrutis (within an octave), taking the ear as the sole judge for
his experiment.

Widdess, however, makes a very strong case for a much more fundamental difference
between the two grāma. He argues that in Bharata’s time the ma-grāma started from Ma and
therefore represented a fundamentally different scale type. He suggests that the distinction
between the two grāma became irrelevant with the introduction of mūrchhanā and jāti.

MEDIEVAL PERIOD

Following in Bharata’s footsteps, Mataṅga (c.800) and King Nānyadeva (r. 1097-1154) reiterated
the theory of twenty-two shrutis. However, it seems that by Mataṅga’s time confusion and
diverging views concerning shruti had already developed among scholars. Mataṅga sums up no
less than five interpretations of the relation between shruti and svara. It is highly significant
that he arrives at the conclusion that svara is manifested through the shrutis, and that svara are
separated from each other by bands of shrutis. As Rowell has pointed out, “this is in striking
contrast to early Western musical thought, in which pitches were traditionally conceived as
points”.

Most Western scholars who tried to unravel the question of the relation between the seven
svara and twenty-two shrutis have tried to look at shrutis as discrete tuning positions, thus
adding to the discrepancy between theory and practice. That this interpretation is rather one-
sided becomes clear from Abhinavagupta’s commentary on the Nātyaśāstra, where shruti
appears in the context of ornamentation, with the aim of heightening the emotional impact of a
song. In addition he indicates that shrutis have a time value, which would obviously be impossible
if it were only a tuning position. In fact, Bharata also explains that the three-shruti interval on
the flute should always be played with vibrato.

12Ibid., 28, 24.
13The Sankhya system, which is based on systematic reasoning, is one of the six philosophical schools of
India that flourished at the beginning of the Christian era. See Durga 1991: 30.
14The experiment involves two identical vinas. At first, both the vinas are tuned to the sadja-grāma scale.
Then, one is changed by lowering the Pa by one shruti. Once more, when it is lowered by one shruti, Ga and Ni
of this altered vina match the Re and Dha of the unaltered vina, thus demonstrating that Ga and Ni each consist
of two shrutis. After the third lowering, Re and Dha match with the original Sa and Pa, indicating that Re and
Dha each have three shrutis. The fourth lowering in a similar manner proves that Sa, Ma and Pa each have four
shrutis. Thus a total of twenty-two is reached for an octave.
16However, Nānyadeva was the first to refer to new intervals, viz., kaśiki-gāndhāra and kaśiki-niṣāda, later
mentioned by Śāṅgīrādeva in his Saṅgītaratnākara. See Ranade 2000: 83.
Śāṅgadeva, author of the thirteenth-century Saṅgītaratnākara, describes shruti as a just-recognizable difference in pitch. According to him, “śruti signifies a pitch value which contributes to the musicality of tone, and is yet by itself devoid of tonal colour”.20 The commentator Simhabhūpāla remarks that: “while establishing notes by appropriate positioning of frets on the vina, the vainika do not think of the number of shrutis, they rather play by ear”.21 Śāṅgadeva gives separate names to each of the twenty-two shrutis, classifying them in five groups. Based on the concept of shruti as the smallest recognizable difference in pitch, Śāṅgadeva introduces the idea of natural (śuddha) and modified (vikṛta) notes. He states that there are twelve vikṛta positions of the notes. While Śāṅgadeva discusses minute shifts of one or two shrutis in one section of his work, as noted by Jairazbhoy, he makes no further reference to them in his following discussion on ragas.22

Sometime during the fourteenth and fifteenth centuries, there was a new development relating to the tonal arrangement, which had a fundamental influence on music-making as well as theorizing. Possibly the most striking change was the fixing of the drone.23 There is a clear indication to this effect in Rasākaumudi of Śrīkanṭha: “ṣadja is the graha (initial note) of all ragas”.24 Once the position of ṣadja or sa, the first note, was established as the immovable take-off point, the existing mūrchhānā system of modulation was transformed into the immutable scale types of the ragas. Where in the old system it was possible to use each of the seven notes of the basic scale (grāma) as the tonic, now the tonic was fixed and all modulated scales were transposed to it.

The Ghunyat al-Munya (1374-75) provides information about the medieval notion of twenty-two shrutis and their division over twelve note positions. It is interesting to note that according to the author, twenty-one shrutis are seen on the frets of the vina and the note that is produced from an open string is recognized as the twenty-second shruti. He also observes that the intervals are mutasāwī, i.e. absolutely equal.25

POST-MEDIEVAL PERIOD

Rāmāmātya (1550) constructed a system of sixteen scale types (mela) and sixty-four ragas in his Svaramelakalānidiśi. While still maintaining the system of twenty-two shrutis, he opposed Śāṅgadeva’s idea of nineteen svara. Instead, he proposed a system of fourteen svara (seven natural and seven vikṛta arising from the natural ones through the change of shrutis).26 Such differences of opinion were bound to arise, since at no point in the history of shruti was it clarified by exact measurements.

In Somanātha’s Rāgasvibodha (c.1609) one finds some of the terms related to intonation, which are used even today in Hindustani music. For instance, tīvra, tīvratara and others are

21Desai 1979: 290.
22Jairazbhoy 1958: 57.
23We find no reference to this effect by Śāṅgadeva. However, his principal commentators, Simhabhūpāla and Kallinātha, discuss this aspect, though not without a certain ambiguity. See Desai 1979: 190, 298.
26Desai 1979: 311.
used to denote pitches with progressively higher shrutis, that is, raised by one shrutis. Although largely a follower of Śāṅgadeva, some of Somanātha’s statements indicate that this was yet another exercise of rearranging the svara positions within the unquestionable authority of the system of twenty-two shrutis.

In his Caturdaṇḍiprakāśā, Venkatamakhin (1620) developed a system of seventy-two mela, which would remain in use till the present day in Karnataka (Carnatic) music. He recognized shruti as a special inseparable attribute of sound. Further, like his predecessors, he too could not resist proposing yet another subjective system of twelve notes (seven natural and five chromatic) fixed on the twenty-two-shruti scale.

The considerable changes that took place in Indian music in the centuries after Śāṅgadeva are reflected in Ahobala’s Saṅgītapārījāta (c.1665). Ahobala still mentions the twenty-two shrutis as a theoretical construction which describes the laws of consonance within an octave, but he also suggests the existence of innumerable shrutis on account of minute pitch differences. Further, the author clarifies that only upon manifestation (in performance) do these shrutis qualify to be known as svara; until such time, they are recognized only as shrutis. It is emphasized that variance related to shrutis attaining the status of a svara has a definite aesthetic significance. As stated before, Ahobala is the first author to discuss the position of the svara in terms of string lengths, in which he basically establishes a system of twelve semitones. Although the explicit formulation of a system of twelve semitones is therefore apparently a late development (and often associated with Indo-Persian influence), Widdess has shown that the division of the octave into intervals of two, three, and four shrutis possibly became obsolete as early as the sixth century.

Contemporaries of Ahobala, notably Hṛdayanārāyaṇa and Śrīnivāsa, further elaborate on the idea of relating pitch to mathematical formulations of interval ratios, in terms of the division of a vibrating string. It is very clear from seventeenth-century treatises that theoreticians struggled hard to reconcile the revered theory of twenty-two shrutis with the twelve-semitone system actually in use at that time. While maintaining the importance of fourths and fifths as a fundament to construct scales, they attempt to show how shrutis were alterations of each of the

27Ibid., 327. In contemporary Hindustani terminology, chautal (higher) and utari (lower) refer to the use of especially augmented or diminished pitches of notes such as gāndhāra in raga Darbāri and raga Todi.
29Venkatamakhin 1934: 2, 2-5. In present-day Karnataka music, the term shruti when used in singular form refers to the drone of the tanpura.
30Ahobala 1879: 5. 40-1.
31Ahobala 1971: 5. 39.
32Ibid., 5. 50-9.
33As pointed out by Emmie te Nijenhuis 1974: 28, it is not certain whether Ahobala or Hṛdayanārāyaṇadeva invented the new temperament, and which of these two musicologists was the first to change the names of the notes. Nevertheless the new system is clearly described in Hṛdayanārāyaṇadeva’s Hṛdayaprakāśā as well as in Ahobala’s Saṅgītapārījāta. Both authors give accurate measurements for the division of the strings in order to determine the position of twelve notes in the octave, and thus enable us to calculate the exact frequency ratios of these notes.
34Widdess 1995: 222, 244.
35Bhatkhande recounts this procedure in detail. See Bhatkhande 1940: 22-35. For more on the tunings of Ahobala and Hṛdayanārāyaṇa, see Levy 1982: 19-20.
twelve semitones. The change from a modulation-based scale system to independent scale types with a fixed drone is reflected in the emergence of a system of eleven ṭhāṭ. First mentioned by Hrdayanārāyaṇa (c.1667) and later on used by Locana Kavi in his Rāgaiṣṭraṅgini (c.1675), this system was adopted by Bhatkhande in the early-twentieth century as a basis for classifying ragas.

Locana gives several terms still used in present-day Hindustani music. For example, when Re and Dha lose one shruti each, they are to be termed as komal, while Ga and Ni, when raised by one and two shrutis, are to be identified as ṭīvara and ṭīvratara respectively. Further, in proposing a system of eleven scale types (ṭhāṭ) for raga classification, Locana mentions the use of ṭīvara Ma, two shrutis higher than the normal Ma, for ṭhāṭ such as Yaman and Dhanashri. Similarly, his statement that the note Dha used in raga Kafi should be recognized as śuddha while the Dha of one shruti higher should be used in ragas like Puriya, indicates his efforts to distinguish ragas on the basis of shrutis and also throws some light on the performing practice of the time.

It is curious that these shruti positions do not seem to correspond in any way to the ragas as we know them today. This also largely holds true for the work Saṅ्गīt Sār, commissioned by Maharaja Pratap Singh of Jaipur (r. 1779-1803), in which a new terminology is used to denote alterations of scale degrees. In fact, even Captain N.A. Willard’s study on musical practice, written a few decades later (1834) contains issues which are difficult to interpret today. This suggests that Indian music has undergone considerable changes in a period of less than two centuries.

THE RECONSTRUCTION OF SHRUTI

In Sanskrit literature on music it is hard to make a distinction between theory and practice. We do not really know to what extent shruti was a purely theoretical concept, nor how and when theory and practice diverged. It is only during the past two centuries or so that such a distinction has actually been made in musicological literature. The battle between the shruti pundits probably reached its zenith in the early-twentieth century, when the discrepancies between theory and practice became most apparent.

LATE-EIGHTEENTH AND NINETEENTH CENTURIES

In his well-known paper “On the Musical Modes of the Hindus” (1792), William Jones was the first to draw the attention of European musicologists to the wealth of Sanskrit texts on the

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36Note that the fundamental scale of Ahobala and Locana Kavi had a minor third and seventh, much like the fundamental scale of Bharata. Also see Desai 1979: 371. Although the basic natural (śuddha) scale of Ahobala apparently resembles the present-day scale of Kafi (with Ga and Ni as flat notes), some of his dictates relating to svara positions seem to correspond to the present Hindustani system in which the śuddha notes form a diatonic major scale. For example, Sa and Pa are immovable, Ma cannot be lowered, Re, Ga, Dha, and Ni can be lowered.

37In the early-twentieth century V.D. Paluskar also maintained that the position of Dha in raga Puriya should be between the flat and natural Dha. See Paluskar 1914: 21.
theory of Indian music and the antiquity of the raga system. Although there was some discussion relating to Indo-Persian texts on music, the very title of the paper clearly reflects a Hindu bias, making obvious Jones’ veneration for India’s Hindu past.

Intonation, as discussed in the Sanskrit treatises, received a great deal of attention from Jones. In a letter to Charles Wilkins he writes:

a little tract called ‘the prosody of music’ enabled me yesterday to discover that the Hindu scale ‘saregamapadany’ consists of two tetrachords exactly equal, and differing only in the sixth and seventh notes from our major scale . . . I find, also, that the Indians have not only semitones but even an enharmonic kind of thirds and fourths of notes.

At the request of Jones, in 1786 an Indian and a British musician, Jiwan Shah and Francis Fowke, worked together in Benares to test the pitches of the bin against those of the harpsichord.

In the beginning of the nineteenth century, the elements of curiosity and dismay so far associated with Indian music made way for more serious and detailed studies. In one such study, J.D. Paterson proposed an interpretation of the twenty-two shruti system which was to have a lasting impact on the discussion of intonation in Indian music. He equated the catubśruti interval (four shrutis) with the major whole tone, the triśruti interval (three shrutis) with the minor whole tone and the dviśruti interval (two shrutis) with the major semitone. Since a diatonic just scale has three major whole tones, two minor whole tones and two major semitones, the total within an octave would be twenty-two shrutis.

Though this solution is elegant, it has the logical corollary that a single shruti can have many different values: 204/4 = 51 cents, 182/3 = 61 cents, 112/2 = 56 cents, 204 – 182 = 22 cents. Given the fact that Bharata’s experiment with the two vinas was done by ear, the difference between 61, 56 and 51 cents may not have been so relevant, while the shruti of 22 cents may well have been his standard pramāṇa shruti. Equating the shruti system with European just intonation led to an approach to the concept of shruti as a minute measurement of tuning distances, which would later prove to be incongruous with the musicians’ view of shruti. Another interesting problem to arise from this interpretation is that when the thirteen-shruti interval is equated with the perfect fifth it logically follows that the Pythagorean comma of twenty-four cents is equal to two shrutis (12 fifths = 13 shrutis × 12 = 156 shrutis, minus seven octaves, which is 7 × 22 shrutis = 154 shrutis).

In the quest for a new nationalism in the second half of the nineteenth century, music was singled out as one of the most Indian aspects of national life. The Indian music scholar Sourindro Mohun Tagore (1840-1914) played an important role in this quest. Tagore was also at the centre of a debate on the nature of shrutis and their representation in notation. Further

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38Bor 1988: 55; Jones 1792.
42Paterson 1965, passim. The idea that the twenty-two shruti system may have been used to discriminate between the major whole tone and the minor whole tone had been made even before by Ouseley, around 1800 (see Ouseley 1965: 169).
43Yet another interpretation of the shruti system takes this anomaly as its foundation: Abdul Karim Khan and Kapileshwari 1968: 96.
controversies raged on the subject fuelled by the differing opinions expressed by a compatriot, Krishnadhan Banerjee. This made it very clear that the issue of representation of music with all its microtonal subtleties was of great concern to musicologists, both Indian and Western.

The harmonium, introduced into Indian music around 1850, would provide new fuel for a heated debate on the nature of the shrutis. It was ironic that while the nationalists propagated a revival of pure “Hindu” music, an imported keyboard instrument with a tempered scale was welcomed with open arms by both professional and amateur singers as a suitable accompaniment to the voice.\(^4^4\) It should be pointed out that equal temperament had become widespread in European music precisely because of the industrial production of instruments like the harpsichord, pianoforte, accordion, and harmonium.\(^4^5\) Even in this period, a number of European musicians and musicologists were opposed to equal temperament, searching for the purity of harmonic intervals in “oriental” culture.

Amongst Western musicologists, the question of tuning systems was still very much debated. It should be remembered that Helmholtz’s authoritative work on acoustics was published only in 1863 and translated into English in 1875 by Alexander Ellis, and that equal temperament became the standard only in the course of the nineteenth century.\(^4^6\) Up to that time there was a minute difference in pitch between C sharp and D flat, and many musicologists felt that equal temperament was undesirable. For Indian scholars, shrutis provided evidence for the existence of complex mathematical acoustics in ancient India and a nearly superhuman pitch discrimination and control on the part of the performers, although there was no substantial evidence to support either of these claims.\(^4^7\) As a result, the subject of shruti continued to dominate the writings of the late-nineteenth- and early-twentieth centuries. The volume of literature produced on this subject is so full of contradictions and rhetoric that it has made the issue even more abstruse than before. Moreover, the literature continues to refer mainly to the music and musical treatises of the past, largely disregarding the practice of contemporary musicians, who in their turn, for a long time remained blissfully unaffected by the musings of the theorists.

Yet late-nineteenth-century writings on music do provide some interesting insights by musicians, music educators, and musicologists into the subject of intonation. For example, Krishnadhan Banerjee notes in his Gita Sutra Satri, “In Indian music no scientific rule has yet been framed as to how much raising or lowering will sharpen or flatten a tone. The ustads sing these vikrit-accidentals by raising or lowering the tones according to their own practice, taste and training”.\(^4^8\) In this work, the topic of intonation seems to have been complicated further with the usage of the term mürchhan. Instead of its original meaning (usually translated as mode), the term seems to have been used among musicians to convey a specific inflection or ornamentation associated with the articulation and intonation of a note.\(^4^9\) At the same time, the

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\(^4^4\)See the chapters by Bor and Miner, and Sorrell in this volume.
\(^4^5\)Goodall 2000: 143.
\(^4^6\)Ellis was one of the first musicologists who empirically studied differences between important musical systems worldwide; see Ellis 1885.
\(^4^7\)Powers 1980: 98.
\(^4^8\)Banerjee 1941: 9.
\(^4^9\)See Tagore 1875, Pingle 1962, and the Encyclopedia of Indian Music with Special Reference to Ragas, 1918. Roychadhuri 2000: 75 also refers to this meaning and spelling of mürccan, and indicates that at present the term is no longer used in this sense.
author of *Gītā Śūtra Sār* considers this a misuse of the term by some Indian and European scholars, insisting that only the traditional meaning is correct.

Two aspects of shruti were constantly in focus throughout the eighteenth and nineteenth centuries. The first one related to the concept, number and mathematical pitch value, and the second one was its visual representation through the medium of notation. Only occasionally was its relation to performance practice touched upon. Implicitly, however, musicologists seem to have realized that its significance in performance practice was a moot issue, as its representation in transcription and notation rapidly disappeared.

When *musicians* speak of shruti they usually refer to a highly specific way of rendering a note within a raga. Musicologists have generally taken this to mean that the note in question should be performed at a specific—non-standard—pitch. This confusion can easily be understood, as terms like *ati komal* (extra low) and *āvrat* (extra high) are often used in this context by musicians. However, musicologists went a step further and tried to relate the shrutis of the musicians to both the ancient Indian theories and the Western concept of just intonation. In the course of the twentieth century it became clear, mainly because of ever-improving methods for analysing pitch in actual performance, that such a relation could not be maintained. What further confused the issue was that musicologists managed to involve practising musicians in their theoretical approach. The musicians themselves were attracted by this endeavour as it not only extolled their fine sense of tuning, but moreover showed this tuning to be based on a millennia-old tradition.

**First Half of the Twentieth Century**

In the twentieth century, the debate on Bharata’s shruti theory centred on two contradictory viewpoints. One is represented by Bhattacharjea, Telang, Popely, Ranade, Bake, Ratanjankar, Kaufmann, and later Jairazbhoy, who all rejected the direct relevance of the Sanskrit treatises. The second is represented by Deval, Clements, Fox Strangways, Daniélou, Bose, Lobo, Omkarnath Thakur and later Arnold and Bel, who rigidly maintained an unbroken link between the musical theory of ancient India and contemporary musical practice.

The view that the Hindustani tonal system consisted of seven main notes (called *śuddha*, “pure”, corresponding to the Western major scale) and that five of these notes could be altered by a semitone, resulting in a twelve-semitone system, was already presented in Ahoala’s *Saṅgitapārijāta*. This view was strengthened by the fact that the tempered harmonium proved sufficient as an instrument of accompaniment. Certainly, not all the notes of the harmonium were considered correct, but the small differences did not stop the harmonium from becoming increasingly popular as an accompaniment to vocal music.

It was, however, V.N. Bhattacharjea, in his monumental contribution to Hindustani musicology, who explicitly stated that musical practice had broken centuries ago with the ancient tradition.

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51 Dilip Chandra Vedi (1901-92), a well-known vocalist and eminent harmonium player, witnessed most of the debate about the harmonium and remarked: “The Ga [major third] of a harmonium is clearly too high, but when we sing, we sing the Ga of the tanpura [i.e. the harmonic major third]. The higher Ga of the harmonium does not disturb us in singing, it is very soft”. Personal communication, 1974.
of twenty-two shrutis and now used a twelve-semitone system. His views provoked, and continue to provoke, highly emotional opposition from those who defend the theory of an unbroken heritage.

Although professional musicians at large ignored the intellectual dispute on theoretical issues, some musicians and scholars played a role in the debate. Celebrated vocalist Abdul Karim Khan (1872-1937), for example, collaborated with K.B. Deval and Ernest Clements in their research on intonation and musical scales. These scholars passionately believed in an unbroken continuity of the Indian tonal system since ancient times, a view later supported by Omkarnath Thakur and many others to this day. They were strongly opposed to Bhatkhande’s view that from the seventeenth century onward, the north Indian tonal system was essentially based on twelve semitones. Instead, they tried to reconcile the ancient scales of twenty-two shrutis with the modern scales, much in the same way Paterson had done before them.

On the basis of pitch measurements with a diachord, Deval came to the conclusion that a two-shruti interval equals a just semitone (112 cents), three shrutis a minor tone (182 cents) and four shrutis a major tone (204 cents). How he arrived at these equations is unclear, and nowhere does he provide information on what he actually measured and whether musicians referred to such intervals as two-, three- or four-shruti intervals. On the basis of his deductions he constructed a shruti harmonium. While insisting that the shrutis were not all of the same size, he claimed that the intervals of Sāṅgadeva were not mere theoretical formulations, but actually the ones practiced during his own (Deval’s) time.

Clements and Deval founded the Philharmonic Society of Western India in 1911. One of its primary objectives was to examine and formulate an opinion regarding the scales given by the ancient textbooks and those in use in their time. Deval, in his introductory speech, asserted that “the aim of the society has been throughout, to swerve not an inch from the old theory and at the same time to devise a method of teaching intonation which will be reasonably simple.” He tried to lend credibility to the work accomplished by the above society:

The theories expounded by these books (published by the society) have been put to searching tests by noted musicians such as Abdul Karim Khan, Barkatulla Khan, Murad Khan, Alladiya Khan, Wahid Khan, Balkrishnabuo Ickhalkaranjikar, G.B. Acharak and late Bhayya Joshi. Clements’ concern about the state of Indian music, especially the aspect of intonation, is apparent in his statement: “Theory is practically non-existent—Correct intonation is only to be found practiced by a few professionals and they cannot impart their secrets, except by example.” He upheld Deval’s conclusions as “beyond controversy” and even claimed to supplement the

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52For a survey of Bhatkhande’s work see Nayar 1989. Bhatkhande’s ideas about the study of Sanskrit treatises are summed up on page 107.
53Thakur 1961, passim.
54This view had been stated as early as 1807, by J.D. Paterson (see Paterson 1965).
55Inspired by the works of Western musicologists such as Helmholtz, Ellis and others relating to acoustic measurements of intervals, this special instrument was claimed to have been devised to suit the specifications of Indian music. It was manufactured by Moore and Moore Company of London.
57Ibid., 15.
58Clements 1927: 5.
pitch-related data of Deval. While maintaining that his own measurements concerning many north Indian ragas did match the corresponding intervals of Deval’s harmonium, he believed that there were more than twenty-two pitches to the octave used in Indian music, although the twenty-two shrutis of Deval’s harmonium were the most common. According to Clements, the hereditary vocalists “have the s’ruti-differences of the ragas fixed in their memories. We can only fix them by setting up a standard tuning for the harmonium. No other instrument will serve the purpose.”

Nonetheless, on the basis of demonstrations of the shruti harmonium at the first all-India music conference, it was concluded that the scales and intervals suggested by Clements for the ragas Kafi, Khamaj and Bilawal did not tally with those sung by the performing artists, including the celebrated dhrupad singer Zakiruddin Khan of Udaipur. Bīnḵār Musharraf Khan of Alwar remarked that for all practical purposes the usual method of describing ragas in terms of the commonly accepted twelve notes was quite adequate and proper.

Like Deval, Clements arrived at his interpretations mainly by inductive reasoning, taking as his point of departure that Indian music was essentially based on just intonation. He dismissed the idea of quarter tones in Indian music. For him the subtle difference of shrutis was comparable to the difference between the major and the minor whole tone. Interestingly, he admits that shruti was rarely used in scales, but rather as an element of ornamentation.

Clements insisted on interpreting many elements of the ancient theory in terms of just intonation and emphasized the importance of the harmonic series. He was convinced that the twentieth-century practitioners of music followed the shruti theory. Further, he claimed that in stringed instruments such as the sitar, although the fret placements may correspond to the twelve-semitone system, microtonal intonation was achieved by a sideways deflection of the string. He was of the opinion that Western musicians also employ such microtonal variations, although theoretically they subscribe to the twelve-semitone tempered scale. Through his lecture-demonstrations Clements attempted to prove that the difference in rasa or the emotional effect between the ragas was entirely due to shruti or quarter-tone differences between scales.

Following Deval and Clements, Fox Strangways also assumed Bharata’s four, three, and two shruti intervals to be the major whole tone, minor whole tone, and semitone, respectively, of the just scale. He strongly argued against the notion of the shruti system being evolved from a conscious division of the octave into twenty-two parts and put forth his own model based on the simple division of a vibrating string length, resulting in a just scale. Also inspired by Deval and Clements, G.B. Acharekar (1885-1939) constructed a harmonium which he called

60The shruti harmonium of Deval did not achieve any popularity in India.
63Clements 1927: 2.
64Encyclopedia of Indian Music with Special Reference to Ragas, 1986, part 3: 16. Here also terms such as quarter tone and microtone are loosely used to denote shruti. It is a curious detail that Clements extensively thanks V.N. Bhatkhande in his ‘Introduction’ for helping him in reading the Sanskrit treatises on shruti, when we realize that these two authors reflected diametrically opposed views, which would remain a bone of contention for almost a century.
65Fox Strangways 1965: 129.
svarasanvādī.\textsuperscript{66} The instrument supposedly had arrangements to play the Western tempered scale as well as the twenty-two-shruti Indian scale.\textsuperscript{67} There is practically no information about its construction. The system of allocating shrutis seems quite different from that proposed by Deval and Clements.\textsuperscript{68}

V.N. Bhatkhande, the most influential theorist of the early-twentieth century, observed that nearly all the more recent Sanskrit and vernacular works described ragas using only twelve tones, and did not mention more than twelve frets for the vina octave.\textsuperscript{69} According to him, these writers attempted to describe and distinguish ragas in terms of āroha, avara, vaḍi, samvādi, and so on, rather than by dwelling upon discussions involving shrutis. But Bhatkhande also made an attempt to reconcile the conflicts between ancient and modern systems, and proposed the following distribution of shrutis among the twelve semitones:\textsuperscript{70}

<table>
<thead>
<tr>
<th>Sa</th>
<th>flat Re</th>
<th>Re</th>
<th>flat Ga</th>
<th>Ga</th>
<th>Ma</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>sharp Ma</td>
<td>Pa</td>
<td>flat Dha</td>
<td>Dha</td>
<td>flat Ni</td>
<td>Ni</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
</tr>
</tbody>
</table>

Bhatkhande considered the present-day Hindustani natural (śuddha) scale, Bilaval ṭhāṭ, as a just major scale with a Pythagorean sixth degree.\textsuperscript{71} Notice, however, that he suggests that the interval from Ni to Sa’ would be a just semitone, which is not the case in actual practice.\textsuperscript{72} A staunch proponent of flexible intonation, he recognized a correlation of pitch with melodic context. While suggesting that terms such as ati komal and ṭīvratā are superfluous in describing features of present-day ragas, he also made broad and non-specific statements such as, “certain notes are said to vary slightly in pitch from one raga to the next”. He cites an example of komal Dha in the raga Asavari, which is supposed to be lower than the same note in raga Bhairavi.\textsuperscript{73}

In an extraordinary and voluminous work on shrutis, Abraham Pandither, a proponent of equal temperament, joined forces with V.N. Bhatkhande and opposed the findings of the Philharmonic Society. Tracing his views to millennia-old Tamil sources, he divided the octave into twenty-four equal parts and designed a vina accordingly. During the Baroda conference he arranged a demonstration intended to show that the scales of Indian ragas could be reproduced exactly on the tempered harmonium. He had taught his daughters to sing in accordance with this instrument. The outcome of the demonstration “was equally accepted by amateurs and

\textsuperscript{66}Acharekar 1974: 117-18.
\textsuperscript{67}It was claimed that the instrument had the possibility of playing embellishments such as mind, a feature missing on the normal harmonium.
\textsuperscript{68}Acharekar 1974: 292, chart 36.
\textsuperscript{69}Bhatkhande 1934: 38.
\textsuperscript{70}Bhatkhande 1952, vol. 2: 9.
\textsuperscript{71}Bhatkhande 1934: 34.
\textsuperscript{72}Meer 2000.
\textsuperscript{73}Quoted in Jairazbhoy 1971: 66. Some of these observations need to be verified experimentally in order to put an end to such speculations.
professionals alike”. The work of Pandith is on the one hand a very meticulous and thorough examination of the theories on shruts that were known to him, giving many detailed tables comparing the different views, while on the other hand, like so many writings on shruti, it is a monumental construction of deductions. This, combined with the biting sarcasm with which he dismisses all other theories, makes his work the prototype of shruti scholarship gone wild. In his particular case the shruti is instrumental in showing that Tamil culture is at the root of all forms of highly developed art music—not only of the Indian subcontinent—but also of ancient Greece, Mesopotamia, and Egypt!

Going even further, Firoze Framjee defined the notes of a hundred and seventy ragas in terms of shruti intervals and vibrations, and then classified them according to the traditional mūrčhana system. Emulating the approach adopted by post-medieval scholars as well as by his own father, B.G. Acharikey attempted to discuss intonation in present-day music on the basis of the tuning of sitar strings and fret positions. Following the principle of perfect fourths and fifths to be maintained between the vādi and saṃvādi notes, he defined notes in various ragas in terms of vibrations per second. This was yet another hapless attempt at validating the twenty-two-shruti dictum of Bharata in terms of modern scientific concepts.

G.H. Ranade supported the view that theoretically there are twenty-two equal shrutis in an octave. However, he maintained that in practice these ratios get modified for aesthetic reasons. He defended flexibility of intonation by stressing that the positions of shrutis may vary considerably in accordance with their melodic context even within a given raga. He also observed a definite influence of factors such as amplitude, timbre and overtone structure on pitch perception. Whilst he seems to have been convinced about the significant role played by the drone harmonics in intonation, Ranade made no attempt to explain the details of this phenomenon. He observed that in certain ragas there is no agreement among the artists about the degree of flatness or sharpness of a note. In such cases, he advocated the significance of tetrachordal symmetry as a guiding factor for intonation.

The Dutchman Arnold Bake was one of the few scholars who argued that for Bharata shrutis were of equal measure. However, like Fox Strangways, he too was opposed to the theory of the conscious division of an octave into twenty-two parts. According to him, the number twenty-

74Encyclopedia of Indian Music with Special Reference to Ragas, 1986, part 3: 36-7. Based on this incident it should not be construed that Bhatkhanda was in favour of equal temperament because in a letter to Pandith he writes: “I never had a shruti theory of my own”.

75Pandith 1917.

76The author claims that “after years of intensive efforts and research [he] succeeded in solving the problem of the traditional shruti theory and proved by concrete facts and accurate mathematical figures in this treatise that the scale used by our modern musicians is the same as that expounded by Bharata in the early part of the sixth century”. See Framjee 1986: 9. Also see chart 12, indicating the pitch of different notes in terms of vibrations per second, as supposedly used in different ragas.


78The author even distinguishes between ragas like Bhupali and Deshkar on the basis of note-positions expressed in terms of cycles per second, viz., augmented Re for Bhupali and consequently, also the higher position for Pa.

79G.H. Ranade 1957: 37.

80Ibid., 33.

81G.H. Ranade 1951: 194.
two resulted merely because of the presence of three intervals of four shrutis each, two intervals of three shrutis each and two intervals of two shrutis each.\textsuperscript{82} He also stressed the importance of shrutis in ornamentation.\textsuperscript{83}

O. Goswami submitted the hypothesis that Bharata’s pramāṇa shruti had evolved from the differences between vocal and instrumental music.\textsuperscript{84} He believed that Bharata was greatly influenced by the ancient Greek tetrachord theory.\textsuperscript{85} Speaking of intonation in modern practice, he maintained that ragas can be distinguished on the basis of shruti alterations. Like later scholars, including Daniélou, he proposed a system of sixty-six shrutis and even believed in the supposed ability of the singers to reproduce them accurately in a performance.

Narendra Kumar Bose’s Melodic Types of Hindustan is second only to the monumental and confounding work of Abraham Panditíther mentioned earlier. The major portion of the work is devoted to a general theory of tuning and scales, using a system of fifty-three comma-shrutis. In his historical survey he observes that there is no continuity from ancient to modern times. He argues that the shrutis only have theoretical significance, and there is really no evidence indicating their practical utility in the ancient treatises.\textsuperscript{86} He concludes that the concept of shruti was merely meant to provide a convenient method for comparing different intervals with respect to their sizes.\textsuperscript{87} However, he contradicts his own viewpoint by providing a complex theoretical system concerning intonation based on microtones. Inspired by Western staff notation, he presents a system in which vowel change and diacritical marks are applied to the note-syllables for indicating microtonal alterations.\textsuperscript{88} Each of the seven svāra have seven possible positions. In the final chapter Bose rises to unusual heights when he inductively arrives at the position of the notes of a number of ragas in relation to his system of fifty-three shrutis, “correcting” the ragas in the process.\textsuperscript{89}

The French musicologist Alain Daniélou, a staunch supporter of the Hindu cause, counterbalanced the authors who had a more pragmatic view of the phenomenon of shruti. He insisted that north Indian music had remained substantially unchanged since ancient times, and hence, that modern performance practice corresponded closely to the ancient theoretical formulations concerning the shruti.\textsuperscript{90} Like Deval and Clements, Daniélou believed that the ancient twenty-two shrutis were not equal in size. Whilst arguing that they were merely the twenty-two most commonly used pitches chosen out of a much larger number of possible ones, he formulated his own elaborate system of sixty-six shrutis, out of which he finally arrived at fifty-three harmonically acceptable pitches.\textsuperscript{91} Like Clements, Daniélou also gave transcriptions

\textsuperscript{82}Bake 1957: 67.
\textsuperscript{83}Bake 1930: 6.
\textsuperscript{84}Goswami 1957: 30. Here, Goswami suggests that vocal music during Bharata’s time was in Pythagorean tuning and instrumental music was in just tuning based on simple divisions of a vibrating string.
\textsuperscript{85}Ibid., 39.
\textsuperscript{86}Bose 1960: 57.
\textsuperscript{87}Ibid., 198-9.
\textsuperscript{88}Ibid., 30-1.
\textsuperscript{89}Ibid., chapters 15-17.
\textsuperscript{90}Daniélou 1980: 5.
\textsuperscript{91}The criteria for acceptability were not clearly defined by the author. Daniélou’s model of sixty-six shrutis was admittedly based on the concept put forward by Kohala, whose work has not survived. However, Mataṅga often referred to Kohala’s contribution.
indicating the precise pitch position of the notes of various ragas. However, he provides no details of the methods by which he arrived at these conclusions.\textsuperscript{92} He indicates that current performance practice shows consistent usage of his fifty-three shrutis, but at the same time realizes that the specific and subtle emotional qualities of each interval are not confined to strict mathematical ratios. Probably because he himself used to play the \textit{bin}, he understood that there was an intimate interrelation of pitch and melodic context.

THE DECONSTRUCTION OF SHRUTI

Deep into the twentieth century, musicologists went on speculating about the shrutis with purely inductive methods, at best using a monochord for measuring intervals. Yet, as early as the 1930s there were attempts at a scientific, empirical approach to measuring shrutis. Notably, C. Subrahmanya Ayyar, a violinist from south India, went to London to make oscillograph recordings of his violin-playing at the National Physical Laboratory in Teddington.\textsuperscript{93} He arrived at the conclusion that many more shrutis (in the sense of pitch positions) were used in an octave than twenty-two. He has only made passing notes on Hindustani music, but the fact that accurate measurements were possible at the time is important enough to notice.

For Hindustani music, Nazir Ali Jairazbhoy was the first to conduct empirical research on intonation used in current performance practice. At the time the techniques for doing such work were limited and posed technical and methodological problems.\textsuperscript{94} But the outcome of his work, done together with Stone, was so remarkable that it should at least have inspired researchers to verify the results and work on better techniques. In order to ascertain whether there is a variation in the intervals used by the musicians in specific ragas, and whether the intervals are always the same throughout the performance, Jairazbhoy and Stone conducted experiments involving six recordings of a raga by six different artists.\textsuperscript{95} On the basis of this research, Jairazbhoy and Stone conclude that accuracy of pitch is relative and subjective rather than consistently precise. Moreover, they found that intonation in performance practice could not possibly be explained by any of the extant theories, least of all the theories that maintained that intonation of Hindustani music had an unbroken link with the millennia-old shruti models.

Of course, the time was ready for this kind of approach, for in the middle of the twentieth century most authors on shruti adopted the view that in contemporary music shrutis existed, but had little or nothing to do with Bharata’s shrutis. Popley (1921), Ranade (1957), Sanyal (1959), Ratanjankar (1961), and others advocated a humanistic model that has aesthetic considerations rather than mathematical formulations alone to address the question of shruti. For Ratanjankar, Bharata’s concept of shruti was a device to indicate relative interval size. Pointing to the fact that the definition of raga contains no reference at all to shrutis, like Bake, he maintains that these microtonal subtleties are confined to embellishments and have a specific aesthetic purpose.\textsuperscript{96}

\textsuperscript{92}Danilou 1968: 38.

\textsuperscript{93} Ayyar 1951: 138. We are indebted to Arvindh Krishnaswamy for indicating this to us.

\textsuperscript{94} Bel 1984.

\textsuperscript{95} Jairazbhoy and Stone 1963: 130–1. The raga selected was Yaman and the artists chosen performed on flute, sarangi, sitar and voice. The limitation of this work was that only three intervals, Sa-Re, Re-Ga and Sa-Ga were analysed. The steady part of the note was considered for determining its frequency. Jairazbhoy points to the difficulty involved in precisely defining the exact pitch of any particular note.

\textsuperscript{96} Ratanjankar 1961: 191.
According to Harold Powers, modern Indian music is largely based on just intonation.\footnote{Powers 1962: 225.} He criticizes the model adopted by Deval and Clements as a combination of hypothetical acoustics and ancient treatises cited without regard for time or place of origin. He notes that their results are simply too good to be true.\footnote{Powers 1965: 4-5.} Further, he suggests that these mathematical speculations should also take into consideration the actual views of the performers themselves regarding their own intonation.\footnote{Bel reports an incident which clearly indicates a need for such interaction with the performers. He concludes that “it is quite useless to analyze recordings without getting the musician, who himself made the recording, to tell where he/she felt that he/she had or hadn’t properly executed his/her intention”. See Bel and Arnold 1983: 43.} Walter Kaufmann, another proponent of flexible intonation, believed that north Indian performers were entirely uninfluenced by the shruti theory. Instead, he maintained that they were solely guided by the sentiment or mood of the raga, for achieving the required intonations.\footnote{Kaufmann 1968: 9.} Based on his analysis of raga Marva, Kaufmann predicted a gradual decline in the significance of microtonal alterations in modern Indian music. He lamented: “An examination of live and recorded performances of this raga shows a glimpse of the road along which future Indian music will travel—away from microtonal alterations”.\footnote{Ibid., 316.}

Assuming that all twenty-two shrus of Bharata were exactly equal in size, Modak emphasized a close approximation of the twenty-two equal shruti system to just intonation, with an error no greater than 1.4 per cent as compared to the maximum 3.4 per cent error of twelve tone equal temperament.\footnote{Modak 1967: 153. As pointed out by Levy, this figure applies only if the major third, perfect fourth, and perfect fifth are considered. The error seems to be greater if additional intervals are included. See Levy 1982: 61.} His experiments, involving measurements of string-tunings by two performers, suggested that intonation in a given raga varies from one performer to another.\footnote{Ibid., 79.} The limitation of his work, however, is that it was conducted in an artificial setting without consideration for actual performance context.

B.C. Deva believed that the essence of Indian music lay in the micro-distinctions between pitches of svara.\footnote{Deva 1973: 16.} On the one hand, citing the experimental work of Ellis, Deva upheld the “holy” figure of twenty-two; on the other hand, he argued against it on the basis of his own experimental work, in which he obtained nearly forty pitches between Sa and Ga alone! Further, recognizing the significance of the melodic context, he noted that it was practically impossible to measure all the pitch variations of shakes (gamak) and glides (m√ind).\footnote{Deva 1967: 109} He dismissed the numerous attempts made at reconciling the ancient theory and modern practice because of the lack of concrete evidence supported by accurate acoustical analysis.\footnote{Deva 1967: 59.}

In claiming that the intonation in certain ragas may have been influenced by the advent of the drone, Deva presents an interesting hypothesis which raises many more questions, related not
only to intonation but also to the origin, history, and significance of the drone. While earlier musicologists occasionally hinted at the fact that for musicians shrutis form part of specific ornamentations, Deva made an explicit case for this approach. As performing musicians have already known and practised all along, he included the shrutis as a pitch area rather than an exact pinpoint, in his model.

A.D. Ranade elaborated this concept further by suggesting that a svara has both a tonal centre and a periphery. Thus the tonal range of any given svara is defined when both are put together. Further, he specified that the tonal range was related to the melodic context. Based on this model, he attempted to define finer levels of intonation such as kansūr (marginally out of tune) and besūr (clearly out of tune).

In a later article on the origins of the shruti theory, Jairazbhoy suggests that all shrutis were considered equal by Bharata, although they may not have been mathematically equal in practice. In an attempt to explain the origin of the twenty-two shrutis proposed by Bharata, Jairazbhoy analyzed the Tamil way of reciting the Rgveda and the Yajurveda. On the basis of this work he proposed that Bharata’s shruti formulation was originally used to determine the interval sizes of Vedic chant which were then applied to the theory of secular music. According to Jairazbhoy: a single shruti appears to have been conceived as the highest common factor of the existing intervals, and not as a musical tone in its own right. . . . The total number of shrutis in the octave, i.e. 22, is only incidental, being determined by the size of the unit of measure. It did not imply that there were 22 tones in the octave. . . .

Continuing the trend set by Clements, Deval and Acharakar, Brahampati constructed a special string instrument, śruti-darpā, to explain Bharata’s twenty-two shrutis. On the basis of this research, he proposed that the shrutis are of unequal measures. According to him, it was not without purpose that Bharata chose to expound the shruti system only after having dealt with aspects such as svara and grāma. Further, Brahampati made an attempt to discuss the notes of the ten thāt of north Indian music in terms of tonal structure (based on shrutis) supposedly defined by Bharata. As with his predecessors, his theoretical work remains speculative.

**RECENT RESEARCH**

It is truly amazing that the empirical work done by Nazir Jairazbhoy did not prevent a number of authors from reinventing the “shruti-wheel”. In fact, to this day there are many musicians and musicologists who maintain that Bharata’s theory of shrutis is a theory of just intonation and that Indian musicians continue to perform those shrutis. Around 1980, Mark Levy, a student of Jairazbhoy, carried out extensive research on intonation in a single performance, in multiple performances by the same musician, and in multiple performances of the same raga by

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107 Modern scholars like Deva claim that it was not until the seventeenth century that the drone was included as a definite component of a musical performance. See Deva 1967: 71, 56.
108 Deva 1965: 64.
110 Jairazbhoy 1975: 54.
different musicians.\textsuperscript{112} In addition, relationships between pitch variations and melodic contour were examined. Through his experimental findings, Levy noted a strong influence from the melodic context. He concluded that intonation in north Indian music appears to be based on a flexible system of twelve semitones, and that no consistent correlation can be observed between the measured pitches and any single theoretical system.\textsuperscript{113}

As usual, any attempt to contradict the classical shruti theory was countered by a group of scholars trying to prove the opposite. Bel constructed another shruti harmonium which could be digitally programmed with an accuracy of about one cent.\textsuperscript{114} However attempts made at determining “ideal” shruti positions for different ragas did not yield consistent results.\textsuperscript{115} The failure of this shruti harmonium in directly establishing the tones led to the construction of the Melodic Movement Analyzer (MMA). Bel claimed that:

since no single existing machine available for acoustic analysis can be perfectly adapted to meet the demands of analysing monodic music like Indian music, MMA is specially designed. . . . With a measurement accuracy better than one cent, MMA surpasses the performance of a melograph.\textsuperscript{116}

Bel made a point of criticizing Levy’s methods and especially his techniques as Levy had worked with the strob-tuner technique introduced by Jairazbhoy.\textsuperscript{117}

The enormous amount of data processed by the MMA showed that intonation was certainly not a pinpoint phenomenon. To this extent, the results supported the views of Jairazbhoy, Stone, Levy, and Deva that pitch in performance occurred in tonal ranges rather than exact points.\textsuperscript{118} However, they strongly disagree with the extent of the tonal range given by Levy’s findings. Using the MMA, Bel and others showed how the performances of reputable musicians reveal that they do try to place the notes in a much more accurate way than “tempered ± 30 cents”. The authors also found that musicians achieve meaningful differences in intonation in different ragas, and argued that these differences could be connected to the ancient shruti theory. One of the members of Bel’s team had earlier written articles which were based on the Deval-Clements model of shrutis, and if anything, the goal of the team’s work was to validate the old model.\textsuperscript{119}

However, Meer later realized that the actual measurements did not tally with any interpretation of the ancient shruti model, as had been concluded earlier by Jairazbhoy and Levy.\textsuperscript{120} Moreover, although the MMA was a major technological advancement, it did not take into consideration

\textsuperscript{112}Levy 1982: 8.
\textsuperscript{113}Ibid., 142. Experimental findings of Bel and Arnold (1983) suggest that Levy’s formulations are rather oversimplified.
\textsuperscript{114}Bel and Arnold 1983: 42.
\textsuperscript{115}This was probably because of the sensitivity of musicians’ ears and the disposition to search for a pitch with extreme care. Also, there was a technical disadvantage of having to programme the note-positions rather than simply having to tune them. See Bel and Arnold 1983: 42.
\textsuperscript{116}Ibid., 46. For the technical details of this machine, see ibid., 45-8.
\textsuperscript{117}Levy’s study drew inspiration from the work of Jairazbhoy and Stone who proposed that “any intonation within certain limits (perhaps 25 to 30 cents on either side of the tempered intonation) can be acceptable”. See Jairazbhoy and Stone 1963: 130-1.
\textsuperscript{118}Deva 1965: 23; Arnold et al. 1984-5: 47.
\textsuperscript{119}Arnold 1974.
\textsuperscript{120}Meer 2000.
the modern developments in the field of pitch perception. Meer had earlier suggested that the
term shruti should be understood as a tonal configuration rather than a deviation from a
predetermined ratio, along the lines earlier expressed by G.H. Ranade.121 Comparing the varying
positions of komal Ga in ragas Sindhura, Bahar, Malhar, Suha Kanada, and Barva, he suggested
that the totality of the sound of a note in a raga is defined by its scale, melodic pattern, and its
specific melodic treatment.122 Rao’s analysis (1990) using the MMA provided further support
for the view that pitch values for different notes are neither rigidly fixed nor randomly varying.
In fact, the musicians do seem to conform to a particular range of pitch values for a given raga.
Further, the same performances, examined using another independent system (LVS) based on
contemporary pitch-perception theory validated the results concerning pitch positions.123 Thus
the viewpoint expressed by Bhatkhande, Ratanjankar, Daniéou, Deva, Meer, and others, that
pitch is related to melodic context, has been verified empirically.124

CONCLUSION

Contemporary musicians use the word shruti in conjunction with highly specific ornamentations
of particular notes in particular ragas. Thus, they speak of the shruti of komal Ga in the raga
Darbari, the shruti of komal Ni in the raga Bhimpalasi or the shruti of komal Re in raga Bhairav.
Many musicologists have tried to link contemporary practice with ancient musicological theory,
sometimes going to the extent of suggesting a “correction” of contemporary practice on the
basis of highly speculative theories. Apparently, the ancient and contemporary meanings of
shruti are fundamentally different. Most scholars have related the ancient concept of shruti to
pitch positions or tuning schemes, whereas the current meaning of shruti seems more related to
ornamentation, or to put it in the words of Nicholas Cook, “music between the notes”.125 Yet
there are grounds to assume that even in ancient times shruti could denote an inflection of a
note.

For nearly two millennia, Bharata’s Natyaśāstra has been a dogmatic starting point for
discussions of shruti. Sanskrit treatises and interpretations in modern languages, including
English, have taken Bharata’s system of twenty-two shrutis divided in specific ways over seven
svara as an axiom. How this division could be related to string lengths or frequencies became a
subject of much speculation from the time of Ahobala (c.1665) onward. It was in this period
that musicologists became aware of an increasing gap between theory and practice. On the one
hand they continued to delve into the ancient system of twenty-two shrutis, but at the same time they conveniently adopted the twelve semitone model for describing contemporary performance practice based on a fixed position of the drone (Sa), resulting in various scale types. Thus there appears to be a dilemma of respecting the tradition, but at the same time resorting to new models of intonation. As has been pointed out by Widdess, most authors have overemphasized the acoustic aspect of consonance (nine and thirteen shruti intervals—the perfect fourth and fifth) whereas from early times the functional aspect of consonance (melodic symmetry) has played a very important role.126

During the twentieth century, Bhatkhande, Bake, Ratanjankar, G.H. Ranade, and Meer acknowledged the significance of microtonal inflections, especially with respect to ornamentation. At the same time, they pointed out that north Indian ragas cannot be differentiated on the basis of pitch difference alone. Given the flexibility of intonation in modern raga performance, they rejected the convention of applying shruti as a fixed pitch.

Among several attempts made by twentieth-century scholars to understand, if not resolve the complex issue of shruti, the following are noteworthy for their findings and observations, which also provided a meaningful direction for subsequent research. V.N. Bhatkhande suggested a correlation between pitch and melodic context which was later supported by G.H. Ranade, Ratanjankar, Danielou, and Deval, and still later was experimentally verified by Jairazbhoy and Stone, Levy, Bel and Rao. G.H. Ranade suggested a comprehensive model to include the influence of amplitude, timbre and overtone structure on pitch perception, in order to arrive at meaningful conclusions regarding intonation.127 Since the mental conceptualization of a given pitch precedes its actual expression through sound-producing mechanisms, Powers suggests that appropriate consideration be given to the actual views of the performers themselves regarding their own intonation. It is indeed vital to understand the musicians’ ideas and impressions in order to arrive at any judgment regarding actual intonation.

B.C. Deva and A.D. Ranade independently suggested that shrutis had to be looked at as continuous pitch areas rather than exact pinpoints. This idea was further supported by the work of Levy, Meer, Bel, and Rao from which it transpires that pitch in performance must be seen as a statistical phenomenon.

For any kind of non-standard intonation, the melodic contours seem to be musically more significant than simple pitch information in terms of frequency, and the melodic shape of or around a note needs to be studied.128 In performance, musicians’ efforts are constantly directed towards achieving specific tonal configurations. When a performer succeeds in this endeavour, knowledgeable audiences immediately respond by showing their appreciation, clearly relating the specific tonal configuration to the core of the given raga.129 As suggested by Bake and

127The subjectivity involved in human auditory perception complicates the issue. Some of the studies undertaken in the area of psychology of pitch perception have concluded that in the case of more complex tones or combination of tones, subjective pitch may not correspond to any measurable frequency in the originally presented sound. See Plomp 1976: 112-14, and Ward 1954: 369-80.
128The expression melodic shape implies pitch in time and does not refer to the form of objects in space.
129It is not uncommon to have appreciative remarks such as “kyā gāndhār lagāya hain”, meaning: “what an intonation of gāndhāra”, from a knowledgeable audience.
Ratanjankar, and emphasized by Meer, the microtonal subtleties of shruti in present-day performance practice are meaningful and significant with respect to raga-specific ornamentations.

The multiplicity of views presented in this chapter suggest that despite all efforts, interpreting Bharata’s system of twenty-two shrutis remains enigmatic. Perhaps it is time to realize the futility of seeking a direct connection between modern-day performance practice and the ancient and medieval sources. Since the music and musical concepts prevalent in Bharata’s time have undergone major transformations resulting in the emergence of different musical systems, how can one justify applying the same age-old norms of twenty-two fixed pitches to interpret intonation in present-day raga performance?

As theorized by Bharata, shrutis seem to be pinpoints with a fixed mathematical relation to each other within the range of an octave. Even the medieval and post-medieval theorists continued to struggle with this interpretation of shruti, later given in terms of string lengths of the vina. Experimental studies conducted during the twentieth century provided evidence for flexible intonation, ruling out the notion of pitches as fixed points. Modern scholars have observed intonation as a statistical phenomenon in which the note densities occur not as exact points but rather as ranges within a certain tonal region. The influence of melodic context on pitch is also clear from these studies.

Throughout this chapter it has been observed that musicians have their own views on intonation, which are handed down within the tradition. Most of them are not consciously aware of academic traditions and hence are not in a position to express their ideas in terms of theoretical formulations. However, their ideas are implicit in musical practice as musicians visualize tones, perhaps not as fixed points to be rendered accurately every time, but rather as tonal regions or pitch movements defined by the grammar of a specific raga and its melodic context. They also attach paramount importance to certain raga-specific notes within phrases to be intoned in a characteristic way. Hence, we need to understand what a performer has in mind about intonation and how he relates these concepts to the actual intonation. Our understanding of human perception of sound in general as well as that of tones in the context of musical performance also needs to be enhanced. The inclusion of these principles would help us to arrive at an explicit model of intonation relating to contemporary north Indian raga performance.
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