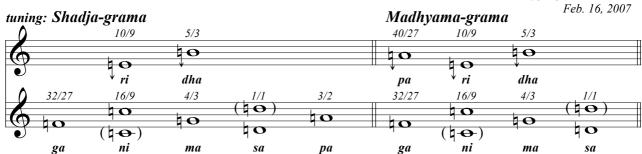
Bharata Muni's experimental tuning procedure with two identical vinas

establishing the three different kinds of SRUTIS, as related in the ancient 'Natya-Sastra'

notated in the 'Extended Helmholtz-Ellis JI Pitch Notation'

Wolfgang von Schweinitz

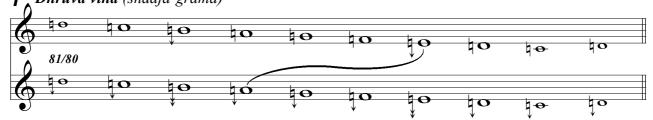


pramana sruti (81/80) = 21.5 cents nyuna sruti (25/24) = 70.7 cents purna sruti (256/243) = 90.2 cents

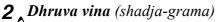


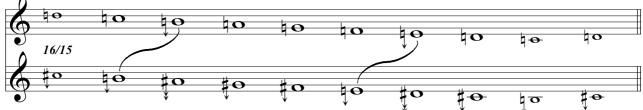
Chala vina (madhyama-grama) with Pa-string lowered by a pramana sruti (producing a major scale on c,
Bhairavi ni or Suddha ni, a major tone below sa, the tonic d)

Dhruva vina (shadja-grama)

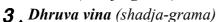


Chala vina (shadja-grama) with all strings lowered by a pramana sruti (Syntonic Comma)



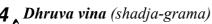


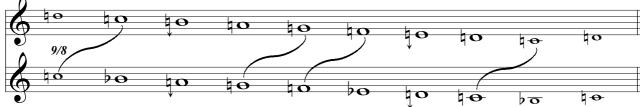
Chala vina (shadja-grama) with all strings lowered by an additional purna sruti (Pythagorean Limma)





Chala vina (shadja-grama) with all strings lowered by an additional nyuna sruti (Minor Chroma)





Chala vina (shadja-grama) with all strings lowered by an additional pramana sruti (Syntonic Comma)

Transcription of a chart presented in 'Ragas in Carnatic Music' by Dr. S. Bhagyalekshmy (CBH Publications, Sriganesh, India, 1990)

Prof. P. Sambamurthy

EXPERIMENTAL VINAS

This commentary explaining Bharata Muni's experimental tuning procedure to establish the *srutis* on two identical harp-like vinas, as related in the ancient NATYA SASTRA more than two thousand years ago, is copied from the chapter 'Early Experiments in Music' of the great anthology 'South Indian Music' Book V by musicologist Prof. P. Sambamurthy, first published in 1963, and in May 1999 in the Seventh Edition by The Indian Music Publishing House, Royapettah, Chennai

The vina was not only used as a concert instrument from early times, but was also used for studying and verifying the various musical laws and phenomena. Both the harp type and the lute type of vinas have been in existence from the vedic times. The emergence of the fretted vina with its immense possibilities for playing subtle gamakas, naturally forced the harp type of vina into oblivion.

A study of the notes obtained in the cycles of fifths and fourths enabled the ancient scholars to perceive the different musical intervals. They were already familiar with the chatussruti interval (9/8 or 204 cents), trisruti interval (10/9 or 182 cents) and the dvisruti interval (16/15 or 112 cents) in the sa grama. The ma grama helped them to appreciate the interval of a pramana sruti, 22 cents. When the notes of the cycles of fifths and fourths, worked up to the 12^{th} cycle in each case, were reduced to one octave and studied, it was found that there were 13 twins of notes, inclusive of the octave shadja, the notes constituting each twin being separated by the interval of a pramana sruti (comma 81/80 or 22 cents). It was also noticed that in each twin, the lower note belonged to the cycle of fourths and the higher note to the cycle of fifths. The same study helped them to realize that in addition to the pramana sruti, there were two other types of ekasruti intervals: 25/24 or 70 cents and 256/243 or 90 cents.

In his *Natya Sastra* (4th cent. B.C.) Bharata has suggested an interesting experiment to get a clear grasp of these three types of ekasruti intervals. These three types of ekasruti intervals are in the increasing order of magnitude respectively termed *Pramana*, *nyuna* and *Purna sruti* intervals or the srutis of minimum, medium and maximum values.

DHRUVA VINA: CHALA VINA EXPERIMENT

Two vinas which were exactly identical in all respects including the timbre of their notes were chosen and tuned to the scale of *sa grama*. That is seven strings of each vina were tuned to the notes of the following frequencies:—

These two seven-stringed vinas were of the harp type and were played on open strings, Fig. 1 shows visually the identical pitch to which the seven strings of the two vinas were tuned. Of the two vinas, the pitch of one was kept constant and this was called the *Dhruva vina* or *Achala vina*. This stationary vina (A) was used for reference. The other vina called *Chala vina*, (B) was subjected to progressive reduction in pitch in four successive stages. At each stage, the reduction effected was by an interval of one sruti. Although the phrase 'reduction by an interval of one sruti' might lead to the inference that the reduction effected in each case was equal, still the rider added by Bharata at the end of each stage, that such and such a note of the chala vina will now be equal to such and such a note of the dhruva vina, conclusively proves that the reduction in pitch, effected at each stage, though within the limits of an ekasruti interval was still not the same.

Now to the experiment described by Bharata: –

Stage 1. 'Let the pa string of the chala vina be reduced by one sruti. The scale of the chala vina will now be that of ma grama.'

Note: The frequency of this reduced panchama was only 40/27 or 680 cents and not any other pitch, since between this note and the dhaivata above there was a chatussruti interval. The panchama string was thus reduced by an interval of a comma or a pramana sruti.

'Now convert the scale of this chala vina into one of *sa grama*, by lowering the pitches of the remaining six strings by the same interval of a pramana sruti.'

The strings were reduced in pitch by slightly decreasing the tension *i.e.*, by loosening the strings to the required extent. Both the vinas became now *sa grama* vinas, but the tonic note of the chala vina was a comma lower down, compared to the pitch of the achala vina, Table 1 clearly shows how each string of the chala vina is a pramana sruti lower than that of the corresponding string of the dhruva vina.

Stage 2. 'Reduce the panchama of the chala vina again by one sruti and afterwards reduce the other six strings also by the same interval. The

gandhara and nishada of the chala vina will now be found to coincide in pitch with the rishabha and dhaivata of the achala vina.' (II). This means that the extent of the reduction was such as to make this coincidence of notes possible. The sum total of the reduction made in the two stages was thus equal to an interval of a diatonic semitone, 16/15 or 112 cents. Since the first reduction was by an interval of a comma, it is evident that the reduction in stage 2 was by an interval of a purna sruti 256/243 or 90 cents. It is clearly seen that each string of the chala vina is a purna dvisruti interval below the corresponding string of the dhruva vina.

Stage 3. 'Reduce the panchama of the chala vina again by one sruti and follow this up by reducing the pitch of the other six strings similarly. The dhaivata and rishabha of the chala vina will now be found to coincide with the panchama and shadja of the dhruva vina.' (III). This means that the extent of the reduction was such as to make this coincidence possible. The sum total of the reduction made in all three stages was equal to an interval of a minor tone, 10/9 or 182 cents. Since the total reduction made at the end of the second stage was a diatonic semitone it follows that the reduction made in the third stage was by an interval of a nyuna sruti, 25/24 or 70 cents. It is thus seen that the pitch of each string of the chala vina is now less than that of the corresponding string of the dhruva vina by the interval of a trisruti or 10/9.

Stage 4. 'Reduce the panchama of the chala vina again by one sruti and carry out this process for the other six strings as well. It will now be found that the pa, ma and sa of the chala vina coincide with the ma, ga and ni of the chala vina.' (IV). It is clear that the reduction effected in this last case was by a pramana sruti, since the notes of the pairs: pa and ma; and ma and ga; and sa and ni have between them a chatussruti interval. We thus find that the pitch of each string of the chala vina is less than that of the dhruva vina by a major tone, 9/8 or 204 cents.

Thus the effective reduction in pitch made in

Stage 1	was a	pramana sruti	81/80
Stage 2	was a	purna sruti	256/243
Stage 3	was a	nyuna sruti	25/24
Stage 4	was a	pramana sruti	81/80

In other words, the reduction has been respectively by the intervals of a minimum sruti, maximum sruti, medium sruti and minimum sruti. In terms of the shadja of the dhruva vina, the frequencies of the panchama string of the chala vina at the four respective stages were: 40/27, 45/32, 27/20 (the frequency of Begada madyama) and 4/3. It should be remembered that the scale of the chala vina at the conclusion of each change of pitch of the seven

strings was one of *sa grama*, the value of the adhara shadja progressively decreasing in each case.

One interesting point in Bharata's experiment is, he asks us to start the reduction in each case with the panchama string. As a practical musician, he knew and fully realized the value of initiating the change from the string which gave the strong consonant note.

The object of Bharata in devising this experiment was: -

- 1. To demonstrate the three types of ekasruti intervals that occurred in the Indian musical scale.
- 2. To familiarize musicians with the idea of inversion of intervals. Thus the Begada madhyama is an inverted minor tone from the panchama.
- 3. To impress the distinction between absolute pitch and relative pitch.
- 4. To illustrate the 22 srutis.

The 22 are easily the possible notes that can be used in a melodic system of music.

It is useful to remember that in ancient times, all musical instruments were tuned to absolute pitch as is the case with European musical instruments even now and the middle octave shadja was a note of a precise frequency just like the international philharmonic pitch.

With the emergence of the concept of adhara shadja in the post-Bharata period, all ragas came to be sung to a common tonic note. Again the emergence of the concept of shadja and panchama as avikrta svaras made the pramana sruti intervals around these two notes pale into insignificance. The note of frequency 40/27 so prominent in the ma grama fell into desuetude along with the ma grama and gradually gave way to the note 64/45 which came to be called by various names as kaisiki panchama, mrdu panchama and varali madhyama.

Bharata in his experiment missed the note 64/45 because he was proceeding downwards from panchama. If he had proceeded upwards from suddha ma, he would have hit upon the note 64/45. He adopted the downward course since he wanted in the first instance to illustrate practically the *ma grama* and hence the note 40/27 had to be touched. The other notes got in successive reductions were only 45/32, 27/20 and 4/3. This is clear from the rider which he has given at each stage, i.e. that such and such a note of the chala vina coincides with such and such a note of the dhruva vina.

Further, musicians at that time were already familiar with the downward progression. The murchanas of *sa grama* were enumerated in the downward order. The progression of *sa ma ga na* music was in the downward order.

This experiment can even now be performed with the *Pradarsana vina* devised by the author of this book and Bharata's conclusions verified. Those who perform this experiment will incidentally get training in the reduction of pitch by such delicate intervals as pramana, nyuna and purna srutis.

In the experiment, Bharata has not mentioned the equivalents of the notes given by all the strings of the chala vina in relation to the notes given by the strings of the dhruva vina. He has referred to the notes of only those strings of the chala vina whose pitches exactly coincided with those of the dhruva vina. He refrained from doing so, since the srutis of the particular strings of the chala vina after reduction, were either close to the other correct srutis or were useless.

The Dhruva vina - Chala vina experiment can be performed in the reverse order starting from the madhyama string and proceeding in the Arohana krama by tightening the string to the desired pitch in each case and the results verified.

It is possible that the four stages of reduction mentioned by Bharata for each of the sapta svaras might have suggested to Mahendra Varman, the author of the *Kudumiyamalai inscription* the four sruti varieties, *ra*, *ri*, *ru*, *re*, *ga*, *gi*, *gu*, *ge*, *etc*. for the sapta svaras.

copied with thanks by Wolfgang von Schweinitz on February 16-17, 2007

BIBLIOTHECA INDICA A COLLECTION OF ORIENTAL WORKS

THE NĀTYAŠĀSTRA

A Treatise on Hindu Dramaturgy and Histrionics

Ascribed to
BHARATA-MUNI

Vol. II (Chapters XXVIII-XXXVI)

Completely translated for the first time from the original

Sanskrit with an Introduction and Various Notes

By MANOMOHAN GHOSH

Work Number 272



Issue Number 1581

THE ASIATIC SOCIETY

1, PARK STREET, CALCUTTA 16

1961

Vastu, Mātrā, Vidārī, Aṅga, tempo (laya), Yati, Prakaraṇa, Gīti, Avayava, Mārga, Pādabhāga, and Pāṇi are the twenty³ formal aspects of the Tāla. These [are] in brief about the Gāndharva. Listen next in details about the same.

The Seven Notes

On the Notes (svara):

21. The seven notes are: Ṣadja (sa), Rṣabha (ri), Gāndhāra (ga), Madhyama (ma), Pañcama (pa), Dhāivata (dha) and Niṣāda (ni).

Mutual relation of the Notes

22. [According] as they relate to an interval of [more or less] Srutis, they are of four classes, such as Sonant $(v\bar{a}din)$, Consonant $(samv\bar{a}din)^2$ Assonant $(anuv\bar{a}din)^3$, and Dissonant $(viv\bar{a}din)^4$.

The Sonant and the Consonant Notes

That which is an Amśa⁵ [note] anywhere, will in this connexion, be called there Sonant $(v\bar{a}din)$. Those two notes

³The text ity ekavimšako should be read as ity evam vimšako.

^{(22) &}lt;sup>1</sup>For an explanation of this and succeeding terms see below and GS. I. pp. 462, 463, 467, 468; GS. II. pp. 117-123, MM. p. 9. MH. p. 108.cf. MI. pp. 27-28.

According to Dr. A. A. Bake (MM. p. 9.) "the sonant note is the melodic centre of the melody." See below note 1 of 76-78.

²See SR. I. 3. 47ff. Kn. says : यथो: खरयोरलरानेचरा: खाधारस्रती विद्याय मध्यवर्तिन्यः स्रुतयो द्वादयाष्ट्री वा इस्मले तौ नियः संवादिनी भवतः दृति । Sbh. too says : द्वादयाष्ट्री वा स्रुतयो ययोरलर वर्तन्ते तौ नियः परस्यरं संवादिनी भवतः. But Matanga (Bd. p. 14, II. 1-2) says : संवादिनस्तु पुनः समस्रुतिकल्ले सित वयोदयनवालारले नाववीद्ययाः ; and Dattilla (18) too says : मिषः सवादिनी क्रोयो वयोदयनवालारौ. The difference between the two views, is more apparent than real. For Sbh. says यथौः स्रुत्योः स्वरावस्थितौ ते स्रुतौ विद्याय मध्यस्था स्रुतयो द्वादयाण्टी वा यदि भवित्त तदा तथोः संवादिलम् द्वायनेनाभिप्रायनेवम् एकम् । मतक्वादिभिन्त् यो यस्य संवादौ तस्यावस्थानस्रुतिमप्त कथे गणधिला वयोदयनवालारम् एकमिति न कथिद विसंवादः (on SR. I. 3. 48-49). ³See below note 2 on 23. ⁴See below note 1 on 23.

From its several variants it appears that the term amia is nothing but amga misread from some very early ms. For more about this see the Introduction.

which are at an interval, of nine or thirteen Srutis from each other are mutually Consonant (saṃvādin) e.g. Ṣaḍja and Madhyama, Ṣaḍja and Pañcama, Ḥṣabha and Dhaivata, Gāndhāra and Niṣada in the Ṣaḍja Grāma. Such is the case in the Madhyama Grāma, except that Ṣaḍja and Pañcama are not Consonant while Pañcma and Ḥṣabha are so. [On these there] is a [traditional] Śloka:

23. In the Madhyama Grāma, Pañcama, and Rṣabha are Consonant while Ṣaḍja and Pañcama are so in the Ṣadja Grāma [only].

The Dissonant Notes

The notes being at an interval of [two or] twenty Srutis are Dissonant' e.g. Rṣabha and Gāndhāra, Dhaivata and Niṣāda.

The Assonant Notes

Now Sonant, Consonant and Dissonant notes having been determined (lit. established) the remaining ones are to be called Assonant², e.g. Rṣabha, Gāndhāra, Dhaivata and Niṣāda to Ṣaḍja; Madhyama, Pañcama and Niṣāda to Rṣabhā; and Madhyama, Pañcama and Dhaivata to Gāndhāra; Dhaivata, Pañcama and Niṣāda to Madhyama;

⁽²³⁾¹Matanga (p. 15. ll 11-12) says : हान्तरलाइ विवादिलम् उक्तम् and Dattila (19) too says : हान्तरी तु विवादिनी Kn. says एकेन सुल्यन्तरिती परस्परं विवादिनी हति लच्चां स्चिंत अवित and reconciles this with the view of the NS, and other earlier writers as follows : 'हवारिकखाधारसूला सह हान्तरलस विविध्यतलादिकसुल्यन्तरितलमेवार्थ: (on SR. I. 3. 49). SR. (I. 3. 40) defines vivādī notes differently. It makes ni and ga, vivādī to ri and dha respectively.

²Matanga (p. 144ff.) says that the mutually anuvādī pairs of notes are: sa and ri, pa and dha, sa and dha, pa and ri in the Ṣadja-grāma. Sbh. adds one more pair (ma and ri) to these (on SR. I. 3. 50).

³The Grāma may be translated as 'scale'. Strangway's theory about its meaning does not appear to be sound (see MH. p. 106). Weber thinks that the Greek word gamma in its musical sense, is nothing but a derivation from the Sanskrit word grāma. Indische Streifen, I.3. (Ref.MM. p. 10). According to Nārada there is one more Grāma named Gāndhāra (NāŚ. I. 2. 8). SR (I. 4. 5) too mentions this. For more about Grāma see MH. pp. 108-112.

Dhaivata and Niṣāda to Pañcama; Rṣabha, Pañcama and Madhyama to Dhaivata. [All these are] in the Ṣaḍja Grāma. In the Madhyama Grāmā too, Pañcama, Dhaivata and Niṣāda [are Assonant] to Madhyama; Rṣabha Ṣaḍja, and Gāndhāra to Pañcama; Ṣaḍjā, Rṣabha and Gāndhāra to Dhaivata; the same (Ṣāḍja, Rṣabha and Gāndhāra) to Niṣāda. As a note [prominently] sounds it is called Sonant; as it sounds in cosonance [with another] it is Consonant; as it sounds discordantly [to another] it is Dissonant, and as it follows [another note] it is called Assonant. These notes become low or high according to the adjustment of the strings, and the varying condition (lit. diversity) of the beam of the Viṇā and of the senseorgans. So much about the aspects of four classes of notes.

Description of the Two Grāmas

Now, there are two Grāmas³: Ṣaḍja and Madhyama. Each of these two (lit. there) include twentytwo. Śrutis in the following manner:

24. Śrutis in the Ṣadja Grāma are shown as follows:—three [in Ṣṣabha],¹ two [in Gāndhāra], four [in Madhyama], four [in Pancama], three [in Dhaivata], two [in Niṣāda] and four [in Ṣadja].

In the Madhyama Grama Pancama should be made difficient in one Sruti. The difference which occurs in Pancama when it is raised or lowered by a Sruti and when consequential slackness or tenseness [of strings] occurs, will indicate a typical (pramāṇa) Sruti. We shall

⁽²⁴⁾ Probably due to the exigency of metre, the NS. in describing here the Srutis of each note, begins from Rsabha.

² Utkarsas (increase) tīvratā, apakarso (decrease) mandatā, Ag.

³ Mārdavam (slackness) tantryāh sithilikaranam, viparītatvam āyatatvam (tenseness) Ag.

^{*}Sruti may be translated as 'interval'. Early authorities differed from one another as to the nature and number of Śrutis. Viśvāvasu thought they were two, some authority considered that their number was three,

explain the system of these [Srutis]. The two Vīnās with beams (danda) and strings of similar measure,5 and with similar adjustment of the latter in the Sadia Grama should be made [ready]. [Then] one of these should be tuned in the Madhyama Grama by lowering Pancama The one of Srutil. The same (Vīnā) by adding one Sruti (lit. due to adding of one Sruti) to Pancama will be tuned in the Sadia Grama. This is the meaning of decreasing a Sruti (lit. thus a Sruti is decreased). Again due to the decrease of a Sruti in another [Vīnā] Gāndhāra and Nisāda will merge with Dhaivata and Rsbha respectively. when there is an interval of two Srutis between them. Again due to the decrease of a Sruti in another (Vinā) Rsbha and Dhaivata will merge with Sadja and Pañcama respectively when there is an interval of [three] Srutis. Similarly the same fonel Sruti being again decreased Pancama, Madhyama and Sadja will merge with Madhyama, Gandhara and Nisada respectively when there is an in interval of four Srutis between them. Thus according this system of Srutis. [each of] the two Gramas should be taken as consisting of twentytwo Srutis. [The following] are the Slokas to this effect:

Śrutis in the Şadja Grāma

25-26. In the Ṣaḍja Grāma, Ṣaḍja, includes four Srutis, Ṣṣabha three, Gāndhāra two, Madhyama four, Pañcama four, Dhaivata three and Niṣāda two.

some twentytwo, some sixtysix and some infinite. Views of the anonymous authorities are known from the following couplet of Kohala:

द्याविश्वति केचिदुदाहरिन स्रुतौ: स्रुतिज्ञानविधारदच्याः। षट्षष्टिभिन्नाः खलु केचिदासामानन्त्रामन्त्र प्रतिपादर्यन्त ॥

See Bd. pp. 4, 5; Sbh on SR. I. 3. 8. 9. For an elaborate discussion on the nature of Śrutis in relation to the seven notes in the ancient Hindu scale see GS. I. pp. 298-379; GS. II. pp. 138-143. The following passage in NŚ. from निर्मान लागान to बानिमति मृत्यः मत्यवगनव्याः occurs in the Bd. (pp. 5-6) with a slight modification. SR. too follows this (See I. 3. 11-22).

⁵Ag. explains this 'measure' (prāmaṇa) as length and thickness, others include the number of strings also in this (प्रमाणम् जानाइपरिणाड़ी; तन्त्रीयां तुकाल संप्यया स्त्रीकादिना चेति नेचित्).