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
Feb. 16, 2007

Tuning: Shadja-grama

Madhyama-grama

<table>
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<tr>
<th>Prama</th>
<th>Sruti</th>
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<tr>
<td>32/27</td>
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<tr>
<td>10/9</td>
<td>5/3</td>
<td>40/27</td>
<td>10/9</td>
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Pramana sruti (81/80) = 21.5 cents  Nyuna sruti (25/24) = 70.7 cents  Purna sruti (256/243) = 90.2 cents

1a Dhrava vina (shadja-grama)

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<td>10 : 9 9 : 8 9 : 8 16 : 15 10 : 9 9 : 8</td>
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Chala vina (madhyama-grama) with Pa-string lowered by a prama sruti (producing a major scale on c, Bhairavi ni or Suddha ni, a major tone below sa, the tonic d)

1b Dhrava vina (shadja-grama)

81/80

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

2 Dhrava vina (shadja-grama)

16/15

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

3 Dhrava vina (shadja-grama)

10/9

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

4 Dhrava vina (shadja-grama)

9/8

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

Transcription of a chart presented in 'Ragas in Carnatic Music' by Dr. S. Bhagyalakshmy (CBH Publications, Sriganesh, India, 1990)
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 1965, 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 divisruti 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 12th 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.
**DHRAVA 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:

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<tr>
<td></td>
<td>1</td>
<td>10/9</td>
<td>32/27</td>
<td>4/3</td>
<td>3/2</td>
<td>5/3</td>
<td>16/9</td>
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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 dhaiavata 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 dvirsruti interval below the corresponding string of the dhrua 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 dhrua 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 dhrua 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 prama 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 dhrua vina by a major tone, 9/8 or 204 cents.

Thus the effective reduction in pitch made in

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<td>1</td>
<td>prama sruti</td>
<td>81/80</td>
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</tr>
<tr>
<td>2</td>
<td>purna sruti</td>
<td>256/243</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>nyuna sruti</td>
<td>25/24</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>prama sruti</td>
<td>81/80</td>
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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 dhrua 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 sama gana 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.

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Wolfgang von Schweinitz
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THE NĀṬYASĀSTRA

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

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Vastu, Mātrā, Vidārī, Aṅga, tempo (lāya), Yati, Prakāraṇa, Gīti, Avayava, Mārga, Pāddhāga, and Pāni 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: Śaḍja (sa), Rśabha (r), Gāndhāra (ga), Madhyama (ma), Paṇcama (pa), Dhāivata (dha) and Niṣāda (ni).

Mutual relation of the Notes

22. [According] as they relate to an interval of [more or less] Śrutis, they are of four classes, such as Sonant (vādin), Consonant (saṃvādin)² Assonant (anuvādin)³, and Dissonant (vīvādin)⁴.

The Sonant and the Consonant Notes

That which is an Aṃśa⁵ [note] anywhere, will in this connexion, be called there Sonant (vādin). Those two notes

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³The text ity ekavimśako should be read as ity evam viṃśako.

²(22) ¹For 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. MF. 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: बंध: संयोगस्तरोपेष्ट्रः साभासुत्ती विवाय साभातिष्ठा: ठिठ्। Sbh. too says: हादाती वा हुवो व्योरक्रि यस्तं तस्मात् श्रवणं स्मरणं मन्त्रं। But Mataṅga (Bd. p. 14, ll. 1-2) says: संविदितं पुनः संविदितकल्य अवदेशवन्धनलो नातिवेद्यम्। and Dattilla (18) too says: निष्ठा: संविदिनी वि विदेशवन्धनवी। The difference between the two views, is more apparent than real. For Sbh. says बंधः: हादातार्थिन ते हुवो विवाय साभास्य: हुवानि हादाती वा यविं प्रभाविता संवाय: संवायल् संवायविभास्यः नकम। मतावतीष्ठतु तथा संवाय: संवायसानुसानुसानिप्रमेयं केषाश: समविदिनुत्तानाविन्यमशः। (on SR. I. 3. 48-49).

³See below note 2 on 23.

⁴See below note 1 on 23.

⁵From its several variants it appears that the term aṃśa is nothing but anga misread from some very early ms. For more about this see the Introduction.
which are at an interval, of nine or thirteen Śrūtis from each other are mutually Consonant (sāmvādīn) e.g. Saḍja and Madhyama, Saḍja and Paṅcama, Rṣabha and Dhai-vata, Gāndhāra and Niṣāda in the Saḍja Grāma. Such is the case in the Madhyama Grāma, except that Saḍja and Paṅcama are not Consonant while Paṅcama and Rṣabha are so. [On these there] is a [traditional] Śloka:

23. In the Madhyama Grāma, Paṅcama, and Rṣabha are Consonant while Saḍja and Paṅcama are so in the Saḍja Grāma [only].

The Dissonant Notes

The notes being at an interval of [two or] twenty Śrūtis are Dissonant e.g. Rṣabha and Gāndhāra, Dhai-vata and Niṣāda.

The Assonant Notes

Now Sonant, Consonant and Dissonant notes having been determined (lit. established) the remaining ones are to be called Assonant e.g. Rṣabha, Gāndhāra, Dhai-vata and Niṣāda to Saḥja; Madhyama, Paṅcama and Niṣāda to Rṣabhā; and Madhyama, Paṅcama and Dhai-vata to Gāndhāra; Dhai-vata, Paṅcama and Niṣāda to Madhyama;

(23)1 Mataṅga (p. 15. II 11-12) says : द्वारकलन्द विभिन्निदिस्त रक्षस् and Dattila (19) too says : द्वारकलन्द विभिन्निदिस्त कर्मित रक्षसं विभिन्निदिस्त रक्षसं रक्षसं अन्तर्वलकित and reconciles this with the view of the NŚ, and other earlier writers as follows : द्वारकलन्द विभिन्निदिस्त कर्मित रक्षसं विभिन्निदिस्त कर्मित रक्षसं रक्षसं अन्तर्वलकित रक्षसं (on SR. I. 3. 49). SR. (I. 3. 40) defines vivādi notes differently. It makes ni and ga, vivādi to ri and dha respectively.

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

3 The 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 Śadja Grāma. In the Madhyama Grāma too, Pañcama, Dhaivata and Niṣāda [are Assonant] to Madhyama; Rṣabha Śadja, and Gāndhāra to Pañcama; Śadja, Rṣabha and Gāndhāra to Dhaivata; the same (Śadja, Rṣabha and Gāndhāra) to Niṣāda. As a note [prominently] sounds it is called Sonant; as it sounds in consonance [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 sense-organs. So much about the aspects of four classes of notes.

Description of the Two Grāmas

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

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

In the Madhyama Grāma Pañcama should be made deficient in one Śruti. The difference which occurs in Pañcama when it is raised2 or lowered, by a Śruti and when consequential slackness3 or tenseness [of strings] occurs, will indicate a typical (pramāṇa) Śruti.4 We shall

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1 Probably due to the exigency of metre, the NŚ. in describing here the Śrutis of each note, begins from Rṣabha.
2 Utkarṣas (increase) svoratā, apakarṣo (decrease) mandatā, Ag.
3 Mārdavaṇ (slackness) tantryaḥ śīthilikaṇaṃ, viparitattvam āyatattvam (tenseness) Ag.
4 Śruti 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 [Śrutis]. The two Vīṇās with beams (danda) and strings of similar measure, and with similar adjustment of the latter in the Śadja Grāma should be made [ready]. [Then] one of these should be tuned in the Madhyama Grāma by lowering Paṇcama [by one of Śruti]. The same (Vīṇā) by adding one Śruti (lit. due to adding of one Śruti) to Paṇcama will be tuned in the Śadja Grāma. This is the meaning of decreasing a Śruti (lit. thus a Śruti is decreased). Again due to the decrease of a Śruti in another [Vīṇā] Gāndhāra and Niśāda will merge with Dhaivata and Rṣbha respectively, when there is an interval of two Śrutis between them. Again due to the decrease of a Śruti in another (Vīṇā) Rṣbha and Dhaivata will merge with Śadja and Paṇcama respectively when there is an interval of [three] Śrutis. Similarly the same [one] Śruti being again decreased Paṇcama, Madhyama and Śadja will merge with Madhyama, Gāndhāra and Niśāda respectively when there is an in interval of four Śrutis between them. Thus according this system of Śrutis, [each of] the two Grāmas should be taken as consisting of twentytwo Śrutis. [The following] are the Ślokas to this effect:

Śrutis in the Śadja Grāma

25-26. In the Śadja Grāma, Śadja, includes four Śrutis, Rṣabha three, Gāndhāra two, Madhyama four, Paṇcama four, Dhaivata three and Niśāda two.

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

शाष्टिहिति कैविदार्शिनः सूत्रीः कुलिस्त्राह्यनिधावधा ॥ प्रायोगिनिः कल्पि कैविदार्शिनमस्मिनि प्रसिद्धमययाः ॥

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 निदार्शित सावाहिनोऽर्थिः प्रायोगिनिः: 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 (प्रामाणयं वाक्यपदितानि; नीलोत्पलुमा रंनवास्तायं वैद्यविसिः).