

Shruti Nidarshanam: The Sarana-Chatushtaya Experiment (Demonstration of Microtones as per Bharata's Theory)

Dr. Vinod Vidwans

Professor and Chair
FLAME School of Fine and Performing Arts
Pune, India

For centuries *shrutis* are considered as an enigma in Indian music. Researchers attempted to demystify the enigma surrounded the concepts of *shrutis* by interpreting three seminal texts on Indian music, namely: *Naradiya Shiksha*, Bharata's *Natyashastra* and *Sangita Ratnakara* of Sharangadeva. However, none of these attempts led to conclusive and convincing understanding of *shrutis*. This paper presents a thorough scrutiny of the *Sarana-Chatushtaya* experiment from Bharata's *Natyashastra* that leads to the conclusive proof for equal temperament twenty two *shruti* paradigm.

During ancient times the concept of *shruti* has evolved in two or three stages. Although the Vedas are called *shruti*, the meaning of the term '*shruti*', was more spiritual than musical during Vedic period. During Vedic period, the term '*swara*' was more prevalent than the term '*shruti*' to denote tonalities of Vedic '*mantras*'. *Naradiya Shiksha* uses the term *shruti* to denote sonar qualities of Vedic *swaras* (especially *swaras* used in *Samaveda*) achieved through tonal variation and modulation and further *Naradiya Shiksha* identifies five categories of *shrutis* as mentioned in *Naradiya Shiksha*:1-7-9, [Bhise, U., p. 99].

Bharata's paradigm is completely different from *Naradiya Shiksha*. For *Naradiya Shiksha* *shrutis* are sonar qualities of a *swara* while for Bharata *shrutis* are twenty two distinct places or pitches distributed across the octave. Thus, apart from spiritual and psychological significance, *shrutis* have musical significance and in modern times can be understood in terms of their frequency values. These are not merely mental concepts as many theories of *shruti* assume.

Bharata's '*Shruti Nidarshanam*' experiment [Bharata, p. 20] as thoroughly discussed in the *Natyashastra* is a conclusive proof of the equal temperament twenty two *shrutis*. This experiment also tells a musician to how to perceive *shrutis* on *Veena* in a step-by-step manner. Bharata gives highly sophisticated *Shruti-Nidarshanam* or *Sarana-Chatushtaya* experiment to experience and demonstrate twenty two *shrutis* which is discussed in the following paragraphs. This experiment is so accurate and sophisticated, that one gets awe-struck by the intellectual and mathematical genius of the creator of such an experiment.

Sharangadeva [Sharangadeva, p. 57] also had devised a variation of the same experiment which also conclusively demonstrates the existence of equal temperament twenty two *shrutis*. It means that the *Sarana-Chatustaya* experiment can be conducted in various ways. There is one more possibility of conducting the *Sarana-Chatustaya* experiment or the *Shruti Nidarshanam* experiment as discussed here.

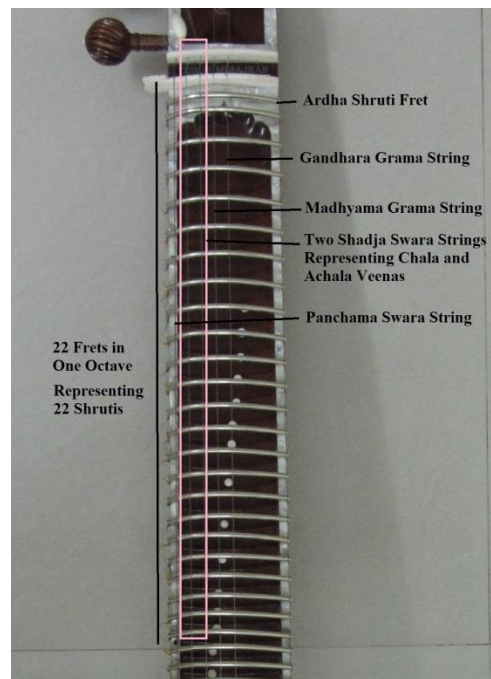
Shruti Nidarshanam on a Single Veena or Sitar

In both the *Shruti Nidarshanam* experiments, mentioned by Bharata and Sharangadeva, we need two equally tuned *Veenas*. However it is possible to perform the *Sarana-Chatustaya* experiment to demonstrate *shrutis* on single *Veena/ Sitar* [Vidwans, p. 68]. For this experiment we need to modify *Veena/ Sitar* in such a way that it will have twenty two frets in one octave. We may call this *Veena/ Sitar* with twenty two frets in each octave as '*Shruti Veena*' or '*Shruti Sitar*'. The author of this paper has used existing *Sitar* as a base to design and develop a '*Shruti Veena*' or a '*Shruti Sitar*'. For the convenience and to maintain the consistency of terminology, throughout this paper, this instrument is called '*Shruti Sitar*'. This *Shruti Sitar* has five main strings, three strings for '*Chikari*' to provide drone-like impact and twenty two sympathetic strings called '*Taraf*'. The *Chikari* strings and the *Taraf* strings are similar as that of a traditional *Sitar*. Among the main strings, we need to establish *swaras* as per Bharata's scheme of establishing *swaras* [Vidwans, p. 46-56] since Bharata's scheme of *swaras* was different from contemporary *swaras*. the first string of the *Shruti Sitar* stands for *Gandhara Grama* and therefore should be tuned into Bharata's *Mandra Gandhara swara*. The second string represents the *Madhyama Grama* and so should be tuned into Bharata's *Mandra Madhyama swara*. (Alternatively, both the *Gramas* can be established on the same string by loosening or tightening the string. By this we can reduce the total number of main strings of the instrument. Currently, two separate strings are used to establish *Gandhara Grama* and *Madhyama Grama*.) The third and the fourth strings are to be tuned in the *Mandra Shadja swara*. These two strings are important because the *Sarana-Chatustaya* experiment is performed using these two strings (otherwise the fourth string can be tuned in Bharata's *Mandra Nishada* for distinct chromatic effect). The fifth and the last string should be tuned in *Ati-Mandra Panchama*.

Now first tune the *Shruti Sitar* appropriately as mentioned above- the first string in Bharata's *Mandra Gandhara*, the second in Bharata's *Mandra Madhyama* and the fifth in Bharata's *Ati-Mandra Panchama swara* and the third and the fourth strings in *Mandra Shadja swara*. Now consider the third string as *Chala* (changeable) string and the fourth string as *Achala* (un-changeable) string (using the terminology of Bharata) [Bharata, p. 20]. We need to follow the description of Bharata's *Shruti Nidarshanam* experiment in a step-by-step manner on these two strings. The third string in this experiment acts as a *Chala Veena* and the fourth string acts as an *Achala Veena* of Bharata's experiment. At the end of the experiment the third string will be lowered by four *shrutis* i.e. it will be tuned to the *Ati-*

Mandra Nishada of Bharata. The frets will help in ascertaining the *shruti* positions on *Chala* and *Achala* strings as it happens with *Chala* and *Achala Veenas* of Bharata. This is a simpler and contemporary version of Bharata's *Shruti Nidarshanam* experiment. For such an experiment we need to make a special *Veena* having equal temperament twenty two frets in every octave. We can have fixed frets like a *Veena* or movable frets like a *Sitar*. Movable frets can really help in exploring various possibilities of un-equal *shruti* positions. With un-equal *shruti* positions number of *shrutis* generated ranges between 26 to 31 *shrutis*. Eventually the experiment will prove that Bharata's *Shruti Nidarshanam* experiment is valid only for equal temperament *shrutis* and thus substantiates the case for equal temperament twenty two *shrutis*. Bharata's paradigm of equal temperament twenty two *shruti* is not a hypothetical construct. On the other hand it was a profound practical paradigm till the times of Abhinavagupta and Sharangadeva i.e. till the thirteenth century A.D. at least.

Following is the photograph of specially designed '*Shruti Sitar*' for conducting the *Sarana-Chatushtaya* experiment. The photo also indicates various parts of the '*Shruti Sitar*'.



***Shruti-Nidarshanam* (Demonstration of Microtones)**

The *Shruti-Nidarshanam* experiment that is also known as a '*Sarana-Chatushtaya*' experiment, is a unique gift of Bharata to the world of music to demonstrate existence of twenty two *shrutis*. This experiment is described in twenty eighth chapter of Bharata's *Natyashastra*. It is not mentioned in any of the earlier treatises on Indian music therefore it

is certain that this experiment was invented during Bharata's times. The original creator of this experiment is not known but since it is mentioned in Bharata's *Natyashastra* it is assumed that Bharata himself must have designed it. This experiment is a conclusive proof of equal temperament twenty two *shrutis*. Following is the description of performing the *Sarana-Chatushtaya* experiment on two strings on a specially designed single *Veena*. Therefore, in the following original description of the experiment by Bharata, two *Veenas* are represented by two strings in the new '*Shruti Sitar*'. For the consistency with original description in Bharata's *Natyashastra*, these two strings are termed as two *Veenas*. Therefore, in the following description where ever there is a mention on *Chala Veena* or *Achala Veena*, it should be understood that they stand for *Chala* String and *Achala* String respectively. As per this experiment, *shrutis* can be demonstrated in a definitive way through an experiment on a single *Veena*. The procedure for this experiment is called '*Sarana-Chatushtaya*' method. This experiment is described as follows in a step-by-step manner.

Following photograph shows *Achala* String and *Chala* String used for the experiment.

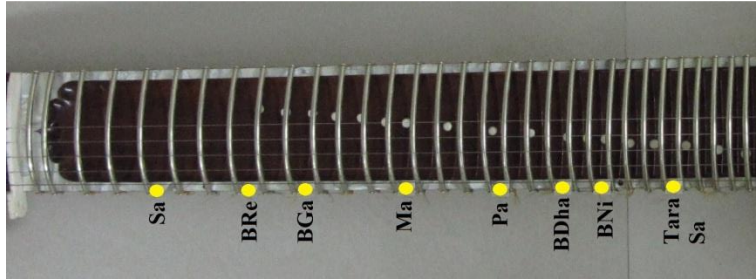


The first *Sarana*:

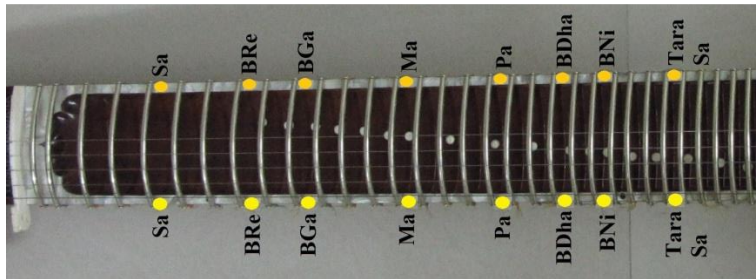
यथा--- द्वे वीणे तुल्यप्रमाणतन्त्र्युपवादनदण्डमूर्छनेकृत्वा षड्जग्रामाश्रिते कार्ये | [Bharata, p. 20]

Take two *Veenas* of same size with equal number of strings (and frets), with same dimensions in terms of length and other parameters. Tune both the *Veenas* in a *Shadja Grama*. Establish seven *swaras* properly on both the *Veenas*. One of them is called '*Dhruva Veena*' or '*Achala Veena*' while the other is called '*Chala Veena*'.

Swara Sthapana [Vidwans, p. 46-56] on the *Achala Veena*: *Swaras* of *Achala Veena* established on fourth string are indicated on lower border of the *Shruti Sitar* near respective frets in the following photograph.



Swara Sthapana on *Chala Veena*: *Swaras* of *Chala Veena* established on third string are indicated on upper border of the *Shruti Sitar* near respective frets in the following photograph.



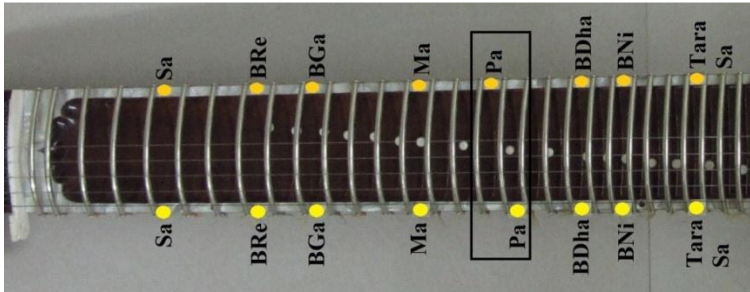
Here two strings are used so two *Veenas* are replaced by two strings tuned in *Mandra Shadja swara*. Both the *strings* need to be tuned to Bharata's seven *swaras* as discussed in the *Natyashastra*. By this all the seven *swaras* will be at their original natural positions called '*Shadja Grama*'. Process of establishing *swaras* on both the *Veenas* is explained in *Natyashastra* during the discussion on '*swara-sthapana*'. As per the description *Shadja* is set on the fourth *shruti* and then rest of the *swaras* are placed as per relative distances as mentioned in the description of '*swara-sthapana*'.

The experiment allows mapping *swaras* of '*Chala Veena*' onto the *swaras* of '*Achala Veena*'. At every step mapping happens in such a manner that groups of two *shrutis*, three *shrutis* and four *shrutis* are demonstrated in a decisive manner along with their individual

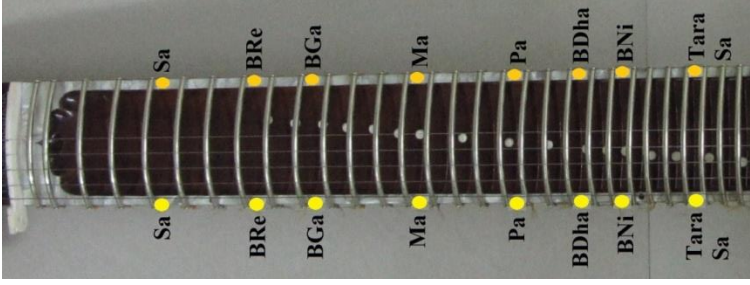
positions. It is possible that the *Veenas* that were commonly used by musicians those days had frets for these twenty two *shrutis*. Out of these musicians can choose the required seven *swaras*. Even today twelve positions of *swaras* are predetermined on the *Veena*. But it is certain that the instrument-makers as well as musicians should have very precise theoretical knowledge of setting up the frets on the *Veena*. If there are predetermined seven or twenty two frets on both the *Veenas* then this experiment is easier to perform. If there are no predetermined frets then a skilled musicians only can perform this experiment. Since it's a theoretical experiment and therefore it is expected that the person should have adequate musical knowledge. Only condition is that both the *Veenas* should be identical in all the respects. If there are no pre-existing frets on both the *Veenas* then after '*swara-sthapana*' one can put marks on both the *Veenas* to identify *swara* positions. In the contemporary version this experiment the '*swara-sthapana*' is done on two identically tuned strings.

तयोरेन्यतरस्यां पञ्चमस्यापकर्षे श्रुतिं मध्यमग्रामिकीं कृत्वा तामेव च पञ्चमस्य श्रुत्युत्कर्षवशात् षड्जग्रामिकीं कुर्यात् [Bharata, p. 20]

Now lower down the *Panchama swara* of *Chala Veena* by one *shruti* (*Pramana shruti*) as discussed earlier during the description of a '*Pramana Shruti*'. So the *Chala Veena* becomes a *Madhyama Grama Veena*. This is achieved by lowering down the *Panchama* of *Chala Veena* such that it will tune with the Bharata's *Rishabha* on the *Achala Veena* with a *Samvada Bhava* of nine-*shruti* distance i.e. *Shadja-Madhyama Bhava*. *Panchama* on the *Chala Veena* is shown shifted to previous fret i.e. one *shruti* lower fret to demonstrate the *Pramana Shruti* & *Madhyama Grama* in the following photograph.



Frequency of *Chala Veena* is lowered down by one *shruti* so that *Panchama* regains its original position and the *Chala Veena* now again is in the *Shadja Grama* in the following photograph.



This is done because there exists a *Shadja-Madhyama Bhava* between Bharata's *Rishabha* and *Panchama* of *Madhyama Grama*. By this a '*Pramana shruti*' is demonstrated. Then tune all the rest of the *swaras* of a *Chala Veena* in such a way that keeps the *Panchama's* new position intact, the *Chala Veena* becomes the *Shadja Grama Veena* again [Bharata, p. 20].

एकश्रुतिरपकृष्टा भवति | [Bharata, p. 20]

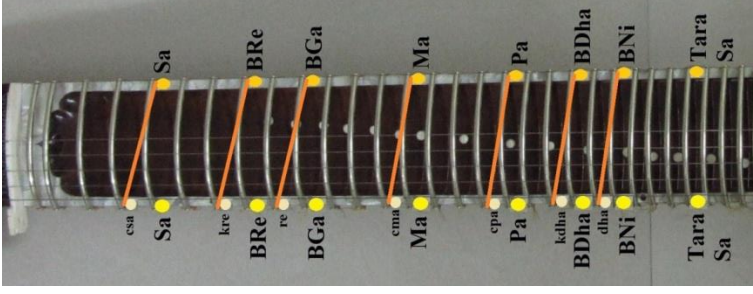
Now the *Chala Veena* is one *shruti* lower than the *Dhruva Veena*. All the *swaras* of *Chala Veena* are one *shruti* lower than all the *swaras* of *Dhruva Veena* [Bharata, p. 20].

Svara frequencies of the *Chala Veena* keep shifting at every step in the whole experiment towards lower side while *Achala Veena swara* frequencies are kept in the original positions. The beauty of the experiment is that at every step one can compare the relative frequencies of each *swara* of the *Chala Veena* with their counter parts on the *Achala Veena*.

For instance, at this first stage, every *swara* of the *Chala Veena* is one *shruti* (*Pramana Shruti*) lower than all the *swaras* of the *Achala Veena*. One can cross check and understand what the aural distance of the *Pramana Shruti* is. In other words one knows the *Pramana Shruti* distance in a definite way.

Along with this process one very important phenomenon is happening and that is as every *swara* of *Chala Veena* is lowered by one *shruti*, each *swara* is mapped on the one-*shruti* lower position on the *Achala Veena*. As a result apart from original *swara/ shruti* positions, seven new positions are generated or mapped on the *Achala Veena*. This shows that *Sarana-Chatushtaya* experiment is also a *shruti* generating process.

Orange lines in the photograph indicate the shifted positions of original seven *swaras*. Names of the newly mapped *swaras* are written with a smaller font size.



These new positions are nothing but seven more *shruti* positions/ frequencies. These can be marked and recorded on the *Achala Veena*. So at the end of first step itself seven original *swara/ shruti* positions plus seven new *shruti* frequency/ positions are generated. As a whole fourteen *shrutis* are demonstrated at the end of the first step.

The newly generated *shrutis* thus would be as follows: *Dvi-shruti Rishabha, Chatuh-shruti Rishabha, Chyuta-Madhyama, Chyuta-Panchama, Dvi-shruti Dhaivata, Chatuh-shruti Dhaivata, and Chyuta-Shadja*. These are the seven new *shrutis* generated at the end of the first step or first *Sarana*. Interestingly newly generated *shrutis* do not overlap on any of the existing seven *swaras/ shrutis*. These are absolutely new *shrutis*.

The Second *Sarana*:

पुनरपि तद्वदेवापकर्षेत्, यथागान्धारनिषादवन्तावितरस्यामृषभधैवतौ प्रवेक्ष्यतः द्विश्रुत्यधिकत्वात् ... [Bharata, p. 20]

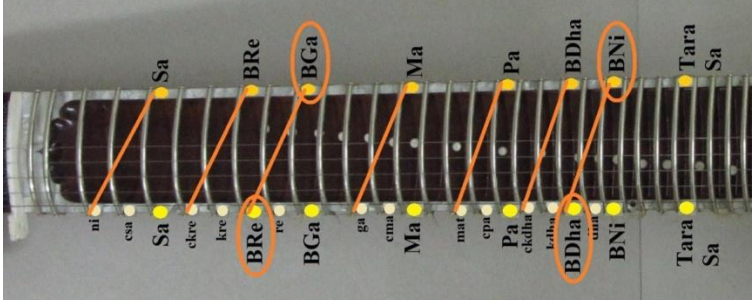
Again in the same manner lower down the *Chala Veena* by one *shruti* so that *Gandhara* and *Nishada* of *Chala Veena* will be tuned into *Rishabha* and *Dhaivata* of the *Dhruva Veena* respectively because now the *Chala Veena* is two *shrutis* lower than the *Dhruva Veena* [Bharata, p. 20].

This is the process of lowering the *Chala Veena* by two *shrutis*. During the earlier step the *Chala Veena* was lowered down by one *shruti*. The process was tricky because one needs excellent aural skill to recognize '*Pramana Shruti*' distance. However this second step is easy because one needs to lower down the *Nishada swara* of *Chala Veena* till it is tuned in with the *Dhaivata* of the *Achala Veena*. Automatically the *Gandhara* of *Chala Veena* will merge into *Rishabha* of *Achala Veena*.

If this does not happen then it means that the original establishment of seven *swaras* is not correct or the earlier aural positioning of '*Pramana Shruti*' is not correct. Here the performer can cross-check both the possibilities and make corrections if required. Corrections can be made either by re-establishing the seven *swaras* or re-establishing the *Pramana Shruti*. If corrections are not required then it shows that the *swaras* are in-tune and established properly.

As a result, all the *swaras* of *Chala Veena* are now two *shruti* lower than all the *swaras* of *Achala Veena*. One can enhance the aural skill of recognizing two-*shruti* distance by comparing all seven *swaras* of *Chala Veena* with their counter parts on the *Achala Veena*. At the end of this step, knowledge of 'two-*shruti*' distance/ interval is enriched.

Orange lines in the photograph indicate the shifted positions of original seven *swaras*. And the Orange circles indicate the *swaras* that are in-tune.



As a result of the mapping process five more *shrutis* are generated at the end of the second *Sarana/* step. These are as follows: *Eka-shruti Rishabha*, *Antara-Gandhara*, *Prati-Madhyama* or *Teevra-Madhyama*, *Eka-shruti Dhaivata* and *Kakali Nishada*. So in all seven plus five i.e. twelve *shrutis* are demonstrated at the end of second stage of the experiment.

Although all the seven *swaras* of *Chala Veena* are lowered by two *shrutis*, only five new *shrutis* are generated because two *swaras* of *Chala Veena*, *Nishada* and *Gandhara* have been mapped on the pre-existing *Dhaivata* and *Rishabha* of the *Achala Veena*. The new *shrutis* are generated on the *Achala Veena* and since *Dhaivata* and *Rishabha* were already there they are not counted as new *shrutis*. So at the end of this step five new *shrutis* are generated.

The Third *Sarana*:

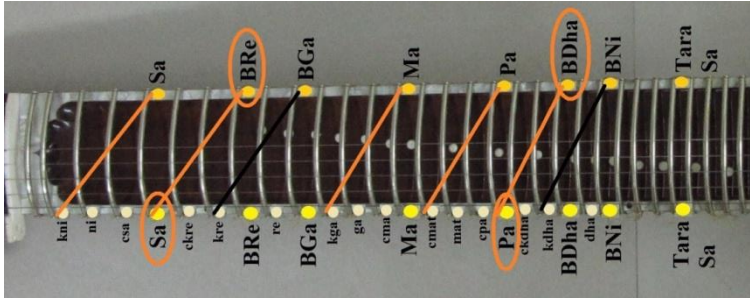
पुनरपि तद्वदेवापकृष्टायां धैवतार्षभावितरस्यां पञ्चमषड्जौ प्रवेक्ष्यतः त्रिश्रुत्यधिकत्वात् [Bharata, p. 20]

Again in the same manner lower down the *Chala Veena* by one *shruti* so that *Dhaivata* and *Rishabha* of *Chala Veena* will be tuned (enter) into *Panchama* and *Shadja* of the *Dhruva Veena* respectively because now the *Chala Veena* is three *shrutis* lower than its original position [Bharata, p. 20].

As a result of the mapping process, in the same manner, three more *shrutis* are generated at the end of the third step. These are as follows: *Sadharana-Gandhara*, *Chyuta-Prati-Madhyama*, and *Kaishiki Nishada*. Although, all seven *swaras* of *Chala Veena* are lowered by one *shruti*, only three new *shrutis* are generated as mentioned above because *Dhaivata* and

Rishabha are mapped on pre-existing *Panchama* and *Shadja* swaras of the *Achala Veena*. Also two more swaras of *Chala Veena*: *Gandhara* and *Nishada* are mapped on *Dvi-shruti Rishabha* and *Dvi-shruti Dhaivata* of *Achala Veena* that were newly generated during the first step of the experiment. Therefore they are not treated as new *shrutis*. As a result only three *shrutis* are newly generated at this step.

Orange lines in the photograph indicate the shifted positions of original seven swaras. Black lines show that the shifted positions of swaras are mapped on the previously generated *shruti* positions or pre-existing swaras. The orange circles show the swaras that are in-tune with each other.



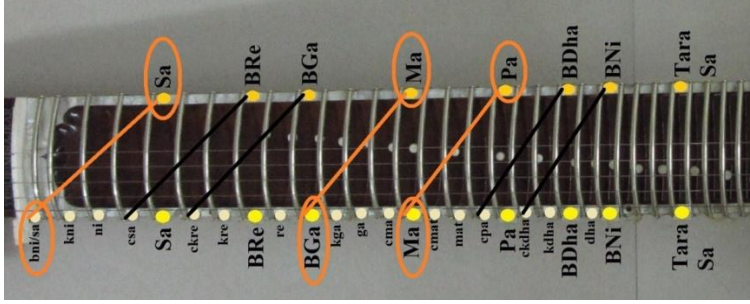
So in all fifteen *shrutis* are demonstrated at the end of the third stage of the experiment. If the original seven *swara* positions are added to this then the number becomes twenty two. So actually at the end of the third *sarana*/ step twenty two *shrutis* are demonstrated in this experiment. Then what is the need of the fourth step in the experiment? The fourth step is a concluding step to show that beyond these twenty two *shrutis* no new extra *shruti* is generated.

The Fourth Sarana:

तद्वत्पुनरपकृष्टायां पञ्चममध्यमषड्जा इतरस्यां मध्यमगान्धारनिषादवन्तः प्रवेक्ष्यन्ति चतुःश्रुत्यभ्यधिकत्वात् [Bharata, p. 20]

Again in the same manner lower down the *Chala Veena* by one *shruti* so that *Panchama*, *Madhyama* and *Shadja* of *Chala Veena* will be tuned (enter) into *Madhyama*, *Gandhara* and *Nishada* of the *Dhruva Veena* respectively because now the *Chala Veena* is four *shrutis* lower than the *Achala Veena* [Bharata, p. 20].

Orange lines in the photograph indicate the shifted positions of original seven swaras. Black lines show that the shifted positions of swaras are mapped on the previously generated *shruti* positions or pre-existing swaras. The orange circles show the swaras that are in-tune with each other.



Interestingly no new *shruti* is generated at this step. All the lowered *swaras* of the *Chala Veena* map exactly on pre-existing or pre-generated *swara/ shruti* positions of the *Achala Veena*. For instance, four remaining *swaras* of *Chala Veena*: *Rishabha*, *Gandhara*, *Dhaivata* and *Nishada* are mapped on *Chyuta Shadja*, *Eka-shruti Rishabha*, *Chyuta Panchama* and *Eka-shruti Dhaivata* of *Achala Veena* respectively. This is the concluding step of the experiment since no new *shrutis* are generated.

The beauty of the experiment is that at every step *Chala Veena* is lowered by one-*shruti* distance. Thus in first step, *one-shruti* distance/ interval, second step *two-shruti* distance/ interval, third step *three-shruti* distance/ interval and in the fourth step the *four-shruti* distance/ interval is demonstrated. At the end of first step maximum number of *shrutis* i.e. seven new *shrutis* are generated. At the end of second step slightly less i.e. five new *shrutis* are generated and in the third step only three new *shrutis* are generated. Thus in all twenty two *shrutis* are demonstrated out of which seven *shrutis* were already there and fifteen *shrutis* are newly generated during the experiment.

The last step does not generate a new *shruti*. So it makes a statement that no more new *shrutis* are possible. If the process continues then the same *shrutis* will keep on mapping one above other but no new *shruti* will be generated.

एवमेतेन श्रुतिनिदर्शनेन द्वौ ग्रमिक्वौ द्वाविंशतिश्रुतयः प्रत्यवगन्तव्या | [Bharata, p. 20]

As a result of this '*Shruti Nidarshanam*' experiment twenty two *shrutis* of two *Gramas* can be experienced or demonstrated [Bharata, p. 20].

A very important insight is that the '*Shruti-Nidarshanam*' experiment is successful if and only if the twenty two *shrutis* have equal temperament. This is the unique condition of '*Shruti-Nidarshanam*' experiment. If the *shrutis* do not have equal temperament then the mapping will go haywire. Logically and mathematically this is the only possibility. If the twenty two *shrutis* are not equi-distanced then they will not map evenly or they will map on extra positions and generate more number of *shrutis* or less number of *shrutis* depending on the relative distances/ intervals. *Svara* positions of *Chala Veena* will not map on the seven *swaras* of *Achala Veena* evenly, in the first step itself, if *shrutis* are not equi-distanced. Therefore, the magic number twenty two is highly critical in this regard.

That is why Bharata puts a strict condition that *Chala Veena* and *Achala Veena*, both should be exactly similar in all respects. Then only this experiment can be conducted. He does not clearly mentions that the *shrutis* should be equi-distanced because the experiment begins with seven *swaras* and not with *shrutis*. In Bharata's system *shrutis* are equal temperament *shrutis* while *swaras* do not have equal temperament. If the *swaras* are fixed on appropriate places then at the end of the experiment it will result into twenty two equal temperament *shrutis*.

The '*Shruti-Nidarshanam*' experiment is such a profound paradigm that its elegance and precision is un-parallel. Only a musical genius with sound foundations in mathematics and logic can design such an experiment. Bharata's paradigm of equal temperament twenty two *shruti* is not a hypothetical mathematical construct. But it was a profound practical paradigm till the times of Abhinavagupta and Sharangadeva i.e. till the thirteenth century A.D. at least. In contemporary era, this may open up the possibility to explore new musical spaces, new consonances, new dissonances, new melodies and harmonies to take Indian music forward.

Shruti-Nidarshanam According to Sangita Ratnakara

Sharangadeva also explains the process of demonstrating *shrutis* in a certain and definite way. The process is same though the details are slightly different than the *Shruti-Nidarshanam* process of Bharata. The process of demonstrating *shrutis* is very subtle and therefore should be performed with due care. Only a knowledgeable person who has very keen sense of tuning is capable of performing this experiment. The description goes on as follows.

एकविंश्या द्वितीयायां वीणैकाऽत्र ध्रुवा भवेत् | चलवीणा द्वितीया तु तस्यां तन्त्रीस्तु सारयेत् || [*Sangita Ratnakara*:1-3-17]

स्वोपान्त्यतन्त्रीमानेयास्तस्यां सप्त स्वरा बुधैः | ध्रुववीणास्वरेभ्योऽस्यां चलायां ते स्वरस्तदा || [*Sangita Ratnakara*:1-3-18]

एकश्रुत्यपकृष्टाः स्युरेवमन्याऽपि सारणा | श्रुतिद्वयलयादस्यां चलवीणागतौ गनी || [*Sangita Ratnakara*:1-3-19]

ध्रुववीणोपगतयो रिधयोर्विशतः क्रमात् | तृतीयस्यां सारणायां विशतः सपयो रिधौ || [*Sangita Ratnakara*:1-3-20]

निगमेषु चतुर्थ्यां तु विशन्ति समपाः क्रमात् | श्रुतिद्वाविंशतावेवं सारणानां चतुष्टयात् || [*Sangita Ratnakara*:1-3-21]

Once the *swaras* are established on both the *Veenas* then reduce all the seven *swaras* by one *shruti* on the *Chala Veena*. This is called first *sarana*. Again follow the same method of reducing all seven *swaras* by one *shruti*. After the second *sarana*, *Gandhara* and *Nishada* of the *chala Veena* will tune in with the *Rishabha* and *Dhaivata* of the *achala Veena* respectively because *Gandhara* and *Nishada* are reduced by two *shrutis* each on *Achala Veena*. Now as a part of the *sarana* process, reduce all the seven *swaras* again by one *shruti* so that *Rishabha* and *Dhaivata* of *Chala Veena* will tune in with the *Shadja* and *Panchama* of

the *Achala Veena* respectively. This is called third *sarana*. In the fourth *sarana*, by reducing all the seven *swaras* once again by one *shruti*, *Shadja*, *Madhyama* and *Panchama* of *Chala Veena* will merge into *Nishada*, *Gandhara* and *Madhyama* of the *Achala Veena* respectively. Thus, the twenty two *shrutis* are demonstrated [Sharangadeva, pp. 60-61]. In this experiment, at every stage or in every *sarana*, *Chala Veena swaras* are reduced by one *shruti* each and simultaneously, *shrutis* are mapped on the *Achala Veena* for demonstration of all the twenty two *shrutis*. The number of *shrutis* thus generated and demonstrated is exactly twenty two, not less nor more.

There are some interesting observations. At the time of *swara-sthapana*, twenty two strings are tuned and seven out of them are selected as *swaras*. Sharangadeva in the process of *Shruti-Nidarshanam* asks to reduce seven *swaras* of a *Chala Veena* by one *shruti*. But he does not mention what happens to the remaining strings on which *swaras* are not established. It opens up many possibilities. So this experiment of *Shruti-Nidarshanam* is different as compared to Bharata's experiment. With a close scrutiny of this experiment it is clear that again it's a mapping process. In Bharata's experiment new *shrutis* are generated and mapped on the *Achala Veena*. In Sharangadeva's experiment *shrutis* are not newly generated because *shrutis* are already established on twenty two strings. Seven *swaras* of *Chala Veena* are mapped on the pre-existing *shrutis* or strings of *Achala Veena*. Again it is logical to say that unless the *shrutis* on the twenty two strings of *Achala Veena* are equidistant, the experiment will not succeed. By reducing seven *swaras* by one-*shruti* distance every time, they will map on pre-existing strings respectively since the *shrutis* have to be equidistant. If the *shrutis* are un-equally established then seven *swaras* will require new places (but actually there are no extra strings available to map) on the *Achala Veena* and will generate extra *shrutis* that goes against the magic number twenty two. Therefore, as per Sharangadeva's experiment of '*Shruti-Nidarshanam*' *shrutis* have to be equidistant. Thus it is concluded that from Bharata's times to Sharangadeva's times *shrutis* were equidistant or equal temperament.

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