

The Methodologies of Bharata Muni and Dr. Vidyadhar Oke for Determination of 22 Shruti-s with Reference to their Practical Applicability: *Evidence and Conflicts*

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Abstract

This research paper aims to comparatively analyze the theoretical models of 22 Shruti-s modelled by Bharata Muni around 200 BCE¹ and by Dr. Vidyadhar Oke in recent times with respect to their practical applicability in the actual practice of music. Dr. Oke is a musicologist, a harmonium player and an inventor of 22 Shruti-s harmoniums who used a quite different method for the determination of his model from Bharata Muni. This paper highlights some subtle and stark differences between their methods, models and even their probable conception of Shruti-s. Subsequently, their models will be scrutinized on the basis of practical evidence acquired through empirical research attempted in the past to measure the exact mathematical denomination of Shruti-s. This will help to ponder upon the applicability of these theocratical models or perhaps any model in the actual practice of music. In addition, this paper will also hint towards the need for new empirical research in this field for making possible future advancements driven by scientific evidence.

Key Words: Shruti-s; Natyashastra; Grama; Veena; Music; Intonation

Introduction:

Similar to any other strong and potent musical tradition Indian classical music claims to have its own distinct system of intonation. According to the treatises of Indian music, it is based on 22 microtones in an octave known as *Shruti-s*. The first explicit description of *Shruti-s* is found in *Natyashastra* which is attributed to a sage known as Bharata Muni. The *Natyashastra* is a treatise mostly dedicated to different aspects of Dramaturgy, but it has also covered some aspects of music. There are inconsistencies in the time regarding its compilation. According to some scholars it was

¹ Tarla Mehta, *Sanskrit Play Production in Ancient India* (New Delhi: Motilal Banarsidass, 1995), 19–20.

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first compiled between the period of 200 BCE and 200 CE,² and others suggest between 500 BCE and 500 CE.³

The word Shruti stems from the Sanskrit term “Shru” whose literal meaning is “what is heard.”⁴ In simple terms, Shruti-s can be understood as the most minute interval of pitch detectable by the human ear and produced by a singer or a musical instrument.^{5 6} These Shruti-s can be understood as the fundamental building blocks of Indian music theory. These Shruti-s, by coming together, form the ancient Indian scale known as *Grama*. On Gramas, other crucial concepts of Indian music such as *Murcchana*, *Jati*, *Varna* and even *Raags* are based upon.

Bharata Muni in *Natyashastra* defines Shruti-s and Gramas as thus –

अथद्वौ ग्रामौ षड्जग्रामो मध्यमग्रामश्चेति।
अत्राश्रिता द्वाविंशतिश्रुतयः स्वरमण्डलसाधिताः।

Ref. Bharata Muni, Natyashastra, ed. M. Ramakrishna Kavi and J.S. Pade, Vol. IV (Baroda: Oriental Institute, 1964), 15.

Translation - “There are two Gramas – the Shadja Grama and the Madhyama Grama. To these belong the twenty-two shrutis contained within the seven notes.”⁷

In layman’s terms Grama means a place where many individuals live together in what is called a Grama or a village; similarly, an interdependent collection of notes is named Grama.⁸ Grama is more or less can be understood as a musical scale with 7 notes, which is based on 22 Shruti-s.

Bharatas division of Shruti-s in *Shadaja Grama*

Table 1 - Shadaja Grama

Shruti-s	1	2	3	4	5	6	7	8	9	10	11
Swaras				Sa			Re		Ga		

² Tarla Mehta, *Sanskrit Play Production in Ancient India* (New Delhi: Motilal Banarsidass, 1995), 19–20.

³ Wallace Dace, “The Concept of “Rasa” in Sanskrit Dramatic Theory,” *Educational Theatre Journal* Vol. 15, No. 3 (October 1963): 249-254, doi:10.2307/3204783.

⁴ Lewis Rowell, *Music and Musical Thought in Early India* (London: University of Chicago Press, 2015).

⁵ Ellen Koskoff, *The Concise Garland Encyclopedia of World Music*, Volume 2 (New York: Routledge, 2008) 936.

⁶ N. Ramanathan, “Influence of Sastra on Prayoga: The Svra System in the Post-Sangitaratnakara Period with Special Reference to South Indian Music” in *The Traditional Indian Theory and Practice of Music and Dance*, ed. Jonathan Katz (Netherlands: E.J. BRILL, 1992), 75–89.

⁷ Ananaya Kumar Dey, *Nyāsa in Rāga: The Pleasant Pause in Hindustani Music* (New Delhi: Kanishka Publishers, 2008), 1.

⁸ Ibid, 2.

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Shruti-s	12	13	14	15	16	17	18	19	20	21	22
Swaras		Ma				Pa			Dha		Ni

(Bharata Muni defined two main Grama-s. In the context of this paper only Shadaja Grama is important.)

Natyashastra describes a method known as *Sarana Chatushtayi* to determine the 22 Shruti-s. It used two veenas. Both were tuned according to Shadaja Grama, one known as *Dhruv Veena*, and the other as *Chal Veena*. The experiment is divided into four parts, described by Bharata as 4 *saranas*. In each *sarana* the *Chal veena* is detuned by one Shruti and through comparing it to the *Dhruv veena* in all 4 parts of the *sarana*, Bharata claimed that all 22 Shruti-s were discovered.⁹

The description of Shruti-s and Grama by Bharata Muni is brief and somewhat introductory. It doesn't address quite a few crucial and even basic questions, such as what is the mathematical measurement of Shruti-s in a Grama? Are they equal or unequal? Why are they 22 in number? Many scholars, Later, many scholars have pondered with philosophical arguments and different models of Shruti-s.

Dr. Vidyadhar Oke's Model of Shruti-s

The most recent and perhaps the most convincing study in the field of Shruti-s has been done by Dr. Vidyadhar Oke. His research has the highest mathematical sophistication and accuracy. Dr. Oke hails from Maharashtra. He is a third-generation harmoniumist, a musicologist, a retired medical doctor, and interestingly an expert in Indian, European, and Chinese astrology. He learned harmonium from late maestro Pandit Govindrao Patwardhan and has accompanied many great stalwarts of Indian music ranging from Pt. Vasant Rao Deshpande to Asha Bhosle. In addition to his musical career, he is a qualified medical doctor and 20 years ago he decided to leave the field of medicine to fully devote himself to music.¹⁰ His model of 22 Shruti-s is considered revolutionary by many known artists.¹¹ Based on his model he created a variety of instruments such as 22 Shruti harmonium, 22 Shruti metallophone, 22 Shruti tanpura, etc, and also designed an application that demonstrates the placement of 22 Shruti-s in approximately 500 ragas.¹²

The research of Dr. Oke is based on assuming the Shadaja Grama or modern Bilawal raag to be equivalent to the major Just Intonation scale. The intervals of Just Intonation are as thus –

⁹ Bharata Muni, *Natyashastra*, trans. N.P. Unni, Vol. II (New Delhi: Nag Publishers, 1998), 750-758.

¹⁰ "About Dr. Vidyadhar Oke," 22-Shruti, Dr.Vidyadhar Oke, 3rd February 2008, http://www.22shruti.com/about_dr_oke.asp.

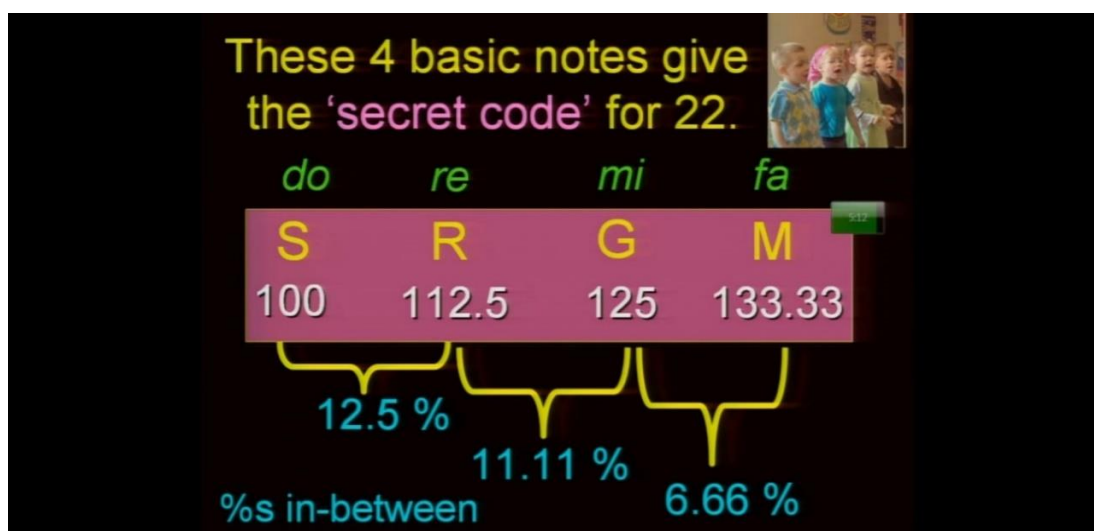
¹¹ "Testimonials - Comments from Musical Maestros & Experts," 22-Shruti, Dr.Vidyadhar Oke, 3rd February 2008, http://www.22shruti.com/expert_comments.asp.

¹² Ibid.

UGC-CARE enlisted & indexed in EBSCO International Database of Journals**Table 2 –**

Note Names	Sa	Re	Ga	Ma	Pa	Dha	Ni	Sa*
Intervals	$\frac{1}{1}$	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	$\frac{2}{1}$

Dr. Oke derived the Shruti-s quite systematically. First, he divided the scale (Major scale) into two parts, the first from Sa to Ma and the second one from Pa to Sa. The reasoning behind this is the consonant theory, that Pa to Sa: Pa, Dha, Ni, and Sa is nothing but the repetition of Sa Re Ga Ma in the scale with higher frequencies but similar ratios between them. Subsequently, he argued any normal child without any music training can sing Sa Re Ga Ma in tune according to the Indian scale because the Indian scale is “natural,” and their ears are not corrupted by listening to “unnatural scales” like 12-tone equally tempered scale (he considers it as unnatural). He added, if we closely observe the frequency of these natural notes, we will find that Re is 12.5% higher, Ga is 25% and Ma is 33.33% percent higher than Sa. If the frequency of Sa is 100, then the relative frequency of other Swaras would be as thus -

Figure 1¹³ -

Derivation of three micro intervals for Shruti-s as Dr. Oke's model is neither simple to understand nor easy to obtain. It is important to note that Dr. Oke has used percentage differences to determine

¹³ "The science of music | Vidyadhar Oke | TEDxIITGandhinagar," Youtube, Google, 9th October 2014, <https://www.youtube.com/watch?v=ipYLnHC5YDo&t=479s>.

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the Shruti-s. As mentioned above that his calculations are based on the Just Intonation scale. The derivation is as thus –

First, we need to take the differences in the intervals of just the Intonation scale by subtracting them from each other. As per the simple mathematical principle of scale theory, in order to subtract the pitches, they are required to be divided and to add them they are required to be multiplied. If we divided the second interval of Table 1, with its first we find: $(\frac{9}{8} \div \frac{1}{1}) = \frac{9}{8}$, by dividing the third with its second we find: $(\frac{5}{4} \div \frac{9}{8}) = \frac{10}{9}$. The rest of the differences are in the set S below –

$$S = \frac{9}{8}, \frac{10}{9}, \frac{16}{15}, \frac{9}{8}, \frac{10}{9}, \frac{9}{8}, \frac{16}{15}$$

To convert the elements of set S them into percentages, we take its elements and subtract them from 1 (the total length of the octave), then multiply by 100 to convert them into percentage. The results are below,

$$100 \times ((\frac{9}{8}) - 1) = 100/8 = 12.5\%$$

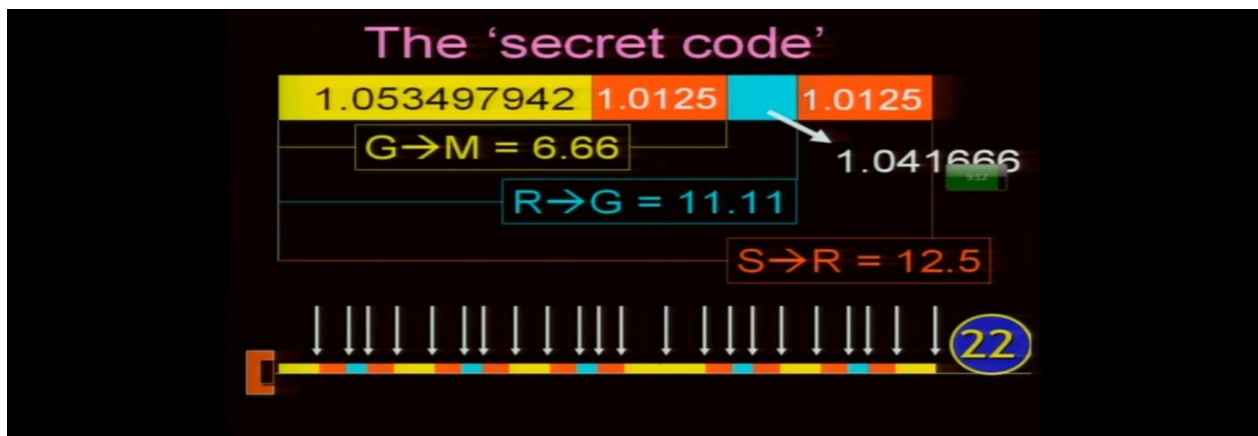
$$100 \times ((\frac{10}{9}) - 1) = 100/9 = 11.11\%$$

$$100 \times ((\frac{16}{15}) - 1) = 100/15 = 6.66\%$$

The use of percentages is not a standard practice in traditional scale theory. Dr. Oke also had the option of using the intervals in the fractional form instead of percentages that wouldn't have affected the result.

In the figure below Dr. Oke depicted how he derived his three Shruti-s –

Figure 2¹⁴ -



¹⁴ “The science of music | Vidyadhar Oke | TEDxIITGandhinagar,” Youtube, Google, 9th October 2014, <https://www.youtube.com/watch?v=ipYLnHC5YDo&t=479s>.

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The figure above depicts the derivation of three Shruti-s which are: 1.0125, 1.041666 and 1.053497942. Let's denote all these micro intervals as a , b and c . According to the figure 2 the derivation is as thus –

$$12.5\% - 11.11 = a$$

$$11.11\% - 6.66\% = b$$

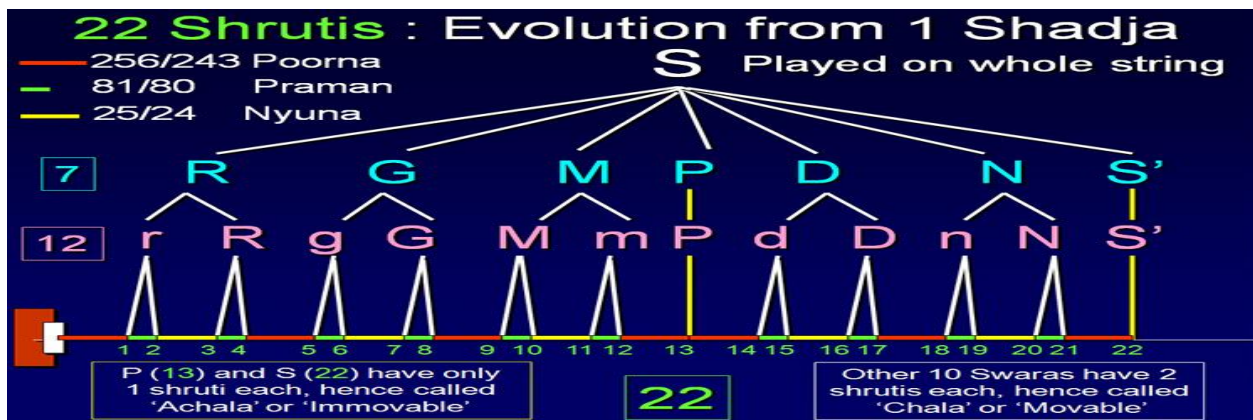
$$a - 6.66\% = c$$

There is a small trick in the derivation. We have to deduct not the percentage values but the fractional values they represent. 12.5% is $\frac{10}{9}$, 11.11% is $\frac{9}{8}$ and 6.66% is $\frac{16}{15}$. If we replace the percentage by its fractional forms and the subtraction sign (-) from the division sign ($\div$), because intervals are required to be divided in order to be subtracted. The derivation would be as thus -

1. $\frac{10}{9} \div \frac{9}{8} = \frac{81}{80}$
2. $\frac{10}{9} \div \frac{16}{15} = \frac{25}{24}$
3. $\frac{81}{80} \div \frac{16}{15} = \frac{81}{256}$

$\frac{81}{80}$ is the fractional form of 1.0125 (a), $\frac{25}{24}$ is the fractional form of 1.041666 (b) and $\frac{256}{243}$ is equal to 1.053497942 (c). Dr.Oke named a Shruti as Praman Shruti, b as Poorna Shruti and c as Nyun Shruti. It is important to note that I have used fractions rather than decimals. Figure 3 below, depicts Dr. Oke's Shruti-Swara model.

Figure 3¹⁵ –



The Table below depicts the Dr. Shruti-Swara model slightly clearer than the figure above.

¹⁵ "What Is The Meaning of a "Shruti"?, 22-Shruti, Dr.Vidyadhar Oke, 3rd February 2008, <http://www.22shruti.com/index.asp>.

UGC-CARE enlisted & indexed in EBSCO International Database of Journals**Table 1-**

	1	2	3	4	5	6	7	8	9	10	11
Swaras	Sa	re		Re		ga		Ga		ma	
Shruti-s	$\frac{81}{80}$	$\frac{25}{24}$	$\frac{256}{243}$	$\frac{25}{24}$	$\frac{81}{80}$	$\frac{25}{24}$	$\frac{256}{243}$	$\frac{25}{24}$	$\frac{81}{80}$	$\frac{25}{24}$	$\frac{256}{243}$
	12	13	14	15	16	17	18	19	20	21	22
Swaras	Ma		Pa	dha		Dha		ni		Ni	
Shruti-s	$\frac{25}{24}$	$\frac{81}{80}$	$\frac{81}{80}$	$\frac{25}{24}$	$\frac{256}{243}$	$\frac{25}{24}$	$\frac{81}{80}$	$\frac{25}{24}$	$\frac{256}{243}$	$\frac{25}{24}$	$\frac{81}{80}$

Conclusively, Dr. Oke determined Shruti-s with three different mathematical values using intervals of the Just Intonation scale. The Shruti-s are $\frac{81}{80}$, $\frac{25}{24}$ and $\frac{256}{243}$. Dr. Oke called them Praman Shruti, Poorna Shruti and Nyun Shruti.

Comparative Analysis of Bharata Muni's and Dr. Oke's Model of Shruti-s:

Dr. Oke's model of Shruti-s is based on assuming that the Indian major scale follows the tuning of Just Intonation. The major tetrachord (first four notes) used by Dr. Oke as a point of reference for further calculations follows the interval ratios of Just intonation. In contrast, Bharata Muni does not precisely hint towards any specific intonation system for his Shadaja Grama. In his description, he is completely blank about the mathematical ratios between the notes of his scale. However, it can be argued that Dr. Oke's assumption is not unreasonable as the Just Intonation scale is the closest approximation of the modern Bilawal scale (Indian major scale). One could argue that these crude discrepancies are bound to exist as both scholars existed in very different eras.

The other difference and perhaps the more significant one is regarding the distribution of Shruti-s in the scale. As depicted in Table 1, Bharata Muni's distribution of Shruti-s in the Grama is quite uneven. His Shruti distribution exists in 3 different bands which are 4, 3, and 2. His distribution of Shruti-s is 4 3 2 4 4 3 2. His model allows Sa, Ma, Pa to have 4 variants, Re and Dha to have 3 variants, and Ga and Ni to have 2 variants. Many scholars succeeding Bharata Muni such as Sharangdev, Matang Muni, Vishnu Narayan Bhatkhande etc have followed this model of distribution.

Dr. Oke's model on the contrary uses a more even distribution of Shruti-s. His model provides every swara except Sa and Pa with 4 variants. Among those 4 variants, 2 are *Shudha* variants and 2 are *Vikrta* variants. The principles of Indian music classify Sa and Pa as Achala Swaras (immovable notes). It is because Dr. Oke has Sa and Pa fixed to a single Shruti hence they are immovable and cannot have any other variants. Any note with a difference of Shruti from Sa and Pa would either be a note higher or lower than theirs.

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Both Bharata Muni and Dr. Vidyadhar Oke have made a crucial contribution to the aspects of Intonation in Indian Musicology. It can be argued that given his primordial era Bharata's model is based more on musical sense and hearing capabilities. On the contrary, Dr. Oke's model is an amalgamation of principles of Indian music laid by great scholars of Indian music such as Bharata himself, and musical sense, and mathematics. Bharata Muni provided the first description of Shruti-s and the first model of their distribution in a Grama. Dr. Oke, by making slight perhaps crucial changes in the Bharata's model has created a bit different model than Bharata Muni. His work is applauded by many great musicians, such as Kishori Amonkar, Padmabhushan Dr. N. Rajam, Padmashree Pandit Vishwa Mohan Bhatt, etc.¹⁶ Based on his model he has created a variety of instruments including a 22 Shruti-s harmonium which is slowly becoming popular among the fraternity of Indian musicians. It can have far-reaching consequences because Dr. Oke has found or perhaps created a route to apply his model of Shruti-s directly in the practice with the approval of many great artists.

Those following Dr. Oke's school of thought would argue that his model does nothing but unveil the microtones which were hidden in nature; therefore, they are universal and would enhance both qualitative and aesthetical aspects of Indian music if followed precisely. As a counterargument, it perhaps will not be incorrect to assume that like preceding models, this model will also have some modifications and we might find a different model or perhaps different models of Shruti-s, given the ever-changing and expanding realm of Indian music.

Practical Applicability of Shruti-s: Evidence and Conflicts:

Despite the continuing acceptance of Dr. Oke's model by great practitioners of Indian music, a crucial question is still unanswered, which is to what extent his model of Shruti-s or perhaps any model is followed by the Indian musicians in the actual practice of music? If the pitch variations in their performances are carefully analyzed using modern scientific equipment including the most subtle variations in pitches, would we find even a tentative model of microtones laid as a foundation of it?

In 1981, a musicologist named Mark Levy attempted to answer this question. Dr. Mark Levy analyzed several recordings of north Indian musicians using a chromatic stroboscope and a tape recorder (the best equipment available at that time). which could accommodate tape loops, allowing individual tones to be isolated and measured.¹⁷

According to Levy, "Many single notes were extremely unsteady with respect to the measuring capabilities of the strobe tuner."¹⁸ "This difficulty was dealt with by taking a visual average of the stroboscope's reading or by measuring only the most stable portion of a held pitch. Within a single

¹⁶ "Testimonials - Comments from Musical Maestros & Experts," 22-Shruti, Dr.Vidyadhar Oke, 3rd February 2008, http://www.22shruti.com/expert_comments.asp.

¹⁷ David Neumann Claman, "Western Composers and India's Music: Concepts, History, and Recent Music," (PhD diss., University of Princeton, 2001), 123.

¹⁸ Mark Levy, *Intonation in North Indian Music* (New Delhi: BIBLIA IMPEX, 1982), 16-22.

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performance by a musician, the intonation of recurrent pitches varied considerably.”¹⁹ He observed abundant variations in the context of different ragas, different registers and in relation to different musical contexts. For example, "[N]otes tended to be sharper in ascending lines than in descending lines, and sharper at melodic troughs than at peaks.”²⁰ As a result, he concluded –

“The laboratory results do not corroborate the insistence of many theorists on extreme precision and consistency with respect to microtonal differentiation in North Indian music. In each of the ten recordings analysed, every note showed a relatively high degree of flexibility in its intonation. Even the ground note Sa tended to vary, although it was almost always considerably more stable than other notes . . .”

“Theories placing North Indian music within the sole provenance of just intonation or Pythagorean tuning (or even a combination of the two) were also not supported by the empirical pitch measurements. On the whole, the data supported only those views which allowed for flexibility in intonation.”

In 1963, a pair of musicologists N. A. Jairazbhoy and A.W Stone made a similar study. They also found a great deal of variation in intonation from one artist to another, as well as within single performances by an artist.²¹ After analyzing recordings of several artists, they concluded that-

“Under these circumstances, it would seem pointless to consider applying the ancient 22 Shruti system, or for that matter, any system of exact intonation to North Indian classical music . . . The whole concept of intervals in North Indian classical music must be broad enough to permit the deviations recorded.”²²

As a student of Indian music who has studied Indian music for more than 10 years both academically and also traditionally under different Gurus of different *Gharanas*, I admit that the terminology of Shruti-s in both teaching and performances of Indian musicians is largely absent. I have never witnessed an instance where a Guru instructed me or another student to sing or play a note a Shruti higher or lower, even while ragas such as Miyan ki Todi or Adana are taught in the class which claims to have some of its notes sharper or flatter than their normal known positions. These minute nuances are generally taught by using words such as “sharp” or “flat” or the student

¹⁹ David Neumann Claman, “Western Composers and India’s Music: Concepts, History, and Recent Music,” (PhD diss., University of Princeton, 2001), 124.

²⁰ Mark Levy, *Intonation in North Indian Music* (New Delhi: Biblia Impex, 1982), 137.

²¹ David Neumann Claman, “Western Composers and India’s Music: Concepts, History, and Recent Music,” (PhD diss., University of Princeton, 2001), 124.

²² Jairazbhoy, Nazir Ali, and Stone, A.W. “Intonation in Present-Day North Indian Classical Music,” *Bulletin of the School of Oriental and African Studies* 26, (1963): 130-131.

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is obligated to understand the positioning of the notes just by Guru's demonstration of them while singing.

Conclusion:

Evidence driven by empirical research and practical observations does not support the claim that practices of Indian classical music follow any specific form of intonation. One could argue that Bharata's model offers greater flexibility because it is based on mere musical sense and instinct which perhaps does not require any precise mathematical model required to be followed. Perhaps it could be argued as one of the foundations of Indian classical music which contributed to making the realm of Indian classical music extremely diverse and unsuited to accommodate a single model of intonation.

Dr. Oke's work argues that his model is a representation of natural sounds that are universal. He presents a sophisticated mathematical model to support his claims. Approval of great artists and musical instruments applying his model directly into the practice is a profound positive in his favor. With that said, his emphasis on the naturality and universality of the microtones cannot completely counter the evidence found by empirical research of the past. And it would be an unintelligent hypothesis that the implementation of his model sooner or later would shape the whole diverse realm of Indian music according to it.

Both models raise some level of conflict whenever they are overemphasized, specifically when they are analyzed in relation to their practical applicability. Therefore, new empirical research attempts are required to make more advances in deciphering the concept of Shruti-s and their relation to the practice of Indian music. New research attempts to replicate the methodology of Dr. Jairazbhoy and Dr. Mark Levy where recordings of Indian classical music would be analyzed by using advanced technological equipment can produce some quite fascinating and perhaps different results. It might provide information about whether there has been any change that has occurred through time in the practice of Indian music regarding pitch preciseness and tuning. With that said, both models should be taught to the students of Indian music as part of Indian music theory without overemphasizing their applicability in the practical realm. By doing so we will support the present advances and leave enough space for future discoveries in the field.

References:

- Ahobal. (1971). *Sangeet Parijat*. Translated by Kalind, 3rd ed. Uttar Pradesh: Hathras.
- Ali, Nazir Jairazbhoy and Stone, A.W. (1963). "Intonation in Present-Day North Indian Classical Music." *Bulletin of the School of Oriental and African Studies* 26.
- Bharata Muni. (1998). *Natyashastra*. Translated by N.P. Unni. Vol. II. New Delhi: Nag Publishers.
- Claman, Neumann David. (2001). "Western Composers and India's Music: Concepts, History, and Recent Music." PhD diss., University of Princeton.

UGC-CARE enlisted & indexed in EBSCO International Database of Journals

- Clements, Ernest. (1931). *Introduction to the Study of Indian Music*. London: Longmans.
- Dace, William. (1963). "The Concept of "Rasa" in Sanskrit Dramatic Theory." *Educational Theatre Journal* 15 (3): 249-254.
- Dey, Ananya Kumar. (2008). *Nyāsa in Rāga: The Pleasant Pause in Hindustani Music*. Delhi: Kanishka Publishers.
- Flood, Gavin. (1996). *An Introduction to Hinduism*. Cambridge: Cambridge University Press.
- Google. "The science of music | Vidyadhar Oke | TEDxIITGandhinagar." Youtube. 9th October, 2014. <https://www.youtube.com/watch?v=ipYLnHC5YDo&t=479s>.
- Koskoff, Ellen. (2008). *The Concise Garland Encyclopaedia of World Music*. Vol. 2. New York: Routledge.
- Lewis, Rowell. (2015). *Music and Musical Thought in Early India*. Paperback ed. London: University of Chicago Press.
- Levy, Mark. *Intonation in North Indian Music*. New Delhi: Bibilia Implex Private Limited, 1982.
- Mehta, Tarla. (1995). *Sanskrit Play Production in Ancient India*. New Delhi: Motilal Banarsidass.
- Muni, Bharata. (1964). *Natyashastra*. Edited by M Ramakrishna Kavi and J.S. Pade. Vol. IV. Baroda: Oriental Institute.
- Nijenhuis, te Emmie. (1970). *Dattilam: A Compendium of Ancient Indian Music*. Netherlands: E.J. Brill.
- Ramanathan, N. (1992). "Influence of Sastra on Prayoga: The Svara System in the Post-Sangitaratnakara Period with Special Reference to South Indian Music" in *The Traditional Indian Theory and Practice of Music and Dance*, Edited by Jonathan Katz. Netherlands: E.J. Brill.
- Oke, Vidyadhar. "What Is The Meaning of a "Shruti." 22-Shruti. Updated February 3rd, 2008. <http://www.22shruti.com/index.asp>.
- Oke, Vidyadhar. "Testimonials - Comments from Musical Maestros & Experts" 22-Shruti. Updated February 3rd, 2008. http://www.22shruti.com/expert_comments.asp.
- White, E. Harvey and White, H. Donald. (2014). *Physics and Music: The Science of Musical Sound*. New York: Dover Publications.
- Witzel, Michael. (2003). *Vedas and Upnishadas*. Edited by Gavin flood. New Jersey: Blackwell Publishing Ltd.