Naad-Nartan
Journal of Dance & Music

UGC-CARE Listed ISSN: 2349-4654
Special Issue, January 2025

Science behind Sampradaya Carnatic Music Vocal Training System

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Abstract

As observed by Sir CV Raman, Carnatic music has one of the most complex musical structures, though taught traditionally in simple way. Though his experiments were more focused on the percussion instruments, and sound production and harmonics, it is note-worthy that he did identify vocal sound production to be equally complex. Carnatic music is based on Ragas, which are structured arrangements of semitones in ascending and descending frequency tones called semitones. These semitones are the building blocks, which when arranged in specific order simulate different moods, feelings, and experiences in livings beings, especially humans. This paper will dissect this concept of tones and semitones in scientific terms and will delve upon science behind how we humans are capable and do produce this complex combination of sounds through vocal training. This paper will also bring out the scientific beauty in the sampradaya training system, that not only makes this vocal training seamless but also procedural and multilayered so as to facilitate musicians of different caliber to be able to learn, practice and perform at their capacity.

Keywords : Carnatic Music, Vocal Training, Science and Sampradaya, Semitones, Ragas, Music Pedagogy

Research Paper

Introduction

Swarams and Swara Sthanas form the keystone to Carnatic Music and it is essential to understand them and have a deeper scientific study in how a human can learn and produce these complex tones distinctively through the vocal cord. The paper we will handle in detail how Carnatic music sampradaya learning system helps students achieve this seamlessly. There are 12 distinct frequency tones that make 16 up Swara Sthanaas (named semi tones), which forms the foundation of the Carnatic Music raga system. The Swarasthanas ordered from lower to higher frequency are:

	Sa Shadjam		
Ri1	Shudha Rishabam		
Ri2	Chatushruti Rishabam	Ga1	Shudha Gandharam
Ri3	Shatshruti Rishabam	Ga2	Sadharana Gandharam
		Ga3	Anthara Gandharam
		Ma1	Shudha Madhyamam
		Ma2	Prati Madhyamam
	Pa Panchamam		
		Da1	Shudha Daivatam
Ni1	Shudha Nishadam	Da2	Chatushruti Daivatam
Ni2	Kaisika Nishadam	Da3	Shatshruti Daivatam
Ni3	Kakali Nishadam		

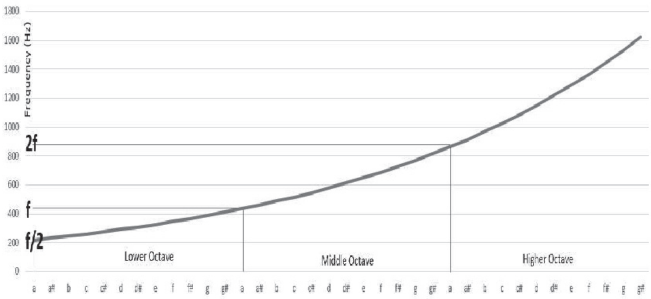
Each row in the above table represents distinct frequency tones, while some of the rows have two swara sthana names. E.g., Ri3 and Ga2 are different swara Sthanas they are same frequency tones. they are named based on the context of the ragas. The Shadjam and Panchama, the non-varying swara sthanams are called Prakruthi Swarams and play an important part in anchoring the octaves a singer is basing his Aadhaar Shadjam.

Sthayi refers to an octave (as in western music), which is a set of predefined frequencies of tones. there are 5 sthais practically possible to generate vocal tones having selected the middle (or base Shadjam) tone.

Considering the **Physics behind the Semitones,** the number $\sqrt[12]{2}$ (12th root of 2 = 1.059) plays a major role in this their arrangement. Each of the distinct semitone is $\sqrt[12]{2}$ times higher than the previous semitone. If the base Shadjam (Sa) is 440Hz tone, then Shudha Rishabam (Ri1) is $\sqrt[12]{2}$ times 440 = 464 Hz. And the next semitones Ri2 and Ga1, which represent same frequency tone, can be calculated as $\sqrt[12]{2}$ times 464 = 464 Hz.

Significance of this magic number is ratio between the Shadjam (Sa) of base octaves and any other octave is a whole number and thus in harmonics. Harmonics represents waves with frequency as multiples, say if we have a wave with frequency f, the waves with frequencies 2f, 3f, 4f are harmonics of the base waveform.

Important characteristics of a signal with waves that form a harmonic pattern is that the individual waves can be distinctly re-constructed, and our brain is no exception in this and can re-generate the individual waves with ease and that these harmonics play a key role in a music being pleasant to ear and at the same time complex.



The Significance of **Shadjam and Panchamam** is that they are Prakruti Swarams that are non-variable either from Swarasthanas and at the same time help in human brain able to clearly distinguish them and reconstruct them back using the superposition of waves algorithm.

$$y_m \sin(k_1 x - \omega_1 t) + y_m \sin(k_2 x - \omega_2 t) =$$

$$2y_m \cos\left[\frac{k_1 - k_2}{2}x - \frac{\omega_1 - \omega_2}{2}t\right] \sin\left[\frac{k_1 + k_2}{2}x - \frac{\omega_1 + \omega_2}{2}t\right]$$

This is the reason the Tambura, the instrument that is used to anchor and emphasize the Aadhaar Shadjam and Panchamam.

Human Voice box is an organ in neck region that helps to generate various frequencies of sounds using by modulating the air being exhaled and inhaled using the vocal cords. Humans learns to use these parts of the vocal system to generate cohesive syllables in few months and further learn to make cognitive words or may be phrases in a year. Basically, the art of producing tones is nothing but able to generate (sound) waves in air vibrating the larynx at a specific frequency. Ability to control this muscle movement is what we can call the primary part art of speaking for humans. The other critical part being the capacity of the brain to instruct on what to speak or what sound to produce.

Human brain is made up of millions of neurons that are connected to form complex neural networks. We can consider this as a massive field of fabric that is used up in portions for each of the human functions like walking, talking, motor-skills, singing, sensory perceptions, scientific calculations, visualizations, and projections and many more activities. All these activities and skills, as processed by the brain, are all learnt and improved over the period from the time of birth and never acquired pre-birth. E.g., a newborn baby does not have a clear vision even though the eyesight is good (the sense organ is working fine). The baby learns this over next few months, on how to interpret the images as sensed by the eyes and form the 3D image of what it sees.

In the same way it applies to hearing, walking, speaking, eating and all the motor skills. The characteristic of this learning is that the whole process is based on experiment, monitor, analyze & adjustments. A baby who wants to stand up trying to imitate elders around, would fail to stand up properly at first. It might be falling back multiple times. And as the baby learns, will try to put more weight on the front and would fall in the front few times until it adjusts its balance to correct values and thus the baby has learnt how to stand properly. Now the baby must repeat this multiple times for it to perfect the skill.

The same process is what is applied without exception for every skill acquired by humans. Carnatic music is no exception to this. Human brain needs to get trained to singing the semitones to generate a melodical, soothing and grammatically perfect music. Sampradaya Carnatic music teaching system is constructed very scientifically to achieve this in a very systematic approach. Let's discuss this in detail next.

Methodology

Qualitative research methodology is used to analyze the human skills to learn and produce sounds, and how the Carnatic music learning system helps streamline and accelerate this process by using a systematic approach. Each of the stages in the learning are deciphered in scientific angle pertaining learning system of the brain. Observations, and Practical Experiences were used to collect data for the research.

Hypothesis

Carnatic music teaching system as architected by Saint Purandara Dasa, is purely scientific keeping in mind the brain's learning methodology and capacity and maximizing the efficiency of learning. Let us consider the sampradaya system step by step to understand this process.

Stage 1: Music Novice

The Carnatic music student in this stage is having minimal or no knowledge on producing any systemic tones or music. Some may have already listened to music, but it's not mandatory. Only expectation is the student can hear and speak, and mentally fit to some extent to be able to grasp what the guru is teaching. This stage can be considered as a baby who does not know how to walk.

Stage 2: Introduction

This is the stage where the Guru sets the context of what is music, and the two basic bed rocks shruti and laya. A theoretical overview is provided to the students. This is like a crawling baby trying to realize there is something different that the elders are doing, which they do not yet know called standing and walking but just know that something different, efficient, and interesting is being done compared to them. This is when the baby gets ready to learn a new skill.

Stage 3: Tambura & "Sa Pa Sa"

Guru identifies the Pitch (fundamental octave range) of the student as the primary step and sets the Tambura to play Pa (lower octave) Sa Sa _ Sa. The students will have to listen to Tambura and imitate the sounds. Guru teaches how to imitate in human voice, which the students are expected to repeat and try to match the sound produced from Tambura. The students train their brain to command the voice box to generate the expected tone. The student initially will fall short of the required frequency or overshoot by a big margin. Depending upon the listening skill, and Guru's hand holding, the student slowly keeps correcting the tone and at some point will succeed in producing the correct sound. This is called positive learning data set and now the student will have to try and repeat this till he/she is able to generate these couple of tones at will.

Stage 4: Sarali Varisai

Seven distinct and conveniently spaced semi tones are introduced to students. Ragam Mayamalavagowla is chosen for the reason it has the most conveniently spaced and non-overlapping semi tones as mentioned below.

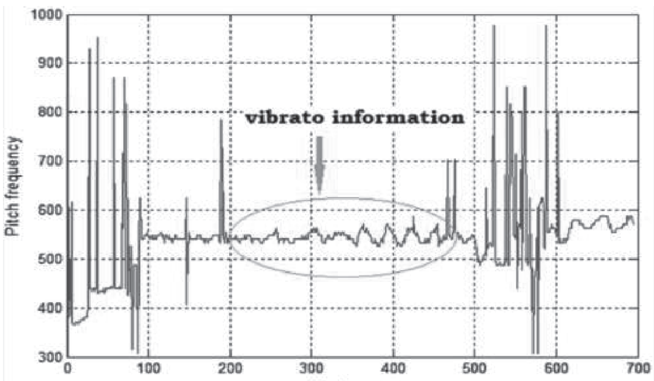
Sa Ri1 Ga3 Ma1 Pa Da1 Ni3

The student is already capable of identifying and reproducing Sa and Pa. Guru teaches to produce the other semi tones as well. Students are made to practices in plain ascending (Aarohanam) and descending (Avaroanam) order initially. This trains their brain to position the voice to a specific tone and produce the tone for desired duration (kaarvai). This is an important step as brain is internally able to calibrate the frequency of each semi tone to the required actuation of the vocal cord. It is impossible to do the √(12&2) based frequency calculations every time a semitone has to be produced. But the human brain can make neural connects based on positive training data set, to map the required actuation of the muscle if a semi tone is required.

Human brain does an indexing and makes access and retrieval of certain neural portions faster based on usage levels. So as the student repeats the Sarali Varisai, the brain can retrieve the actuation information much faster, producing the tones easier. Student also gets trained to listen deeply and identify the fine difference in the frequency and correct the leaning in the neural schema. Simple taalam called Adi taalam is introduced in this stage. This is another very critical skill of maintaining consistent tempo and making beating actions in parallel to making tone sounds. As the student advances in Sali Varisai, and comfortably able to generate tones in order, Guru teaches them to proceed till different semi tones and back as well. This gives better control on the tone productions as the tone is reversed from every specific tone.

Stage 5: Jantai Varisai

As the second step of learning process, it's the repetitions. Jantai Varisai deals with repetitions of individual semi tones and even complex patterns of semi tones. This is like a baby trying to make a stable walk.



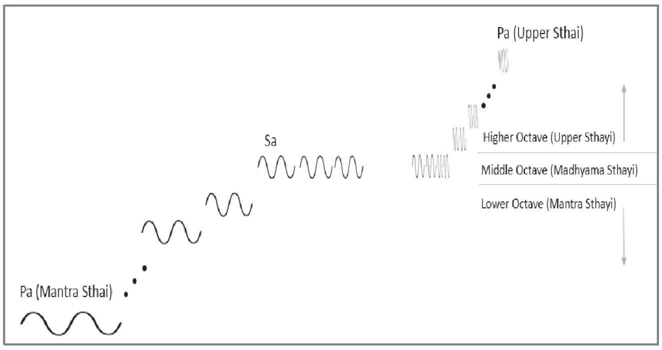
It is very important for the baby to be successfully make pairs of steps to be able to calibrate its leg movements to its body weight and height and size, and at the same time maintain the stability. Very critical step in brain's learning method is re-enforcing the already learnt weights and adjustments to the network by the way of comparison of actual and expected values. Repetition of successive semitones and patterns helps in this process of making the brain self-test its learnt network layer.

A critical learning which happens at this stage is Sphuritha Gamakam. Gamakam is an effective way of making the discrete tones looks continuous. There are various types of Gamakam, of which Sphuritha Gamakam is used for stressing a semitone.

In this stage as the student is gets confident of repeating the semitones based on the base shruti without making mathematical calculations or forced voice modifications to try and achieve the frequencies. Student's brain is now capable of successfully attenuate the voice box muscle to generate the required frequency at will.

Stage 6: Higher and Lower Octave Exercise (Upper Sthayi & Mandra Sthayi Varisai)

Next is extending the vocal range of the student to the octaves higher and lower to the base octave. In any field of arts and games training globally, increasing the range of operation of the athlete, it boils down to increasing the range in steps. One shot increase to target rage will never work with the human brain. Brain's most efficient training methodology is to reinforce on the basic and increasing the range in small steps till we reach the required max and min. It is also very interesting to note that reinforcing and repeating the basics is also critical for the brain to retain the basics and make it accessible faster.



Stage 7: Datu Varisai

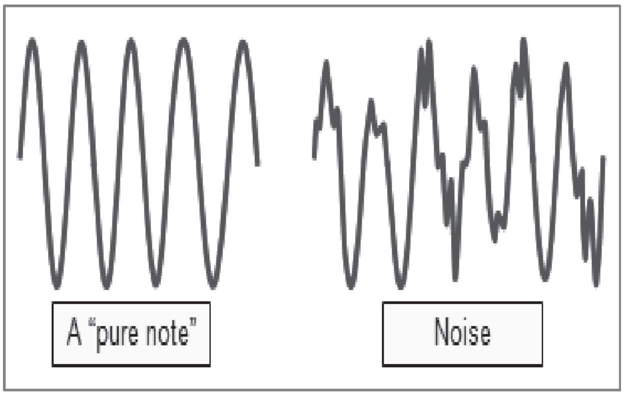
Best ways for our brain to make sure the learning is perfect, is by skipping steps. Let's consider a baby that has just learnt walking, would get more confident in the act by trying to jump. This will make sure the human brain is able to actuate the body parts so be able to land at any level of choice and still be in stable state. Same way, Dhattu Varisai helps the students to be able to land and get back to any semitone and get back to starting semitone. This gives the maximum confidence for the music students to generate any sequence of semitones, which is critical to understand and sing complex ragas, that might have complex and discontinuous patterns of tones.

Stage 8: Alankaaram

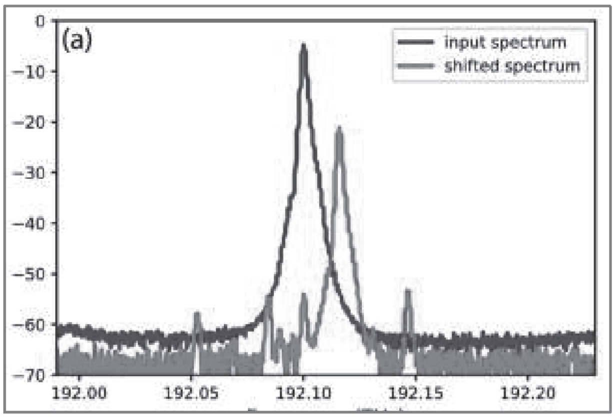
For a new art to be learnt with maximum efficiency, it is essential to be learning that at a time the brain has already learnt the basic for the art previously. Now students introduced with new concept of seven taalam and multiple speeds or kaalapramanam. There is one alankaaram for each of the taalam. The student slowly starts to learn making the taalam while singing. Two different body parts are being actuated parallel and to be in perfect synchronicity. Kaalapramanam is another important aspect to be learnt by the students and get mastery over it to become a Carnatic music practitioner.

Stage 9: Akara Saadhakam

This is the stage where the student can reduce the SNR (Signal to Noise Ratio) in the musical tones generated. Noise can be generated in two ways, addition of small non-harmonic frequency tones in the pure tone, and the other one is small undesired shift in the tone frequency which is generated.



Added non-harmonic tones.



Shifted frequency Noise (frequency spectrum)

Akhara Saadhakam is the practice methodology used to correct these noise levels and get pure tones at will. This specific methodology requires the student to generate the semitones in one specific syllable (vowels like 'a', ‘e’, ‘i’) instead of using the semitone sthana names like Ri, Ga etc. This helps the Human brain to identify the noises and do auto correction and precise adjustments to the muscle actuation logic. Another major learning happens is the breadth control. It’s very critical skill to know to control breadth to make precise tones and pauses.

Stage 10: Geetham

This is the first-time lyrics is introduced to the students. This involves completely another half of the brain which is used for memorizing text and words and deals with literature and meaning. This is again a great steppingstone in the learning process. Simple Ghamakams are introduced in this stage, along with new Ragams like Malahai, Mohanam, Shudha Saveri, Kalyanai, Saveri, Kambhoji, Aarabhi, Bhairavi, Anandha Bhairavi and Sri Ragam are introduced. Each of these ragas have special characteristic and structuring of the semitones. Complexity is added beautifully in steps like introducing Prathimadhyamam, Ghana & Bhasanga Raga, Higher & Lower Octave sanchaaram, retrograde semitone arrangement etc.

Step 11: Swara Jathis, Varnams & Krithis

Swara Jathis introduces to the students more complex sahitya structure, and more importantly the raga Swaroopam, Bhavam (mood) & Rasam (essence) for important ragams. Krithis with similar complexity are as well introduced simultaneously. Varnams & Krithis introduces a lot of Prayogams and complex laya structures & Ghamakams, initiating the ideas of mano dharmam (impromptu improvisation) and thus set the platform for students to embark on a wholistic performance journey at ease with deeper knowledge of varied dimensions and perspectives of musical and literary aspects from different composers.

Stage 12: Advanced Tutelage

This stage is generally for serious learners who would like to get an advanced knowledge and understanding of the art and be able to perform on stage. There are a lot of mathematical complexities and musical nuances involved in this stage, which gets embellished by the Guru, and listening to innumerable concerts from stalwarts and contemporaries.

Conclusion

Carnatic music is a never-ending continuous learning process, with every learning opportunity embellishing and refining the knowledge. The Sampradaya Learning system makes sure this process is streamlined and systematic as defined above to make sure each learner gets an opportunity to get to next level based on practice and makes sure they do not get into negative training data set, which would hamper the learning at any point.

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