

1. Introduction:

‘Raaga’ the unique feature of Indian music and its appeal to emotion has captured the minds and hearts of art pilgrims all over the world. However, the fundamental concepts of consonance and dissonance, which are employed to build a raaga, are the same which are universally applicable to all the music systems of the world. The rules that differ from system to system and prima facie appear arbitrary become clear once their rationale is understood. The understanding of this rationale lays the foundation of the laws of science of music in general.

Rationale of the study;

The raaga system is the most unique and glorious feature of Indian music. It may not be hyperbolic to say that it makes the very backbone of our musical system as no form of our music, whether classical or light, can have their existence without it. It may look surprising but, it is a fact that even the simplest types of folk music do follow the principles of raaga i.e. ‘raaga tatwa’ (जल रत्न) though it may not be following the full scale /grammar of the same.

The raaga system is no doubt the most complicated and scientifically evolved feature of our music. Though, originally the talented artists took their inspirations from the simple folk songs but their creative genius, their constant search for finding something marvel and beautiful and their powerful desire for self expression has given rise to the thousands of artistic patterns and hundreds of scales of music. Simultaneously, the scientists also had kept themselves busy in discovering some law and order i.e. the basic principles governing the structure of raagas and prepared its grammar and tried to bring the art under the flow of scientific order and had given the art of music, a science and discipline of raaga. But, it was not in the artist’s nature to remain bound within the rigid discipline of the science, he, therefore, deviated very often from these rigid rules and gave birth to new and original combinations of swaras/notes to create various melodies. Scientists, in their turn found out new scientific basis for such deviations and also kept on making the scientific theories more & more general which had/could have had wider applicability.

With this background in mind, the researcher had attended many live concerts of the legendary performers as mentioned earlier wherein it had been observed that

only the selected few raaga scales had been performed by the different artists, whether they were vocalists or instrumentalists. The artists of Carnatic music also were found repeating the selected few raagas in their performances. However, while analyzing these raaga scales in the light of scientific rules, which govern the laws of sound, the researcher had felt & experienced that many popular raagas are very closely related with one another. For example if the sequence of music intervals of swaras used in raaga Bhupali (Sa,Re,Ga,Pa,Dha,Sa) are reversed keeping the tonics 'Sa' as the base , we get swaras of one other very popular raaga i.e. raaga Malkaus (Sa, komal Ga , Ma, komal Dha, komal Ni, Sa) which itself is one of the established raagas and is as melodic in nature as raaga Bhupali (the process & logic of reversal of order has been explained in detail later in the document).

It was seen that the resemblance in these two raagas is of similar nature as that of one object & its visual mirror image. We all know that the mirror image of an object has the same ratios of its length & breath as that of the object itself, the change only takes place in its orientation as the left side/lower side of the object becomes the right side/upper side of the mirror image & vice versa, keeping all other proportions/ratios among various other parts of the picture, the same. Also, that the mirror image keeps the basic visual appeal of the original object. In raagas and melodies too, while reversing the order of swaras/notes, the music intervals of both the original & the mirror image remain the same, and it is only the order of the swaras i.e. their sequence that changes from aarohi/avrohi (ascending/descending) to avrohi/aarohi (descending/ascending), keeping the intervals between them intact and thereby keeping the tonal ratios/proportions between them also intact.

Similar observations had also been made while reversing the sequence of musical intervals of swaras used in raaga Durga (Sa,Re,Ma,Pa, Dha,Sa). In doing so the Swaras of raaga Dhani (Sa, komal Ga, Ma, Pa, komal Ni, Sa), which also is an established Raaga were found. Such observations had also been made in few of the raagas used in Carnatic music, such as raaga Hindolam & Mohana where, the sequence of musical intervals of swaras used in both raagas are the mirror images of one another. It was seen that such pair of raagas are related with one another in the same way as that of the visual mirror images of any object, as explained above and therefore they could , on the similar analogy, be termed as the audio mirror images of one another. Such raaga pairs though would be having the same musical intervals between their various swaras but, will have a totally different audio appeal. This

phenomenon will be in the same way as the mirror images of a tree or a bus; though their mirror images have the same proportions of length & breadth as the original object but, they have a totally different visual appeal than their originals. Also the famous Guru-Chela picture explain the concept wherein the the same picture, if turned upside down, change its visual appeal, the first being that of a Guru (master) and the later looking like a Chela (pupil).

The present study is an effort to find such inverse relationship between various established raagas. There is also an effort to analyze the aesthetic appeal of such audio mirror images of the raagas. In many cases such audio mirror images of the raagas have been found to be having the same melodic character as the original raagas themselves.

Objectives of the study:

The main objective of the study has been to understand the various processes involved, both scientific & aesthetic, in the formation of raagas in Indian music, mainly Hindustani Music, right from the inception of this term raaga, its historical background etc. and to see the possibility of existence of inverse raaga relationships. For achieving this objective the following subjects have been identified for the present study:-

- 1) Study of the laws of Sounds, the principles of consonance & dissonance, which are primarily used in the formation of the musical scales in general & raaga scales in particular as used in Hindustani & Carnatic music.
- 2) Study of the evolution of raagas from the musical scales starting from Moorchana (eWZk), Jaatis Gayan (t k r xk u) & Raaga- Ragini (j k x & j k f x u h) system etc.
- 3) Study of the rasa theories of raagas and the factors responsible for the aesthetic appeal of Indian melody and raagas along with the associated scientific basis etc.
- 4) Study of the physics involved in knowing the consonance & dissonance level of various swaras used in raaga scales and appreciation of the consonance/dissonance levels of the mirror images of various swaras with the prime swara 'Sa' i.e. primarily the understanding of the logic, according to which, swara 'Pa' is considered inversely related to the swara 'Ma' and vice

versa. And similarly the logic by which the swaras Re, Ga, Dha & Ni are considered inversely related to swaras komal Ni, komal Dha, komal Ga & komal Re respectively.

- 5) Study of the process of using inversely related swaras in raaga scales and the melodic significance of raaga scales so formed.
- 6) Exploring the possibility of finding the inverse relationships in various existing raaga scales of Hindustani/Carnatic music & also exploring the possibility of existence of new raagas scales based on this inverse relationship.
- 7) Ascertaining the utility and existence of such inverse raagas relationship and new raagas so explored during the study.
- 8) To draw conclusions about the existence of 'inverse raagas', which are useful in understanding both the science and the art of the Indian music so that it becomes useful to the society in general and music society in particular.

Subject of Enquiry:

In simple words, 'raaga' is a melodic law or order. Technically, it is a swara pattern obeying the laws of consonances & dissonances. We know that in a musical scale, there are seven main swaras, which can be divided into two groups. One group each from the basic swara i.e. madya 'Sa' to the fourth swara of the musical scale viz. 'Ma' & the other from the fifth swara of the musical scale i.e. 'Pa' to the upper tonic swara i.e. taar Sa. It is also already known that in any raaga formation the following rules are usually observed:-

i). A minimum of 5 swaras are used in raaga. ii) Swara 'Sa' is necessarily an indispensable swara of the raaga and at least one swara each from the above mentioned two groups of swaras is used in it. iii) The raaga does not exclude both swaras Ma & Pa at the same time. iv) The raaga does not use both the komal & teevra varieties of the same swara consecutively one after the other. v) The raaga scale must be capable of giving a unique aesthetic experience. vi) The raaga uses the Vaadi (o^lah) & Samvaadi (l^oah) swaras. Vaadi Swara is the most dominant swara of the raaga, and it is so related to samvaadi swar that both the swaras bear the 4th or 5th swara interval relationship with the other. Also, these two swaras and their relationship with the tonic swara 'Sa' mainly determine the character and mood of the raaga.

The present study undertakes to examine the existence & validity of inverse raaga scales formed by the mirror images of the already established raagas in the background of all the above mentioned general rules of formation of raagas and also tries to ascertain, if the new inverse raaga scales do have any independent aesthetic appeal and character of their own etc.

Inverse harmonic relationships & mirror images;

For the first time in Indian or international literature on the subject, this study undertakes an elaborate assessment of universal harmonic relationship of swaras & the possibility of existence of inverse raaga scales, which satisfy all the existing rules of raaga formation as discussed above. Though the theory, that the two swaras having one particular harmonic relationship have the same degree of consonance or dissonance, even when the harmonic relationship between them is reversed, has been propounded by the earliest mathematicians of 3rd century B.C, the great Greek mathematician, Pythagoras was the first scholar to suggest the following cyclic musical scale based on the above principle.

$F \pm C \pm G \pm D \pm A \pm E \pm B$ i.e. $Ma \pm Sa \pm Pa \pm Re \pm Dha \pm Ga \pm Ni$

In this scale, the positive ascending order (ascending 5th) is of swaras

$F + C + G + D + A + E + B$ i.e. $Ma + SA + Pa + Re + Dha + Ga + Ni$

& the negative descending order of fifth (i.e. descending 5th) is

$F - C - G - D - A - E - B$ i.e. $Ma - Sa - Pa - Re - Dha - Ga - Ni$

In the above scale, the basic tonal relationship of Sa & Pa has been used, which are related with each other with the harmonic relationship of 1: 3/2 i.e. the frequency of Pa is 3/2 times the frequency of 'Sa', the base swara. We can also say that Pa is 3/2th harmonic of 'Sa'. If the frequency of 'Pa' is again multiplied by 3/2, we get the frequency of Re which would be 3/2th harmonic of swara 'Pa' or we can say that Re is the $3/2 \times 3/2 = 9/4$ th harmonic of 'Sa'. If we use the same logic further, we get the swara Dha, which is 3/2th harmonic of swara Re etc. The scale using positive ascending order i.e. ascending 5th, therefore, becomes as under

Swara : Sa - PA - Re - Dhaetc.

Swara Ratio: 1 3/2 9/4* 27/8*

(3/2 x 3/2) (3/2x3/2x3/2)

*(All swaras of upper Octave (Taar saptak) have the frequencies that are double of the frequencies of respective swaras of middle octave (Madya saptak). Similarly all swaras of lower octave (Mandra saptak) have the frequencies that are half ($\frac{1}{2}$) of the frequencies of respective swaras of madya saptak).

If, however, this order is reversed we get the following scale:-

Swara :	Sa -	Ma -	komal Ni
Swar Ratio:	1	$\frac{2}{3}$	$(\frac{4}{9})$
		(1 divided by $\frac{3}{2} = \frac{2}{3}$)	($\frac{2}{3}$ divided by $\frac{3}{2}$)

This way we see that using the ascending order of 5th we get the Scale 'Sa, Pa, Re, Dha, Ga, Ni' & so on , while using the descending order of 5th we get the scale 'Sa- Ma-komal Ni , Komal Ga, komal Dha, komal Re & so on. We will see that Ma- Pa, Re-komal Ni, Ga-komal Dha, Dha-komal Ga, & Ni-komal Re are inversely related with each other in terms of harmonic relationships with respect to the basic swara Sa.

This concept has been discussed by many scholars of musicology at many forums which include a seminar of Psychology of Music held at Pune in 1975 and thereafter a seminar on Musicology in 1980 held at IIT Madras.

The present work explores the understanding of the raagas and their mirror images, both in Hindustani & Carnatic system of Indian music based on the concept of these inverse relationships of swaras in the background of the scientific laws which govern the consonance/dissonance of musical sounds.

Universal Applicability:

The principles of consonance & dissonance, being mathematical in nature, are universal in their applicability. The present study has tried to examine if the concept of mirror images of audio patterns of raagas as used in Indian Music as discussed above, is also applicable in other systems of the world i.e Chinese, Arabian &, mainly in the Western system which is based on harmony and chords. It has been seen that this concept of musical inverses has the universal applicability as it is based on principles, which are scientific in nature and are applicable all over like all the other principles of science such as Newton's laws of motion in Physics, Pythagoras theorem of right angle triangles in Geometry & Trigonometry etc.