

RELATIONSHIP BETWEEN MUSICAL NOTES AND COLOURS: A PHYSICAL ANALYSIS

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Abstract: Periodic variations in sound waves which are appealing to the ears are called music. Similarly, the seven colours in the visual region can be mixed and arranged to create aesthetically appealing paintings. This leads to the idea of a relation that exist between the seven notes of the music and the seven colours in the visual region of electromagnetic spectrum. Many scientists have made attempts on similar grounds with varying degrees of success. While these previous works tried to establish such a link between Western music and colours, the present work concentrates on Carnatic music. The present approach follows the establishment of a colour related to each of the swarasthana (musical note). The validity of this approach is then checked by comparing the resultant colour (and the consequent emotion) produced by a raga (equivalent to scale in Western music) and the emotion supposed to be evoked by that raga.

Key words: Persistence of vision, persistence of hearing, Raga, Kalam, Swarasthana

INTRODUCTION

The most important of our sense organs, the eyes and the ears get stimulated by waves; visual sense being stimulated by visible range of electromagnetic waves and auditory sense by audio range of sound waves. An analogy can be seen to exist between these visual and auditory spectrums; because, irrespective of the sense organs (eyes or ears) through which we receive the stimuli, both can evoke the same kind of emotions in our mind.

Regular variations of sound waves which is aesthetically appealing to the ears constitute what is called Music. Although there exist different musical systems in various parts of the world, all or most of them has seven basic notes as their foundation (Pierce 1992). When we look at the visual spectrum of electromagnetic waves, a similar division into seven colors can be observed. From the time of Greeks itself there have been attempts to introduce an analogy between the 7 colors and the 7 notes of music (or if we speak more specifically, between the audible and visual perceptions of energy).

In this work, a similar problem is addressed. Unlike the already made attempts, where an analogy with western music have been made, here a trial is made to do the same for the seven notes of Carnatic music. The work is further extended by trying to identify a particular color for a specific raga. It is a known fact that a particular color is associated with a certain emotion. Similarly, every raga is observed to project a certain emotion. Hence, in this work the authors are also trying to see whether the color that can be associated with certain raga agrees with the emotion it project.

Music therapy and colour therapy are popular holistic therapeutic systems that have been less researched and consequently less understood (Azeemi and Raza 2005). The current research is an attempt to establish the link between these two systems of healing. If such a link can be found, it will increase the effectiveness of both the systems by manifold. In such a case it will be possible to complement one system of healing with the other (Hollfoth 2000).

THEORY AND METHODOLOGY

SWARAS AND SWARASTHANAS

The most basic unit of Carnatic music is the swara (or note) which simply indicates the position in the audible spectrum occupied by a particular sound or pitch of the sound. Actually, the spectral position is better described as swarasthana. There are 7 swaras in Carnatic music, namely, Shadjam (S), Rishabham (R), Gandharam (G), Madhyamam (M), Panchamam (P), Daivatham (D), Nishadham (N).

These 7 swaras are divided into 12 swarasthanas. In Carnatic music, an octave (Shadjam to Nishadham) is based on the ratio 1:2; Panchamam is located through the ratio 2:3; similar definitions exist for all the twelve swarasthanas. The seven basic swaras occupy various swarasthanas and produce a total of sixteen swaras that form the basis of the raga scheme. The Shadjam and Panchamam swaras are like the foundations upon which the rest of the melody is constructed. So, these occupy fixed sthanas (positions) (Sairam 2009). The names of the swaras, the swarasthanas they occupy and the frequency ratio are given in the Table 1.

Table 1

Swara sthana	Name of swara	Notation	Frequency ratio
1	Shadjam	S	1
2	Suddha rishabham	R1	1.07
3	Chatusruthi rishabham	R2	1.13
	Suddha gandharam	G1	1.13
4	Shatsruthi rishabam	R3	1.2
	Sadharana gandharam	G2	1.2
5	Anthara gandharam	G3	1.25
6	Sudha madhyamam	M1	1.33
7	Prati madhyamam	M2	1.48
8	Panchamam	P	1.5
9	Suddha daivatham	D1	1.6
10	Chatusruthi daivatham	D2	1.69
	Suddha nishadham	N1	1.69
11	Shatsruthi daivatham	D3	1.8
	Kaisiki nishadham	N2	1.8
12	Kakali nishadham	N3	1.88

KALAM AND RAGA

Kalam is equivalent to the concept of tempo in western music. It is inherently connected with talam, the rhythmic beat which acts as the regulating factor of musical recitation. Once the singing of a composition has begun, the length of an aksharam (number of musical notes in one beat) must remain constant. When the delivery of the composition involves one note per aksharam, it is said to be in first Kalam. But the music can be made to appear faster by changing the duration of notes.

Thus, there may be two notes per aksharam, four notes per aksharam and so on. These correspond to the second and higher Kalams.

Ragas are sometimes defined as the melody types. The raga system is a method of organizing tunes based on certain natural principles. Ragas are not simply abstract collection of swaras that occur together to produce a tune. Each raga has associated with it an emotion that it induces in the listener and the performer (Balaji 2019). Table 2 contains the different emotions or Rasa and their corresponding colour as given in Natyashastra.

Table 2

Rasa	Meaning	Color
Shringar (erotic)	Delight	Pale light green
Hasya (humorous)	Laughter	White
Karuna (pathetic)	Sorrow	Grey
Raudra (terrible)	Anger	Red
Veera (heroic)	Heroism	Pale orange
Bhayanaka (fearful)	Fear	Black
Bibhatsa (odious)	Disgust	Blue
Adbhuta (wonderous)	Wonder	Yellow
Shanta (peaceful)	Peace	White

Our attempt is to relate 12 swarasthanas (audible spectrum) in Carnatic music with the visible spectra.

REQUIREMENTS/LOGIC

- The frequencies of the musical notes should fall into the visible range of electromagnetic spectrum.
- ‘S’(Shadjam) is the musical note which is having the lowest frequency in an octave. So the ‘S’ in the chosen octave should be corresponding to the lowest frequency in the visible spectrum ie, red.

RESULTS AND DISCUSSIONS

While in Western music there are different schemes of frequency standards for musical notes, in Carnatic music, the frequency associated with each swara is not fixed, but is relative. The frequency of all swaras depend on the frequency of the basic swara ‘S’. All other swaras have a fixed ratio with ‘S’ (Holmes and Hallam 2017). In order to satisfy the above mentioned requirements, we choose the ‘Sauveur pitch’ standard which is based on middle C (C4) being set to 256 Hz (Gaab and Zuk 2017). Thus, we choose the frequency of ‘S’ in the fourth octave to be

256Hz and is kept doubling. At the 25th octave, it is found out that the wavelength corresponding to that frequency falls in the visible region of the electromagnetic spectrum.

$$F_s = 256Hz$$

After 25 octaves,

$$F_s = 256 \times 2^{21} = 536.87MHz$$

Hence the corresponding wavelength can be found out by

$$\lambda = \frac{v}{F_s} = \frac{343}{536.870912 \times 10^6} = 639 \times 10^{-9}m \text{ (approximately).}$$

639 nm is the wavelength which corresponds to the colour Scarlet (Hue-Red). In this way, the swara which has the lowest frequency is related to the colour which also falls in the lower frequency region. As discussed earlier, the frequency of all the swaras depends on the frequency of the basic swara, 'S'. They can be determined by using Table 1. The results are tabulated below in Table 3.

Table 3

Swarasthana	Notes	Frequency (Hz)	Wavelength
1	S	256	639
2	R1	274	597
3	R2	289	566
	G1	289	566
4	R3	307	533
	G2	307	533
5	G3	320	511
6	M1	340	481
7	M2	379	432
8	P	384	426
9	D1	410	399
10	D2	433	378
	N1	433	378
11	D3	461	355
	N2	461	355
12	N3	481	340

Next attempt is to find out the colours corresponding to the above-mentioned wavelengths. Following sites were used to identify the colours: academo.org/demos/wavelength-to-colour-

relationship; www.rgbworld.com; www.colour-blindness.com/colour-name-hue/. The identified colours corresponding to different wavelengths are tabulated in the Table 4.

Table 4

Notes	Wavelength x 10 ⁻⁹ m	R	G	B	Hex	Colour name
S	639	255	38	0	FF2600	Scarlet
R1	597	255	200	0	FFL800	Tangerine Yellow
R2	566	213	255	0	D5FF00	Electric Lime
R3	533	105	255	0	69FF00	Bright Green
G1	566	213	255	0	D5FF00	Electric Lime
G2	533	105	255	0	69FF00	Bright Green
G3	511	9	255	0	09FF00	Lime
M1	481	0	218	255	00DAFF	Deep Sky Blue
M2	432	51	0	255	3300FF	Han Purple
P	426	80	0	255	5000FF	Electric Indigo
D1	399	130	0	177	8200B1	Dark Violet
D2	378					UV (Ultra Violet)
D3	355					UV
N1	378					UV
N2	355					UV
N3	340					UV

When a ‘Keerthanam’ (musical composition) in a particular raga is recited, it is done through the Arohanam (the sequence of notes used in the Carnatic raga in the ascending order) and Avarohanam (the sequence of sounds used in the Carnatic raga in the descending order) of the musical notes of the raga. It is well known that a raga has the ability to evoke emotions in a listener. So an attempt is made to assign a particular colour to a specific raga to predict the emotion which it induces in a listener. When a person hears a sound, their ear drum vibrates for 0.1 sec. This gives rise to what can be called the persistence of hearing, which is analogous to the persistence of vision in the case of eyes. When music is recited in the fifth kalam, the temporal gap between consecutive swaras is approximately 0.1sec. Hence, in this case, a ‘mixing up’ of these sounds will happen in the ear drum and what is heard by the listener will be a combined effect of both these sounds. Hence, when someone is listening to a particular raga, the swaras composing the raga might be undergoing the persistence of hearing in their ears and must be making a resultant effect in their brain. This must be the reason for attributing a particular emotional quality to each raga.

Since the objective of this study is to find a chromatic analogy to each raga, the method of averages is used. Two ragas are taken as examples and the above formulated procedure is applied.

HAMSADHWANI:

Arohanam : S R2 G3 N3 S

Avarohanam: S N3 P G3 R2 S

Average frequency, $F = 283\text{Hz}$, wavelength = 578nm. This wavelength corresponds to the colour 'Yellow' [RGB(249,255,0) Hex:#F9FF00]

This raga creates 'veera' rasa (Valour) and a happy mood, the colour corresponding to which falls in the Red-Yellow region. Whereas the 'Yellow' colour signifies positive feelings like joy, energy, honor etc. Thus, we can say that the result in the present case is only partially correct.

HINDOLAM:

Arohanam: S G2 M1 D1 N2 S

Avarohanam: S N2 D1 M1 G2 S

Average frequency= 297Hz and wavelength = 551 nm. This wavelength corresponds to the colour 'Spring bud' (hue-green) [RGB (166,255, 0) Hex: #A6FF00]

Hindolam creates mixed positive feelings in the mind of listeners. Green is an emotionally positive color related to balance and harmony. Green is also the color of growth, spring and renewal. Thus, in this case, the colour can be said to be in match with the emotion created by the raga.

CONCLUSIONS

In this work, the attempt was to establish the existence of a relation between music and colour. It is a trivial fact that both music and colour can affect emotions (Rebecca 2021). This fact is used to check whether the assumptions and procedures adopted in this work are right or not. As it is seen in the previous section, in the case of some raga, expected result was obtained. But there are cases where the observations are contrary to what is expected. This suggests the need for a modification of the colour assignment scheme. Also, the present procedure is limited in its applicability to the case of music recited in the fifth or higher Kalam. Hence, the development of a procedure which can be applied irrespective of the Kalam of the music is very much relevant. Also, such a limitation in the applicability of the present procedure to higher Kalam alone leads to the noteworthy inference that the emotion projected by a certain raga will change with the Kalam in which it is sung.

REFERENCES

Azeemi, S T, and Raza S. M. 2005 "A critical analysis of chromotherapy and its scientific evolution". Evidence-Based Complementary and Alternative Medicine. 2(4): 481-488.

- Balaji, S. 2019 “Exploring Raaga Improvisations of Carnatic Music with Mathematical Proof Writing”. In Bridges 2019 Conference Proceedings. p. 403–406. Available from: <https://archive.bridgesmathart.org/2019/bridges,2019,403.pdf>
- Gaab, N, and Zuk J. 2017 “Is There a Link between Music and Math?”. Scientific American Mind. 28(3):74. Available from: <https://www.scientificamerican.com/article/is-there-a-link-between-music-and-math/>
- Hollfoth, K. 2000 “Der Einfluss der Colortherapie auf Gesundheit und Wohlbefinden: Farben sind mehr als nur "Physik" [effect of color therapy on health and wellbeing: Colors are more than just physics]”. Pflege Z. 53(2): 111-112.
- Holmes, S, and Hallam S. 2017 ”The impact of participation in music on learning mathematics”. London Review of Education. 15(3): 425–438. Available from: <https://doi.org/10.18546/LRE.15.3.07>
- Pierce, J.R. 1992 “The Science of Musical Sound”. W. H. Freeman and Company: New York.
- Rebecca N. H. de Leeuw, Sophie, H. Janicke-Bowles and Qihao, Ji. 2021 Mass Communication and Society. 25: 626-648.
- Sairam, T.V. 2009 “Melody and Rhythm& ‘Indianness’ in Indian Music and Music Therapy”. Music Therapy Today. 7: 876–91.