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MODELING MELODIC PHRASES FROM HINDUSTANI CLASSICAL MUSIC FOR STUDY OF INVOCATION OF EMOTIONS

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ABSTRACT

36 individuals from various strata of life and of varying knowledge of music were subjected to listen to short clips of instrumental music in Indian classical format for about 3 minutes. The clips were drawn from various ragas dealing with known types of emotions. The listeners were asked to select the segment of the clip that invokes the concerned emotion most intensely. After collecting data, the most accepted segments were expressed as melodic phrases in terms of musical notes. The phrases were quantified in terms of frequencies of the notes involved. A basic statistical model was formed that can reduce a phrase to a numeral that can be treated and the pattern thus arrived at can be statistically analyzed. It was found that the numerals associated with the ragas with changing emotions gradually from pathos to frolic and back to pathos, coinciding with time zones of the day that the ragas are allotted actually went on increasing to reach the maxima and started back reducing in value. This gives an impetus to further carry out a detailed research to validate the hypothesis that it is the melodic phrases formed by permutations of musical notes with varying emphases on each, that are responsible for invocation of various emotions and not the isolated notes as generally believed and taught in music schools.

Keywords: *Sound, Tones, Swaras, Shruti, Intonation, Raga, Emotions, Phrase*

INTRODUCTION

Indian Classical Music (ICM) is one of the most ancient, sophisticated and evolved art forms. It is mainly based on mono aural melodic structure i.e. devoid of harmony. The melodic structures called ragas are drawn from various scales. The ragas follow rigid frameworks of rules, yet giving out virtually an infinite space for improvisation for the artists even while performing. The ragas-identified by now-run into hundreds. Some may use exactly the same set of notes as some others but still evoke different, even diametrically opposite emotions due to differences in other rules they follow. Even if the composition is without lyrics or just instrumental, the same emotions are evoked, validating the power of musical energy beyond reasonable doubts.

ICM, like any music, is composed of basically musical notes, but duly customized into fundamental entities called Swaras. It has been believed for long as evident from various literature pieces that these swaras are individually associated with various emotions. However, this concept needs a serious review due to various contradictions observed. The research has been started by the author and the outcome of the initial feasibility is brought out here, that convincingly endorses the view that it is the melodic phrases formed by various permutations of the swaras rather than the swaras by themselves that are responsible to stimulate the brain to feel a certain emotion by performing or even by just listening to them as part of the rendering of the ragas in various formats. This outcome paves the way for further extensive research to arrive at precise relations between music and science such as mathematics and statistics in order to probably extend their applications to improve music training.

1. SOUND AND MUSIC

For those uninitiated in the arena of sound and music as a scientific and artistic synergy, it is imperative to throw some light on the basics, before we get on to the subject proper.

Sound is a form of energy that propagates in the form of waves. It is a physical quantity having attributes such as wavelength, frequency and intensity. They are measured in meters, hertz and decibels respectively. It travels through a medium such as air and reaches the ears. Nervous system carries it to the brain where it is processed and interpreted, so as to have an impact on emotions.

From Indian musicology, it is learnt that sound, called Naad is of two types viz aahat and anahat. While anahat naad is inaudible and used for communication between saints and Gods as believed. Aahat naad is produced by impact of objects on each other and is audible

provided it falls in the audible range, which happens to be 20 Hz to 20 KHz for humans. Obviously there are virtually infinite frequency points even within this range.

An interesting part to know is that all the musicians' world over came to consensus albeit at different points in time that there are only certain frequency points in the audible range that appeal to the brain and thus can be used for the purpose of music. These points are separated from each other with fixed intervals. Universally 12 such intervals are recognized. ICM has added 10 more points within these intervals, thus totaling it to 22, called Shruties.

1.1 **Tones, Notes and Swaras.** There are seven main frequency points called Tones. They are very regular and pure. They represent a sinusoidal waveform. Also there are five more frequency points lying as intermediate points in the main seven intervals. The total 12 points thus obtained are known as Semitones. This complete interval is known as an octave or a Saptak. There are numerous such octaves in the audible range.

It is however observed that production of pure tones or semitones is almost impossible with mechanical means including vocal chords. What we actually obtain is a mix of frequencies with one prominent desired value. It is this peculiar combination of notes that qualify a tone as a Note provided it soothes the brain rather than creating a jarring effect such as grating.

Coming to ICM, the Swaras are probably the smallest but complete musical entities that are a customization of notes and not to be taken as the notes themselves. The swaras are the notes that are ornamented based on the way they are presented in a melodic structure such as a raga. It is the rules of the raga that decide as to how a note will be approached, dwelled upon and left behind during progression of the composition. So swaras though named as Sa, Re, Ga, Ma, Pa, Dha and Ni, they actually occur in different avatars in different ragas. They are not stand-alone entities but their avatar depends on the presence of other swaras and their interaction in a particular melodic structure.

1.2 **Intonation**. :The tones which were universally accepted as musically usable bear fixed mathematical relations with each other. There is a root note called tonic and allotted the status of Shadaj or Sa. All other notes are in fixed ratios with the tonic and its octave, i.e. higher Sa has the frequency that is exactly double that of the tonic. These fixed ratios are different for different notes. This is because this is how they are found in nature or they are the ones that actually appeal to the brain the most. When a scale uses notes with these ratios, the scale is called Just Intonation (JI) scale. This scale is used in ICM. In the western world, in order to simplify the whole affair to facilitate making of musical instruments, the ratios were tempered with. They were rounded off and made the same for all semitones with the preceding ones. This came to be known as an Equally Tempered (ET) scale. In the ET scale, a semitone has the frequency exactly equal to that of the previous semitone multiplied by

twelfth root of 2. Indian musical instruments are amenable to produce either of the scales as against western, which rigidly follow only ET scale tuned with procedures such as Pythagorean tuning, using complex mathematics. Thus ICM is considered the purest form, albeit highly sophisticated.

1.3 **Timbre**. It is another attribute of sound, not covered earlier since it is considered qualitative rather than quantitative. It is this attribute that distinguishes various sounds from each other, such as the sound of a male voice from a female voice, a train versus an airplane, sitar versus violin and so on. Although it is called a qualitative attribute due to its effect sensed, actually it is highly quantifiable. When any sound is produced, along with a fundamental frequency which is the loudest, its higher harmonics, its integral multiples are also produced. Besides the neighboring frequencies as brought out before, the higher harmonic decides the timbre of the sound produced. The detailed analysis can be carried out using mathematical tools such as Fourier analysis. This quantification of timbre has enabled synthetic production of sounds of various musical instruments with electronic synthesizers.

So much so far as basic sound and music theory is concerned. The aim was to convincingly bring out that all the aspects of sound and music are strongly quantifiable and can be mathematically dealt with.

2. THE MUSICAL ENIGMA CALLED A RAAGA

A raga is a melodic structure that is beyond the scope of words. It is not merely a scale. It follows a rigid framework of rules that must be religiously followed. A raga is associated with emotions and within its framework of rules, provides an infinite canvas at the hands of the performer to paint on.

A raga has minimum five notes of an octave, duly tailor-made and qualified as swaras. Sa being the root note that can be located at any note in the scale. Correspondingly all other notes get automatically deployed, thanks to the fixed ratios from the tonic.

Though the five or six or seven swaras of a raga can form infinite permutations by taking together one or two or three, etc at a time, all the permutations are not permissible under the laws governing the particular raga. The permissible permutations or phrases however can be presented in almost an infinite number of ways, thus making the ICM amenable to improvisation even during rendition.

Ragas are associated with time of the day and seasons. This makes them consonant with emotions experienced during respective time periods and seasons. It is seen that the mood of a normal person in normal circumstances is fresh, hopeful and energetic in the morning. By afternoon the energy is at peak and then it starts receding. So does the state of

mind. Late evenings are tired and look for calm. Nights tend to be sad, somewhat hopeless and pathetic. Rainy seasons bring joy, summer heat pain and so on. The ragas associated with the times of the day and seasons are seen to aggravate these emotions.

3.SCIENCE BEHIND MUSIC: WHY STATISTICS?

The foregoing sufficiently explains that there is science behind music that can be very precisely quantified and analyzed. Whether it is loudness, pitch or timber or appeal to the brain or annoyance, all have been mathematically explained.

To move the process further, it was felt that a research is needed to examine statistically as to how various melodic phrases give rise to various emotions. Here Statistics is considered more suitable than pure mathematics because of the presence of a vast-near infinite-number of melodic phrases possible and thus needing statistical tools to analyze them.

Melodic phrases are the groups of swaras that are used in ICM for improvising the composition during its rendition. These phrases, well within the framework of rigid rules of the respective ragas provide a structure to the composition. The raga, so to say, is rendered creatively by the artist by presenting these signature phrases in different formats without much repetition. His or her aim is to invoke the desired emotion. Various musical ornamentation is utilized to make the melody emotionally intense. Dynamics coupled with rhythm also plays an equally important role in this exercise. All in all, all these creative processes give rise to such a high number of variations or permutations ie phrases that a composition is almost impossible to be repeated even by the same artist. Analysis of such a vast number of phrases along with the randomness at which they occur, can only be carried out using statistical methods.

3.1. **Our Hypothesis**. While it has been scientifically proven that music does evoke human emotions, these more of brain- response studies mostly dealt with tempi of various musical compositions but not the compositions per se. As brought out earlier, it has always been believed that it is the isolated musical notes that invoke various emotions. The nav-rasas are associated with the individual notes as follows:-

Ser No	Note	Rasa associated	Emotion Invoked
1.	Shadaj	Veer	Valour
2.	Rishabh	Roudra	Wrath
3.	Gandhar	Karuna	Pathos

4	Madhyam	Hasya	Frolic
5	Pancham	Shringar, Hasya	Romance, Frolic
6	Dhaivat	Bibhatsa	Stench
7	Nishad	Karuna	Pathos

There are some serious observations to this association as elucidated below:-

(a) The above table considers only tones and not semi-tones. As brought out earlier there are only seven tones but 12 semitones. Further there are 22 recognized and discernible frequency points, the use of which has been found to have profound impact on invocation of various emotions. The same note sounds differently in different ragas e.g. komal Gandhar of Darbari is different from that of Bageshree, komal Rishabh in Puriya Dhanashree is different from that in Shree and so on. These so-called same notes have different frequencies in different ragas or their different shruties are used. This important detail seems to have been rounded off with arbitrary allotment of just six out of 10 emotions. This exercise appears to trivialize such a grave subject matter.

(b) Numerous raga-pairs or even triplets such as {Miya Malhar, Bahar}, {Bhupali, Deshkar}, (Marwa, Puriya, Sohoni}, {Darbari, Adana} and so on share same musical notes but evoke different emotions from each other.

(c) Notes Madhyam and Pancham are thought to evoke hasya raas or laughter. Madhyam as Vaadi note in Bageshree, Malkauns, Bhimpalasi, etc. and Pancham as Vaadi note in Darbari, Puriya Dhanashree are rendered the most as per the definition, but these ragas evoke emotions of pathos, melancholy and not anywhere close to laughter. There are numerous such examples.

(d) In ICM, the tonic i.e. Shadaj can be placed on any note. Hence all the notes have locations or frequencies as chosen by the renderer. This means, the Madhyam supposedly evoking laughter for the singer A, can be Dhaiwat for a singer B, evoking sadness.

(e) A single note as a single frequency is never rendered in ICM. It is always a part of a melodic phrase or at least developed to form a swara of the particular raga as brought out earlier.

The above observations led us to put forward our hypothesis that it is the melodic phrases that evoke emotions and not individual notes in isolation.

4. THE FEASIBILITY SURVEY

36 volunteers were chosen to participate in the experiment. They were drawn from different musical backgrounds from totally musically illiterate to visharad levels in order to have unbiased responses.

16 ragas from different time zones of the 24 hour time-cycles i.e. associated with different emotions were chosen. Three -minute-clips of each ragas only in instrumental renditions were recorded. The participants were made to listen to the clips and asked to tell which of the 4, 5 segments of the particular clip evoked the associated emotion most intensely.

The responses were analyzed statistically and the most effective phrases were converted into numerals using an initial model that was specially evolved for the purpose.

5. THE ANALYSIS

Following steps were taken for quantification process:-

(a) The tonic i.e. Shadaj of each composition was determined by trained listening. This also means the pitch or the scale e.g. kali 1, safed 2, or C sharp, D etc. The respective frequency of the tonic was thus precisely determined.

(b) The notes in the phrase identified in the survey were determined and their respective frequencies found out using fixed ratios with Shadaj as per the microtone or the Shruti of the note used in that raga.

(c) An effective phrase that invokes the given emotion from a particular raag, as agreed to by the majority was considered for the scrutiny. With the hypothesis in mind it was decided to form an algorithm wherein a basic mathematical cum statistical model using the phrases would be evolved , which would be improvised with at subsequent stages as iterations necessitated by more academic and practical inputs. Accordingly to begin with, it was considered necessary to arrive at a numerical figure representing a phrase so that mathematical and statistical analysis of the vast number of phrases as occurred in ICM can be carried out. This number was named “Phrase Index” and the model was constructed in stages to arrive at the most realistic values of phrase indices. In the first stage, the following model was made that simply gives out summation of the frequencies of various notes of the phrases with reference to the frequency of the respective tonic note, Sa. This gave us the first model as,

$$I_p = \sum A_n X,$$

Where,

I_P = Phrase Index

A_n = Ratio (A_n) of the frequency of the n^{th} note of the phrase to that of the tonic of the composition.

X = Fundamental Frequency of the tonic.

On running this model, it was found to be too simplistic, given the high degree of sophistication governing ICM in that it was found that this model entails its first upgrade i.e. significance to be accorded to the chronology of notes within the phrases. Cases in point here are; while the phrase MgRS of raag Bhimpalasi invokes romance, the phrase gMRS of raag Abhogi Kanada creates a very serious atmosphere, albeit both phrases consist of same notes hence yielding same value of I_p due to mere summation. Similarly the phrase .NRS of Yaman is somewhat devotional (Bhakti Ras) while the phrase R.NS of Vrindavani Sarang creates a playful romantic feeling. Yet another case involves the phrase DNSr. of raag Sohoni that gives a fast moving happy feeling as against the phrase DNr.S of raag Puriya that deals with melancholy. These and numerous other examples amply dictate the need to modify the model to give importance to chronology of notes. An expression (7-n) was considered appropriate for insertion in the model with the following explanation.

(i) The term n denotes chronological position of the note in the phrase. Its incorporation accounts for the sequence of notes in the phrase.

(ii) A raag consists of five, six or seven notes. Hence a phrase would have maximum six notes; a seventh note would render its value zero and thus nullify its contribution to invocation of an emotion. Further addition of notes will actually have negative values thus reducing the effect of the phrase due to diminishing returns. Hence the value of n has been limited to 6 with the expression (7-n). Multiplying with this term gives due importance to chronology of the notes within the phrases.

Due to above, the model gets upgraded to the following avatar:-

$$I_p = \sum(7\text{-}n)\, A_n\, X,$$

Besides providing a valid up gradation this modification brings in an important inference that the phrases are not mere combinations of notes but are actually permutations, thereby increasing the vastness of their numbers and thus requiring statistical treatment to the whole phenomenon rather than just mathematical.

(d) The second iteration as above was run but again could not provide a significant impetus to the proceedings, necessitating a further iteration of modification. Further scrutiny led to the thought that the mode of rendition of a note within the phrase might also have something to do with emotions. The cases in point here are; the phrase .P.nSRg of raag Adana creates a light romantic emotion whereas the same phrase when rendered with a heavy andolan or shake on komal Gandhar creates a profound and grave emotion. Similarly the phrase .NrG invokes totally different emotions in ragas Marwa and Puriya wherein more weightage to Komal Rishabh in Marwa gives a serious and pitiful effect while that to Shuddha Gandhar in case of Puriya gives a shringaric feeling. This exercise revealed the need to provide weightages to be accorded to each note as per the time dwelled, inter-se importance of the note in that raaga, whether it is in the arohi or avarohi i.e. ascending or descending mode and so on. The following statistical model was evolved after going through details of music theory and discussions with musicologists as to what factors carry higher weightage and thus merit the place as what mathematical position such as multiplier, exponent, etc.

$$I_P = \sum (7\text{-}n)\ (A_n X)^{Wn}$$

Where,

w_n =weightage of the nth note

Figure included in the following section rationalizes the octave of the note in the phrase.

6. **THE RESULT**

When the model was run with the phrases obtained through the survey and duly quantified, we got a very interesting result. The values of phrase indices are ascending as the time of raag progresses from midnight to afternoon, thereby indicating time versus change in the emotions which becomes serious to happy progressively. From afternoon to midnight, in the 2nd half the values are progressively decreasing indicating a change of mood from happier towards sadness which is actually experienced and already otherwise established.

The following summary shows the ragas and the phrase indices. Top of the circle corresponds to midnight and progressive 24 hours along the circle. The ragas of all time zones, viz night, morning, afternoon, evening, etc are seen with progressive increase and then decrease in the phrase index as the time of the day progresses.

ICM follows the concept of eight time zones of three hours each. The experiment begins with Raag Bageshree for the mid-night, Bhairav, Alahaiya Bilawal for the morning, Vrindavani Sarang for Afternoon, Puriya for the evening and so on.

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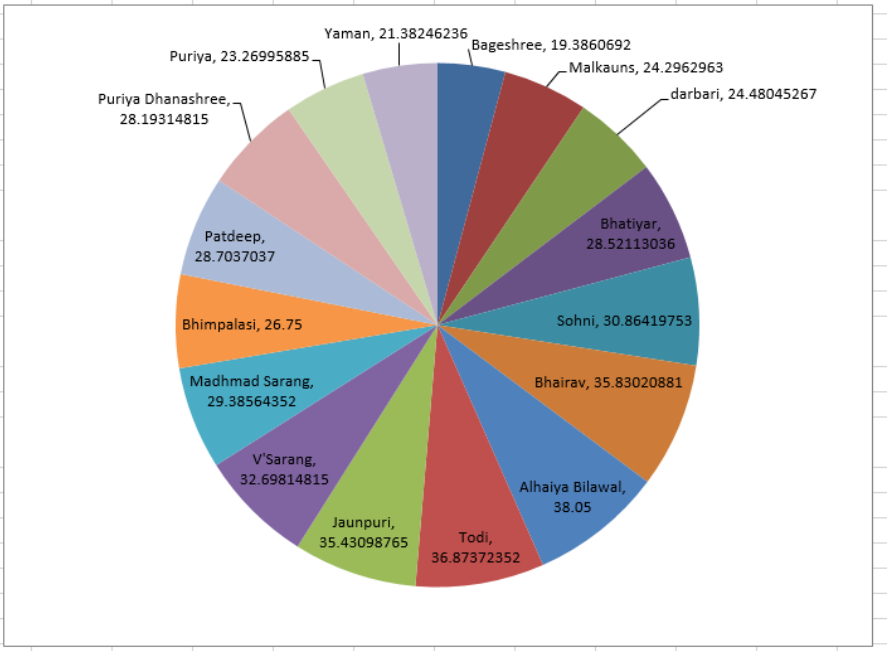
Summary		
Raag	Phrase Index	Time
Bageshree	19.3860692	21 to 00
Malkauns	24.2962963	00 to 3
darbari	24.48045267	00 to 3
Bhatiyar	28.52113036	3 to 6
Sohni	30.86419753	3 to 6
Bhairav	35.83020881	6.00
Alhaiya Bilawal	38.05	6 to 9
Todi	36.87372352	6 to 9
Jaunpuri	35.43098765	9 to 12
V'Sarang	32.69814815	12.00
Madhmad Sarang	29.38564352	13.00
Bhimpalasi	26.75	12 to 15
Patdeep	28.7037037	15 to 18
Puriya Dhanashree	28.19314815	18.00
Puriya	23.26995885	18 to 21
Yaman	21.38246236	21 to 00



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1. The result establishes a certain and precise relationship between phrases and emotions they invoke.

2. There is a certain pattern in which the change in the phrase index leads to corresponding change in the emotions.

3. Further research involving a larger sample of raga base and subjects for the survey can yield further refined results with higher resolution.

4. The final result can be utilized to generate a vast number of phrases corresponding to a given emotion under the constraints of raga rules by statistical tools such as Linear or non-linear Programming Problem with the use of suitable software.

5. The result can be used to create a training tool for students of ICM that can replace the traditional Guru-shishya parampara at least to an extent.

CONCLUSION

Result of the experiment reinforces the scientific base of emotional response to music. It encourages and endorses the impetus of the statistical treatment to make the research feasible for further study, which is underway. Such research is important and with the proper use of technology can go a long way to save our great art-forms such as Indian Classical Music from extinction, besides making it more user friendly in the field of music production and rendition.

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