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Giving Ragas the Time of Day: Linking structure, emotion and performance time in North Indian Classical Music using the Harmonic Network

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Abstract

This paper demonstrates that the Harmonic Network can be an appropriate representation of pitch relations in ragas and their parent classes in North Indian Classical Music (NICM), and that the relation between each raga and its associated emotion is elucidated by its spatial configuration on the Harmonic Network. Ten main parent classes, collections of pitches called *thaats*, form the structural basis for melodic improvisation in NICM. Each *raga*, belonging to a thaat, conveys a particular emotion. The Harmonic Network, also known as the *tonnetz*, is a well-known representation of pitch relations in Western Classical Music. We map the ten thaats to their corresponding structures on the Harmonic Network. These structures – differing in symmetry and the weight distribution of pitches relative to a prime axis – reveal connections between the symmetries and functions of the raga. The symmetries provide explanation for the choice of the ten thaats. Further analyses show strong correspondence between the pitch patterns of each raga and its emotion and traditional performance time.

1. Introduction

This paper explores the use of the Harmonic Network in representing pitch relations in North Indian Classical Music (NICM). Numerous theorists have used the Harmonic Network, also known as the *tonnetz*, to study and model *tonality*, the system of pitch relations underlying western tonal music (see Lewin 1982 and Cohn 1998). In this paper, we show that the Harmonic Network is an effective model for pitch relations in NICM as well.

NICM consists of improvisations on a fixed set of pitch classes. Unlike western classical music, which is based on two main modes (major and minor), the pitch collections in NICM can be drawn from a wide array of modes, called *ragas*. The set of ragas is broadly classified into ten parent classes, called *thaats*. Longuet-Higgins & Steedman (1971) have shown that major and minor modes map to compact clusters that form distinct shapes on the Harmonic Network. In this paper, we map the ten thaats to the Harmonic Network and analyze the symmetry patterns exhibited by the geometric structures.

We demonstrate a direct correspondence between the mood or emotion conveyed by the pitch patterns of a raga and its geometric configuration on the Harmonic Network. We study the implications of two different pattern types: symmetric vs. asymmetric structures and top-heavy vs. bottom-heavy structures. Finally, we propose connections between these symmetry patterns and the function of the ragas. In particular, the geometry of these structures provides an explanation for the choice of the ten thaats.

Section 1.1 describes the raga in Indian Classical Music and 1.2 the types of emotions associated with ragas. Section 2 presents the ten *thaats* and their corresponding patterns on the Harmonic Network. Section 3 classifies the pitch configurations by their symmetry patterns, analyzes the symmetry types to explain the choice of the ten thaats, and links the structures with the ragas' emotional content and performance time. Section 4 discusses the results and their implications for the study of NICM.

1.1 The Raga

The two forms of Indian Classical music in existence today are the North Indian Classical Music (NICM, also known as *Hindustani* music) and the South Indian Classical Music (SICM, also known as *Carnatic* music), each originating from and practiced in different geographical locations in India. Although both forms of music are based on the basic concept of the interplay of *Dhun* (melody) and *Tal* (Rhythm), the two styles and schools of thought differ. Both NICM and SICM are based on *raga* as the fundamental pitch structure. The two schools differ in style, lyrical content and ornamentation techniques of notes. For NICM, the pitch collections with characteristic note progressions (each known as a *pakad*) form the basis for identifying the raga.

One of the most important concepts in *Hindustani* music is the conveying of a particular kind of emotion through melodic improvisation on a fixed set of pitch classes. Music has been the medium adopted to narrate stories of heroism, devotion and defeat for thousands of years across India, which is why communicating an emotion plays a vital role in this form of music. However, pitches by themselves do not have the power to emote. It is only when they are used in conjunction with others do they have a capability to bring about a certain mood in the mind of the listener. Sets of pitches consisting of distinct seven tones form parent classes. Mathematically, there can be a total of 792 (the total number of ways to choose seven elements from twelve) possible parent classes. In practice, only ten such classes have been adopted to serve as the foundation of NICM from which hundreds of ragas have been derived.

A collection of pitch classes with distinct inter-pitch relations forms the underlying structure of a raga. Each collection consists of five, six or seven pitches selected from among a total of twelve pitch classes. Although, it appears to the ear that a musician uses the 12 pitch classes in a performance, in reality, she touches upon the hundreds of microtones existing between these tones by means of a smooth, continuous glissando from one pitch to the other. Krishnaswamy (2003) showed using pitch-tracking methods applied to South Indian Classical (*Carnatic*) Music performances that twelve distinct intervals are sufficient to represent all intervals present in Carnatic music. According to Krishnaswamy, even though pitch inflexions are a common feature in Indian classical music, some can be classified as ornamentations and others as different versions of a fundamental tone. Since NICM and SICM differ more in their cultural origins, rather than the study and theory associated with them, we claim that twelve pitch classes is sufficient to represent all tones present in Indian

classical music. We represent all possible pitch classes present in NICM using the conventional pitch class notation:

0 1 2 3 4 5 6 7 8 9 10 11

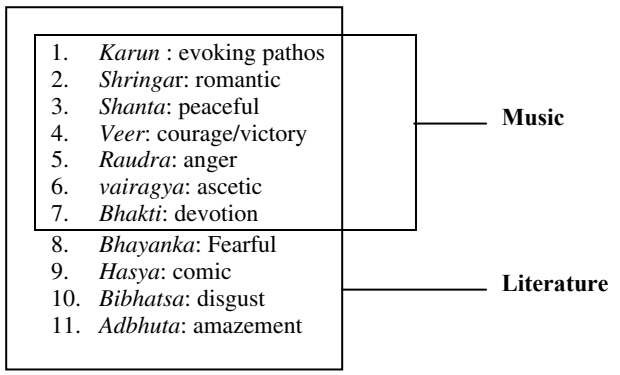
where 0 refers to the most stable pitch class and each number represents the semitone displacement from 0.

Like western tonal music, the pitch set of each raga forms tonal hierarchies. Lerdahl (2000) explores tonal hierarchies in various models for tonality in western music. Bharucha, Castellano & Krumhansl (1984) provide experimental ramifications for the existence of these tonal hierarchies. Like the concept of a tonal center in western tonal music, associated with each raga is a *vadi*, the most important pitch. In addition, there exists a *samvadi*, the second most important pitch. These two significant pitches are separated at least by four semitones and often occur in different registers (lower: 0-7; upper: 8- 12) of an octave. Such restrictions on the possible combinations of the vadi and samvadi restrict the number of ragas in NICM.

1.2 Emotions and Ragas

As described in the previous section, each raga is uniquely defined by its pitch collection and characteristic phrase. *Raga* is also a Sanskrit word meaning 'color' or 'passion. Each raga has some mood associated with it that can be related to its pitches and their relations one with another. Certain pitch classes commonly occur in ragas conveying a particular kind of emotion. For example, in relation to pitch class 0, the pitch class 1 is a flattened counterpart of pitch class 2 and hence brings about a more pensive and grave mood. Although individual pitches are not solely responsible for a particular emotion and cannot always be characterized as such, it can be inferred from sufficient observations that certain pitches in combination with others do bring about a mood that is conveyed with greater emphasis than are the others.

The pitch set of a raga and its characteristic phrase establish the flavor or mood of the raga. It is a well-accepted notion that there are 11 basic moods (based on "Raga, the soul of classical music") in NICM that can be depicted through a combination of music, dance and poetry:



Music alone cannot convey all 11 sentiments and its scope is limited to the first 7 moods. In contrast, literature is considered the most powerful medium of expression, a medium that can express all 11 emotions. In the realm of music, individual notes by themselves are not capable of generating expressive effects. It is the interplay of notes one with another, with the use of proper stressing on pitches, resting places, ornamentation that goes a long way in creating any sentiment. The mapping of any raga to the Harmonic Network considers only the pitch set and not the typical note progressions. However, the structures that arise from such a mapping are shown to provide strong links between emotion and the pitch pattern of a raga.

2. Mapping Ragas to the Harmonic Network

A raga can be identified by the pattern of its pitch set and its characteristic phrase. The depiction of the raga on the harmonic network brings our attention to one of these two aspects – the structure based only on the pitches existing in the raga. The harmonic network does not convey adequate information about the characteristic transitions (*pakad)* amongst the pitches. However, this mode of representation is still successful in broadly relating the mood of a raga to its collection of pitches. The pitches on the harmonic network are located in a particular frequency ratio to one another. Figure 1 shows a section of the Harmonic Network, also known as the *tonnetz*. Pitch classes along the horizontal axis are related by frequency ratios of 2:3, and pitch classes along the diagonal are related by ratios of 3:4. The structure forms a torus in the case of equal temperament tuning.

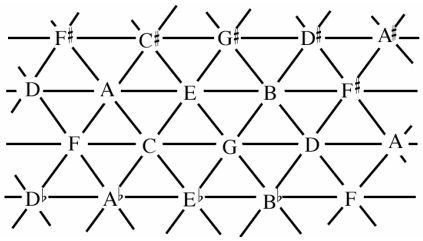


Figure 1: The Harmonic Network

We map the pitches of the ten parent classes on the harmonic network. The ten parent classes are:

1. Bhairav – an early morning raga usually played at daybreak.
2. Bhairavi – a morning raga often played at the finale of any musical performance.
3. Asavari – a morning raga popularly known as a romantic raga.
4. Todi – a morning raga, meditative in nature.
5. Kafi – this raga does not have a performance time, known for its *shringar* (romantic) mood.
6. Marwa – a raga played around dusk bringing about an ascetic mood.
7. Purvi – an afternoon raga conveying a mood of serenity.
8. Khamaj – an evening raga, often used in semi-classical and folk music owing to its lilting character.
9. Kalyan – an evening raga used to convey descriptions of beauty.
10. Bilawal – a morning raga that conveys joy.

Figure 2 shows their corresponding structures on the Harmonic Network. Two different representations for Asavari (2.3) have been adopted for comparing symmetries. They both represent the same set of pitch classes, with 2.3 (b) representing a compact version of 2.3 (a).

3. Observations

Based on the ten structures obtained from the mapping, we analyze the symmetry and weight distribution of the structures. The symmetry structures help to explain the choice of the ten thaats, while the distribution can be linked directly to the emotional content of the ragas. The details of the analyses are described in greater detail in the following sections.

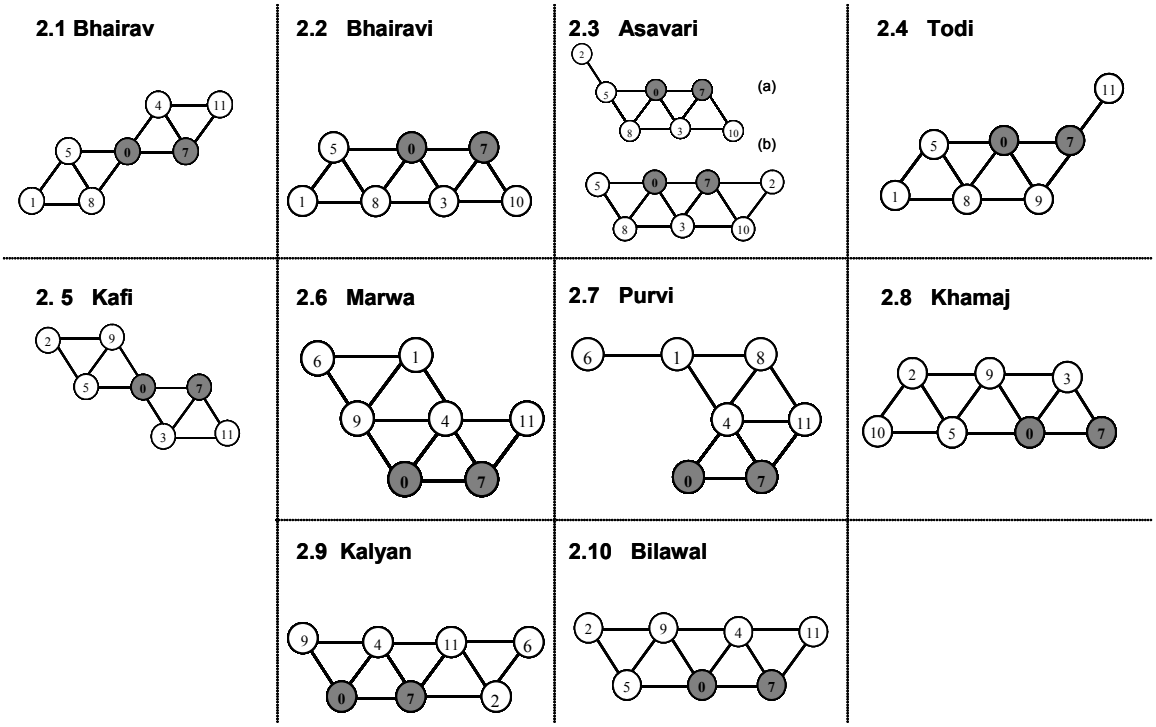


Figure 2: Mapping the parent classes (*thaats*) to the Harmonic Network.

3.1 Symmetry Axes and Network Coverage

We posit that the choice of the ten thaats maximize the coverage on the Harmonic Network using compact structures. Maximal coverage is achieved by mirror images reflected across a stable axis. Such mirror image pairs maximize the coverage of different pitch patterns around the region of greatest stability and can be used to group a large number of ragas having a similar structure.

We consider the axis containing the pitches 5 – 0 – 7 to be the prime axis since it contains the two most stable tones, 0 and 7. It is seen that among these ten parent classes, many are mirror images of each other. Some mirror image pairs are:

1. Kafi (shown in Figure 2.5) and Bhairav (Figure 2.1);
2. Bhairavi (Figure 2.2) and Bilawal (Figure 2.10);
3. Bhairavi (Figure 2.2) and Kalyan (Figure 2.9); and,
4. Asavari (Figure 2.3 a) and Todi (Figure 2.4).

The parent classes Bhairavi (Figure 2.2) and Khamaj (Figure 2.8) are translations one of another. Similarly, the parent classes Asavari (2.3), Kalyan (2.9) and Bilawal (2.10) are translations on the plane.

The mirror image pairs give maximal coverage of the network. For example, Bhairavi (2.2) and Bilawal (2.10) cover all pitch classes except "6". Bhairavi (2.2) and its derived ragas would all extend below the 5-0-7 axis covering the pitch space in that direction. Bilawal (2.10), and its derived ragas which extend in the opposite direction would cover the pitch space above the prime axis. In addition, Bhairav (2.1) and Kafi (2.5) cover all pitch classes except "6". Bhairavi (2.2) and Kalyan (2.9) together cover all pitch classes.

Bhairavi (2.2) and Asavari (2.3 b) have identical spatial arrangements, a two-tier pattern with the 5 – 0 – 7 axis on the top.

It is interesting to note that both the Bhairavi and Asavari cover a range of similar emotions, a similarity that is paralleled in their pitch patterns.

3.2 Prime Axis, Pitch Distribution & Emotion

Since the 5 – 0 – 7 axis is critical in the structure of each thaat, another way of classifying the structures is by what we call "top heavy" or "bottom heavy" natures. This is determined by the location of the majority of pitches above or below the prime axis. The pitches on the harmonic network are arranged such that the tones that appear flat relative to the prime axis occur below and the tones that appear sharp or natural relative to the prime axis occur above. In NICM, Flat tones are characterized by a poignant mood, and combinations of flat and natural/sharp tones occur in most ragas. Depending on the distribution of flat and natural/sharp tones in a raga, its corresponding structure on the harmonic network will be top-heavy or bottom-heavy.

The ragas associated with a grave or solemn emotion tend to be bottom-heavy. For example, Todi (2.4), Asavari (2.3 a&b) and Bhairavi (2.2) have a majority of their pitch weight below the prime axis. This structure indicates a predominance of flattened notes in the raga, giving rise to a more grave or solemn emotion.

Top-heavy structures are associated with joyful ragas. Kalyan is one such parent class having a top-heavy structure. Consider Raga Bhoopali, belonging to the Kalyan class, with the following ascending and descending scales:

0 2 4 7 9 12 / 12 9 7 4 2 0

It is an established fact that Raga Bhoopali, an early evening raga, is light-hearted and imparts a sense of tranquility to its listeners with its frugal and pure notes.

Other top-heavy ragas, consisting primarily of "pure" or "natural" tones, are the Khamaj, Bilawal and Yaman. These ragas often

lighten up the mood of the listener by evoking a lighter or a happier emotion. Khamaj is often used in semi-classical musical compositions such "thumris" (melodies belonging to the light classical genre) and devotional folk songs as it has a lilting spirit.

In contrast, consider Raga Bhupal-Todi (from the Todi parent class) that has the following ascending and descending scales:

0 **1** 4 7 **8** 12 / 12 **8** 7 4 **1** 0

The pitch set is essentially like that of the Kalyan except for two differences. By flattening two pitches, the sound and feel of the Raga Bhoopali is changed from joyful to grave. In addition, this raga is typically performed in the late night or early morning before dawn. As expected, the Todi parent class exhibits a bottom-heavy structure.

In general, the top-heavy and bottom-heavy classification is an appropriate indication of the emotional content of the raga. We now address the exceptions: the Marwa (2.6) parent class and the Purvi (2.7) parent class. These thaats appear as top-heavy structures and one might expect a lighter mood to be projected by these ragas. However, the Marwa and Purvi express renunciation and pathos. The structural explanation is that: the first tier above the prime axis contains pitches that are sharp/natural with respect to the prime axis. The second tier contains pitches that have equivalent representations in the first tier below the prime axis. Hence, pitches in the second tier (except for "6") should be classified as below the prime axis.

The pitch class "6" is unusual, occurring only in the parent classes: Marwa, Purvi and Kalyan. "6" with respect to "0" is the classical *tritone*, an interval that until recent times is avoided in western classical music. In NICM, enharmonic equivalence can be assumed in general. However, the use of "6" (with respect to "0") is always considered a sharp version of "5". Another reason for this treatment of "6" is that 0 – 7 are the most stable tones and are never sharpened or flattened.

3.3 Raga and Time of day

In NICM, there is a customary time of day associated with the performance of most ragas. These performance guidelines ensure that each raga achieves its desired effect. We posit that it is possible to infer the time of day associated with a raga by observing its structure on the Harmonic Network. Ragas that are performed during the day (late morning, afternoon and early evening) have a top-heavy structure, and ragas that are performed between late night and early morning have a bottom-heavy structure.

Vishnu Bhatkhande, the nineteenth century Indian musicologist, suggested a theory linking the vadi and samvadi pitches of a raga to its associated time in the day. According to him, ragas with their vadi pitch in the upper register (between pitch classes 8 – 11) were to be performed between 12 am-12pm and those with the vadi in the lower register (0-7) were to be performed from 12 pm-12 am. Furthermore, ragas were assigned a time frame depending on their use of certain pitch classes: {2,4,9} are linked to 7-10 am/pm, {1,4,11} to 4-7 am/pm and {3,10} to 10-4 am/pm. The morning (am) or evening (pm) time is further decided by the location of the vadi in the lower or upper registers. For example, Raga *Yaman*, a derivative of the parent class Kalyan, has the assigned time between 7-10 am/pm since it uses the pitches 2,4 and 9. Since its vadi is 4, lying in the lower register, its time frame is narrowed down to 12pm-12 am. Based on this reasoning, Raga Yaman is considered an evening raga.

We propose a simpler way to determine the time of day. Table 1 shows the performance time for ragas from each parent class, and the associated structure. We conclude that top-heavy ragas are performed in the day, and bottom-heavy ragas in the night.

Parent Class	Time of day	Structure
Bhairav	Pre-Dawn	Bottom-heavy
Bhairavi	Dawn	Bottom-heavy
Asavari	Early Morning	Bottom-heavy
Todi	Early Morning / Late Night	Bottom-heavy
Kafi	Afternoon	Top-heavy
Marwa	Late Night	Bottom-heavy
Purvi	Dusk	Bottom-heavy
Khamaj	All Day (except Late Night & Early Morning	Top-heavy
Kalyan	Evening	Top-heavy
Bilawal	Late Morning	Top-heavy

Table 1: Linking Performance Time to Structure

4. IMPLICATIONS

We have shown in the paper that the Harmonic network is a suitable model for ragas and their parent classes in NICM. The physical location of pitches and their spatial relation one to another on the harmonic network can help explain the choice of the ten parent classes, and can be used to infer the mood and performance time for a given raga. This could be of tremendous use in understanding the NICM tradition.

Like Longuet-Higgins & Steedman's algorithm for key-finding, one can use the Harmonic Network and the thaat templates to determine the parent class of a raga. By extension, one can also determine the mood conveyed by that parent class and the typical performance time for that raga.

5. REFERENCES

Bharucha . J, Castellano . M, Krumhansl Carol (1984). "*Tonal Hierarchies in the Music of North India*", Journal of Experimental Psychology, Vol 113, No. 3, 394-412.

Cohn, Richard (1998). "Introduction to Neo-Riemannian Theory: A Survey and Historical Perspective," *Journal of Music Theory*, **42**: 2, pp.167-180.

Krishnaswamy, Arvindh (2003). "Application of Pitch Tracking to South Indian Classical Music," *Proceedings of the IEEE International Conference on Multimedia and Expo*, Baltimore, MD, July 1999.

Lewin, David (1982). "Generalized Musical Intervals and Transformations," Yale University Press: New Haven, CT.

Longuet-Higgins, H.C. & Steedman, M.J. (1971). "On Interpreting Bach," In *Machine Intelligence*, Vol. 6, B. Meltzer and D. Michie (Eds.) Edinburgh University Press.

Jasani. Tarun, "*Ragas of the Morning*", *http://www.amc.org.uk/education/article*

Raga – the soul of classical music: *http://www.surdhwani.com/mus_raga.html*