Q1
A study on improvisation in a musical performance using multifractal detrended cross correlation analysis

Q2 Shankha Sanyal, Archi Banerjee *, Anirban Patranabis, Kaushik Banerjee, Ranjan Sengupta, Dipak Ghosh

Sir C.V. Raman Centre for Physics and Music, Jadavpur University, Kolkata, 700032, India

ARTICLE INFO

ABSTRACT

MFDFA (the most rigorous technique to assess multifractality) was performed on four Hindustani music samples played on same '*raga*' sung by the same performer. Each music sample was divided into six parts and 'multifractal spectral width' was determined for each part corresponding to the four samples. The results obtained reveal that different parts of all the four sound signals possess spectral width of widely varying values. This gives a cue of the so called 'musical improvisation' in all music samples, keeping in mind they belong to the *bandish* part of the same *raga*. Formal compositions in Hindustani raga are juxtaposed with the improvised portions, where an artist manoeuvers his/her own creativity to bring out a mood that is specific for that particular performance, which is known as 'improvisation'. Further, this observation hints at the association of different emotions even in the same *bandish* of the same raga performed by the same artist, this interesting observation cannot be revealed unless rigorous non-linear technique explores the nature of musical structure. In the second part, we applied MFDXA technique to explore more in-depth about 'improvisation' and association with emotion. This technique is applied to find the degree of cross-correlation (γ_x) between the different parts of the samples. Pronounced correlation has been observed in the middle parts of the all the four samples evident from higher values of γ_x whereas the other parts show weak correlation. This gets further support from the values of spectral width from different parts of the sample — width of those parts is significantly different from other parts. This observation is extremely new both in respect of musical structure of so called improvisation and associated emotion. The importance of this study in application area of cognitive music therapy is immense.

1. Introduction

From a physical point of view, musical signals are approximately periodic in micro and macro forms. In this approach, musical signals seem to have a deterministic behavior but this is not really the case, as music would then be a deterministic issue of rational human thought [1]. On the other hand, there is a widespread opinion (in linguistic, aesthetic and cognitive philosophy) that music is a complex, and multidimensional nonlinear system [2]. A number of earlier studies are based on rhythmic and harmonic structure of the musical notes, while frequency analysis may fail to decipher the real dynamics

* Corresponding author.
  E-mail address: archibanerjee7@gmail.com (A. Banerjee).

in case of polyphonic recordings. A few studies have been done to correlate complex actions coordinated by people with complex rhythmic musical sequence [3,4]. One such study says [3] that as people listen to rhythmic structure of music; a stable multi-periodicity pattern arises psychologically, which is a manifestation of the temporal structure of the rhythm. In this study, we want to specify some parameters with which we can quantify the improvisational cues in four different renditions of a single "*raga*" performance of a Hindustani music performer.

The *raga* is a sequence of musical notes and the play of sound which delights the hearts of people. The word Raga is derived from the Sanskrit word "Ranj" which literally means to delight or please and gratify [6]. Although there are a number of definitions attributed to a Raga, it is basically a tonal multifarious module. The listener has to listen to several pieces of the Raga in order to recognize the Raga. The goal of a performer of Hindustani music is to convey the musical structure and expression so that the audience gets pleasantness. The presentation of a Raga is started with *Alap*. The *Alap* is the opening section of a typical Hindustani Music (HM) performance [7]. In the *alap* part, the *raga* is introduced and the paths of its development are revealed using all the notes used in that particular *raga* and allowed transitions between them with proper distribution over time. *Alap* is usually accompanied by the tanpura drone only and sung at a slow tempo or sometimes without tempo. Then comes the vilambit *bandish* part where the lyrics and *tala* are introduced. *Bandish* is a fixed, melodic composition in Hindustani vocal or instrumental music, set in a specific *raga*, performed with rhythmic accompaniment by a tabla or pakhawaj, a steady drone, and melodic accompaniment by a sarangi, harmonium etc. [8]. *Vilambit* is a type of *bandish* which is sung at a very slow tempo, or *laya*, of 10–40 beats per minute. In HM the existing phrases are stretched or compressed, and the same may happen to motives from the phrases; further motives may be prefixed, infixed and suffixed. Phrases may be broken up or telescoped with others, and motives or phrases may be sequenced through different registers [9]. Thus, during a performance, a singer steadily loosens the strangle hold of the rules of music in a subtle way. He does not flout them, he merely interprets them in a new way, which is the beauty of Hindustani classical music and there comes the wisdom that *Raga* and its grammar are only means and not ends in themselves. The way in which a performer interprets a *raga* during each specific performance is unique and is the very essence of improvisation in Hindustani music (HM). Unlike symphony or a concerto, *Raga* is unpredictable; it is eternally blooming, blossoming out into new and vivid forms during each and every performance which is the essence of "improvisation" [10].

Improvisation is a common form of musical practice across cultures, and yet remains scarcely studied or understood from a scientific musical analysis point of view. It is said that—in Hindustani music (HM), other than *Aarohan* (ascending), *Aborohan* (descending), *Chalan* (main phrase) and *Bandish* (composition), everything depends on the artist's own imagination, creativity, *Talim* (learning) and *Riyaz* (intense practice) [11]. There is no notation in HM system like western music and the musician is himself the composer. A musician while performing expresses the raga according to his mood and environment surrounding him. Thus there are differences from one rendition to another. Even if an artist sings or play same *Raga* and same *Bandish* twice then there is supposed to be some dissimilarity in between the two performances. These differences in the rendition of a raga several times on different days are generally called improvisation. A number of studies in ethnomusicology reports musical tradition among performers and the interactions that play an important role shaping the social hierarchy of North Indian Classical music [12–14]. In Western musicology, improvisation is considered as an opposite of composition, hence traditionally been regarded as an inferior to art music, where the importance of pre-composition is paramount [15]. The situation is a stark contrast in Hindustani classical music, where "improvisation" is the central and defining term in any performance. Improvisation is crucial and indispensible feature of Hindustani Music (HM) which depends upon the imagination, originality and ingenuity of a particular artist [8] and can be best identified by analyzing the variation imposed by the artist in different renditions of the same musical piece. There have been a number of approaches to study improvisations, especially in jazz and folk music [16–18], while in music therapy, the analysis of improvisations is gaining more ground in recent years, informing directly the therapeutic process [19–22]. Another recent study [23] using cross wavelet spectral analysis sheds new light on the spontaneous improvisation made by the coordination of the musician with his/her co-performers to produce novel musical expressions. Performative gestures are considered important to listening amongst all genres of music [24]. For e.g., in an analysis of B. B. King's music, it was found that some gestures have the effect of drawing the listeners' attention to local aspects of music, specifically to the nuanced treatment of individual notes, and away from larger scale musical structure [25]. The importance of gesture has been realized until recently [26,27] as something outside language; Indian music, with its emphasis on note combinations has often regarded gestures as something outside music. In Hindustani classical music, the gestures that accompany improvisation are closely coordinated with the vocal action; they are never taught explicitly and seem to come as an expression for melody. The importance of gestural dispositions in Hindustani *raga* performances has been extensively studied in Ref. [28]. A study [29] on search for emotion in Hindustani vocal music based on human response data showed that segments from the same raga elicit different emotions which can be assigned into prescribed categories. Also cross-cultural similarity of the elicited response is significant. Another recent study on Indian classical instrumental music also based on human response data categorizes the *alap* and *gat* portion of *raga* as elicitor of specific distinct emotions [30]. In the present study, for the first time, we attempt to quantify the improvisational cues in a Hindustani music performance with the help of different non-linear parameters.

At first sight music shows a complex behavior: at every instant components (in micro and macro scale: pitch, timbre, accent, duration, phrase, melody etc.) are close linked to each other [5]. All these properties (above stated in a heuristic characterization) are peculiar of systems with chaotic, self organized, and generally, nonlinear behavior. Therefore, the analysis of music using linear and deterministic frameworks seems not to be useful.