ON IDENTIFYING A COMMON GOAL BETWEEN MUSICIANS AND SCIENTISTS

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Abstract

The aim of this article is to identify a common goal between musicians and scientists. Our analysis ends on a positive note suggesting that the "gap" between the two, so to say, exists only in the nature of the paths undertaken. There is hardly any gap so far as the goal is concerned. This realization, which I believe will be helpful in bringing scientists and musicians together thereby raising the standard of music appreciation, music therapy and music-learning, bears a sure relevance in the context of those developing countries such as India to which this author belongs where music therapy is not yet an established profession, nor is scientific research in music as popular as in the west.

Key words

Music appreciation; music therapy; music learning

1. Introduction

Discovering similarities between the pursuits of scientific research and musical arts is a compelling and perennially interesting topic that has been discussed for around a century. This article gives my subjective personal opinion on the topic and bears a sure relevance in the Indian context where music therapy is not yet an established profession, nor is scientific research in music as popular as in the west. For further literature, however, the reader is referred to Parncutt and McPherson (2002), Hallam, Cross and Thaut (2009). See also Levinson (2003).

1.1 Discovering science in art

Morgan and King (1986) have distinguished art from science as follows:-

Science is a body of systematized knowledge. Art on the other hand is a skill that can be developed only by continuous practice.

While recording the song *Meri Awaz Suno*, of the old and popular Hindi film *Naunihaal* (1967), the singer Mohd. Rafi was unable to deliver the lines "*Maine ek phool jo seene pe sajaa rakhkha tha*/*Uske paarde mein tumhe dil se lagaa rakhkha tha*" (translated free, it reads: it was a flower that I kept in my heart to decorate/behind whose curtains I held you

as a secret) to the satisfaction of the composer Madan Mohan. The "life" of the song was contained in these melody lines. Madan Mohan would not give up. He insisted that Rafi should give another try, then another, then another….Accepting the challenge, after hours of persistent effort, Rafi finally delivered it to perfection (the soulful lyrics of this song are credited to Kaifi Azmi, father of the leading Indian actress Shabana Azmi).

While appreciating the perseverance of both these artists over a single line, which explains why these old songs are able to sustain themselves even today over their melodic and rhythmic content, I take the opportunity to ask a trivial question:

Why and how do we finally succeed in doing an activity correctly after several attempts despite failures or partial success in the initial attempts?

If you attempt to answer this question, you will probably discover that what has been classified as an "art" in Morgan and King's definition has a definite, deep and complex science embedded within. With each attempt, how the brain learns something about an activity and transmits the knowledge to the other organs……. by the time your discovery is complete, my trivial question will end up with a non-trivial solution.

1.2 The different conceptions of beauty

A raga, in Indian classical music, is a melodic structure with fixed notes and a set of rules characterizing a certain mood conveyed by performance (Chakraborty (2009)). In a *raga*, a *vivadi swa*r is a note that is not allowable in the raga. However there have been occasions where a celebrated artist has used a *vivadi swar* deliberately at a "peak time" creating an electric feeling that did beautify the melody and drew immediate applauds from the enthusiastic listeners. Let us not forget that "art is good when beautiful and bad when not" [Brandt (2009] and the artist is within his/her right to seek such beautification, at times even breaking a certain music theory. This is what is debated rather hotly as "romanticism vs classicism" in Indian music, a conflict between unrestricted beautification and disciplined beautification. I had a long discussion with Vanamala Parvatkar (2009a), a renowned vocalist of the Banaras Gharana and the former Head (vocal music), Faculty of Performing Arts, Banaras Hindu University, on this issue. She expressed the opinion that such romanticism
(i) should be attempted only by experts,
(ii) is more effective when extempore than when pre-planned and
(iii) should be treated as a beautiful retreat from the musical grammar and in no case should this exception be made the grammar (i.e should be attempted, if at all, only a few times in one concert).

Do we have an influence of beauty in science? We do! But science being a broad periphery of knowledge, I will illustrate my answer by referring to only the base of all sciences, namely, mathematics. What is the mathematician's concept of beauty and how does it differ from that of an artist such as a musician?

I give two classic examples. The first is on the infinitetude of prime numbers. Euclid was the first to prove it as follows:

Suppose, if possible, that the number of all primes be finite in which case there is a largest prime = Z, say. Define a number $X = p_1\ p_2 \ldots\ldots Z + 1$ where p_i is the i-th prime. This number X will not be divisible by any of the primes (leaving a remainder 1 in each case) and will not be divisible by the composites either (each of which is a unique product of primes by the unique factorization theorem) and is therefore a prime. But X is evidently greater than Z contradicting Z being the largest prime. Hence the number of all primes is infinite. Q. E. D.!

Subsequently, several mathematicians including Euler supplied other proofs independently which were analytically stronger than Euclid's elementary proof but even to this date, mathematicians agree that Euclid's "elementary proof" is the *most elegant*.

At this stage, I ask a second question:

Is simplicity a manifestation of beauty and is this one of the ways the mathematician conceives it?

I move to the next example. Which is the *most beautiful equation* in mathematics?
We all know it is the Euler's equation

$$e^{\pi i} + 1 = 0$$

We call this equation the most beautiful as it involves the simultaneous presence of 0, 1, i, π and e *exactly once in the same equation*, each number holding its own importance. This leads to my third question:

Is the simultaneous occurrence of several interesting things in an interesting way another manifestation of beauty in the eyes of the mathematician?

If you think deep, both these examples can be put under one umbrella, namely, that the mathematician's concept of beauty seems to be in the *abstract* sense as compared to that in the *aesthetic* sense for an artist. In other words, both are lovers of beauty; it is just that they are conceiving it differently.

However, sometimes there is an overlap between the aesthetic and abstract senses of beauty when mathematicians start thinking of mathematics as an art form or a creative activity and compare it with music and poetry. Bertrand Russell, for example, said:

"Mathematics, rightly viewed, possesses not only truth, but supreme beauty — a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than Man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as poetry". (Russel, 1919)

As another example, I quote Paul Erdős:

"Why are numbers beautiful? It's like asking why is Beethoven's Ninth Symphony beautiful. If you don't see why, someone can't tell you. I *know* numbers are beautiful. If they aren't beautiful, nothing is." (Devlin, 2000) See also Benson (2006) and Martin et. al. (2008) for other relationships between mathematics and music.

1.3.1 Expectations and un-expectations

I am somewhat skeptical on measuring meaning mathematically, given that previous attempts have not been very successful. If they were, entropy could have been made a science of measuring meaning in a message. It is not; it measures the amount of surprise in a message. According to Carol Krumhansl, Professor of Psychology at Cornell University who is well known for her works in music, we listen to music *in order to fulfill our expectations* [Krumhansl (2002)]. I add, to her thoughtful insight, that we also appreciate surprises (or something that we did not expect) brought about by a musician. The previous example of romanticism of using a *vivadi* swar in *raga* rendition suffices (Chakraborty 2010). The use of entropy in music analysis is important therefore and I refer to Snyder (1990) for more information. Musical expectations, as opposed to un-expectations or surprises can also be scientifically measured using probability. This is what Temperley (2007) has successfully accomplished using a classical Bayesian approach. Bayesian analysis rests on the concept of conditional expectation.

I am also critical of melody being defined as a sequence of musical pitches which is "meaningful" in some sense as "meaningful" is a rather obscure term. One should use the word "complete" instead of "meaningful". This settles another problem, namely, explaining why a segment is so called, obviously because it is a sequential subset of a melody but is itself incomplete. For instance, in the popular Beatles number, the note sequence corresponding to the line "Yesterday, all my troubles seemed so far away" will be a melody while the note sequence corresponding to only the part "Yesterday, all my troubles" will be a segment. The difference is not only because one is a complete sentence and the other is not. You will feel a difference in "musical completeness" in addition to the difference in "speech completeness" by suppressing the speech part and playing them one after another in an instrument. However, a segment can also be important in a performance and one should measure the significance of both melodies and segments. As a second example, from Indian classical music, in the raga *Kafi*, the note sequence {Sa, Sa, Re, Re, Ga, Ga, Ma, Ma, Pa} is a melody and {Sa, Sa, Re, Re} is its segment, being an incomplete but sequential subset (Chakraborty et. al. 2009).

1.3.2 Perhaps a new *raga-rasa* theory?

As another example, rather than clubbing both ragas *Bageshree* and *Shivaranjani* as "*karuna-rasa*" ragas or ragas of pathos (this may serve some purpose but does not explain how one raga differs from the other) which I find similar to classifying both bananas and mangoes as "sweet" (of course when ripe!), it is a better strategy to assert that banana has a characteristic taste of its own which we agree to call "banana-taste" and likewise mangoes have a "mango-taste". In that respect, it would be more correct to

assert that Bageshree has a "*Bageshree-rasa*" and *Shivaranjani* has a "*Shivaranjani-rasa*". Here by the term *rasa*, we are referring to its emotional content that is perceived aesthetically. We then ask: how far did the "*Bageshree-rasa*" of *Bageshree*, as rendered by an artist, fulfill our *expectations*? It is natural to have some expectations from the artist as well especially if the artist is well known. So we additionally ask: how far did the artist himself/herself fulfill our expectations? We further ask: what *surprises* were brought about in the raga-rendition? And answers to these would be provided aesthetically first followed by a quantified measurement, the former using the ear-brain coordination and the latter using probability, entropy and statistics. Listeners would be asked to subjectively judge a raga-rendition and answer the aforesaid questions in a ten point scale (or say 10%, 20%.....100%). When several listeners are involved (they should be grouped with respect to their musical or non-musical background, and subgroups with respect to age within each group), the data would be worth a statistical consideration for analysis. The ideas can be applied to other music genres also. Suvarnalata Rao (2000) has given a good discussion on the *raga-rasa* theory from an acoustic perspective; however, -what kind of musical stimulus leads to what kind of sensation in the brain- is a subject matter of Psychophysics of music. And this is a branch of Psychology and not Physics! [see my review of Roederer's classic, Roederer (2008)]. Krumhansl's expectation theory [Krumhansl (2002)] is purely based on human psychology and hence my interest. If you think deep, you will be convinced that listening to music whether for "aesthetic pleasure" or "inner joy" or "self-fulfillment" or even "spiritual *sadhana*" etc. or their combination are all ultimately fulfilling our expectations in one way or the other. Krumhansl's theory also explains why we tend to escape sadness in real life but appreciate sad music; obviously because the former did not fulfill our expectations in some way which the latter accomplished in some other way. Since we shall be using probability and statistics for the quantified measurement of expectations and surprises (entropy is a probabilistic concept) the new *raga-rasa* theory proposed here is clearly psycho-statistical.

The morale is that musical meaning should be assessed through expectations and un-expectations, completeness as well as incompleteness (Chakraborty 2010), which can be aesthetically conceived and quantifiably measured. The latter is not a substitute of the former; it is a supplement. That said, I close this section.

1.4 Discovering *order*: the final common goal!

A musician is not merely a juggler of musical notes. He arranges them *in a certain order*, moving from one note to another *in a certain way*, with *expressive timing, even micro-tonality especially in ragas* and *loudness* so that emotion can be properly conveyed. When he calls this articulation a "*spiritual sadhana*" he is actually discovering this *order* that leads to inner fulfillment and joy as well as giving the aesthetic pleasure to others. On the other hand, a scientist strives to capture the *order* or law in some natural phenomenon he observes. And when he finds one, as Newton discovered it is the gravitational force of the earth which pulled the apple down, he is equally thrilled. Thus both are looking for *order*, albeit their paths are different and both believe that such *orders* do exist in nature.

I recently reviewed a decent book on the interface of physics and music in which the author, who is a physicist, has made a similar remark:

"We believe that order exists, and we look for it. In that respect the aims of science and of music are identical--the desire to find harmony. And surely, without that very human desire, science would be a cold and sterile undertaking". [Johnston (2009)]

I said the paths of the scientist and the musician are different. The scientist is a *logical* man (or woman). Also, a scientific idea such as the theory of relativity is ultimately a thought and so can be effectively explained in words. Music on the other hand is ultimately *emotion* (although it is influenced by thought and vice versa; also thought is needed to convey the emotion properly) and this explains why it cannot be fully described using words or symbols although music analysts and critics have been trying to do this with only partial success. Sometimes a strange question comes to my mind. How excellent would it be if great writers such as Chekhov had been musicians and agreed to write on music? Could they not express the emotional content of music powerfully the way Neville Cardus brought cricket "live" through words? (remark: interestingly, Neville Cardus was also a good music critic, http://en.wikipedia.org/wiki/Neville_Cardus)

Sometimes these two different paths overlap and we discover science in art or vice versa. A scientific idea which is a science in principle may become an art in practice, e.g., computer programming. Why did the world famous computer scientist Donald Knuth (Stanford University) call his "bible" on algorithms the "art" of computer programming? Similarly some aspects of an art can and do have steps logically linked. When we talk about what kind of musical stimulus lead to what kind of emotional reaction, as mentioned earlier, we are referring to the *psychophysics* of music. How sound patterns are generated, how they propagate through the environment--this is the physics part--and how they are sensed by the ear and interpreted in the brain--the psychology part--are both crucial.[Roederer (2008)]. I have already given another example of discovering science in art at the beginning of this article. A magician's performing a trick is a good example of art in science. All magical tricks have some scientific basis. But the magician ultimately has to make sure he is not caught only through rigorous practice. Magic is a science in principle and an art in practice. So is statistics; I remember how a statistical investigator in my country struggled to get the true age of an old lady who forgot it; finally the question "How old were you when India became independent?" did the trick.

2. Conclusion

The scientist and the musician have a common goal: *they are both looking for order*. Although their paths are different, they are often overlapping. Despite this commonality, it is sad that there is some "gap" between these two communities and this is largely on account of some misconceptions about each other and, unfortunately, some misacts and very casual comments. The misuse of neural networks to "manufacture" an artist [this has been sharply criticized by Shukla and Chakraborty (2009) in a recent work] or the board of scientists asking a musician to give a quantified difference in pitch contour between *komal gandhar* of *raga Kafi* and the same note of *raga Malkauns* (it was the scientists'

job to measure this, not the musician's!) and rejecting the musician's plea that he could at best only give a live demonstration of the two [this incident was narrated to me by Vanamala Parvatkar (2009b) who for obvious reasons refused to name the scientists and the musician] are two good examples of misacts committed by scientists which will be disliked by the musicians and music lovers.

As another example, the legendary claim "…**During the period 1750 to 1850 the time of the musical trinity, Tyagaraja, Muthuswami Dikshitar and Syama Sastry, Tyagaraja brought to life a person declared dead by singing a composition *Naa Jeevadhara* in the raga *Bilahari***" [Rammohan (2006) and Rammohan (2009); see also Sairam (2004)] is likely to be criticized in a scientific forum which may want to know what diagnostic tests were conducted to confirm death. Alternatively, it could be that Tyagaraja actually brought a *dying* man (and not a *clinically dead* man) back to normal life, which is also no less creditable for a musician given that this is always the ultimate ambition of a doctor and, more importantly, it is its *acknowledged possibility* that makes the medical profession a noble one. Tyagaraja's musical genius cannot be questioned and I do believe this Grandmaster of Carnatic music could certainly accomplish the alternative feat if not what is originally claimed in the quote. While I deeply regret that we shall perhaps not see such rare displays of artistic wizardry of the highest class ever again, I hope the scientific community will agree that credit be immediately given to this legendary musician for reviving a dying man at least if "dead" seems controversial, with an acknowledgement that if, through future research, death can be confirmed, scientists must wholeheartedly accept and place Tyagaraja's feat as a *miracle* which they know they themselves cannot achieve. The only explanation I can offer for the miracle, in case it turns out to be true, or its alternative is that *perhaps there is not much difference between the musician and God at the highest level of music. Given that God has been given the status of "God" only for His power to give life, perhaps a musician acquires the same power when he attains this level.*

I know it very well that reviving a dying man through music may not be regarded as the highest form of art by some music critics and some "professional" musicians who perform either with the sole purpose of getting at best a standing ovation or at worst of inflating their bank accounts or both. I would like to point out to these "professionals" that *if they think reviving a dying man through music is not the highest form of art, it is still the highest form of humanity of which art is only a subset*. Surprisingly, scientists have not taken the legendary claim or its alternative seriously either. The legendary claim was lying in an aesthetic domain (and gathering dust) until it caught my attention. I ask the scientific community: *when a doctor - who is a scientist - gets the credit for reviving a dying man, why is a competent musician denied the credit? Are the scientists here only to felicitate themselves?* I feel hurt, being a scientist. By attempting to get Saint Tyagaraja duly credited in a scientific forum, I protect the prestige of the scientific community from being lowered while at the same time I take the first step, which is always the most important step in a journey of thousand miles, of satisfying my farseeing ambition of having music therapy as an established profession in the developing countries like India.

Remark: It should be understood that there are two parts in the incident debated here: the declaration of death (which is credited to the doctors treating the patient) and the revival to life

(this is credited to Tyagaraja). The scientific community can only question the diagnosis (which is not credited to Tyagaraja) but not the revival! **Naa Jeevadhara in raga Bilahari is one of the well known "kritis" of Tyagaraja.**

In contrast, the seven notes in Indian music are related to cries of certain animals and birds (like bull, elephant, peacock etc.). The assignment does not seem to be very scientific. Notes correspond to pitch. Cries of animals and birds differ on the basis of quality of sound technically called timbre. Pitch and timbre are not the same thing. Pitch depends on the fundamental frequency and being frequency it is expressed as the *number* of vibrations per second (sec^{-1} or Hertz). Timbre in contrast depends on the *nature* of vibrations characterized by the "spectrum and envelope" (Benson, 2006). And what if I make a change of scale? Will you say the bull is now crying like an elephant?

The musical and scientific communities are both human and will commit mistakes. With a little more care in what they say and do, these misunderstandings can be sorted out. But what do we gain finally when musicians and scientists agree to work together, having realized that they have a common goal? There are three definite gains at least:-

1. Music Appreciation: knowledge and understanding of music is more complete when our aesthetic appreciation is coupled by quantified information as provided by scientific research in music. According to Swami Vivekananda, music is the highest form of art and, *provided you understand it*, also the highest form of worship. Therefore, "understanding" music is crucial. As mentioned earlier, scientific findings are supplementary to and not a replacement of the aesthetic perception.

2. Music therapy: This can be a success and an established discipline if and only if medical professionals, musicians and music researchers work together. Modern science and discoveries conclude that music has healing powers particularly in relieving psychological diseases and negative emotions. Aldridge (1994) has provided a helpful review on music therapy. Although an established profession in the United States, as well as being widespread in Japan, Australasia and Europe and other parts of the world, a lot more is still to be explored. It is time we pick up the momentum in this potentially challenging field and press for its systematic study and teaching in our universities and institutes. While ragas in Indian classical music are indisputably rich in their emotional content and varieties, it is an irony that we are struggling to establish music therapy as a profession here. Same is the story in other developing countries.

3. Scientific research in music can assist the music-learners (e.g. in optimizing their practice routine, in making better use of their instruments and voice, in assessing versatility in performance and improving the same etc.). It is important for the scientist to convince this to the music-learner. In the words of Prof. Richard Parncutt (2007), professor of Systematic Musicology at the University of Graz, Austria, "Research on musical expression (structural, emotional, bodily) may raise students' awareness of their expressive strategies and help them to plan and practise the expression that they bring to specific works, linking analysis to

interpretation. Research on memory, sight-reading, improvisation and intonation may help students to enhance their skills in these specific areas. Research on performance anxiety may help students to turn anxiety to their benefit. Research on music medicine may help students to prevent and treat injuries." It is unfortunate that since music performance is more intuitive than logical, these aspects are not included in our music-curriculum.

The time is just ripe, I feel, that musicians and scientists sit together and discuss these issues, more so in the developing countries like ours where such a fruitful collaboration is a rare sight indeed! [Concluded]

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