

Impact of Hindustani ragas in stress management: A statistical study

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ABSTRACT: This work is a part of our ongoing research project entitled *Hindustani Raga Analysis Using Statistical Musicology with Therapeutic Applications for Stress Management*. Using the perceived stress scale (PSS), baseline data were collected on 28 participants, 14 for the control group (non-music intervention group) and the remaining 14 for the case group (music intervention group), the allotment of a participant to one of the groups being done using randomized control trial (RCT) to prevent bias in allocation. After 5 music therapy sessions, the follow-up data were collected and the scores (0, 1, 2, 3, 4) were filled for the 10 questions in the questionnaire of the PSS scale. The rating is 0–13 implying low stress, 14–26 implying moderate stress and 27–40 implying high stress. As per the PSS rule, those having stress levels below 13 were dropped from the study. Thus, the actual number of participants in both groups would be less than those interviewed (sample size $n = 7$ for each group). Using paired t test, it is found that the case group participants have shown considerable improvement in comparison to the control group. Thus, the efficacy of music intervention in combatting stress is established.

KEYWORDS: perceived stress scale; paired t test; music therapy; Hindustani raga; music transcriber

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1. Introduction

Scientists through their studies have revealed the healing powers of music in controlling blood pressure, negative emotions and stress. Statistics and probability have been used to analyze music successfully both in western and non-western (including Indian) music. For details, please refer to the books by Thaut^[1], Beran^[2], Temperley^[3], Tewari and Chakraborty^[4] and Patel^[5] and the references cited therein, while the paper by Singh *et al.*^[6] provides a brief survey on music intervention in both western and non-western (Indian) music. In an earlier work, Priyadarshini and Chakraborty^[7] used statistical

modeling, inter-onset interval and rate of change of pitch (pitch velocity) to distinguish between restful and restless ragas in Hindustani classical music. In Indian classical music (both Hindustani and Carnatic), a raga may be defined as a melodic structure with fixed notes and a set of rules that characterize a particular mood conveyed by performance^[8].

2. Literature review

Aldridge^[9] provides a good source of literature review on music therapy. The main emphasis on music therapy intervention is on the soothing ability of music and the necessity of music as

an antidote to an overly technological medical approach. Most of these articles are concerned with receptive (passive) music therapy and the playing of pre-recorded music on patients emphasizing the need for healthy pleasures like music, fragrance and aesthetic visuals for the reduction of stress and the enhancement of well-being. The overall expectation is that the recreational, emotional and physical health of the patients would improve^[10]. A good account of research findings about the neurobiological foundation of rhythm and the brain with a thrust on how music can affect both musical and non-musical brains can be found in Thaut^[11] which gives the new therapeutic methodology of neurologic music therapy dealing extensively with clinical techniques and implementations in rehabilitation. Sarkamo and Soto^[11] found that listening to pleasant music can have a facilitating effect on visual awareness in patients with visual neglect, which is associated with functional coupling between the emotional and attentional areas of the brain region. Secondly, daily music listening can improve auditory and verbal memory, focused attention, and mood as well as induce structural gray matter changes in the early post-stroke stage. Although some information on music therapy in the context of Indian music is available (Sairam^[12], Rammohan^[13], Singh et al.^[14]), it is seriously limited. Scientific research in Indian music especially from a therapeutic angle is still at the beginning stage. Thus, there is a clear gap in music therapy research in western music and the Indian counterpart and this motivated us to experiment with Hindustani ragas to combat stress.

3. Our contribution

A project titled *Hindustani Raga Analysis Using Statistical Musicology with Therapeutic Applications for Stress Management* is currently underway in our institute in which the first author is officiating as a principal investigator, the second author is developing a music therapy app, the third author, a certified music therapist, is guiding the

music therapy interventions and the fourth author, who has joined this project as a project fellow, is working on a music transcriber.

The objective of the project, novelty and deliverables are outlined next.

- Objective: building a music transcriber and a music therapy app to combat stress by analyzing and applying the melodic structure of Hindustani ragas using statistical musicology. Statistics being the science of exploring and studying patterns in numerical data will be helpful in relating the musical patterns with the corresponding emotional changes in the brain. Musical data are numerical and hence allow statistical analysis.

- Novelty: building a music transcriber & music therapy app to control stress using Hindustani ragas. The transcriber will provide the musical data in digitized form using the STFT algorithm (Short-time Fourier transform). The musical data would provide information on note duration, inter-onset interval, pitch velocity & pitch movements between notes. The project fellow who has joined this project is working on it using MATLAB and Python coding. The working of the music therapy app is given in Section 6.

- Deliverables: music transcriber, music therapy app, and research papers/monograph on Hindustani ragas.

4. Methodology: Perceived stress scale (PSS); paired t test

4.1. The perceived stress scale (PSS)

PSS is a classic stress assessment instrument.

The tool, while originally developed in 1983, remains a popular choice for helping us understand how different situations affect our feelings and our perceived stress. Refer to perceived stress scale^[15] for further details on the questionnaire and scoring in PSS.

4.2. Paired t test

Paired t test is always used on the same group of individuals. Thus, if x_i is the PSS score

at baseline and y_i is the PSS score after music therapy intervention for the i -th individual, $i = 1, 2, \dots, n$ for n individuals, we calculate the statistic.

$t = d_{mean}/[sd/\{SQRT(n)\}]$ which follows student's t distribution with $(n - 1)$ degrees of freedom (d.f.), where $d_i = x_i - y_i$, $d_{mean} = \Sigma d_i/n$ and $sd^2 = [1/(n - 1)]\Sigma(d_i - d_{mean})^2$, where the summation extends over $i = 1$ to n . $SQRT$ implies square root.

Here our null hypothesis is that the difference d_i values are due to sampling fluctuations only which would be rejected if the calculated value of t exceeds the tabulated t with $n - 1$ degrees of freedom and 5% level of significance.

5. Summary of the experimental results

Using PSS (perceived stress scale) baseline data were collected on 28 participants, 14 for the control group (non-music intervention group) and the remaining 14 for the case group (music intervention group), the allotment of a participant to one of the groups being done using randomized control trial (RCT) to prevent bias in allocation. Each participant is identified by a unique (roll) number and is allocated to one of the two groups randomly with equal probability using RCT. After 5 music therapy sessions covered in 45 days, the follow-up data have been collected. The participants were personally interviewed by a certified music therapist and her assistant and scores (0, 1, 2, 3, 4) were filled for the 10 questions in the questionnaire of the PSS scale. The questions in the PSS scale are such that, for some questions, less score is desirable while for others, more score is better. To induce uniformity, the scores were reversed for the latter

type of questions so that after reversing, for all questions, less score is deemed as better. Now the scores from the 10 questions were added and this sum is our variable under study. The rating is 0–13 implying low stress, 14–26 implying moderate stress and 27–40 implying high stress. As per the PSS rule, those having stress levels below 13 were dropped from the study. Thus, the actual number of participants in both groups would be less than those interviewed (sample size $n = 7$ for each group). Using paired t test, it is found that the case group participants have shown considerable improvement in comparison to the control group. Thus the efficacy of music intervention in combatting stress is established, since the allocation of the participants to both the groups was done by RCT.

Place of study (data collection): Department of Mathematics, Birla Institute of Technology, Mesra, Ranchi-835215, India.

Place of music therapy intervention: Music Room, Birla Institute of Technology, Mesra, Ranchi-835215, India.

Results of paired t test applied to the control group and the case group participants.

Let $\mu_d = E(d) = E(X - Y)$ for the control group:

$H_0: \mu_d = 0$ (not undergoing music therapy does not have any effect on PSS score);

$H_1: \mu_d < 0$ (not undergoing music therapy worsens the PSS score);

$\alpha: 5\%$.

Test statistic: paired $t = d_{mean}/[sd/\{SQRT(n)\}] \sim t_{(n-1)d.f.}$

Solution:

The analysis of the PSS scores for the control group participants is shown in **Table 1**.

Table 1. Analysis of PSS score for control group participants

Participant No.	The control group		
i	Pre test PSS score (X_i)	Post test PSS score (Y_i)	$d_i = X_i - Y_i$
1	17	23	-6
2	26	32	-6
3	22	26	-4
4	17	21	-4
5	21	22	-1
6	24	28	-4
7	22	18	-4

$$d_{mean} = -29/7 = -4.142857$$

variance of

$$d = Var(d) = \Sigma d_i^2/n - (d_{mean})^2$$

$$= (36 + 36 + 16 + 16 + 1 + 16 + 16)/7 - (4.142857)^2$$

$$= 19.571429 - 17.163264$$

$$= 2.408165$$

$sd = +SQRT(2.408165) = 1.551826$
 where $+SQRT$ implies positive square root is to be taken.

$$t = (-4.142857)/(1.551826/2.645751)$$

$$= -7.063273$$

Table $t_{0.05}$ for $7 - 1 = 6$ d.f. for one tailed test = 1.94 (equivalent to table t at 10% level of significance for two tailed test as seen from t table).

As calculated $t <$ table t , the null hypothesis is rejected and we conclude that the PSS score of

the control group not subjected to music therapy worsened possibly due to examination stress, job insecurity and other factors.

For the case group:

$H_0: \mu_d = 0$ (undergoing music therapy does not have any impact on the PSS score);

$H_1: \mu_d > 0$ (undergoing music therapy significantly lowers the PSS score; i.e., music therapy is able to combat stress);

$\alpha: 5\%$.

Test statistic: paired $t = d_{mean}/[sd/\{SQRT(n)\}]$

$\sim t_{(n-1)d.f.}$

Solution:

The analysis of the PSS scores for case group participants is shown in **Table 2**.

Table 2. Analysis of PSS score for case group participants

Participant No.	The case group		
i	Pre test PSS score (X_i)	Post test PSS score (Y_i)	$d_i = X_i - Y_i$
1	19	10	9
2	21	7	14
3	24	12	12
4	21	13	8
5	28	8	20
6	24	9	15
7	22	5	17

$$d_{mean} = 95/7 = 13.571429$$

variance of

$$d = Var(d) = \frac{\Sigma d_i^2}{n} - (d_{mean})^2$$

$$= (81 + 196 + 144 + 64 + 400 + 225 + 289)/7$$

$$- (13.571429)^2$$

$$= 199.857143 - 184.183685$$

$$= 15.673458$$

$$sd = +SQRT(15.673458) = 3.958972$$

$$t = (13.571429)/(3.958972/2.645751)$$

$$= 9.069683$$

As before, table $t_{0.05}$ for 6 d.f. for one tailed test = 1.94.

As calculated $t >$ table t , the null hypothesis is rejected and we conclude that the PSS score of the case group subjected to music therapy is significantly lowered.

The encouraging results motivated us to build a music therapy app called “MusiHeal”. The working of this app, developed by the second author, is explained next.

6. Music therapy app “MusiHeal”

1) About the environment:

(1) The app is built on android studio (a software for building mobile applications) using the flutter framework, which targets both the platform devices—android and iOS, from a single code-base. Flutter uses dart programming language (which is C++ based) and hence this mobile app is built on dart.

(2) Database, testing, and analytics will be implemented (if needed in future) using firebase developed by Google.

2) About the app:

(1) The app starts with a beautiful “Splash screen”, followed by an interactive instructions interface, and the user will be directed further only after reading all the instructions.

(2) Now the user will be directed to a filter-based interface which will contain five filter categories.

- Age (0–100 years).
- Musical background (yes {low, medium, high} & no).
- Mental health (normal, anxiety disorders, mood disorders).
- Psychotic disorders (dementia).
- Physical health (normal, physically challenged), and music type (Indian, western; both having classical and modern subtypes)

(3) After selecting the filters, the user will be directed to the “home screen” which contains:

- Real-time refreshing “Did you know?” component.
- An option for going to meditation page.
- Help and support option.
- List of symptoms (pain, fever, nausea/vomiting, depression and anxiety, sleep disturbance, breathing problem) from which the user can choose accordingly.

(4) After choosing the symptom, the user will be directed to the “raga song list screen” which will hold a list of raga songs, going from top-to-bottom, the raga element will increase in the list. Selecting any song from the list will redirect them to a “music player screen”. There will also be an option for a pure raga songs list, only for those users who have good knowledge of music, which will be determined from the initial filters.

(5) Now, the “music player screen” will contain a music player interface having elements such as raga-song name, play/pause, current-time/remaining-time, repeat, speaker/headset, favorites, and a container showing the next upcoming raga song.

(6) The “help and support screen” will contain details about the app and some songs, all the instructions, and our team contact details.

(7) The meditation screen will contain the songs list beneficial for meditation, which will be categorized based on the frequency suitable for the user, which will be determined from the initial filters. Selecting any meditative track will lead again to the “music player screen”.

(8) The “pure raga screen” will contain the pure raga soundtracks, and symptom name followed by a filter that will bifurcate the list into instrumental or vocal. Selecting any raga track will lead again to the “music player screen”.

7. Discussion

The study plan of our research consists of three phases:

Phase 1: assessing the impact of music especially Hindustani ragas in reducing stress.

Phase 2: assessing the musical properties of the Hindustani ragas and raga based songs (e.g. Tagore songs), helpful in reducing stress, through statistical musicology.

Phase 3: brain imaging study through EEG signals to explore the emotional changes caused in the brain by Hindustani ragas and raga based songs and how they are actually helping in reducing stress.

See Chakraborty and Katyayan^[16] for further details on our ongoing research.

The work done in this paper refers to phase 1 of the study. The PSS score of the control group not subjected to music therapy worsened possibly due to examination stress, job insecurity and other factors. On the other hand, the PSS score of the case group subjected to music therapy is significantly lowered. In other words, music therapy intervention is able to combat stress, given that the participants were allocated to the control and case groups using randomized control trial and there was no bias in allocation. We propose to extend our research on Hindustani ragas to combat migraine episodes, in the pain

management in cancer patients, lower the anxiety level in pregnant women, combat stress in type 2 diabetes, control hypertension and assess the impact of these ragas in psychiatric cases.

8. Concluding remarks

The paired t results show that music therapy is able to combat stress. The encouraging results motivated us to build a music therapy app called “MusiHeal”. We do believe this app will be of immense value to society in healthcare. The specific Hindustani ragas, raga based songs and other genres of music and songs therein used in the study profitably have been noted. The corresponding emotional changes they bring in the brain would be studied through EEG signals which is reserved as a rewarding future work.

Remark: what kind of physical stimulus leads to what kind of emotional changes in the brain is a subject matter of psychophysics which is a branch of psychology. The interested reader is referred to the book by Roederer^[17].

Author contributions

Conceptualization, SC; methodology, SC; software, AP and PS; validation, SC and AC; formal analysis, SC and AC; investigation, AC; resources, AC, AP and PS; data curation, AC; writing—original draft preparation, SC, AP, AC and PS; writing—review and editing, SC; visualization, SC; supervision, SC; project administration, SC; funding acquisition, SC.

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Ethical declaration

The authors hereby declare that they have no conflict of interest. As the participants were 9th semester students of the institute in our department, formal permission from the dean of students’ affairs was taken to carry out the music intervention followed by a formal consent form filled out and signed by the participants of both the control and case group.

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