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Effect of Music on Patients by Study of EEG Signals

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Abstract: In this paper a pilot study is made on the effect of Indian music (mainly Rabindrasangeet/ Nazrulgeeti/ popular regional old modern songs) by studying the EEG signals of the patients of a Hospital, who are suffering mainly from tension headache and migraine problems and who are taking drugs as prescribed by the physicians for the relief of their pain. The analysis of the results of experiments is purely statistical in nature.

Keywords: EEG signals, Rabindrasangeet, Musiogenic Epilepsy

1. Introduction

Effect of music on mind is a very challenging topic. Scientific works towards measuring psycho-physiological effects of Indian classical music are comparatively less than the corresponding works done with Western classical music. So far as physiological changes in the EEG pattern is concerned, it may be mentioned that Crichley[1] was the first to note the impulses in EEG due to the aesthetic appeal of music in 1937. Since then the topic has been technically named as 'Musiogenic Epilepsy'. During sixties and seventies of the last century, experimental works on this topic were done significantly. Servit et al[2] reviewed twenty cases where seizures were triggered by music; many reports indicated that the induced seizures were located in the temporal lobe and probably arose from foci of the auditory cortex. Poskanzer[3] reported that only a discrete frequency band of *church bell* caused musiogenic epilepsy. Marsden et.al[4] mentioned the case of a patient whose grandmul seizures were initially provoked by certain type of classical orchestral and church music, and who could be induced to have a

fit by Beethoven's Fifth Symphony. It was also mentioned that everything was related to something 'devotional'. Ray G. S and his coworkers[5,6,7] started their initial experiments on music lovers known for their knowledge and appreciation of Indian classical music. Among the music lovers, several objects used western classical including Beethoven's symphony. Though the signature in EEG and the spikes were obtained during the experiment, the numbers were less and the spikes were of smaller magnitudes. Ultimately it was realized that devotional music with devotees as subjects could give the best result; possibly the aesthetic appeal along with the stress of devotion helped the subjects to reach the epoch moments. Sometimes some objects were advised to use imagery to get a better result. Subsequently they gave a theoretical explanation for these happenings in[5,6]. They continued such studies in[6,7]. In musiogenic epilepsy, they found that the consciousness transcends the time domain with quick reentry and in many cases (as in petimal epilepsy of children) it does not seriously disturb the continuity of consciousness, just as blinking of eye does not disturb the continuity of vision. EEGs containing transcendences were picked up from subjects under the spell of music. After preliminary analysis, the portion of EEGs containing the number of spikes were termed epoch periods (usually of the duration of few mili-seconds), the rest of the near normal EEGs were non-epochs. In most of the cases, the music and data were played back to the subjects and they identified that epoch periods coincide with the moments the subjects found extremely pleasant or they were 'swept away'.

It is not out of context to mention that number of patients suffering mainly from Headache and Migraine problems is increasing day by day. Further the rating of their headache is also alarming, although they are habituated to take drugs as prescribed by the physicians. Naturally it remains open to see whether music can play an additional role in the form of what is called music therapy. As most of the people of India prefer listening to Rabidrasangeet/ Nagrulgeeti/ regional popular old modern songs, so we prefer to find the role of Indian music of this type only. It may be remarked that proper scientific study towards the effect of Indian music of the above type is still very few in number. This is the motivation behind such pilot study on the effect of music.

2. Materials and Methods : Study area and population

The pilot study was carried out in the Bangur Institute of Neurology. It is located at the center of the city of Kolkata, which is the capital of West Bengal, situated in the eastern part of India. The study was made on a small sample of 21 patients who had been suffering mainly from tension headache

and migraine problems. Out of them nineteen patients were reported to take drugs of different types; for some of them, the drugs were common. The patients were both males and females. Some of them were literate and some of them were illiterate. Some of them were interested in listening to music and some were not so, at all. Out of those who were interested in music, some were also specific in their choice of music preferring only one category.

Study Materials

Computer oriented EEG machines available in the Hospital

Study Phases

1. **First Phase:** In the first phase, 21 patients were chosen at random, from the totality of all patients who used to come to the Hospital for their treatment during the last three months, and who suffered mainly from tension headache and migraine problems. For such a sample of 21 patients, a list was made with their name, age, education status, sex, type of headache suffering from, history of drug intake, and type of music of interest, if any [Table I].

Table I: Type of headache and headache score

Age	Gender		Literacy
	Men	women	
10-19	1	2	SC-2, HS-1
20-29	1	2	SC-1, HS-1
30-39		8	
40-49	2	5	

Type of headache	Men	Women
Migraine	1	11
Tension	3	3
Mixed	0	3

Headache score	Pre-music	Post- music
0-4	3 (14.3%)	9 (42.85%)
5-7	12 (57.1%)	9 (42.85%)
8-10	6 (28.6%)	3 (14.30 %)

Headache score	Tension Headache (n=-6)		Migraine (n=12)	
	Pre music	Post Music	Pre music	Post music
0-4	2 (33.33%)	3 (50.00%)	1(8.33 %)	5 (41.68%)
5-7	4 (66.67%)	3 (50.00%)	6 (49.99%)	4 (33.33%)
8-10	0	0	5 (41.68%)	3 (24.99%)

Headache score	Mixed	Mixed
	Pre music (3)	Post Music (3)
0-4	0	0
5-7	3	3
8-10	0	0

2. **Second Phase:** In the next phase, their intensity of headache was rated by the following two standard tests [Table II]:

i)Visual Analogue Scale (VAS) for quantifying pain

ii) Migraine Disability Assessment Scale (MIDAS)

a. Missing at office work/school
or
b. >50% reduction in office work/productivity / school performance
or
c. Missing at household works
or
d. >50% reduction at household productivity
or
e. Number of headache in last 3 months, degree of severity of the headache and also its duration (if it lasted for more than 1 day)

(Severity of headache is rated 0 for No pain and 10 for Worst one)

Table II

PRE-MUSIC

8-9 Hz Alpha activity

10-11 Hz Alpha activity

9-10 Hz ALPHA activity

9-10 Hz ALPHA activity
9-10 Hz Alpha activity

11-12 Hz Alpha activity

8-9 Hz Alpha activity

10-11 Hz Alpha activity

11-12 Hz Alpha activity
9-10 Hz Alpha activity

8-9 Hz Alpha activity

10-11 Hz Alpha activity

9-10 Hz Alpha activity

Ill-defined Fast Activity

8-9 Hz Alpha activity

8-9 Hz Alpha activity

8-9 Alpha activity

9-10 Hz Alpha activity

9-10 Hz Alpha activity

8-9 Hz Alpha activity

9-10 Hz Alpha activity

EEG

Positive = 11

3. **Third Phase:** In this phase, first of all, for each one of the 21 subjects, EEG signals were taken for 20 minutes. Each signal was taken with the first and last 5 minutes without music input; rest 10 minutes in between under the input of music. After taking the EEG signals for the 21 patients, the Neurologists examined the EEG signals and noted the EEG signal pattern in the pre-music, during music and post-music stages. Then they explained the patterns of the signals in the three stages as per standard rules followed in such cases and noted the differences, if any. Next they again rated the

intensity of headache in the post music stage as done earlier in the pre music stage. Lastly they tried to relate the post-music ratings of headaches with the changes in the EEG pattern.

4. **Last Phase:** Lastly the ratings of the pre-music and post-music stages were analyzed statistically to

(i) Find out their correlation coefficient using Pearson's rank correlation coefficient [Table III] and use it to perform related significance test for correlation coefficient.

(ii) Find out variances of the samples [Table IV] and use it to carry on related significance test for difference in sample means.

Table 3. Correlation of Pre-music and Post-music data

Sl. no	Pre Music	Rank R1	Post Music	Rank R2	D=R1-R2	D^2
1	5	14	4	14.5	-0.5	0.25
2	8	5	6	10.5	-5.5	30.25
3	10	2	8	3	-1	1
4	5	14	3	18.5	-4.5	20.25
5	4	19.5	4	14.5	5.5	30.25
6	5	14	3	18.5	-4.5	20.25
7	4	19.5	3	18	1	1
8	8	5	6	10.5	-5.5	30.25
9	7	9.5	4	14.5	-5.5	30.25
10	7	9.5	7	6	3.5	12.25
11	10	2	10	1.5	0.5	0.25

12	7	9.5	7	6	3.5	12.25
13	8	5	6	10.5	-5.5	30.25
14	7	9.5	7	6	3.5	12.25
15	10	2	10	1.5	0.5	0.25
16	6	13.5	6	10.5	3	9
17	5	14	3	18.5	-4.5	20.25
18	2	21	1	21	0	0
19	7	9.5	7	6	3.5	12.25
20	6	13.5	4	14.5	-1	1
21	7	9.5	7	6	3.5	12.25

Spearman's Rank Correlation Coefficient

$$r = 1 - \frac{6[\sum D^2 + \sum_k \frac{1}{12}(m^3 - m)]}{n(n^2 - 1)},$$

where m is the number of items of the same rank and k is the number of times the items of same rank occur.

In this case

$$\sum_k \frac{m^3 - m}{12} = 3 \times \frac{2^3 - 2}{12} + 2 \times \frac{3^3 - 3}{12} + 4 \times \frac{4^3 - 4}{12} + 1 \times \frac{5^3 - 5}{12} + 1 \times \frac{6^3 - 6}{12}$$

$$= 3 \times .5 + 2 \times 2 + 4 \times 5 + 10 + 17.5 = 1.5 + 4 + 20 + 10 + 17.5 = 53$$

$\sum D^2 = 286$, n = 21

Hence we have r = .71 (approximately).

Remark 1: This shows that Pre Music and Post Music scores of the samples are correlated nicely. The question remains to interpret whether the Pre Music Scores and Post Music scores of the whole population of patients suffering from headache and or migrane (divided in two groups with and without music input) differ significantly. In other words we are to be sure whether the value of the correlation coefficient ρ in the population is zero and observed value of r has arisen due to fluctuation of sampling. R. A. Fisher has shown that when the null hypothesis $H_0(\rho = 0)$ is true, the test statistic $t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$ follows student's t-distribution with n-2 degrees of freedom, provided the sample size is small (less than 30). As our sample size is 21, so we apply the aforesaid Fisher's test of significance on correlation coefficient.

Test of significance on correlation coefficient: We take the null hypothesis $H_0(\rho = 0)$. In our case $t = \frac{.71\times\sqrt{19}}{\sqrt{1-.71}} = 5.68$.
Since in this case, the alternative hypothesis is both sided (ρ is less than or greater than zero), so we find from standard table that for 5% level of significance with n-2 **(= 19)** degrees of freedom the critical region is $|t| \geq 2.09$, for 1% level of significance with n-2(= 19) degrees of freedom the critical region is $|t| \geq 2.86$. As 5.86 is greater that both 2.09 and 2.86, so we conclude that the alternative hypothesis is true both at 1% and 5% level of significance. Thus we find that even at 1% level of significance the null hypothesis is false. This proves that the original populations aught to be significantly correlated. In other words music has significant effect on persons suffering from headache and or migraine.

Remark 2: We note that to find the difference in means of the populations we can apply t-test as the sample size is small (less than 30). But this test is possible only when we are sure that at certain level of confidence the variances of the populations are to be same. So we first apply F-test on the sample variances and try to see at what level of significance it is possible to accept that the population variances do not differ.

Table 4. Variances in sample means from Pre Music and Post Music scores

Pre Music x	Post Music y	u=x-5	v=y-5	u*u	v*v
5	4	0	-1	0	1
6	6	3	1	9	1
10	8	5	3	25	9
5	3	0	-2	0	4
4	4	-1	-1	1	1
5	3	0	-2	0	4
4	3	-1	-2	1	4
8	6	3	1	9	1
7	4	2	-1	4	1
7	7	2	2	4	4
10	10	5	5	25	25
7	7	2	2	4	4
8	6	3	1	9	1
7	7	2	2	4	4
8	6	3	1	9	1
7	7	2	2	4	4
10	10	5	5	25	25
6	6	1	1	1	1
5	3	0	-2	0	4
2	1	-3	4	9	16
6	4	1	-1	1	1
7	7	2	2	4	4
		33	11	139	119

Fisher's F-test

The sample variances S_1^2, S_2^2; s_1^2, s_2^2; F are calculated as follows:

$$S_1^2 = \frac{\sum u^2}{n} - (\frac{\sum u}{n})^2 = \frac{139}{21} - (\frac{33}{21})^2 = \frac{1830}{21\times 21}$$

$$S_2^2 = \frac{\sum v^2}{n} - (\frac{\sum v}{n})^2 = \frac{119}{21} - (\frac{11}{21})^2 = \frac{2378}{21\times 21}$$

$$s_1^2 = \frac{n_1}{n_1 - 1}\times S_1^2 = \frac{1830}{20\times 21}, s_2^2 = \frac{n_2}{n_2 - 1}\times S_2^2 = \frac{2378}{20\times 21}$$

$$F = \frac{s_2^2}{s_1^2} = 1.3$$

We take the null hypothesis $H_0 : \sigma_1^2 = \sigma_2^2$; now from the standard table it is found that at degrees of freedom (20, 20), the value of F is 1.84 at 5% level and 2.42 at 1% level. Thus the calculated value 1.3 is less than the tabulated value at both levels of significance. Hence even at 1% level of significance, the null hypothesis $H_0 : \sigma_1^2 = \sigma_2^2$ is true.

t-test for population means

Null hypothesis is $H_0 : \mu_1 = \mu_2$. Alternate hypothesis is $\mu_1 \neq \mu_2$.

If $\bar{x}_1, \bar{x}_2$ denotes the sample means and $s_{E(\bar{x}_1 - \bar{x}_2)}$ denotes the standard errors of the difference between the sample means, then formula for t is $t = \dfrac{\bar{x}_1 - \bar{x}_2}{s_{E(\bar{x}_1 - \bar{x}_2)}}$,

$s_{E(\bar{x}_1 - \bar{x}_2)} = s\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}$, where $s^2 = \dfrac{n_1 S_1^2 + n_2 S_2^2}{n_1 + n_2 - 2}$. On calculation we get

$s^2 = \dfrac{4178}{40 \times 21}, s_{E(\bar{x}_{11} - \bar{x}_2)} = \sqrt{\dfrac{4178}{21 \times 40 \times 21}} = \dfrac{1}{15}$.

Finally we get $t = \dfrac{22/21}{1/15} = 15.7$. As it is a two sided test so we get from standard table, the critical region given by $|t| > 2.04$ at 5% level and $|t| > 2.75$ at 1% level with 40 degrees of freedom. Thus in both the cases the calculated value 15.4 is far greater than the tabulated value. This proves that even at 1% level, the alternate hypothesis $\mu_1 \neq \mu_2$ is true. Thus we conclude that the population means μ_1, μ_2 differ significantly.

Remark 3: Apart from showing that μ_1, μ_2 differs significantly, we can even show by what amount they differ with the help of **Interval of confidence.**

This is given as follows: The interval of confidence at 5% and 1% levels are respectively given by

$$\frac{22}{21} - \frac{2.04}{15} < \mu_1 - \mu_2 < \frac{22}{21} + \frac{2.04}{15},$$

$$\frac{22}{21} - \frac{2.75}{15} < \mu_1 - \mu_2 < \frac{22}{21} + \frac{2.75}{15}$$

Results and Discussion

(1) EEG reports of Table II indicate that in almost fifty percent cases there has been positive effect of slowing down. This proves clinically that there is significant effect of standard popular music on minds of persons suffering from headache and migraine.

(2) Spearman's correlation coefficient r and related correlation coefficient significance test prove statistically the positive effect of music on patients.

(3) F-test on the variances and subsequent t-test on the differences of means also prove statistically the positive effect of music

Future plan of work

1) To increase the Data set sufficiently (greater than thirty) and to apply other statistical tests of significance.
2) To carry on similar analysis by considering other inputs like specific Rabindra Sangeet of slow pace
3) To investigate by increasing times of applying the inputs
4) To apply only the music (and not the song as such) in order to ascertain whether the effect is solely due to music composition or due to the effect of musical composition and proper wordings of the song.
5) To carry on all such investigations with Hindustani Classical Music.

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