Music and Medicine
5(2) 67-75

DOI: 10.1177/1943862113485903
mmd.sagepub.com
SAGE

Impact of Hindustani Ragas on Visual Acuity, Spatial Orientation, and Cognitive Functions in Patients With Cerebrovascular Accident and Diffuse Head Injury

Shashi Bhushan Singh, MSc[1], Soubhik Chakraborty, PhD[2], Keashav Mohan Jha, MCh[3], Satish Chandra, MD[4], and Shanti Prakash, MD[5]

Abstract

The objective of this article is to study the impact of Hindustani ragas on the cognitive functions of the right and left cerebral hemispheres, especially of the parieto-occipital lobe, in patients with cerebrovascular accident and diffuse head injury. A randomized control trial was conducted. The case group consisted of 30 patients who received both medicine and ragas, while the control group of 30 patients received only medicine. A total of 10 Hindustani ragas were taken up, and 4 follow-ups with baseline were conducted. Nahor-Benson test, a subtest of the Post Graduate Institute–Battery for Brain Dysfunction, was used at different time intervals. Univariate repeated measures analysis revealed significant differences between the 2 groups at different time intervals, confirming that listening to ragas improved visual perceptual acuity, spatial orientation, and the cognitive functions involving both right and left hemispheres of the case group patients.

Keywords

cerebrovascular accident, cognitive functions, diffuse head injury, Hindustani ragas, univariate repeated measures analysis

Introduction

This article focuses on randomized control trial that was conducted to assess the impact of Hindustani ragas (North Indian Ragas) on patients with cerebrovascular accident (CVA) and diffuse head injury (DHI) during a rehabilitation phase, at Rajendra Institute of Medical Sciences (RIMS), Ranchi, India. The study found that, in addition to medicine, listening to ragas played a vital role in improving the cognitive impairment of the patients in the rehabilitation phase (after the patient is stabilized). This study was approved by the Institutional Ethical Committee (IEC), RIMS, Ranchi, India. A raga, the nucleus of Indian classical music (both Hindustani and Carnatic), may be defined as a melodic structure with fixed notes and a set of rules characterizing a certain mood conveyed by performance. By "a set of rules" we mean the typical way the permissible musical notes are to be used in the raga, the typical note combinations, the *aroh–awaroh* (ascent–descent) pattern to be followed, and so on. These rules help in characterizing the raga mood.[1]

Literature Review

There is a limited amount of valid clinical research material from which substantive and scientific conclusions can be drawn on the impact of music with this population. In many cases, neurological diseases become traumatic because of their abrupt appearance, resulting in physical and/or mental impairment.[2] Music appears to be a key in the recovery of former capabilities in the light of what at first seems to present as a hopeless neurological devastation.[3-5] For some patients with brain damage following head trauma, the problem may be temporary, such as a loss of speech (aphasia). Music therapy has been shown to play a valuable role in the aphasia rehabilitation.[6] A good

[1]Department of Preventive and Social Medicine, Rajendra Institute of Medical Sciences (RIMS), Ranchi, India
[2]Department of Applied Mathematics, Birla Institute of Technology, Mesra, Ranchi, India
[3]Department of Neuro-surgery, Indira Gandhi Institute of Medical Sciences, Patna, India
[4]Department of Pharmacology, Rajendra Institute of Medical Sciences (RIMS), Ranchi, India
[5]Department of Anesthesiology, Rajendra Institute of Medical Sciences (RIMS), Ranchi, India

Corresponding Author:
Soubhik Chakraborty, Department of Applied Mathematics, Birla Institute of Technology, Mesra, Ranchi-835215, India.
Email: soubhikc@yahoo.co.in

account of research findings about the neurobiological foundation of rhythm and the brain, with a thrust on how music and rhythm can affect both musical and nonmusical brains can be found in Thaut's work that provides a therapeutic methodology of neurologic music therapy dealing extensively with clinical techniques and implementations in rehabilitation.[7]

Much more information about music therapy in the context of Indian music is also developing.[8] Music therapy has a positive effect on mood in poststroke patients.[9] Music therapy, used in rehabilitation phase, has been shown to stimulate brain functions involved in emotion, cognition, speech, and sensory perception.[10] In a study on the mechanism of music therapy through functional magnetic resonance imaging (fMRI), unpleasant music showed activation of the limbic and paralimbic systems (the centers of feelings), but pleasant music stimulated the inferior frontal gyrus and Rolandic operculum that reflect working memory.[11]

Such results seem to indicate that music therapy can intervene with feelings through the stimulation and nonstimulation of these structures, and it appears that music can enhance functional abilities by inspiring motivation for rehabilitation treatment through improvement in depression and anxiety. Music is a multimodal stimulus that activates many brain structures related to sensory processing, attention, and memory and can stimulate complex cognition and multisensory integration.[12-14] After stroke, listening daily to self-selected music may improve verbal memory and attention. Music listening during the early poststroke stage can enhance cognitive recovery and prevent negative mood.[14] Significant improvements in speech-in-noise perception have been attained in adult individuals with no prior music training but with a training program that incorporated cognitively based listening exercises to improve speech-in-noise perception.[15] Music listening could be considered a useful clinical tool in stroke rehabilitation.[16] Listening to pleasant music can have a short-term facilitating effect on visual awareness in patients with visual neglect, which is associated with functional coupling between emotional and attention area of brain regions. Second, daily music listening can improve auditory and verbal memory, focused attention, and mood as well as induce structural gray matter changes in the early poststroke stage.[17]

There is no great deal of research that reflects the impact of Indian music. Although some descriptions are available about the impact of raga therapy, in-depth scientific research in Indian music especially from a therapeutic angle is still at a beginning stage.[18] Indian music therapy is an integration of ancient healing practices and musical traditions coupled with the recent modifications derived from the modern-day practice and the knowledge gained by current clinical studies undertaken.[19]

Cerebrovascular accidents, traumatic brain damage, and congenital brain anomalies can lead to selective disorders of music processing. However, brain specialization for music should not be equated with the presence of a single ''musical center'' in the brain. Rather, multiple interconnected neural networks are engaged, of which some may capture the essence of brain specialization for music. The encoding of pitch along musical scales is an essential component. The implications of the existence of such special-purpose cortical processes are that the human brain might be hardwired for music. This valuable resource of evidence is suggestive of the existence of neural networks in brain, which are dedicated to music.[20]

Notably, music therapy is showing significant results in the rehabilitation of patients with stroke and Parkinson disease. However, the author has suggested the need for more rigorous studies based on clear procedures and strong methodological research criteria.[21]

A study giving special attention to the perception of components of music processing, music structure, laterality effects, cultural issues, links between music and movement, emotional processing, expertise, and amusias demonstrated the important role that music can play in forming broad theories of higher order cognitive processes, such as music, in humans.[22] Music-supported therapy (MST) in stroke rehabilitation brings about changes in neuromagnetic beta-band oscillation.[23] The incorporation of music into rehab training significantly improved both the objective measures of hand motor performance and the self-ratings of motivation for training in a single session.[24]

Objective

The objective of our study was to understand the possible impact that Hindustani ragas might have on visual perceptual acuity, spatial orientation, and the cognitive functions involving both right and left hemispheres in patients with CVA and DHI.

Materials and Methods

A randomized control trial was conducted to assess the impact of Hindustani ragas in patients with CVA and DHI, during the rehabilitation phase, at RIMS, Ranchi, in collaboration with the Birla Institute of Technology (BIT), Mesra, Ranchi, India. A total of 60 patients 18 years of age or older, were recruited for this study. Rapport was established, and written informed consent was obtained from the patients or the head of his or her family. Baseline data were collected from all 60 patients. A case group (hereafter referred to as music group) of 30 patients were those to whom both medicine and prerecorded Hindustani ragas were administered, while the control group of 30 patients received medicine only. Ten Hindustani ragas were selected for the music group patients as detailed in Table 1, along with their suitable time of rendition. The intervention began on an average after 15 days only when the Glasgow Coma scale (GCS) score was recorded to be greater than 8, indicating that the patient was out of the life-threatening phase. The statisticians and the medical professionals were blinded for this study to reduce the researcher biasness. While the statisticians were involved with the analysis part, it is the medical professionals who are authorized to do the treatment of the patients, and

Table 1. Ragas and Their Suitable Time of Rendition.

S. No.	Ragas Administered to Patients	Suitable Time of Rendition
01	Bhairav	5 AM to 8 AM
02	Ahir Bhairav	5 AM to 8 AM
03	Bilaval	6 AM to 9 AM
04	Todi	9 AM to 12 noon
05	Bhimpalashree	1 PM to 3 PM
06	Pilu	1 PM to 3 PM
07	Multani	3 PM to 6 PM
08	Yaman	6 PM to 9 PM
09	Bhairavi	6 PM to 9 PM
10	Bageshree	9 PM to 12 midnight

hence the medical professionals are truly credited with data collection.

Inclusion Criteria in the Selection of Patients.

- Patients older than 18 years of age and a resident of Ranchi district;
- patients with DHIs and CVA and
  - who were stabilized from life-threatening medical and neurological complication (GCS > 8) and
  - whose medical and clinical status, level of consciousness, and social and environmental factors were considered acceptable.

Exclusion Criteria.

- Patients' age less than and equal to 18 years and not a resident of Ranchi district;
- those having acute illnesses.

Intervention of Music Therapy. The patients in the music group were subjected to both medicine and music therapy (Hindustani ragas), while the patients in the control group were given medicine only. A prerecorded cassette and a cassette player along with a headset were used for listening to ragas. All cassettes, cassette players, and headsets used by the patients in the music group were identical and of the same company. The patients were subjected to each of the previously mentioned ragas for a duration of 20 minutes every day, for up to 6 months (total of 3 hours 20 minutes each day for all the 10 ragas), per their convenience but within the time of day as mentioned in Table 1.

While listening to the ragas, the patients were instructed to follow certain steps as listed here:

1. closing their eyes;
2. focusing on the breathing process by placing their hands on the abdomen; and
3. listening to the raga intently.

For the patients who were unfamiliar with ragas, some songs based on a particular raga (even songs from movies) were played first before the raga itself. The idea is to get the patient acclimatized to the raga mood by listening to something familiar and related. Here selecting a movie song randomly will not help as the song has to be related to the raga. Although one of the researchers knows classical music and could easily do the song selection, we took the services of a DMus (vocal) artist (from Banaras Hindu University) who is not related to our research, in an attempt to reduce the researcher's bias. Further, the song to be used for a specific patient was selected by lottery from the list of songs. For example, the songs "Chingari koi bhadke" sung by Kishore Kumar in the Bollywood movie *Amar Prem* and the song "Jyot se jyot jagate chalo" sung by Mukesh in another Bollywood movie *Sant Gyaneshwar*, both based on the raga Bhairavi, were in the list. But we decided by lottery which patient would listen to which of the 2 songs.

The patients were given liberty to adjust the music sound (volume, etc) per their liking. They were also encouraged to use their vocal cords through gentle murmurs. The patients in both the music group and the control group were observed, and the patients in the music group were helped to listen to the ragas directly during their stay in the hospital. Before discharge, the patients were again trained regarding the specific period of the day for listening to specific raga, duration of listening to each raga, and proper way of listening to each raga as mentioned earlier, so that they would follow the listening protocol at home.

The strategy behind the choice of the ragas in the present study is that the benefits of some of these ragas were explored in earlier studies.[18] For example, *Ahir Bhairav* relieves stress-related disorders. *Bhairav* is thought to help in anger management, bringing down the excitement. *Bageshree* works well in sleep disorder. *Yaman*, being a restful raga, brings relaxation. *Todi* has been found to be useful in the treatment of hysteria, while *Bhairavi* works well for a number of maladies from sinusitis to cancer. *Pilu* tackles depression. The present study was expected to reconfirm the utilities of all these 7 ragas as well as explore the other 3, namely, *Bilaval*, *Bhimpalashree*, and *Multani* for possible therapeutic effects on such patients. Each raga is closely related to the specific part of the day, according to changes in nature and development of a particular emotion, mood, or sentiment in the human mind.

Since a higher frequency is beneficial rather than harmful (unlike higher doses of drugs that exhibit side-effects), the patients in the music group were subjected to each of the 10 ragas for a duration of 20 minutes only every day within the previously mentioned time of the day per their convenience, for a duration of 6 months. The choice of 20 minutes although subjective was necessitated primarily due to 2 factors: (1) the duration should not be too short as the raga atmosphere takes some time to build, and (2) the duration should not be too long either that it becomes taxing for the patients.

Tool and Techniques Used for Data Collection

Nahor-Benson Test. It is one of the components of Post Graduate Institute–Battery for Brain Dysfunction (PGI-BBD), consisting of 8 cards (see Appendix). Of these, 5 cards contain a design each and 3 cards contain the instructions to be followed. Cards

Table 2. Interpretation of the Raw Scores of Nahor-Benson Test.

Educational Level	Error Score	Dysfunction Rating
Those who can read with considerable difficulty	0-3	0
	4-5	2
	6-8	3
Those who can read fluently	0-2	0
	3-4	2
	5-8	3

1 to 5 decide the perceptual acuity that will be disturbed depending upon the extent of lesion in the right parieto-occipital region. The last 3 cards (6 to 8), where instructions are to be read, understood, and executed, will involve the left hemisphere and disturbance in transference from left to right. Thus, this test provides for simultaneous assessment of cognitive behavior of both hemispheres of the brain. Generally, drawing tests measure the functioning of the right hemisphere related to parieto-occipital lobe.

Patients were asked to copy the design of the cards 1 to 5 one by one. Patients were asked to follow the instructions on cards 6 to 8. Scoring is given on the basis of the "all or none" law; that is, either a design is correct or it is incorrect. Each incorrect drawing was given a score of 1 (Table 2).

Plan for Data Collection

Using the aforementioned tool, the patients in both the music and the control groups were assessed as shown in the flowchart (Figure 1).

Data Analysis

A template for data entry was generated in MS Excel 2007 (Microsoft, Redmond, Washington), and 10% data were randomly checked to assure the quality of data. Data analysis was done using SPSS version 12 (SPSS Inc, Chicago, Illinois). Using Kolmogorov-Smirnov test, we checked the normality of data on dysfunction score of Nahor-Benson test (N.B. test) in different follow-ups. Univariate repeated measures analysis (URMA) using a split plot design was used to see whether the dysfunction score of N.B. test was statistically significant between the 2 groups in different follow-ups. A P value of less than .05 was considered statistically significant.

Experimental Results

A total of 60 patients were studied. The majority of the patients were male (37 out of 60 [61.7%]). The average age of the patients was 55.5 years. Regarding the education status, it was found that the majority (54 out of 60 [90%]) of the patients were fifth standard passed. The details of the sociodemographic profile of the patients are provided in Table 3. Table 4 shows that the data were normally distributed in baseline as well as in all the 4 follow-ups. Table 5 shows that the mean of dysfunction rating score (DRS) of N.B. test before music therapy in both the music group and the control group was 3.00. The mean score after music therapy came down to 0.533, indicating a fall of 2.47 after the fourth follow-up, whereas in the control group, the score came down to 1.47, indicating a decrease of 1.53 only, which is comparatively less. This means the recovery rate is faster in the music group (Figure 2). The recovery rate is also statistically significant in the fourth follow-up, as shown in Table 5.

The URMA using a split plot design revealed that the F statistic for dysfunction scores of N.B. test is 67.719, which is significant between the groups (P value = .000). This is for the group effect. Both the follow-up effect and the interaction effect between follow-up and group effects (indicated in the table as follow-up × group effect) use the error mean square as the error term. The F statistic for the follow-up effect is 319.303, which is significant (P = .000). The F statistic for follow-up × group effect is 19.599, which is also significant (P = .000; Table 6). Significance of the F statistic for the group effect implies the better response of the group given the combined treatment of medicine and music. Significance of the F statistic of the follow-up effects indicates the recovery rate of the patients in both groups gets better and better significantly with more and more follow-ups, but the important and interesting finding is that the interaction (group × follow-up) effect is also significant, substantiating the fact that the recovery rate is faster in the music group with follow-ups compared to the control group, which is a very positive sign that goes in favor of the therapeutic value of Hindustani ragas.

Discussion

Further research is needed in the field of raga therapy before it can be formalized into a definite prescription for the patients. Until then, a balanced approach to understand and explore the role and effect of raga therapy seems necessary. In India, music therapy has not received as much attention as in the West. The Medical Council of India has so far not recognized music therapy as a branch of modern medicine, necessitating all the more effort for using an appropriate music scientifically. Despite its rich traditions in raga and yoga, strangely, India is very much lagging behind in such pursuits. The current research may be helpful in substantiating our existing knowledge of music therapy.

We studied the impact of Hindustani ragas on patients with CVA and DHI. The levels of cognitive functions of both hemispheres of the brain were found to be significantly improved as compared to control group as a result of music intervention. Furthermore, music reduced the time of recovery in the music group patients. These findings are similar to previous studies, showing that improvement on the Montreal Battery of Evaluation of Amusia correlated mostly with the recovery of focused attention, verbal memory, visuospatial perception, and attention in music patients from the acute stage to the 3-month poststroke stage.[25] In our study, we found that the improvement in visual acuity, spatial

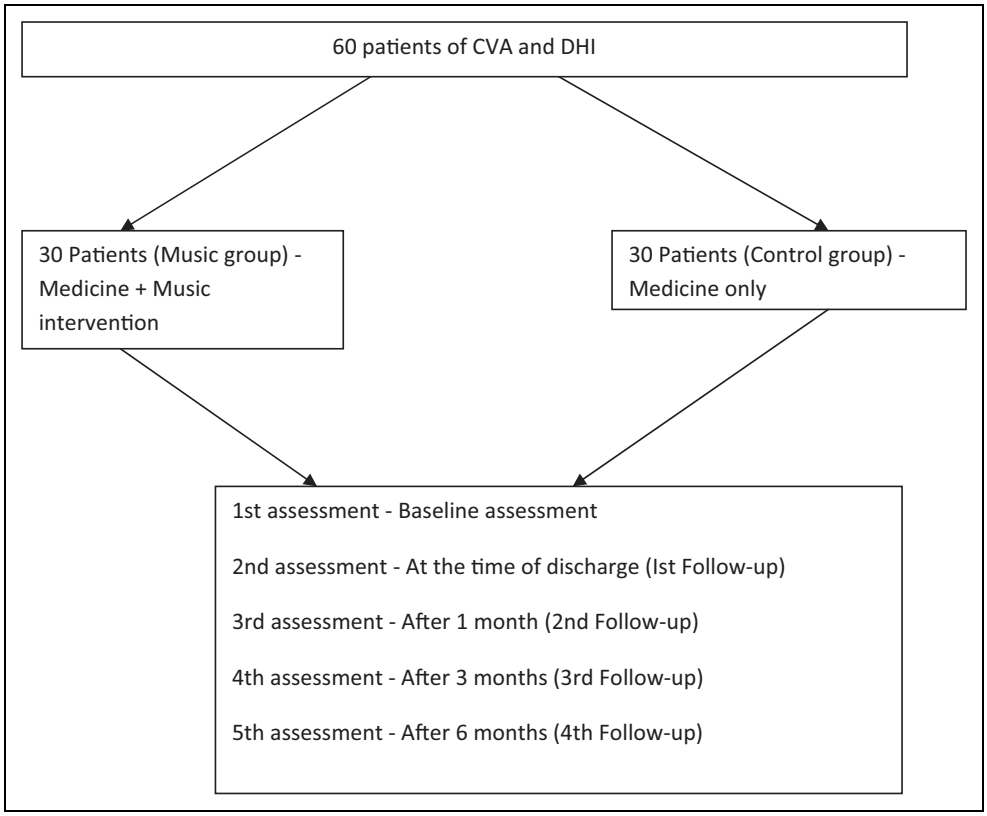


Figure 1. Flowchart for method of data collection.

Table 3. Sociodemographic Profile of the Patients.

		Group		
Variables	Category	Case (N = 30), n (%)	Control (N = 30), n (%)	Total (N = 60), n (%)
Sex	Male	21 (70.0%)	16 (53.3%)	37 (61.7%)
	Female	9 (30.0%)	14 (46.7%)	23 (38.3%)
Age, years	Mean (SD)	55.23 (17.7)	55.80 (12.5)	55.5 (15.2)
Education	Fifth pass	28 (93.3%)	26 (86.1%)	54 (90%)
	Tenth pass	1 (3.3%)	2 (6.7%)	3 (5%)
	Graduation	1 (3.3%)	2 (6.7%)	3 (5%)

Table 4. One-Sample Kolmogorov-Smirnov Test—Dysfunction Score of N.B. Test.

		Baseline	First Follow-Up	Second Follow-Up	Third Follow-Up	Fourth Follow-Up
N		60	60	60	60	60
Normal parameters[a,b]	Mean	3.0000	2.9500	2.9667	2.7000	1.0000
	Std deviation	0.00000[c]	0.21978	0.18102	0.46212	1.00844
Most extreme differences	Absolute		.540	.540	.442	.339
	Positive		.410	.427	.258	.339
	Negative		−.540	−.540	−.442	−.339
Kolmogorov-Smirnov *Z*			4.183	4.181	3.423	2.628
Asymp sig (2 tailed)			.000	.000	.000	.000

Abbreviations: N.B. test, Nahor-Benson test; Std deviation, standard deviation; Asymp, asymptomatic; sig, significance.
[a]Test distribution is normal.
[b]Calculated from data.
[c]The distribution has no variance for this variable. One-sample Kolmogorov-Smirnov Test cannot be performed.

Table 5. Mean and Standard Deviation of Dysfunction Score Based on Nahor-Benson Test.

Different Visits	Music Group (N = 30)	Control Group (N = 30)	*t* Value	Degree of Freedom	*P* Value
Baseline	3.0 (0.0)	3.0 (0.0)	NA	58	NA
First follow-up	2.90 (0.305)	3.0 (0.00)	−1.795	58	.078
Second follow-up	2.93 (0.253)	3.0 (0.00)	−1.439	58	.155
Third follow-up	2.60 (0.499)	2.80 (0.407)	−1.703	58	.094
Fourth follow-up	0.53 (0.899)	1.47 (0.899)	−4.018	58	.00

Table 6. Repeated Measure Analysis (Dependent Variable: Dysfunction Score of Nahor-Benson Test).[a]

Source		Type III Sum of Squares	*df*	Mean Square	*F*	Sig
Intercept	Hypothesis	1614.720	1	1614.720	6327.957	.000
	Error	14.800	58	0.255[b]		
Group	Hypothesis	17.280	1	17.280	67.719	.000
	Error	14.800	58	0.255[b]		
Subject (group)	Hypothesis	14.800	58	0.255	1.451	.029
	Error	40.800	232	0.176[c]		
Follow-up	Hypothesis	224.613	4	56.153	319.303	.000
	Error	40.800	232	0.176[c]		
Follow-up × group	Hypothesis	13.787	4	3.447	19.599	.000
	Error	40.800	232	0.176[c]		

Abbreviations: *df*, degrees of freedom; sig, significance; MS, mean square.
[a]Computed using $\alpha = .05$.
[b]MS (subject (group)).
[c]MS (error).

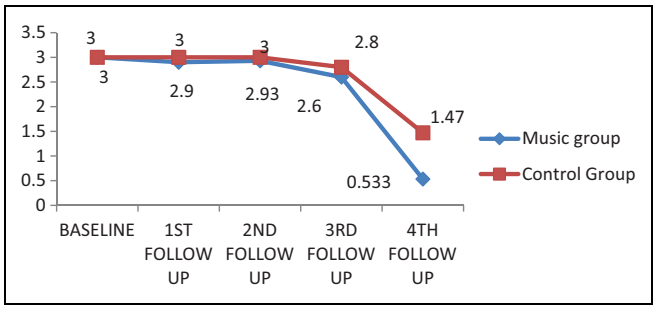


Figure 2. Average dysfunction scores of Nahor-Benson test of the patients in different follow-ups.

orientation, and cognitive functions involving both hemispheres is faster in the music group with follow-ups than that in the control group. It was also found that Hindustani ragas progressively improved the cognitive functions of the memory of patients with CVA and DHI.[26] The MST to patients with stroke resulted in marked improvement in movement quality, as assessed by the 3-dimensional movement analysis. Moreover, fMRI of a sequential hand movement revealed distinct therapy-related changes in the form of a reduction in excess contralateral and ipsilateral activations. This was accompanied by changes in cortical excitability evidenced by transcranial magnetic stimulation. Functional MRI in a music listening task suggests that one of the effects of MST is the task-dependent coupling of auditory and motor cortical areas.[27]

Conclusion

The URMA revealed that improvement in visual acuity, spatial orientation, and cognitive functions involving both right and left hemispheres is faster in the music group with follow-ups than that in the control group. It is a positive sign that goes in favor of the therapeutic value of Hindustani ragas. Hence, this study concludes that Hindustani ragas as a therapeutic tool may act as a catalyst in improving cognitive functions of both hemispheres of the brain in patients with CVA and DHI. However, further studies are required in this field.

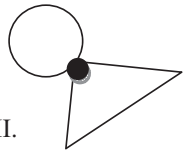
Appendix

Cards of the Nahor-Benson Test (Sample)

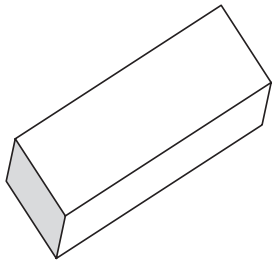
Cards of the Nahor-Benson Test (Sample)

I.

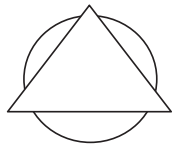
II.



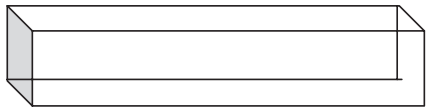
III.



IV.



V.



VI. DRAW A CIRCLE

VII. DRAW A CUBE

VIII. DRAW A CLOCK SHOWING THE TIME OF 5:20

Acknowledgments

We cordially thank the Director, RIMS, as well as the faculties of the Neuro-surgery Department for their cooperation, the patient subjects, and their families for their participation and effort.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Chakraborty S, Ranganayakulu R, Chauhan S, Solanki SS, Mahto K. A statistical analysis of raga Ahir Bhairav. *J Music Meaning*. 2009; 8(2):1. http://www.musicandmeaning.net/issues/showArticle.php?artID=8.4.
2. Jochims S. Coping with illness in the early phase of severe neurologic diseases. A contribution of music therapy to psychological management in selected neurological disease pictures [in German]. *Psychother Psychosom Med Psychol*. 1990;40(3-4):115-122.
3. Aldridge D. Creativity and consciousness. *Art Psychother*. 1991; 18(4):359-362.
4. Jones C. Spark of life. *Geriatr Nurs*. 1990;11(4):194-196.
5. Sacks O. *The Man Who Mistook His Wife for a Hat*. London: Pan Macmillan; 1986.
6. Lucia CM. Toward developing a model of music therapy intervention in rehabilitation of head trauma patients. *Music Ther Perspect*. 1987;4:34-39.
7. Thaut MH. *Rhythm, Music and the Brain: Scientific Foundations and Clinical Applications*. New York, NY: Taylor and Francis; 2005.
8. Raju MVR. *Health Psychology and Counseling*. New Delhi: Discovery Publishing House Pvt. Ltd; 2009.
9. Kim DS, Park YG, Choi JH, et al. Effects of music therapy on mood in stroke patients. *Yonsei Med J*. 2011;52(6):977-981.
10. Bradt J, Magee WL, Dileo C, Wheeler BL, McGilloway E. Music therapy for acquired brain injury. *Cochrane Database Syst Rev*. 2010;7:CD006787.
11. Koelsch S, Fritz T V, Cramon DY, Muller K, Friederici AD. Investigating emotion with music: an fMRI study. *Hum Brain Mapp*. 2006;27:239-250.
12. Koelsch S. A neuroscientific perspective on music therapy. *Ann N Y Acad Sci*. 2009;1169:374-384.
13. Thaut MH, Gardner JC, Holmberg D, et al. Neurologic music therapy improves executive function and emotional adjustment in traumatic brain injury rehabilitation. *Ann N Y Acad Sci*. 2009;1169:406-416.
14. Zatorre RJ, Chen JL, Penhune VA. When the brain plays music: auditory-motor interactions in music perception and production. *Nat Rev Neurosci*. 2007;8(7):547-558.
15. Song JH, Skoe E, Banai K, Kraus N. Training to improve hearing speech in noise: biological mechanism. *Cereb Cortex*. 2012; 22(5):1180-1190.
16. Forsblom A, Laitinen S, Sarkamo T, Tervaniemi M. Therapeutic role of music listening in stroke rehabilitation. *Ann N Y Acad Sci*. 2009;1169:426-430.
17. Sarkamo T, Soto D. Music listening after stroke: beneficial effects and potential neural mechanisms. *Ann N Y Acad Sci*. 2012;1252: 266-281.
18. Sairam TV. *Raga Therapy*. Chennai, Tamil Nadu: NADA Centre for Music Therapy; 2004.
19. Sunder S.Traditional healing systems and modern music therapy in India. *Music Therapy Today*. 2007;8(3):397-407.
20. Peretz I. Brain specialization for music. *Neuroscientist*. 2002; 8(4):372-380.
21. Raglio A. The efficacy of music and music therapy in the neuromotor rehabilitation. *G Ital Med Lav Ergon*. 2012;34(1):85-90.
22. Levitin DJ, Tirovolas AK. Current advances in the cognitive neuroscience of music. *Ann N Y Acad Sci*. 2009;1156:211-231.
23. Fujioka T, Ween JE, Jamali S, Stuss DT, Ross B. Changes in neuromagnetic beta-band oscillation after music-supported stroke rehabilitation. *Ann N Y Acad Sci*. 2012;1252, 294-304.
24. Friedman N, Chan V, Zondervan D, Bachman M, Reinkensmeyer DJ. Music glove: motivating and quantifying hand movement rehabilitation by using functional grips to play music. *Conf Proc IEEE Eng Med Biol Soc*. 2011;2011:2359-2363.
25. Kohlmetz C, Altenmüller E, Schuppert M, Wieringa BM, Münte TF. Deficit in automatic sound-change detection may underlie some music perception deficits after acute hemispheric stroke. *Neuropsychologia*. 2001;39(11):1121-1124.
26. Singh SB, Chakraborty S, Jha KM. Assessment of level of recovery of cognitive impairment in the cerebrovascular accident and head injuries cases: therapeutic impact of North Indian ragas. In: Ystad S, ed. *CMMR'11 Proceedings of the 8th International Conference on Speech, Sound and Music Processing: Embracing Research in India (CMMR/FRSM 2011, LNCS 7172)*. Heidelberg, Berlin, Germany: Springer-Verlag; 2012:44-52.
27. Rojo N, Amengual J, Juncadella M, et al. Music-supported therapy induces plasticity in the sensorimotor cortex in chronic stroke: a single-case study using multimodal imaging (fMRI-TMS). *Brain Inj*. 2011;25(7-8):787-793.

Author Biographies

Shashi Bhushan Singh, MSc (Statistics), is currently working as lecturer cum statistician in the Department of Preventive and Social Medicine, Rajendra Institute of Medical Sciences (RIMS), Ranchi, India. His contribution to the article includes both interaction with the patients and statistical analysis.

Soubhik Chakraborty, PhD (Statistics), is an associate professor in the Department of Applied Mathematics, Birla Institute of Technology, Mesra, Ranchi, India. He is also a harmonium player. His contributions to the article include providing expert statistical opinion and views on issues related to music as well as designing of the article. He is also the corresponding author for this article.

Keashav Mohan Jha, MCh (Neuro-surgery), is an additional professor, Department of Neuro-surgery, Indira Gandhi Institute of Medical Sciences, Patna, India. His contribution to the article includes providing patients' selection, diagnosis, and treatment, thereby offering expert neurosurgical and neuro-musicological opinion.

Satish Chandra, MD (Pharmacology), is a professor, Department of Pharmacology, Rajendra Institute of Medical Sciences (RIMS), Ranchi, India. His contribution to the article includes the rehabilitation part and follow-ups of the patients and providing medical opinion in the work.

Shanti Prakash, MD (Anesthesiology), is an associate professor, Department of Anesthesiology, Rajendra Institute of Medical Sciences (RIMS), Ranchi, India. His contribution involves both treatment (intensive care) and rehabilitation as well as giving an overall opinion from the medical side.