

# Neurofeedback training to enhance learning and memory in patient with traumatic brain injury: A single case study

Rajakumari P Reddy M Phil, Jamuna N Ph D, B Indira Devi M Ch, Thennarasu K M Sc

Departments of Neurosurgery, Neuropsychology & Biostatistics

National Institute of Mental Health and Neurosciences (NIMHANS), Bangalore-29 (Karnataka)

**Abstract:** Road traffic injuries are the leading cause (60%) of brain injury. It is estimated that India would occupy third position for Traumatic brain injury (TBI) by 2020. The most vulnerable group of population is the young adults for TBI. The purpose of the present study was to examine neurofeedback training (NFT) to enhance verbal and visual learning and memory in patients with traumatic brain injury (TBI). Single case pre- and post-intervention study was adopted. The neuropsychological profile of the patient was compared pre and post NFT. Patient with mild head-injury was given 20 sessions of NFT, 45 min / day, 5 days a week. The training incorporated video feedback to increase the frequency of alpha waves (8-12 Hz): and to decrease theta waves (4-7 Hz). The pre assessment showed impairment in verbal learning and memory. Results indicated improvement in both verbal and visual learning memory in patient post NFT. The present study puts forward that NFT should be taken into account to plan for rehabilitation of patients with TBI for enhancement of learning and memory.

**Keywords:** head injury, neurofeedback, traumatic brain injury.

## INTRODUCTION

Traumatic brain injury (TBI) is defined as an insult to the brain caused by an external force that may produce diminished or altered states of consciousness, which results in impaired cognitive abilities or physical functioning<sup>1</sup>. Road traffic injuries are the leading cause (60%) of brain injury. A vehicular accident is reported every 3 minutes and it is estimated that nearly 1.6 million people in India sustain head injuries annually<sup>2</sup>. Memory deficits are the most frequent chronic cognitive disturbance reported in TBI<sup>3,4</sup>.

Neurofeedback Training (NFT) is a state of art training based on operant conditioning. It requires an individual to modify the amplitude, frequency or coherence of the electrical activity and learn to influence the electrical activity of their brain. The goal is to train the individual to normalize abnormal EEG frequencies<sup>5</sup>. Patients with TBI have benefited with NFT<sup>6,7</sup>. Slowing of EEG, of varying degree and duration, scattered spike activity of varying intensities was reported in TBI<sup>8</sup>.

*Address for correspondence:*

Dr. Jamuna. N  
Assistant Professor,  
Department of Mental Health & Social Psychology,  
NIMHANS, Bangalore-560029, India.  
Email:jamunarajan@nimhans.kar.nic.in

## CASE REPORT

Patient S was a 30-year-old married male from middle socio economic status, employed in a garment factory with nil significant personal, past and family history presented with complaints of poor memory, increased irritability associated with increased distress in meeting the demands of family. He had sustained a mild head injury in road traffic accident one year earlier. He reported significant memory problems in the form of frequently leaving money at home, forgetting information related to work. He experienced anxiety about his memory deficits. He was referred to neuropsychological evaluation in view of his cognitive deficits.

## MATERIALS

The assessment was done using the Rivermead Post-Concussion Symptoms Questionnaire<sup>9</sup>, Rivermead Head Injury Follow Up Questionnaire (RHFUQ), Edinburgh's Handedness inventory<sup>10</sup>, Quality of life Scale<sup>11</sup>, NIMHANS Neuropsychological Battery<sup>12</sup> - Verbal Learning and Memory was assessed by the Auditory Verbal Learning Test and visual learning and memory by Complex Figure Test (CFT).

## PROCEDURE

With informed consent the patient was assessed with adequate rest pause during the testing. The patient's pre

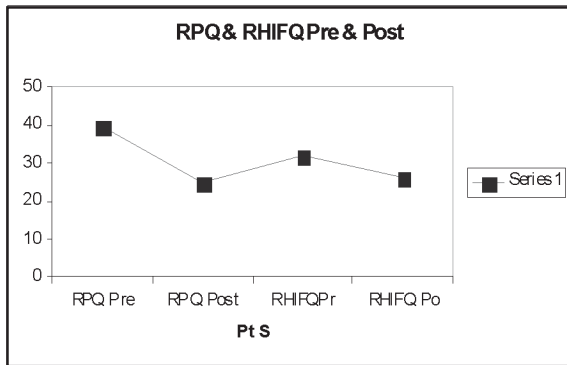
training revealed impairment in verbal learning and memory indicating the involvement of left medial temporal lobe. Following the assessment the training was carried out for 4 weeks of 45 minutes, 20 individual training sessions. Electrodes were placed according to the 10–20 International System on O1, O2, with two reference and one ground point. The training was to enhance alpha and to decrease the frequency of theta waves. The post assessment following the completion of training revealed significant improvement of verbal learning and memory.

**RESULTS**

The post NFT demonstrated significant changes from the pre training in the verbal learning and memory. There was reduction of scores in post concussion symptoms on RPQ and RHIFQ. There were positive results in areas of physical, social, psychological and environmental factors on QOL. There was significant improvement for verbal learning and memory on AVLT. Visual learning and memory on CFT improved. There was increase in alpha and decrease in frequency of theta waves. Tables and graphs 1, 2, 3, 4 and 5 are showing the scores on RPQ, RHIFQ, WHO- QOL, AVLT, CFT and Alpha-Theta pre- and post training.

Table 1: Shows the scores of RPQ and RHFUQ Pre & Post intervention.

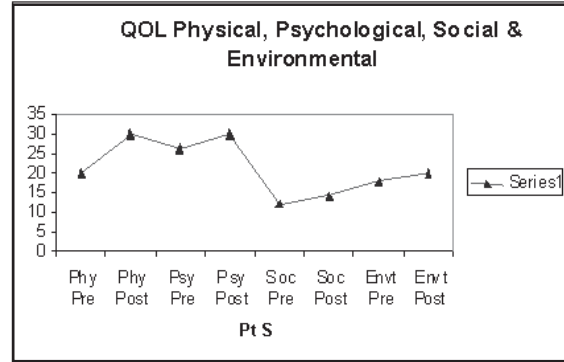
RPQ Pre	RPQ Post	RHIFQ Pre	RHIFQ Post
40	25	32	26



Graph 1: Shows Pre & Post scores of RPQ & RHIFQ

Table 2: Shows the scores of WHO-QOL Pre & Post intervention

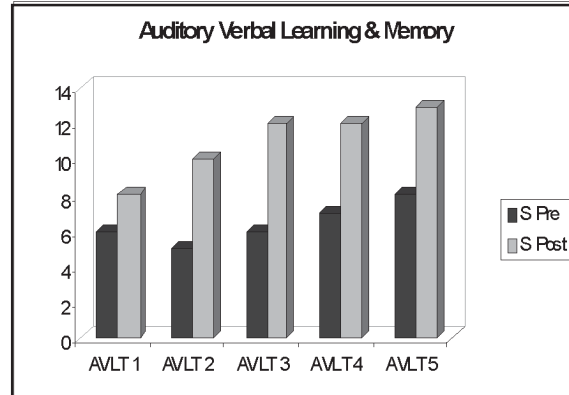
QOL	Physical		Psychological		Social		Environmental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
S	20	30	26	30	12	14	18	20



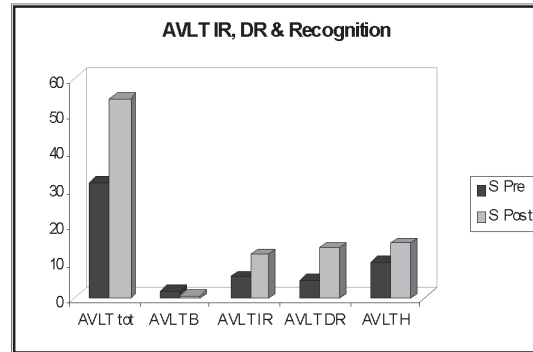
Graph 2: Shows the scores of WHO – QOL Pre & Post intervention

Table 3: Shows the Percentiles of AVLT Pre & Post intervention.

Pt S	Total AVLT		Immediate Recall		Delayed Recall	
	Pre	Post	Pre	Post	Pre	Post
	5	60	5	30	5	75



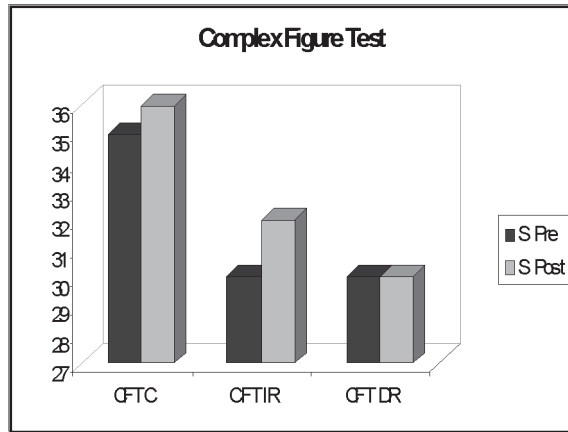
Graph 3: Shows the scores AVLT Pre & Post intervention across 5 trials.



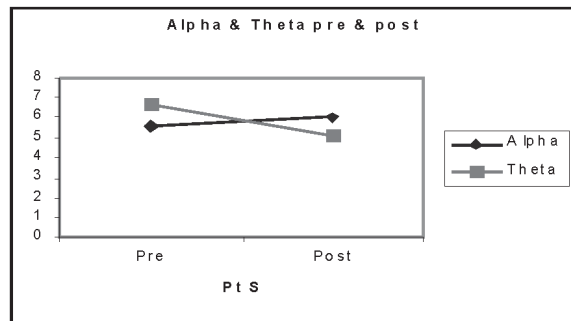
Graph 4: shows the scores total, immediate and delayed recall in AVLT Pre & Post intervention.

Table 4: shows the Percentiles of CFT Pre & Post intervention

CFT IR Pre	CFT IR Post	CFT DR Pre	CFTDR Post
90	95	90	95



Graph 5: shows the scores of Complex Figure Test Pre & Post intervention.



Graph 6: showing the pre post Alpha & Theta scores

## DISCUSSION

The purpose of this study was to examine neurofeedback training in enhancement of verbal and visual memory in TBI. Patient S was assessed on measures of handedness, post concussion symptoms, quality of life, verbal and visual memory. The pre training results indicate severe impairment in verbal memory. After completion of training the patient demonstrated improvements post concussion symptoms, quality of life, in verbal learning and memory. Patient reported improvement in memory and found the training beneficial. These results could be attributed to the research findings that the theta activity has an influence on the cellular mechanisms of memory through its role in facilitating long-term potentiation<sup>13</sup>, recognition memory processes<sup>14</sup>, whilst upper alpha (9.5–12 Hz) reflects retrieval from long-term memory<sup>15</sup>.

## CONCLUSION

- This study demonstrated that the NFT was useful for patient with TBI to enhance his learning and memory.
- Patient's post concussion symptoms reduced with improvement in quality of life.
- There was increase in Alpha decrease in Theta frequency
- However there is greater need for further work with large sample.

## REFERENCES

1. Menkes, J.H. (1990). *Textbook of child neurology* (4th ed.)
2. Gururaj G. Epidemiology of traumatic brain injuries: Indian scenario. *Neurology Res* 2002; 24: 24-8.
3. Serino A, Ciaramelli E, Di Santantonio A, Malagu A, Servadei E, La' Dava E. (). Central executive system impairment in traumatic brain injury. *Brain Injury* 2005; 22: 132-9.
4. Keshav Kumar. (1999), *Unpublished Thesis*, NIMHANS, Bangalore.
5. Hardt, J. V. (1975). The ups and downs of learning alpha feedback. *Proceedings, Biofeedback Research Society*, 6, Monterey.
6. Hoffman D, Stockdale S, Hicks L, Schwaninger J. Diagnosis and treatment of head injury. *Journal of Neurotherapy* 1995; 1: 14–21.
7. Thornton K. Improvement/rehabilitation of memory functioning with neurotherapy/QEEG biofeedback. *Journal of Head Trauma Rehabilitation* 2000; 15: 1285-96.
8. Ronne-Engstrom E, Winkler T. Continuous EEG monitoring in patients with traumatic brain injury reveals a high incidence of epileptiform activity. *Acta Neurologica Scandinavica* 2006; 114: 47–53
9. King NS, Crawford S, Wenden FJ, Moss NE, Wade DT. The Rivermead Post Concussion Symptoms Questionnaire: A measure of symptoms commonly experienced after head injury and its reliability. *Journal of Neurology* 1995; 242, 587-92.
10. Oldfield RC. The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia* 1971; 9:97-113.
11. The WHOQOL Group. Development of the World Health Organization WHOQOL-BRIEF Quality of life assessment. *Psychological Medicine* 1998; 28, 551-558.

12. Rao SL, Subbakrishna DK, Gopukumar K. NIMHANS Neuropsychology Battery-2004. *NIMHANS Publication*(2004) Bangalore, 2004.
13. Pavlides C, Greenstein Y J, Grudman M, Winson J. Long-term potentiation in the dentate gyrus is induced preferentially on the positive phase of theta rhythm. *Brain Research*, 1988; 439: 383-7.
14. Burgess A P, Gruzelier J H. Short duration synchronization of human theta rhythm during recognition memory. *NeuroReport* 1997; 8, 1039-42.
15. Klimesch W, Doppelmayr M, Schimke H, Ripper B. Theta synchronisation and alpha desynchronisation in a memory task. *Psychophysiology* 1997; 34, 169-76.
16. Tunks,E, & Bellisimio,A.(1991). *Behavioral Medicine: Concepts and Procedures*. NewYork: Pengamon Press.