Efficacy of EEG Neuro feedback Training on Verbal and Visual Learning and Memory in Patients with Depression

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Abstract

Depression is one of the most prevalent mood disorders, which also causes significant disruptions in the socio-occupational life of an individual. Diagnosis and treatment of depression have traditionally focused on mood symptoms. However, cognitive functioning especially memory is one of the major domains impaired in depression and hence associated with significantly poor functional outcome. This indicates an increased need for cognitive rehabilitation in depression. The aim of the present study was to examine the efficacy of EEG Neuro Feedback Training (NFT) on verbal and visual learning and memory in patients with mild to moderate Depression. An experimental pre post randomized control group design has been used.

A sample of 10 patients with mild to moderate depression was taken purposively and assigned to a Treatment Group (TG) and Treatment As Usual group (TAU). Patients in the treatment group has received 20 sessions of NFT at the Occipital 1 and 2 scalp locations at a frequency of 3 days a week along with pharmacotherapy. Patients in the treatment as usual group received only pharmacotherapy. Clinical changes were documented on the Hamilton Depression Rating scale, Auditory Verbal Learning Test and Complex Figure test. Results indicated that there is a significant improvement in verbal as well as visual learning and memory in TG in comparison to TAU.

Depression is one of the most prevalent mood disorders. It is characterized by diverse symptoms including sad mood, loss of interest, and unhappiness, and shows high co morbidity with other brain dysfunction (Currie and Wang, 2004, De Rubeis et al, 2008). Epidemiological studies have shown that depression is common throughout the lifespan of an individual, with 20% of the population worldwide experiencing a depressive episode during their lifetime and 2–5% of the population being affected by severe depression (Kessler et al, 2005).

Diagnosis and treatment of depression have traditionally focused on mood symptoms. However, cognitive dysfunction is often present in the disorder and has been shown to contribute independently to poor functional outcome (Jaeger, 2006). Literature suggests that depression is associated with wide range of cognitive deficits, which is not just secondary to mood symptoms related to depression. The major cognitive domains affected by depression are mental and psychomotor speed, attentions, executive functions and learning and memory (Porter and Hodge, 2012). Learning and memory are the capacity by which a person is able to gain experience and retain it. Depressed people are having difficulty not only retrieval but also encoding of information into memory, especially in the beginning of a task when demands on cognitive effort are high (Brand, Jolles & Gispen-de Wied ,1992)

Neurofeedback (NFT) has emerged as one such technique aimed at altering processes in the brain to as to enhance certain cognitive functions. It works on brain waves to improve various aspects of functioning. It involves reinforcement of particular EEG frequencies thus increasing or reducing their occurrence. It is used to modify amplitude, frequency and even coherency of one's own brain waves using operant conditioning methods (Thatcher et al, 1999).

In this sensors are placed on the scalp and devices are used to monitor and provide moment- to- moment information that is fed back to the individual about his/ her physiological brain activity for purposes of improving brain functioning (Hammond et al, 2011). Neurofeedback treatments for depression (Baehr, Rosenfeld, & Baehr 1997) appear very promising not only in bringing relief from depression, but in modifying the underlying biological predisposition for becoming depressed. Neurofeedback focuses on retraining the brain, for example, reversing the frontal brainwave asymmetry, with the goal of producing an enduring change that does not require people to remain on medication indefinitely. Training often requires about 15 to 20sessions. It is effective in the sense that it has direct access to the underlying vulnerability which can in turn affects the cognitive areas and mood.

Four major processes by which NFT effects changes in the brain are (Collura, 2003) are auto regulation, Operant conditioning, Intention to be still, focused and relaxed and Post reinforcement synchronization.

Aim:

The aim of the present study was to examine the effect of EEG Neurofeedback on verbal and visual learning and memory patients with depression.

Hypothesis:

There will be no significant difference on the pre- post EEG NFT of the TG and the TAU group on verbal and visual learning and memory.

Design:

An experimental pre post randomized control group design will be used.

Sample:

Ten patients diagnosed with mild-moderate depression will be screened and referred by Department of Psychiatry, NIMHANS and 5 each will be randomly assigned to TG and TAU group. The TAU group will include those patients who have been diagnosed as mild to moderate depression and are on routine medication.

Tools:

1. Socio- demographic data sheet
2. Mini-international neuropsychiatric interview (MINI Screen) (Sheehan, et al., 1998)
3. The Edinburgh Handedness Inventory (reference) (Oldfield, 1971)
4. Hamilton Depression Rating Scale (HDRS) (Hamilton, 1960)
5. Selected tests of NIMHANS neuropsychology battery (Rao, Subbakrishna and Gopukumar, 2004)

- Verbal Learning and Memory: Auditory Verbal Learning Test (Rey, 1964)
- Visual Learning and Memory: Complex Figure test (Meyers and Meyers, 1995)

Procedure

Pre training assessment

Assessment was carried out on all the ten patients using Socio-demographic data sheet, Hamilton depression rating scale, Auditory Verbal Learning Test, Complex Figure test.

Neuro Feedback Training

Twenty sessions of NFT were administered for 5 patients in the TG. The patients were given alpha theta training on the O1 (occipital 1) and O2 (occipital 2) channels of Neuro feedback in the 20 sessions. The brain wave pattern were amplified by the machine and gave feedback to the patients by way of visual signals. Each session was of the duration of 20-40 minutes, and 3 sessions per week. Initial 5 sessions were kept at 20 minutes each for the patients to be acquainted to the NFT. The next 15 sessions were of 40 minutes duration.

Post Training Assessment

The post assessment was done for the treatment group on the completion of the 20 sessions of Neuro feedback training and for the treatment as usual group one and half months to two months after the pre assessment**.**

Descriptive statistics were used for the analysis of socio demographic variables. For comparing independent means that is between TG and TAU group Mann Whitney U test was used and for paired median comparison, Wilcoxon Signed rank test was used.

Results and Discussion

Comparison of TG and TAU on pre assessment

The mean age of the patient in TG was 25.20 ± 2.28 and that of TAU group was 37.60± 5.32. There was a significant difference found between the TG and TAU group with regard to age. On statistical analysis, no significant difference was found between the TG and TAU group based on education. Similarly, there was no statistically significant difference between TG and TAU group based on gender.

The level of depression for TG and TAU were 13.00± 2.64 and 14± 2.73respectively. Hence, there is a significant difference in age of onset of illness there is no significant difference between TG and TAU with regard to mean duration of the episode and level of depression. The comparison of the pre assessment data of the TG and TAU group was carried out across the outcome variables to evaluate for comparability of the two groups. Statistical analysis showed that there was no significant difference between the TG and TAU group on pre assessment of verbal and visual learning and memory (Table 1.1)

Table 1.1 Comparison of TG and TAU on verbal and visual learning and memory

Variable	TG(n1=5)		TAU group(n2=5)		P value
	Mean	SD	Mean	SD	
		AVLT			
Total learning-verbal	48.00	10.100	38.80	10.71	.169
IR-verbal	10	2.23	8.60	3.13	.528
DR-verbal	9.20	2.49	9.20	2.68	.522
		CFT			
Copy-visual	34.80	1.78	33.60	2.51	.369
IR-visual	17.40	6.22	19.20	6.41	.528
DR-visual	16.80	4.08	19.40	7.33	.753

*Note: - * significance at 0.05 level AVLT: auditory verbal learning test, CFT: complex figure test, IR: immediate recall, DR: delayed recall*

There was no significant difference between the TG and TAU group on pre assessment of verbal and visual learning and memory.

Table 1.2 (a) - Comparison of pre test and post test data on verbal learning and memory for TG (n1=5)

Variable (AVLT)		TG (n1=5)			P value
		Mean	SD	Median	
T	Pre	48	10.10	42	.043*
	Post	61.20	4.81	60	
IR	Pre	10	2.23	10	.043*
	Post	13.80	.83	14	
DR	Pre	9.20	2.49	9	.042*
	Post	13.80	.44	14	
H	Pre	13	1.87	13	.066

*Note: - * significance at 0.05 level AVLT: auditory verbal learning test, T: total learning, IR: immediate recall, DR: delayed recall*

There was a significant difference on total learning, immediate recall, and delayed recall in the pre post assessment of TG.

Table 1.2 (b) - Comparison of pre test and post test data on verbal learning and memory for TAU (n1=5)

Variable (AVLT)		TAU (n1=5)			P value
		Mean	SD	Median	
T	Pre	38.80	10.71	35	1.000
	Post	35.40	18.92	35	
IR	Pre	8.60	3.13	8	.257
	Post	9.60	2.40	9	
DR	Pre	9.20	2.68	8	.102
	Post	8.20	3.11	7	
H	Pre	12.40	1.67	12	.461

*Note: - * significance at 0.05 level AVLT: auditory verbal learning test, T: total learning, IR: immediate recall, DR: delayed recall*

There is no significant difference on pre and post assessment on verbal learning and memory for the TAU group

Table 1.3 (a) - Comparison of pre test and post test data on visual learning and memory for TG (n1=5)

Variable (CFT)		TG (n1=5)			P value
		Mean	SD	Median	
C	Pre	34.80	1.78	36	.655
	Post	34.60	1.34	34	
IR	Pre	17.40	6.22	20	.042*
	Post	23.40	5.36	24	
DR	Pre	16.80	4.08	19	.041*
	Post	24.40	6.69	24	

*Note: - * significance at 0.05 level CFT: complex figure test, C: copy, IR: immediate recall, DR: delayed recall*

There is a significant difference in pre and post assessment on immediate recall and delayed recall part of visual learning and memory, however there was no significant difference in copy part for TAU.

Table 4.3 (b) - Comparison of pre test and post test data on visual learning and memory for TAU (n1=5)

Variable (CFT)		TAU(n1=5)			P value
		Mean	SD	Median	
C	Pre	33.60	2.51	34	1.000
	Post	33.20	2.28	34	
IR	Pre	19.20	6.41	17	.068
	Post	22.20	5.97	22	
DR	Pre	19.40	7.33	18	.066
	Post	22.60	6.76	22	

CFT: complex figure test, C: copy, IR: immediate recall, DR: delayed recall

There was no significant difference in pre and post assessment on visual learning and memory for the TAU group.

On verbal learning and memory, it was found that there was a significant improvement in scores on total learning, immediate recall and delayed recall in TG. However, in TAU group there was no significant difference in any of the variables (Table 1.2). Hence, it could be hypothesized that that the memory enhancement in TG is attributed to NFT as there was no significant difference in the scores for memory tasks for TAU group. The findings were corroborated by single case study by Reddy et al (2009) in which NFT training was given to TBI patients and significant improvement happened in verbal learning and memory. Another randomized control group study on TBI patients by Reddy et al (2010) also showed consistent finding.

On visual learning and memory, which was assessed using Complex figure test it was found that there was a significant difference in the pre and post assessment on immediate and delayed recall for TG. However, there was no significant improvement for TAU group. On copy part of it both the groups didn't show any significant difference in the pre post assessment (Table 1.3). Since the significant improvement was seen only in the TG group, it can be hypothesized that the improvement is due to NFT. Similar finding was reported on a study in which NFT was given to patients with Schizophrenia. In which Performance on visuo-spatial memory has been improved from the pre to the post condition (Ahluwalia, 2014).

In the current study patients in TG showed improvement in both verbal and visual learning and memory as compared to TAU group after undergoing alpha theta NFT. Similar results have been replicated in a study NFT was given to patients with major depressive disorder and the results showed the effectiveness of this intervention in a variety of cognitive functions such as memory, attention, and executive functions (Escolano, 2013) .Hence the first hypothesis which states that there will be no significant difference on the pre and post assessment of the TG and the TAU group on verbal and visual learning and memory after NFT has been rejected.

In conclusion, NFT holds promise as a treatment program for the improvement of memory functions in patients.

Bibliography

Ahluwalia, H. (2014). Patients with schizophrenia – an *f*MRI, cognitive and quality of life study. Unpublished dissertation submitted to NIMHANS, Bangalore

Baehr, A.L., Rosenfeld, J.P., & Baehr, R. (1997). The clinical use of alpha asymmetry biofeedback protocol in treatment of depressive disorders: two case studies. *Journal of Neurotherapy*, 2, 12-27

Brand, A.N., Jolles, J., Gispen-de Wied, C. (1992). Recall and recognition memory deficits in depression. *Journal of Affective Disorders*, 25(1), 77-86

Collura, T.F. (2003). *Foundations and applications of neurofeedback*. IL: Brain masters technologies India: A metaanalysis. *Indian Journal of Psychiatry*, 40, 149–57

Currie, C. R. & Wang, J. (2004). Chronic back pain and major depression in the general Canadian population. *Journal of Pain,* 107, 54–60

DeRubeis et al., (2008). Cognitive therapy versus medication for depression: treatment outcomes and neural mechanisms. *Nature reviews neurosciences*, 9, 788–796

Escolano, C., Navarro-Gil, M., Garcia, J., & Minguez, J. (2013). EEG-based upper-alpha neurofeedback for cognitive enhancement in major depressive disorder: A preliminary,uncontrolled study. *Conference proceedings of medical biology social journa*l, 6293-6

Hamilton, M. (1967). Development of a rating scale for primary depressive illness. British *Journal of Social and Clinical Psychology*, 6(4), 278–96

Hammond, C.D., Bodenhamer-Davis, G., Gluck, G., Stokes, D., Harper, S.H., Trudeau, D., MacDonald, M., Lunt, J., & Kirk, L. (2011). Standards of Practice for Neurofeedback and Neurotherapy: A Position Paper of the International Society for Neurofeedback & Research, *Journal of Neurotherapy: Investigations in Neuromodulation, Neurofeedback and Applied Neuroscience*, 15(1), 54-64

Jaeger (2006) Neuro-cognitive deficits and disability in major depressive disorder. *Journal of Psychiatry Research*, 145, 39–48

Kessler, R. C., & Berglund, P. (2005). Lifetime prevalence and age-of-onset distributions of dsm-iv disorders in the national co morbidity survey replication. *General Psychiatry*, 62(6), 593-602

Oldfield, R. C. (1971). The assessment and analysis of handedness: the Edinburgh inventory. *Neuro-psychologia*, *9*(1), 97-113

Porter, R.J., Gallagher, P., Thompson, J.M., & Young, A.H. (2003). Neurocognitive impairment in drug-free patients with major depressive disorder. *British journal of psychiatry*, 182, 214-20

Rao, S. L., Subbakrishna, D. K., & Gopukumar, K. (2004). NIMHANS Neuropsychology Battery-2004 Manual Bangalore: National Institute of Mental Health and Neurosciences (Deemed University)

Reddy, R.P., Rajan, J., Bagavathula, I., & Kandavel, T. (2009). Neuro feedback training to enhance memory and learning in patients with traumatic brain injury: A single case study. *International journal of psychosocial rehabilitation,* 14, 21-28

Reddy, R.P., Rajan, J., Bagavathula, I., & Thennarasu, K. (2010). Neurofeedback training in patients with traumatic brain injury. PhD thesis submitted to NIMHANS, Bangalore

Thatcher, R.W., Moore, N., John, E.R., Duffy, F., Hughes, J.R., & Krieger, M. (1999). QEEG and traumatic brain injury: rebuttal of the American Academy of Neurology 1997 report by the EEG and Clinical Neurosciences Society. *Clin Electro-encephalogr,* 30(3), 94-98