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Effects of Neurofeedback on Cognitive Function with Emphasis on Memory

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Objective: The aim of present research is to investigate the effects of Neurofeedback on Cognitive Function with emphasis on Memory**.** ***Method:*** This study is an experimental study. For this reason using a stratified sampling procedure sample of 30 subjects in 2 groups of experimental and placebo was selected. Investigated Subjects were assessed with the Wechsler Memory Scale in two stages (pretest and post-test). Data were analyzed through covariance. ***Results:*** The results revealed that after 30 sessions of neurofeedback training, the experimental groups' improved in general memory. The two groups had significant differences in memory. ***Discussion:*** we can say neurofeedback control brainwave then increase total memory such as visual memory.

Keywords: Neurofeedback, Cognitive Function, Memory

Effects of Neurofeedback on Cognitive Function with Emphasis on Memory Neurofeedback training is based on the principle of operant conditioning and involves informing the subject in real time about the workings of their organism in order to incite them to modify their behavior. The term "biofeedback" is used when the information provided concerns physiological parameters such as body temperature, breathing rhythm and heart rate. Biofeedback has been used for treating migraines (Nestoriuc & Martin, 2007), Raynaud's disease (Karavidas, Tsai, Yucha, McGrady, & Lehrer, 2006) urinary incontinence (Glazer & Laine, 2006). Neurofeedback training (NFB) or electroencephalographic biofeedback (EEG) involves providing the subject in real time with information relating to the rhythmic cortical electrical activities that reflect the electrical activity of specific cortical areas and functions (Evans & Abarbanel, 1999; Masterpasqua & Healey, 2003). The aim of NFB is to enable the subject to become aware of particular patterns of cortical activity that we know or assume to be associated with a more (Juhel, 2011).

The conceptualization of NFB as an agent of cognitive change is essentially based on the correlations observed between certain EEG frequency bands and various aspects of information processing (W Klimesch, Vogt, & Doppelmayr, 1999; Wolfgang Klimesch, 1999; Wolfgang Klimesch, Schack, & Sauseng, 2005; Sauseng & Klimesch, 2008). For example, theta activity appears to be related to working memory processes and episodic memory.

It was studied the effects of two different NFB training modalities on the performance of young adults in a memory task involving semantic work (conceptual span paradigm) and in a visual attention task (continuous performance paradigm). The first training condition was a stimulation of theta waves (4 - 7 Hz, in connection with working memory) and an inhibition of delta waves (<4 Hz, associated with sleep) and alpha waves (8 - 12 Hz, associated with physical relaxation). The second training condition simultaneously included a stimulation of SMR waves (12 - 15 Hz, associated with attention) and an inhibition of beta waves (18 - 22 Hz, associated with problem-solving, and also sometimes anxiety disorders). For example, theta activity appears to be related to working memory processes and episodic memory. It appears that lower alpha waves are largely associated with attentional processes, while upper alpha waves reflect recovery processes in semantic memory. Beta waves associated with motor activity are also assumed to be involved in the activation of attentional processes. Finally, gamma activity may play a 'universal' role in sensory and cognitive

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processing (E Başar, Başar-Eroğlu, Karakaş, & Schürmann, 2000). The amplitude of lower frequency bands (delta and theta) and upper frequency bands (gamma) tends to increase in line with cognitive effort while the amplitude of alpha and beta waves tends to decrease (Basar, 2004; Erol Başar, Başar-Eroglu, Karakaş, & Schürmann, 2001).

The aim of this research is to examine these initial findings in the light of the observations of subjects trained specifically to increase the SMR frequency band (12-15 Hz) and inhibition power of the theta band (4 - 7 Hz). The NFB training sessions by participants in the experiment were expected to generate two chief observations: first of all, a change of EEG activity resulting in an increase of the SMR and decrease of the Theta; secondly, an improvement of cognitive performance, measured in this case in memory.

Method

Participants

40 subjects (23 women and 17 men, age range: 22 to 51) took part in this study. Participants were shared randomly between an experimental group, a control group and a test/retest group of equal sizes.

Assessment

Neurofeedback machine: neurofeedback machine is a device that analyzes the received raw brain waves through located electrodes on the head to frequencies of different waves. These frequencies are delta, theta, alpha, and beta waves. During neurofeedback training electrodes are located on brain located 20-10 international system. Usually two electrodes are located in position which EEG activity of normal individuals contains more deviation in comparison whit EEG activity. Patient is located in front of computer and he/she can observe what the computer shows as a video game or as showing two column diagrams which one them represents effective brain wave. In the situation patient focuses on computer screen. By decreasing inappropriate activity and increasing appropriate activity there is heard a sound. In beginning changes in brain waves are temporal but permanent changes will be gradually conditioned by repeating sessions and gradual changing thresholds for preventing inappropriate activity of healthier brain waves (Demos, 2005).

Wechsler memory scale (WMS-IV) for adult: this device has been designed for memory studying. Wechsler memory test is used to evaluate memory as an objective measure and it is the result of several years of research and survey about functional simple and immediate memory and provision of information for separation action disorders of memory .Wechsler memory scale (form A) Contain 7 Subscale: information and orientation mental control, logic memory, Digit Span, Verbal Paired Associates, and Visual Reproduction. Cronbach's alpha coefficient is 0/96, 0/93. 0/69, 0, 89, 0/77, 0/83 and 0/81 for subtest (Shokri et al., 2008).

Procedure

The experiment design and data collection procedure incorporated recent recommendations concerning the need to have EEG measurements in pre- and post-tests and the need to include a non-contingent control group. Participants were shared randomly between an experimental group, a control group and a test/retest group of equal sizes The participants, presented no known neurological or psychiatric antecedents or any known psychological disorder. None of the participants had undergone psychotropic treatment.

Neurofeedback training

Training period was as 30 sessions each 45 minutes for test of experiment and control group. They were studied neurofeedback in 30 sessions and their feedback was based on their performance. Placebo group was located in front of computer during 30 sessions in order to remove suggestion and their feedback was not based on their performance (in fact they did not receive any neurofeedback training). Firstly pre-test of all tests was studied individually in the first session. Then neurofeedback training was carried out for experiment group by protocol of increasing SMR wave (12-15Hz) and decrease high beta (19-32Hz) and theta (4-8Hz) in Cz area.

Result

The case study was as the following in demographical indicators point of view: in both situation they are 22-51 years old with average 34/06 and standard deviation 8/07, scores of memory in pre and post-test steps were compared in experiment and control group in order to study this hypothesis whether neurofeedback training can affect memory.

Average of memory scores in experiment group in pre and post-test are 68/30 and 77/30 respectively which their comparison shows effect of independent variable of neurofeedback training on memory development of experiment group which such a difference is not seen in control group.

Table 1
Covariance analysis

Variable	Partial Eta Squared	Sig	F	Mean Square	Df	Type III Sum of Squares
Group Mental control	0/100	0/101	2/895	2/790	1	2/790
Error	0/077			0/96	26	25/06

Group logic memory		0/152	2/179	16/25	1	16/25
Error				7/46	26	193/95
Group Digit Span	0/017	0/509	0/448	0/221	1	0/221
Error				0/49	26	12/83
Group Verbal Paired Associates,	0/015	0/532	0/401	0/448	1	0/448
Error				1/11	26	29/02
Group Visual Reproduction	0/010	0/611	0/265	0/098	1	0/098
Error				0/372	26	9/65
Group Total	0/073	0/166	0/036	20/913	1	20/913
Error				10/271	26	267/05

After assurance from regression slope as necessary default for using covariance analysis we get to table 1 about memory result.

As indicated in table 1 supposed slope has not been significant with F(1/26)=2/89 For mental , F(1/26)=2/17 for logical memory, F(1/26)=0/448 for Digit Span, F(1/26)=0/401 for Verbal Paired Associates, F(1/26)=0/265 for Visual Reproduction, F(1/26)=0/203 for general memory .therefore supposed regression slopes have been implemented for variable of Wechsler memory.

Therefore supposed regression slopes have been implemented for variable of Wechsler memory. By considering to the above data there was used covariance analysis for studying the considered hypothesis which its result are shown in table 2 for memory respectively.

As indicated in table 2 result of covariance analysis in the table shows that sub-measure of mental control with (0/002), Digit Span with (0/03), Verbal Paired Associates with (0/04), Visual Reproduction with (0/000), and total memory score whit (0/000) are meaningful in level 0.05, and sub-measure of logic memory with (0/36) is not meaningful.

Acquired results show that neurofeedback improves memory. Several studies provided same result in this field (Berner, Schabus, Wienerroither, & Klimesch, 2006; M Schabus et al., 2006; Manuel Schabus et al., 2004; Vernon et al., 2003). In fact neurofeedback is a mechanism for conditioning person repairs and rebuilds his/her brain waves again. The changes are short term but they will be permanent gradually. Persons can improve their wave's pattern by continuous feedback and training and practice. It is like as practice for brain and increases memory. There are evidences which show unconscious processes that they effect this learning phenomenon and person can learn without direct awareness (Barzegar & Yaghubi, 2009). Evidences of supporting learning without awareness have been discussed during recent 25 years which neurofeedback has been completed. As neurofeedback effectiveness is based on learning and conditioning process, its cure time is long term (30 sessions), especially neurofeedback deals with brain conditioning, and changing brain learning which it longs cure duration (M Schabus et al., 2006). This method is a long term learning process, so its result will be seen by time. All researchers of neurofeedback agree that neurofeedback learning is like as skill learning. Lubar (2003) considers neurofeedback learning as bicycle learning used protocol in the study was to increase SMR wave in Cz area (Schwartz & Andrasik, 2003).

Table 2
Covariance analysis of sub-measures

Variable		Partial Eta Squared	Sig	F	Mean Square	Df	Type III Sum of Squares
Mental control	Pre- test	0/4	0/001	18	18/57	1	18/57
	Group	0/292	0/002	11/13	11/48	1	11/48
	Error				1/54	27	27/85
logic memory	Pre- test	0/478	0/001	24/69	192/26	1	192/26
	Group	0/030	0/36	83/0	6/52	1	6/52
	Error				7/78	27	210/2
Digit Span	Pre- test	0/931	0/001	364/93	176/41	1	176/41
	Group	0/154	0/035	4/90	2/37	1	2/37

	Error				0/483	27	13/05
Verbal Paired Associates	Pre- test	0/741	0/001	77/31	84/393	1	84/393
	Group	0/143	0/04	4/49	4/90	1	4/90
	Error				1/09	27	29/47
Visual Reproduction	Pre- test	0/623	0/001	44/575	16/109	1	16/109
	Group	0/465	0/001	23/456	8/477	1	8/477
	Error				0/361	27	9/758
Total	Pre- test	0/706	0/001	64/701	690/064	1	690/064
	Group	0/430	0/001	20/39	217/545	1	217/545
	Error				10/66	27	287/969

It a be said that neurofeedback training in Cz sensory-motors, motors, and cingulate cortexes. Therefore patients who have difficult in understanding logical continuity of cognitive function can use neurofeedback training in sensory motors cortex in left hemisphere (C3). Training in sensory motors cortex in right hemisphere (C4) facilitates mixed answer. Neurofeedback training in Cz effects sensory-motor and cingulate cortexes. In cingulate systems which deals with excitement feeling, attention, and work memory, they have a close relationship which they from energy source of internal and external functions .increasing sensory-motor wave rhythm decrease overlapping processing unrelated motives and facilitates integrity of motives related to performance (Gruzelier & Egner, 2005). Sensory–motor rhythm effects on revise performance of conceptual memory directly (Vernon et al., 2003). Other protocol in the study was to defeat theta in Cz area. Theta deals with confusion, inattention, imagination, depression and anxiety (Wolfgang Klimesch, 1999). However it seems that all researchers agree that increasing activity of slow theta is problematic and it can be considered by neurofeedback training (Vernon, Frick, & Gruzelier, 2004). Yet this research does imply several limitations that explain why stimulating SMR and theta waves how to improve kind of memory. Another limitation of this research is related to the good overall level and relative homogeneity of memory performance displayed by participants, one potential effect Must be omitted is a decrease of the chances of observing an improvement of memory performance. Finally, the type of tasks used in this research to assess memory performance may have been insufficiently matched with the cognitive processes associated with the frequency of wave ranges targeted by NFB training. It is suggested that these limitations will be overcome in future studies.

Discussion

NFB training provides a field of inquiry and potential applications that we are only just beginning to explore in the subjects. The present study illustrates this by showing that it is possible to train subject to modify the amplitude of certain wave ranges according to the optimal model of regulation of EEG activity using an original NFB protocol targeting several wave ranges. Currently, we know that the relations between specific patterns of EEG activity and levels of cognitive performance also require considering NFB as a training technique aimed at encouraging an individual to produce specific patterns of cortical activity in connection with an improved level of cognitive performance. Our own observations do corroborate the hypothesis of the effect of NFB training of different frequency ranges (in particular a stimulation of SMR and theta waves) on memory performance in subjects. A more rigorous and more systematic assessment of the effects of NFB training on cognitive performance in subjects is therefore required to improve our understanding of the conditions of application of the different NFB protocols that are applicable to this group, to specify the possible indication and to better specify the effects on memory performance.

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