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Effects of Neurofeedback on Cognitive Function of Headache Patient

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Abstract

Headache is sever type of pain which can be *treated* in different ways. Recent studies have demonstrated that neurofeedback is a good option for treatment of headaches. The main aim of present research was to investigate the effect of neurofeedback on Memory of headache patients. To do so, a sample of 30 subjects was selected for experimental and control groups by a accessible sampling procedure. Subjects were assessed with the Stroop test and the Wechsler Memory Scale in two stages (pretest and posttest). The obtained data were analyzed through covariance analysis method. After 30 sessions of neurofeedback training, considerable improvement in executive function and general memory of the experimental group was observed. Also the two groups (experimental and placebo) presented significant differences in the executive function and memory. According to the researcher's view, headache patients are able to control their brainwaves with participating in neurofeedback training sessions, so their total memory and executive function would be increased.

Keywords: Neurofeedback; Headache patients; Memory; Executive function

Introduction

A headache or cephalalgia is pain anywhere in the region of the head or neck. It can be asymptom of a number of different conditions of the head and neck [1]. There are over 200 types of headaches, and the causes range from harmless to life-threatening. The description of the headache, together with findings on neurological examination, determines the need for any further investigations and the most appropriate treatment [2].

The most common types of headache are the "primary headache disorders", such as tension-type headache and migraine. They have typical features; migraine, for example, tends to be pulsating in character, affecting one side of the head, associated with nausea, disabling in severity, and usually lasts between 3 hours and 3 days. Rarer primary headache disorders are trigeminal neuralgia (a shooting face pain), cluster headache (severe pains that occur together in bouts), and hemicrania continua (a continuous headache on one side of the head) [2]. During a given year, 90% of people suffer from headaches. Of the ones seen in the ER, about 1% have a serious underlying problem [3]. Primary headaches account for more than 90% of all headache complaints, and of these, episodic tension-type headache is the most common [4].

Memory is non-separable component on individuals cognitive system [5]. It is a process that knowledge will be coded, reserved, and remembered. In addition, many of important behaviors are learned. Our personal values depends on what we have learned and what we will remember [6]. Memory is able to maintain information within an internal researchable keeping system, as this information is accessible and usable. In the recent decades, understanding natural and disturbed memory has been developed more than other cognitive features [7]. All of our learning, thinking, planning and social behaviors are shaped base on our memory. Human being's memory is as equal as his senses. Recognition of smells (smell memory), sounds (hearing memory), tastes (tasting memory), colors (observing memory), and roughness and smoothness (touch memory) require their recollection in memory. Human beings cannot make relationship with others, execute their tribal customs, represent their senses, recognize face of their friends and even knows the way to their home.

Memory would be influenced by many factors, including multi-language, intelligence, and mental health [7]. Therefore, methods and techniques which are able to improve memory are very important. Among these, 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, Decreasing Theta and increasing sensory motor rhythm (SMR) activity (10–13 Hz) lead to improve cognitive performance [8].

The executive system is a theorized cognitive system in psychology that controls and manages other cognitive processes. It is responsible for processes that are sometimes referred to as the executive function, executive functions, supervisory attentional system, orcognitive control. These functions are largely carried out by prefrontal areas of the frontal lobe.

Executive function is an umbrella term for cognitive processes such as planning, working memory, attention, problem solving, verbal reasoning, inhibition, mental flexibility, multi-tasking, initiation and monitoring of actions [9].

The executive functions are located primarily in the prefrontal regions of the frontal lobe. These areas have multiple connections with othercortical, subcortical and brainstem regions [10].

Generally, in neurofeedback training sessions, person will be familiar with his/her different situations of brain waves, and he/she can control them. In fact, neurofeedback is based on implicit and non-conscious learning and conditioning [11,12].

Vernon et al. [13] concluded that neurofeedback has positive effect on some dimensions of cognitive performance, including precision at work memory. In another study, Gholizade et al. [14] evaluated effect

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of neurofeedback training on observing memory of students. In the study 30 students learned to control their brain waves voluntarily and increased memory performance by it.

Method

This is an experimental study with pre-posttest plan with control group. In this study, Neurofeedback training is considered as independent variable, and memory as dependent variable.

The sample of present research contains 30 headache patients who selected by accessible sampling. 15 subjects were allocated to neurofeedback (experimental) group and 15 participates were allocated to control group. The range of samples' age was 22-51 years old with average 34.06 and standard deviation 8.07. The number of male and female participates were 17 and 23, respectively. The obtained data were analyzed through covariance analysis method with spss version 17.

Instruments

Neurofeedback amplifier: Neurofeedback amplifier is a device which 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 scalp according to 20-10 international system. Patient is requested to seat in front of computer and control the video games which are showing in screen, by concentration on computer screen. The games go on by decreasing inappropriate wave activity and increasing appropriate wave activity. In the beginning, brain waves' changes are temporal but permanent changes will be gradually occurred by repeating sessions [15].

In this study researchers used a neurofeedback device, made by Thought Technology Ltd. that called ProComp2™. The ProComp2™ is a 2 channel device that contains a built-in EEG sensor (simply connect an extender cable for EEG monitoring and biofeedback). The ProComp2™ system contains all the peripherals to easily connect it to a desktop or laptop IBM-compatible PC.

Wechsler memory scale (WMS-IV) for adult: This scale has been designed for memory assessment as an objective measure and it is based on several years research and survey about functional simple and immediate memory and provide information for separation action disorders of memory. Wechsler memory scale (form A) Contain 7 Subscale including information and orientation mental control, logic memory, Digit Span, Verbal Paired Associates, and Visual Reproduction. Shokri et al. [16] evaluated Cronbach's alpha coefficient for Wechsler memory subscales. The results showed 0.96, 0.93, 0.69, 0.89, 0.77, 0.83 and 0.81 for information and orientation mental control, logic memory, Digit Span, Verbal Paired Associates, and Visual Reproduction, respectively.

Stroop test: The Stroop effect has been used to investigate a person's psychological capacities; since its discovery during the twentieth century, it has become a popular neuropsychological test [17].

There are different test variants commonly used in clinical settings, with differences between them in the number of subtasks, type and number of stimulus, times for the task, or scoring procedures [17]. All versions have at least two numbers of subtasks. In the first trial, the written color name differs from the color ink it is printed in, and the participant must say the written word. In the second trial, the participant must name the ink color instead. However, there can be up to four different subtasks, adding in some cases stimuli consisting of groups of letters "X" or dots printed in a given color with the participant having to say the color of the ink; or names of colors printed in black ink that have to be read [17]. The number of stimuli varies between less than twenty items to more than 150, being closely related to the scoring system used. While in some test variants the score is the number of items from a subtask read in a given time, in others it is the time that it took to complete each of the trials [17]. The number of errors and different derived punctuations are also taken into account in some versions [17].

This test is considered to measure selective attention, cognitive flexibility and processing speed, and it is used as a tool in the evaluation of executive functions [17].

Procedure

For each subject 30 neurofeedback training sessions was held and each session lasted 45 minutes. The experimental group received feedback based on their performance, in contrast control group's feedback was not based on their performance (in fact their sessions weren't neurofeedback training and they didn't know that they conducted placebo training). In the first session, before neurofeedback training, memory test were performed on all subjects, individually. Then neurofeedback training was carried out for experimental group according to this protocol: increasing SMR wave (12-15Hz) and decreasing high beta (19-32 Hz) and Theta (4-8 Hz) in Cz area.

Date analyses

Data were analyzed using SPSS (Statistical Packages for the Social Sciences) PC version 17 for Windows. All differences were considered significant if the probability of error was $p<0.05$. To compare memory scores between groups multivariate analysis of variance (MANOVA) was use

Result

To evaluate mean and standard deviation of subjects' memory scores in pre and post test descriptive analysis was used. The results have been demonstrated in Table 1.

As has been shown in Table 1, the memory scores mean of experiment group in pre and post test were 68.30 and 77.30, respectively. In addition, the results showed that the control subjects' mean of memory scores were 72.8 and 75.33, respectively.

In the present study in order to compare differences between headache patients and control groups on memory scores, the individual's

	Control group				Experimental group			
	Post –test		Pre –test		Post –test		Pre –test	
Variable	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean
Information	0	6	0	6	0	6	0	6
Orientation	0	5	0	5	0	5	0	5
Mental control	1/6	7/73	1/3	7/8	0/457	8/71	0/67	7/8
logic Memory	3/8	13/9	4/1	12/7	3/7	15/1	4/14	13/06
Digit Span	3/58	12/5	4/6	12/8	0/83	9/7	1/2	8/3
Verbal Paired Associates,	2/5	17/7	2/17	17/03	1/3	19/76	1/37	18/23
Visual Reproduction	7/06	75/33	5/98	72/8	4/48	77/10	5/15	10/93
Total memory	7/06	75/33	5/98	72/8	4/48	77/10	5/15	68/30

Table 1: Mean and standard deviation of memory scores in pre- and post test.

scores on Wechsler memory scale and its subscales in post test stage were evaluated as multivariate analysis (MANOVA). The MANOVA's results have been given in Table 2.

As have been shown in Table 2, MANOVA revealed significant differences between experimental and control groups on total memory score F (1,28) = 26.88, p<0.000. In addition, the results showed that some subscale scores were significantly different between two groups, such as mental control F (1,28) = 16.66, p<0.001, Digit Span F (1,28) = 20.86, p<0.001, Verbal Paired Associates F (1,28) = 4.53, p<0.05, Visual Reproduction F (1,28) = 33.55, p<0.001. Significant differences between groups reflected that headache subjects had greater scores on memory scale than control participates after neurofeedback training.

On the other hand, as have been shown in Table 2, the findings indicated that the two groups differences on logic memory was found to be non-significant, F(1,28) = 0.49, NS, that reflected neurofeedback training didn't influenced logic memory of headache patients.

		Df	F	P
Model	Mental control	1	0.463	0.463
	logic memory	1	8.53	0.007
	Digit Span	1	8.62	0.000
	Verbal Paired	1	36.36	0.000
	Visual Reproduction	1	182.68	0.000
	Total	1	84.79	0.000
Group	Mental control	1	16.66	0.000
	logic memory	1	0.492	0.492
	Digit Span	1	20.86	0.000
	Verbal Paired	1	4.530	0.492
	Visual Reproduction	1	33.554	0.000
	Total	1	26.88	0.000
Error	Mental control	28		
	logic memory	28		
	Digit Span	28		
	Verbal Paired	28		
	Visual Reproduction	28		
	Total	28		

Table 2: Tluser Avona.

	Control group				Experimental group			
	Post –test		Pre –test		Post –test		Pre –test	
Variable	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean
Error in A cart	0/25	0/066	0/000	0/000	0/0	0/0	0/000	0/000
Error in B cart	0/25	0/066	0/25	0/066	0/0	0/0	0/25	0/66
Error in C cart	0/51	0/13	0/25	0/066	0/0	0/0	0/48	0/33
Error in D cart	0/45	0/26	0/63	0/6	0/0	0/0	1/03	0/93

Table 3: Mean and standard deviation of executive function scores in pre- and post test.

		Df	F	P
Model	Stroop	1	7/11	0/013
Group	Stroop	1	4/76	0/038
Error	Stroop	26	2/429	

Table 4: Tluser Avona.

To evaluate mean and standard deviation of subjects' executive function scores in pre and post test descriptive analysis was used. The results have been demonstrated in Table 3.

In the present study in order to compare differences between headache patients and control groups on executive function scores, the individual's scores on Stroop test and its subscales in post test stage were evaluated as multivariate analysis (MANOVA). The MANOVA's results have been given in Table 4.

As have been shown in Table 4, MANOVA revealed significant differences between experimental and control groups on stroop score F (1,26) = 4.76, p<0.038. In addition, the results showed that some subscale scores were significantly different between two groups, reflected that headache subjects had greater scores on executive function scale than control participates after neurofeedback training.

Discussion

The main aim of the present study was to investigate the effect of neurofeedback training on Memory of headache patients. The results showed that neorofeedback training improved memory of these subjects. several studies provided research's result [18-23]. In fact, neurofeedback is a mechanism for repair and reconstruction of brain waves. Patients could improve their wave's pattern by continuous training, feedback and practice. It is a practice for brain and so with this training session the memory will be increased and the changes will become permanent gradually. There are evidences during recent 25 years, which show this learning phenomenon would be influenced by unconscious processes and person can learn without direct awareness [12]. As neurofeedback is based on learning and conditioning process (especially deals whit brain conditioning), its effect occurs after about 30 sessions [24]. The protocol which used in present study was to increasing SMR wave on Cz area (Sensory motor cortex and cingulate cortexes). Also, the patient who has difficulty in understanding logical continuity of cognitive function can use neurofeedback training on sensory motor cortex in left hemisphere (C3) and training on sensory motor cortex in right hemisphere (C4) could facilitate mixed answer. Cingulated system deals with excitement feeling, attention and working memory. So, increasing sensory-motor rhythm decrease unrelated motives and facilitates integrity of motives related to performance [25] and consequently, effects on conceptual memory directly [11]. In addition, in the study theta was inhibited on Cz area. Theta wave is related to confusion, inattention, imagination, depression and anxiety [26]. Therefore, it seems all researchers agree with this idea that increasing activity of slow theta is causing the problem and it could be solved by neurofeedback training [25].

It is known from previous research that theta activity has an influence on the cellular mechanisms of memory through its role in facilitating long-term potentiation [27], and more recent studies have documented a link between recognition memory processes and theta activity recorded from the scalp [28]. Convincing evidence of the direct relationship between theta and working memory stems from data showing that, during the encoding phase of a recognition task, only words that were later correctly recognized exhibited a significant increase in theta activity [29]. In addition, during the later recognition phase, greater theta activity was found for correctly recognized words but not distracters. Based on research showing that working memory utilises the posterior association cortex, involved in the storage of sensory information, and the pre-frontal cortex which updates the information [30-33]. One proposal is that theta activity links these two regions together during memory task.d.

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