Effect of low-intensity magnetic stimulation on human attention span-Experimental Study

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ABSTRACT

Attention is a cognitive and behavioral process that selectively focuses on the individual aspects of subjective or objective information. It has been shown that transcranial magnetic stimulation of the brain, or rTMS, can affect the networks of attention in the brain of some peoples. In this study we report the effects of our experimental setup(Beta-1 Device) on human brain. Current research shows the influences of our setup on human concentration and attention. Respected to the low number of sessions of this stimulation using the beta1 device and the significant effect of this stimulation, the beta1 system can be helpful in the treatment or improvement of attention deficit disorders.

It is suggested that the effectiveness of this machine in increasing attention and focus should be studied by repeating this research and increasing the number of magnetic stimulation sessions of the brain. Due to the results of the previous researches in the stimulation of the DLPFC area and its relevance with the recovery of depression, the effect of stimulation of brain by this device on depression is expected.

In the present study, the final scores of attention and visual and auditory focus in the IVA test were considered. It seems that repeating the research and measuring the different components of attention mentioned in this test can illuminate the dark angles of the present study.

Keywords:

Introduction

Magnetic stimulation of brain is an evolving method based on which the neurons of brain are stimulated by a magnetic coil forming the frequency function of the stimulated neurons. It is a non - invasive process that causes the emergence of electric currents in certain areas of the brain. The magnetic stimulation of the brain is defined in three general terms: Single-Pulse Transcranial Magnetic Stimulation (TMS), Paired-Pulse Transcranial Magnetic Stimulation and Repetitive Transcranial Magnetic stimulation (rTMS)^[1] . Attention is a cognitive and behavioral process that selectively focuses on the individual aspects of subjective or objective information; it focuses on either top-down and down-top mechanisms for processing selectively or inhibits the contents of multiple sensory inputs in different fields^[2] . In other definitions, attention is a cognitive process that selectively focuses on a certain aspect of data that can be subjective or objective and can be ignored in some information in this process. A form of arousal is defined as the allocation of limited cognitive processing resources^[3] .

Attention is given to other cognitive functions such as memory, language, problem solving, and reflection of complex multiple independent systems distributed within the brain or disrupting it^[4] . The activity of the DLPFC area on the left is considered as the focal point to influence the attention and focus of individuals^[5] . Therefore, it seems possible to influence the attention and focus with stimulation of this area. The variables studied included activity in the PFDLC area as an independent variable, and attention and concentration as dependent variable.

It has been shown that repeated magnetic stimulation of the brain, or rTMS, can affect the networks of attention in the brain of alcoholics and addicts. This stimulation in the prefrontal regions can have important cognitive effects^[6] . It has shown that magnetic stimulation of the brain in the left DLPFC region improves emotional attention in methamphetamine addicts. In some sources, the role of transcranial magnetic stimulation (ADHD) on Attention Deficit Hyperactivity Disorder (ADHD) has been discussed^[7] . Stimulation of different parts of brain can affect different types of attention. For example, stimulation of the posterior parietal cortex (PPC) can effect spatial attention^[8] . The role of transcranial magnetic stimulation on vision, attention, and cognitive processes has been studied and emphasized^[9] .

In some studies, the positive effect of low-intensity magnetic fields on brain metabolism is noted^[10] . Some studies have shown that brain can be affected by low-intensity transcranial magnetic stimulation. For example, it has been shown that low-intensity TMS can produce up to 60% below

the threshold of motor activity in the brain^[11]]. A study using low-intensity magnetic field coils on human subjects concluded that even at low-intensity stimulation, significant changes in brain function could be observed^[12]]. Another study has shown that low-intensity transcranial magnetic stimulation, or LI-rTMS, can cause functional changes in brain of animal subjects^[13]]. It has shown that high-frequency and low-intensity stimulation of the DLPFC region can be effective and may lead to changes in PTSD treatment approaches^[14]]. Low-intensity and high-frequency stimuli have been shown to have a positive effect on conscious perception of visual stimulus^[15]]. The effect of high-frequency and low intensity stimulation on different parts of the brain, such as the motor cortex, has also been the subject of research. Research has shown that such stimulation can produce a potent inhibitory effect on the motor cortex^[16]]. Previous research has mainly focused on the use of high intensity magnetic stimulation from close distance and in a localized manner. But in the present study, the results were obtained using low- intensity excitation and over larger areas. The purpose of this study was to determine whether magnetic field stimulation with very low field intensity and broadly stimulated prefrontal cortex stimulation by Beta1 device affects different focus and attention indices.

Materials and Methods

In this study, participants were divided into two groups: healthy and ADHD, according to the IVA score. 33 Healthy subjects and 30 subjects with ADHD participated in this study. The subjects were able to fully complete the research modality. Subjects were selected from both males and females. Thirty-three healthy subjects included 16 male and 17 female subjects. 30 ADHD subjects as experimental group included 16 women and 14 men. The age of the subjects ranged from 19 to 48 years. The subjects ' education level was Bachelor's and higher. Random sampling method was used to select a statistical sample. The statistical population in the ADHD group consisted of people who had a psychiatrist confirmation and the score obtained from the IVA test. In the control group, the statistical population of healthy individuals was introduced by a psychiatrist. Inclusion criteria The study included subjects who had no history of drug use from one month prior to the study and had no history of TMS stimulation or similar technologies. The health of these people (except ADHD) had been approved by a psychiatrist. Exclusion criteria of this study included subjects with other physical or psychological disorders and subjects who had a history of mental anomaly 6 months prior to the study. The subjects who had used any medicine during the study, or the subjects that had not participated regularly during the period, were excluded from the research.

Beta-1 device was used for magnetic stimulation of subjects (Figure 1). The device is capable of stimulating its adjacent cortex through low-intensity transcranial magnetic stimulation.

IVA version 2 software was used to measure visual and auditory attention. IVA (Integrated Visual and Auditory attention test), The IVA-2 CPT is decision support software that helps clinicians test and evaluate both visual and auditory attention and response control functioning. This test is from Braintrain Company. Quantitative electroencephalography or qEEG was used to measure brain cortex activity. The brain activity of the samples was analyzed by quantitative electroencephalography method. In this method, data were collected from 19 cranial regions. A brain activity map and diagram were prepared. Data were recorded using Win EEG software version 2.127 and Mitsar 201-m electroencephalograph were used to record the data. Neuroguide software version 3.0.1 and Neurostate software were used to analyze EEG data. The participants were not informed about their results and their group subdivisions during tests and interventions. Initially, an IVA test was used to determine the exact parameters of Sustained Auditory Attention Quotient and Sustained Visual Attention quotient as the main scores of IVA test. Then, qEEG test was used to assess the brain activity of subjects. This test was performed in two eye-opening and closed-eye modes. The duration of each of these modes was 5 minutes. Then, the subjects positioned in three sessions under the low-intensity transcranial magnetic field stimulation with the beta1 device. This stimulation was performed at a frequency of 17 Hz with an intensity of about 140 micro-tesla. The duration of each stimulation was 25 minutes. The interval between each stimulation session was 2 days. After 6 days, IVA and qEEG tests were performed again. All tests were performed in one room. To prevent the effect of fatigue on IVA test results, IVA test was performed first. The qEEG test was also performed with a 10-minute interval. The ethics code IR.TUMS.VCR.REC.1396.4736 was used in this study. This code was obtained from the Research Ethics Committee of Tehran University of Medical Sciences. Two-way paired t-test was used for statistical analysis of the results. The analysis was performed separately for the healthy control and experimental (ADHD) groups.

Results

The data were analyzed in two category of pre-test and post-test and in Sustained Auditory Attention quotient and Sustained Visual Attention Quotient for two groups of ADHD and healthy. The statistical analysis of the data is presented in Table 1 . Initial data analysis in the eight pre-test and

post-test groups between control and experimental groups and in each of SVAQ and SAAQ scenarios. (SVAQ) stands for Sustained Visual Attention Quotient and (SAAQ) stands for the phrase Sustained Auditory attention quotient.

IVA test data were analyzed by Kolmogorov-Smirnov test for normality, which was determined to be normal distribution of all data. After that, the homogeneity test of variance performed and it was found that the variance of the groups did not have a significant difference in four comparisons. The results of pre-test and post-test IVA test using two-tailed paired t-test in control group (with 95% confidence level show that), Sustained Auditory attention quotient changes were significant ($t = -1.740$, $df = 32$, Sig. (2-tailed) = .091). In the same group, Sustained Visual Attention Quotient was also significant ($t = -1.844$, $df = 32$, Sig. (2-tailed) = .074).

The results of pre-test and post-test IVA test using two-tailed paired t-test in ADHD group (with 95% confidence level) show that, Sustained Auditory attention quotient changes were significant ($t = -6.623$, $df = 29$, Sig. (2-tailed) = .000). In the same group, Sustained Visual Attention Quotient was also significant ($t = -3.391$, $df = 29$, Sig. (2-tailed) = .002).

Results are presented in Figure 2. The averages in the ADHD group and in the Sustained Visual Attention Quotient section have been shown to increase from 52.1 in the pre-test to 66 in the post-test. The standard error of this section went from 10.7 to 16.2.

The mean in the healthy control group in Sustained Visual Attention Quotient increased from 102.2 in the pre-test to 105.3 in the post-test. The standard error of this section ranged from 8.4 to 6.24. The mean in the ADHD group and in the Sustained Auditory Attention Quotient section increased from 47.1 in the pre-test to 71 in the post-test. The standard error of this section increased from 22.5 to 30.6. The averages are increased in the healthy group and in Section Sustained Auditory attention Quotient from 106 to 108.8. The standard error of this part increased from 6.1 to 10.1.

Pre-test and post-test qEEG data were analyzed by Neurostate software in healthy and ADHD groups. FFT Absolut Power Group Paired t-Test was used.

The results show that in both groups the mean of absolute power of brain waves increased

in Fp1, C3, F7 regions ($P = 0.06$). Figure 3 shows the variation of absolute power in the pre-test and post-test of control and experimental groups.

Discussion

The aim of this study was to investigate the effect of magnetic stimulation with lower intensity of 150 microtesla using Beta1 device on attention and focus. Based on the scores gained in IVA test, findings show a significant impact on increasing visual and auditory attention and focus in both control and experimental groups using Beta1 device.

This increase is greater in people with ADHD than in healthy people. The application of Beta1 device has a significant effect on increasing the activity of 17 Hz beta waves in the left frontal areas, especially in ADHD group.

The results confirm previous findings that transcranial magnetic stimulation of DLPFC has a positive effect on attention and focus¹⁷. Like previous studies¹⁸, stimulation of DLPFC can have a favorable effect on attention and learning abnormalities. The results of this study, along with other studies, show that low-intensity stimulation by a well-modulated beta1 device can have a significant effect on increased attention and focus, as like as other types of transcranial magnetic stimulation.

Respected to the low number of sessions of this stimulation using the beta1 device and the significant effect of this stimulation, the beta1 system can be helpful in the treatment or improvement of attention deficit disorders.

It is suggested that the effectiveness of this machine in increasing attention and focus should be studied by repeating this research and increasing the number of magnetic stimulation sessions of the brain. Due to the results of the previous researches in the stimulation of the DLPFC area and its relevance with the recovery of depression, the effect of stimulation of brain by this device on depression is expected.

In the present study, the final scores of attention and visual and auditory focus in the IVA test were considered. It seems that repeating the research and measuring the different components of attention mentioned in this test can illuminate the dark angles of the present study.

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Table 1: Descriptive Statistics

TestName	N	Minimum	Maximum	Mean	Std
VAQ.ADHD.PRETEST	30	37.00	66.00	52.17	10.73
VAQ.ADHD.POSTTEST	30	29.00	106.00	66.00	16.29
VAQ.HEALTHY.CTRL.PRETEST	33	76.00	112.00	102.30	8.14
VAQ.HEALTHY.CTRL.POSTTEST	33	86.00	116.00	105.12	6.00
AAQ.ADHD.PRETEST	30	0.00	82.00	47.10	22.52
AAQ.ADHD.POSTTEST	30	7.00	114.00	71.06	30.60
AAQ.HEALTHY.CTRL.PRETEST	33	96.00	115.00	105.90	6.22
AAQ.HEALTHY.CTRL.POSTTEST	33	78.00	119.00	108.81	9.90
Valid N (listwise)	30

Figure 1: Low-intensity transcranial magnetic stimulator (Beta1)

Figure 2: Mean pre-test and post-test of the two ADHD and healthy groups in each of the SVAQ and SAAQ modes. (SVAQ) stands for Sustained Visual Attention Quotient and (SAAQ) stands for Sustained Auditory Attention Quotient. In all cases the mean of post-test increased

Figure 3: a: FFT Absolut Power Group Paired t-Test results for the ADHD group, the altered areas show a significant increase in the absolute power of the 17 Hz waves in the left and centro-frontal areas. b: the results of FFT Absolut Power Group Paired t-Test Analysis for healthy group, the changed areas indicate a significant increase in the absolute power of the 17 Hz waves in the left frontal areas.