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Treatment of Test Anxiety by Stimulating Transcranial Direct to the Brain

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Abstract

This study aimed at investigating the effectiveness of transcranial Direct Current Stimulation (tDCS) on test anxiety in the students of primary and secondary high school. This study was a semi-experimental one with a pretest-posttest design and control group. The statistical population of the study included all the male and female primary and secondary high school students in the 2019-2020 academic year in Baladeh (N=200), among whom 30 students with a score of below 40 were randomly selected and assigned to the experimental and control group (15 subjects in each group). The experimental group received transcranial direct current stimulation therapy, but the control group did not receive any treatment. After the end of the treatment, all the subjects participated in the posttest. The research tool included a test anxiety questionnaire [1]. The results of univariate ANCOVA showed that there were significant differences between the posttest scores of the subjects of the two groups. It can be concluded that transcranial direct current stimulation therapy was significantly effective in the reduction of test anxiety.

Keywords: Transcranial direct current stimulation; Test anxiety; Students

Introduction

Exams constitute an inseparable part of people's life. The results of the exams are so effective in all the dimensions of people's life [2]. Test anxiety is one of the common educational problems faced by school and university students. This problem can affect their learning and academic achievement. Test anxiety is considered a kind of mental self-employment that is manifested by self-concept and doubt in one's abilities. It usually creates a negative cognitive assessment, lack of concentration, unfavorable physiological reactions, and declined academic performance in the students, and it also has a destructive role in the students' mental health [3]. Test anxiety has been defined as a set of behavioral, physiological, and phenomenological responses that are accompanied by the concern about the probable negative outcomes or failure in a test or assessment situation [4]. According to Soysa & Weiss (2014) [5], test anxiety is a kind of mental self-employment that is accompanied by an inferiority complex, lack of self-confidence, and doubt in one's abilities which lead to academic failure and put the person's mental and physical health at risk. Various treatments have been proposed for this complication to make humans secure against its negative consequences.

Nowadays, pharmacological treatments have been replaced by non-invasive brain treatments [6]. Over the past two decades, transportation management systems and transcranial direct current stimulation have been used for promotion of the brain performance. Transcranial direct current stimulation refers to the neural stimulation of brain areas that is usually done by creating an electrical or magnetic field. Such stimulation can be applied by seizure or non-seizure therapy. Non-seizure brain stimulation can be done by direct stimulation of neural pathways by applying an electrode or by non-invasive transcranial stimulation. The tools and technologies used for brain stimulation are used for evaluating the brain functions and also as a treatment option for psychiatric patients who have not been improved by other methods such as pharmacological methods and seek more effective treatments [7]. Transcranial direct current stimulation is a neural treatment in which, a weak direct current is applied to the cerebral areas and it facilitates or inhibits the neural activity of that area. Transcranial direct current stimulation is a form of neural stimulation that is used constantly by transferring a weak current to a specific area of the brain by small electrodes. This weak direct current can stimulate or inhibit the underlying neurons by the connection of the anode and cathode electrodes. Cathodal stimulation reduces brain stimulation and anodal stimulation

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increases that. Transcranial direct current stimulation does not create any action potential in neurons; rather it changes the resting potential of the neuron membranes by 1-2 mV, and so, it changes the neuron stimulation [8,9]. The tests performed on healthy adults have shown that transcranial direct current stimulation can promote cognitive function in a variety of tasks related to the stimulated area of the brain [10]. Furthermore, studies on anxious students have shown the effectiveness of this method in the improvement of their anxiety [6]. Depending on the learning environment, schools can be stressful for the students. Every year, schools accept a significant number of the child and adolescent population and they are responsible to promote their scientific and practical abilities in a specific period of time to provide educated forces for society. Due to the various factors, the education period is a stressful time. As the students face new educational methods and unpredictable demands in this period and they do not have the required information, they may experience unfavorable feelings and they might be unable to adapt to the environment [4]. This situation sometimes leads to test anxiety. Test anxiety has been widely studied since the early 20th century. It has been always considered a serious problem in the education of children, adolescents, and even adults [11].

In recent years, test anxiety and its dimensions have constituted one of the most expanded research areas. Test anxiety is one of the most prevalent emotional-psychological disorders in children and adolescents. So, it is one of the serious problems in today's societies [12]. The prevalence of test anxiety has been reported as 10-30% among school and university students [4]. In this regard, test anxiety threatens the students' mental health and impacts their efficiency, flourishing, personality, and social identity. As one of the common phenomena among the students, it can impact their academic achievement and optimal performance, especially in their assessment.

With the development of human knowledge about the brain, new treatments have been proposed for psychological disorders. These methods are highly effective and have lower side effects. One of the latest treatments is transcranial direct current stimulation. In resting mode, neural cells have a negative load. When the simulation is applied to the neural cells the negative load shifts toward a positive load. This process should exceed a threshold to create electrical impulse or action potential this method leads the neural cell from the resting mode toward the positive load and it can increase the probability of creation of action potential by the cell. Studies have shown that transcranial direct current stimulation is more useful than drugs and placebos used for the treatment of depression. Also, it can be widely used for the treatment of other disorders such as drug abuse, smoking, anorexia nervosa, and bulimia nervosa [13]. Nevertheless, the use of this method should be studied in the treatment of test anxiety. Research works performed by Vaghef et al. (2019) [8], Saeidmanesh et al. (2019) [10], Ahmadi & Rezaei (2020) [13], Nazeri, Mohammadzadeh, Tabatabaei, & Rezasoltani (2019) [14], Aghajani, Seyfollah, Taherifard, Mina, & Alireza Guradel (2018) [15], Rajaeipour & Saeidmanesh (2018) [16], Sud (2020) [17], Wang et al. (2019) [18], Mennella, Patron & Palomba (2017) [19], and Berryhill & Jones (2012) [20] suggest the effectiveness of transcranial direct current stimulation in the improvement of test anxiety. In this regard, the present study aims to investigate the following question: Is transcranial direct current stimulation effective in students' test anxiety?

Method

This research (performed under the ethics code of IR.IAU.BABOL.REC.1399.028 and the research code of IRCT20190817044550N3: IRCT) is a semi-experimental study with a pretest-posttest design and control group. Table 1 presents the research specifications.

The research population includes all the male and female primary and secondary high school students of Baladeh region in the academic year 2019-2020 (N=200). First, all the students answered the online test anxiety questionnaire (Friedman). The subjects with a score of below 40 were determined as the major samples (N=73). Then, out of the major samples, 30 people were selected and randomly assigned to the experimental and control groups (15 people in each group) (Table 2). The experimental group received the transcranial direct current stimulation in ten 20-min sessions, but the control group did not receive any intervention. After the intervention, the subjects of both groups participated in the posttest.

The research tools included the text anxiety questionnaire, TCDS scale, and text anxiety questionnaire of Friedman and Bendas-Jacob (1997) [1] including 23 items. Friedman's test anxiety questionnaire included the three subscales of social humiliation, cognitive error, and tension. The items are scored based on a four-point Likert scale ranging from 0 (quite disagree) to 3 (quite agree). Questions 1 to 8 evaluate social humiliation, questions 9-17 evaluate cognitive error, and questions 18-23 evaluate tension. In this questionnaire, higher scores indicate a low level of test anxiety and lower scores indicate a high level of test anxiety.

In the research performed by Friedman and Bedas-Jacob (1997) [1] in a 3700-people sample, the Cronbach's alpha co-efficients were respectively obtained as 0.86, 0.85, and 0.81 for every subscale and 0.91 for the total scale. In this research, reliability of the scale (Cronbach's alpha) was respectively obtained as 0.89, 0.77, and 0.84 for social humiliation, cognitive error, and tension, and 0.90 for the total scale. Friedman and Bendas-Jacob (1997) [1] evaluated the validity of this

Table 1: Research specifications.

Test	Intervention	Test	Assignment	Groups
Posttest (T2)	Transcranial direct current stimulation	Pretest (T1)	Random	Experimental group
Posttest (T2)	-	Pretest (T1)	Random	Control group

Table 2: Distribution of the main sample in terms of educational program and gender.

Groups	Primary high school		Secondary high school		Total
	Male	Female	Male	Female	
Transcranial direct current stimulation	4	3	5	3	15
Control	5	3	4	3	15
Total	9	6	9	6	30

Table 3: Descriptive statistics of the subjects' test anxiety scores in the two groups (pretest-posttest).

Groups	Transcranial direct current stimulation		Control	
	Mean	SD	Mean	SD
Pretest	31.13	6.28	32.07	5.75
Posttest	39.47	5.99	32.20	5.80

questionnaire in terms of its correlation with the Spielberger's test anxiety score and they reported the result equal to 0.84 for male students and 0.82 for female students. In the research performed by Berryhill ME, Jones KT (2012) [20], the validity of this questionnaire was evaluated in terms of construct validity and factor analysis. In factor analysis, all the 23 items were included in the test, and none of the items were correlated by less than 0.30. So, it was concluded that the test has an adequate level of validity, and its face validity was also approved by experts and professors. Meanwhile, the reliability of this questionnaire was calculated by Cronbach's alpha coefficient and the results were reported as 0.90 (social humiliation), 0.85 (cognitive error), and 0.83 (tension), and 0.91 for the total scale [3].

After getting permission from the Education Organization of Baladeh region, the number of male and female primary and secondary high school students of Baladeh in the academic year 2019-2020 was determined, and the online test anxiety questionnaire was answered by all the students *via* Whatsapp. Then, the students with a score of below 40 were specified (N=73), and 30 people were randomly selected and assigned to the experimental and control groups (15 people in each group). The subjects and their parents received some explanations about the research goal and nature and the advantages and disadvantages of transcranial direct current stimulation, and they also filled the informed consent letter. The subjects were assured about the privacy of their information and the researcher's responsibility for any probable incident. Transcranial direct current stimulation was performed in the experimental group, and at the end, the subjects of both groups participated in the posttest after the intervention. In the experimental group, transcranial direct current stimulation was applied in ten subsequent sessions (with 48-hour intervals). In each session, a 2-mA current was applied on the F3 area using an anodal electrode with a small pad (16 cm) and on the Fp2 area using a cathodal electrode with a large pad (24 cm) for 20 minutes. The electrode site was determined based on the international 10-20 system.

Results

As seen in Table 3, the mean and SD of test anxiety were respectively reported as 31.13±6.28 and 39.99±5.99 in the pretest and posttest of the experimental group and 32.07±5.75 and 32.20±5.80 in the pretest and posttest of the control group. The results suggest a significant decrease in the subjects' test anxiety scores after the intervention. It should be mentioned that the higher scores on the test anxiety questionnaire indicate a low level of anxiety and lower scores indicate a higher level of test anxiety. So, the increased scores of posttests compared to the pretest scores in the treatment groups indicate the decrease in the students' test anxiety after the intervention.

The results of the Shapiro-Wilk test show that the statistics of the pretest and posttest scores of the experimental and control groups are higher than the critical value (α=0.050. Therefore, the null hypothesis suggesting the normality of data distribution is approved and the assumption of non-normal distribution is rejected. Since the values of skewness and kurtosis range from -2 to 2, it can be stated that data distribution is normal. The results of Levene's test showed that the significance level of test anxiety (P=0.687) is higher than 0.05. So, homogeneity of variance is observed in test anxiety.

As seen in Table 4, the f ratio resulted from the ANCOVA suggests that after eliminating the effect of the auxiliary random variable (pretest), there was a significant difference between the modified posttest scores of test anxiety (F (1, 27) =183.47; P<0.01). It suggests that transcranial direct current stimulation has been effective in the students' posttest score of test anxiety. In other words, transcranial direct current stimulation has decreased the students' anxiety in the posttest. The eta square shows that 87.2% of the changes (decrease) in the students' anxiety in the posttest results from the effect of transcranial direct current stimulation.

Discussion and Conclusion

The present research was aimed to investigate the effectiveness of transcranial direct current stimulation in the improvement of the students' test anxiety. The findings suggest a significant difference between the modified scores of test anxiety in the posttest. It suggests that transcranial direct current stimulation has been effective in the student's test anxiety in the posttest. In other words, transcranial direct current stimulation has decreased the students' anxiety in the posttest. This finding is consistent with the results reported by Vaghef et al. (2019) [8], Ahmadizadeh & Rezaei (2020) [13], Wang et al. (2019) [18], Manenla et al. (2017) [19], and Berihil & Johns (2012) [20]. Anodal cranial stimulation reduces intracortical inhibition while increasing cortical facilitation. However, cathodal stimulation has negative effects. Cranial stimulation is not a difficult procedure and the tools used for this treatment are less risky and simpler than the tools used for other treatments. Unlike methods such as repetitive transcranial magnetic stimulation, in transcranial direct current stimulation, the applied stimulation cannot create any action potential and response. Rather, the changes are led to improve the structure and performance of neurons in the desired manner. The function of a transcranial stimulation device is to pass the current through the brain by putting positive and negative electrodes on the cranium. It has been found that increased activity of the dorsolateral prefrontal cortex by non-invasive stimulation is effective in the reduction of the symptoms of negative emotions such as anxiety. Meanwhile, incremental or decremental stimulation of the left or right prefrontal areas can disturb the balance in the activity of the two hemispheres. Stimulation of the posterior lateral area of the left prefrontal cortex and the posterior lateral areas of the right prefrontal cortex can normalize the anxiety states. Furthermore,

Table 4: The results of univariate ANCOVA for the effectiveness of transcranial direct current stimulation in posttest.

Test	Source of Change	Sum of squares	Degree of Freedom	Mean square	f ratio	Sig	Effect size
Posttest	Group	565.76	1	565.76	183.47	0.001	0.872
	Error	83.26	27	3.08	-	-	-
	Total	1362.17	29	-	-	-	-

boosting the performance of the areas of the prefrontal cortex and improvement of the operational functions that are considered high-level cognitive functions (including the control and directing the automatic functions) and low-level cognitive functions can mediate the effectiveness of transcranial direct current stimulation in anxiety [8].

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