J Biochem Tech (2019) Special Issue (2): 140-144
ISSN: 0974-2328

The Effects of Transcranial Direct Current Stimulation (tDCS) on Attention and Shooting Performance in Shooters

Naser Goodarzi*, Masoud Nosratabadi, Hamid Ahmadi

Received: 20 September 2018 / Received in revised form: 10 March 2019, Accepted: 21 March 2019, Published online: 25 April 2019

Abstract

The purpose of this study is to examining the effectiveness of transcranial Direct Current Stimulation (tDCS) on attention and shooting performance.in this clinical trail the experiment group received 10 sessions tDCS on left dorsolateral prefrontal cortex (DLPFC) during hunting training and the control group received sham stimulation during training. The IVA attention test and performance test by Scott machine administered to evaluating subjects in pretest and posttest. the results indicated that the performance and attention of active tDCS group promoted after 10 sessions (F3, 31=4.98, p<.05, partial η 2= 32/Pillai's trace) and (F3, 31=10.31, p<.001, partial η 2= 49/Pillai's trace). Therefore, it can be said that the transcranial Direct Current Stimulation (tDCS) by targeting the left DLPFC improved the attention and performance of the shooters.

Keywords: tDCS, Attention, Performance

Introduction

The research studies and examinations in the area of neuroscience that are conduced everyday have opened a new window into its military applications. These applications are commonly referred to as the "Future solder" project that includes the old military concerns, such as leaning, decision-making, and performance under stressful conditions, and also the new concerns, such as cognitive fitness, brain-computer interfaces, biologic markers, and neural states (Kruse, 2007). Human performance optimizing (HPO) includes the use of strategies that keep the performance in the desired level in the face of stressors that are detrimental to performance. One way of optimizing the human performance is a set of measures aimed at improving the performance of brain neurons. These methods are called Neuromodulation. The most commonly-used method of Neuromodulation is the transcranial Direct Current Stimulation (tDCS) due to being an easy-to-use and fast-acting method.

In the tDCS, a low current (up to 4 mA) is sent to the neurons using two electrodes, namely anode and cathode that are placed on the selected areas on the head. The anodal stimulation increases the brain activity, and the cathodal stimulation reduces it. The Defense Advanced Research Projects Agency (DARPA) supports the use of the tDCS as a method of creating cortical modifications and improving cognitive ability (Hamilton et al., 2011), including learning (Ukueberuwa & Wassermann, 2010) and memory (Tennison & Moreno, 2012).

Many studies have also been conducted on motor learning. These studies have mainly considered motor networks, including the primary motor cortex, the premotor area, and the parietal area. The primary motor cortex is involved in the primary learning phases (Honda et al., 1998) to create general motor coordination in the chain learning tasks (the learning that requires performing multiple tasks at the same time). Anodal tDCS on the primary motor cortex during or immediately after performing a task leads to enhanced learning (Antal et al., 2004 ; Hunter et al., 2009; Nitsche et al., 2008; Tecchio et al., 2010).

Different brain areas seem to be involved in motor learning. For example, in visual-motor tasks in which the primary motor cortex and cerebellum are involved, the anodal stimulation of cerebellum improves learning, while the anodal stimulation of the motor cortex leads to the stability of the learned movements (Galea et al., 2010).

Several studies have also shown that the tDCS impacts learning and formation of memory in such domains as visual memory, emotional memory, object location, learning numbers, and examination of possibilities (Kuo & Nitsche, 2012; Kraft et al., 2011, Tommasi et al.,

Naser Goodarzi*, Masoud Nosratabadi
PHD, Department of Psychology, AJA University of Medical Science, Tehran, Iran.

Hamid Ahmadi
MD, Resident of anesthesiology, Iran University of medical Science, Tehran, Iran

2015). In most cases, anodal tDCS on the cortical areas involved in learning and memory, improves performance.

Tomassi et al. (2015) examined the effects of tDCS on the performance of selected professional shooters. The shooters received real or sham (to control the effects of placebo) stimulations while shooting. The results based on the Scott test showed that the participants' shooting performance improved during real stimulation. They also measured heart rate as an index of arousal. The results showed an increase in the level of arousal during the real stimulation, indicating an increase in the selective attention. These results were significantly different from those of the sham stimulation.

In another study, Falcone et al. (2012) examined the effects of tDCS on learning. In this study, the percipients received stimulation at the start of the practice session or one hour following the practice. The anodal stimulation was applied on the 10F region with currents in the range of 1 to 2 mA (the cathodal electrode was placed on the left shoulder). Then the participants were asked to select pictures with signs of threat from a series of ambiguous pictures. The results indicated that the electrical stimulation improved the participants' performance on the practice. In addition, there was a significant improvement in the participants' performance in identifying the pictures with signs of threat. Moreover, it was found that stimulation at the start of practice was more effective than that at the end of practice, and that the positive effects were maintained until the next session (Falcone et al., 2012).

In another study by the United States Air Force, the effects of tDCS on the performance of people in charge of air traffic control were examined. The goal of this study was to examine the "Vigilance decrement" phenomenon. In this phenomenon, when a person spends a lot of time on a fixed task, experiences a gradual reduction in the ability to detect signals. In this study, through examination of physiological indicators, such as the blood flow speed in the middle cerebral artery or the cerebral cortex oxygen levels, the time of performance reduction in each participant was determined. Every time the reduction was observed, the researchers could bring the person's performance to the optimum level (Nelson et al., 2014).

Given the role of tDCS in performance improvement, the present study is aimed at examining the effectiveness of the transcranial Direct Current Stimulation (tDCS) in improving attention and performance of shooters.

Materials and Methods

An experimental design with an experimental and a control group was used. Given that an experimental design was used, soldiers who were learning shooting were divided into two 20-membr groups (20 people in the experimental group and 20 people in the control group). Because of a small statistical population, a total of 40 soldiers were selected using a convenience sampling method, and divided into experimental and control groups, based on a matching method and their scores on different scales at the pretest. The experimental group received the tDCS intervention and the control group received no intervention. During the course of the study, two participants in the control group left the study, therefore, a total of 38 participants (20 people in the experimental group and 18 people in the control group) were included in the final analysis.

Brain stimulation

A direct electrical current was released from a battery-driven simulator, and transferred through a pair of 5×5 cm electrodes. In order to target the DLPFC, the Anode electrode was on the F3 region, and the cathode electrode was on the FP2 region (based on the international 10-20 assessment system). The electric current delivered by a standard device (nNeurostim2; SN:). Intensity was 2 mA, and the stimulation duration was 20 minutes. There were 10 sessions for experiment group. For the control group, there was not any intervention.

The Integrated Visual and Auditory Test (IVA+PLUS)

the IVA+PLUS is a 13-minute visual-auditory continuous test that assesses two main factors, i.e. response control and attention. This test is used to evaluate such problems as self-control problems related to head injury, sleep disorders, depression, anxiety, learning disabilities, dementia, and other medical problems, and to evaluate attentional performance in normal individuals. The task in this test includes response/no response (response inhibition) to 500 stimuli. Every stimulus is only presented for 1.5 seconds. Therefore, the test requires attention maintenance. The participant should press the left mouse button when seeing or hearing the target stimulus (number 1), but not to respond when seeing or hearing the non-target stimulus (number 2). Research evidence has shown that the IVA+PLUS test has adequate sensitivity (92%) and a strong predictive power (98%) for diagnosing attentional problems. It has 22 subscales. Test-retest reliabilities in the range of .46 to .88 have been reported for the test. In the present study, the subscales of Commission error, Omission error, and Variability were used.

Omission errors are target respond failures, commission errors are inappropriate responses to the non-target stimulus which is a impulsivity or control measure and the variability of the correct response times, which represent consistency of attention.

Shooting performance (SCAT)

Test description: The target was set at a distance of 10 m. Shooting performance was studied based on six indicators to analyze performances via a dedicated device called ‘‘Scott.’’ This device is made for shooting analysis and consists of two major sections: software (Version 5.28) and hardware. The latter includes an optical receiver that is placed under the rifle, an electronic target that can be installed between 4 and 12m away from the shooter, a control unit, and related cables. The indicators were as follows (Bal et al., 2003):

Variables:

1. Shoot results: The results were between 0 and 10.9. Scott could record the results in decimal. Mean results were considered in decimal for each shooter.
2. Steadiness in 10.a0: Percentage of time the shooter kept the aim point in an area the size of the 10 scoring zone. This was used to indicate the steadiness of aiming.
3. Steadiness in 10.0: Percentage of time the shooter kept the aim point in the 10 scoring zone. This was used to indicate the accuracy of aiming.

After administering the scales and collecting the data, they were analyzed in the computer, using the SPPSS software, version 20. The multivariate analysis of variance (MANOVA) was used to analyze the data and control the pretest effects.

Results and Discussion

38 individuals participated in the present study. The mean and standard deviation of the age of the participants was 22.3±1.38 for the experiment group and 22.05±1.05 for the control group. Two groups were not significantly different on age (t=-1.87, p=0.06).

The effects of tDSC on shooting performance:

After making sure that all the assumptions for MANCOVA were met, it was used to compare the experimental and group groups. The main group effect was statistically significant (F3, 31=10.31, p<.001, partial η 2= 49/Pillai’s trace), indicating a significant difference between the two groups at least in one of the variables. The results of MANCOVA are presented in the table below. As you can see in the table, after removing the effects of pretest, the intervention effects were significant in terms of Shooting results (F=14, p<.001), and accuracy (F=19.22, p<.001), but not significant in terms of Steadiness (F=0.76, p<.001).

Table 1: MANCOVA results of shooting performance

Source	Dependent variable	Sum of squares	df	Mean square	F	Sig	Partial eta squared
Corrected model	Shoot results	3.212	4	0.803	13.96	0.001	0.629
	steadiness	326.813	4	81.703	26.26	0.001	0.761
	accuracy	3501.979	4	875.495	171.38	0.001	0.954
intercept	Shoot results	0.422	1	0.422	7.33	0.011	0.182
	Steadiness	8.377	1	8.377	2.69	0.110	0.075
	accuracy	0.666	1	0.666	0.13	0.720	0.004
Group	Shoot results	0.827	1	0.827	14.38	0.001	0.304
	Steadiness	2.366	1	2.366	0.76	0.389	0.023
	accuracy	98.223	1	98.223	19.22	0.001	0.368
error	Shoot results	1.898	33	0.058			
	steadiness	102.661	33	3.111			
	accuracy	168.574	33	5.108			

The effects of tDCS on attention:

After making sure that all the assumptions for MANCOVA were met, it was used to compare the two groups. The main group effect was statistically significant (F3, 31=4.98, p<.05, partial η 2= 32/Pillai’s trace), indicating that there was a significant difference between the two groups, at least in one variable. The results of MANCOVA are presented in the table below. As shown in the table, after removing

the effects of pretest, the intervention effects were significant in terms of Commission error (F=5.75, p<.05) and Variability (F=4.76 p<.05), but not significant in terms of Omission error (F=5.75, p<.05).

Table 2: MANCOVA results of attention variables

Source	Dependent variable	Sum of squares	df	Mean square	F	Sig	Partial eta squared
Corrected model	Omission error	3074.76	4	768.69	35.08	0.001	0.810
	Commission error	2822.86	4	705.71	36.71	0.001	0.817
	Variability	364.52	4	91.13	2.24	0.085	0.214
intercept	Omission error	151.33	1	151.33	6.90	0.013	0.173
	Commission error	100.83	1	100.83	5.24	0.029	0.137
	Variability	216.04	1	216.04	5.33	0.027	0.139
Group	Omission error	81.829	1	81.829	3.73	0.062	0.10
	Commission error	110.547	1	110.547	5.75	0.022	0.148
	Variability	193.104	1	193.104	4.76	0.036	0.126
error	Omission error	722.941	33	21.907			
	Commission error	634.397	33	19.224			
	Variability	1336.948	33	40.514			

Conclusion

Human performance optimization is applying emerging technologies to improve and preserve the capabilities of military members." TDCS is ultimately aiming to modulate neurofunctional networks to improve human cognitive functions and performance. The primary aim of the study was to investigate the effects of tDCS on shooting performance and attention in expert shooters. For This purpose, we put anode electric on the left DLPFC and cathode electrode on the right supraorbital through 10 sessions. Results demonstrate that after the intervention, attention and and shooting performance improved in the experiment group comparing to sham group.

The study results indicated a significant difference between the experimental and control groups after controlling the pretest effects. Therefore, it can be said that the transcranial Direct Current Stimulation (tDCS) by targeting the left DLPFC improved the attention and performance of the shooters. A more statistical examination also indicated an improvement in the subscales of Commission error and Variability following the attention stimulation, but there was no significant change in Omission error. To be more specific, the tDCS had a positive effect on response control and attention maintenance.

In a clinical trial Miler and colleagues (2017) found that one session of tDCS over left DLPFC in healthy subjects improve executive attention which means coordination of voluntary responses and control involuntary and automatic responses. In the mentioned study alerting and orienting didn’t change fallowing the intervention.

According to the results of ANCOVA, the changes in the participants’ performance resulted from the effects of intervention on Shooting results and Accuracy, but the effects on Steadiness were not significant.

Kamali and colleagues (2018) in clinical trial found that the simultaneous anodal stimulation of cerebellum and cathodal suppression of DLPFC improved shooting score in experienced pistol shooters even though no significant effect was reported for average shooting time.

References

Antal, A., Kincses, T. Z., Nitsche, M. A., Bartfai, O., & Paulus, W. (2004). Excitability changes induced in the human primary visual cortex by transcranial direct current stimulation: direct electrophysiological evidence. *Investigative ophthalmology & visual science*, *45*(2), 702-707.

Ball, K., Best, R., & Wrigley, T. (2003). Body sway, aim point fluctuation and performance in rifle shooters: inter-and intra-individual analysis. *Journal of sports sciences*, *21*(7), 559-566.

Falcone, B., Coffman, B. A., Clark, V. P., & Parasuraman, R. (2012). Transcranial direct current stimulation augments perceptual sensitivity and 24-hour retention in a complex threat detection task. *PloS one*, *7*(4), e34993.

Galea, J. M., Vazquez, A., Pasricha, N., Orban de Xivry, J. J., & Celnik, P. (2010). Dissociating the roles of the cerebellum and motor cortex during adaptive learning: the motor cortex retains what the cerebellum learns. *Cerebral cortex*, *21*(8), 1761-1770.

Hamilton, R., Messing, S., & Chatterjee, A. (2011). Rethinking the thinking cap Ethics of neural enhancement using noninvasive brain stimulation. *Neurology*, *76*(2), 187-193.

Honda, M., Deiber, M.P., Ibáñez, V., Pascual-Leone, A., Zhuang, P. & Hallett, M. (1998) Dynamic cortical involvement in implicit and explicit motor sequence learning. A PET study. Brain, 121, 2159–2173.

Hunter, T., Sacco, P., Nitsche, M. A., & Turner, D. L. (2009). Modulation of internal model formation during force field-induced motor learning by anodal transcranial direct current stimulation of primary motor cortex. *The Journal of physiology*, *587*(12), 2949-2961.

Kamali, A. M., Nami, M., Yahyavi, S. S., Saadi, Z. K., & Mohammadi, A. (2018). Transcranial direct current stimulation to assist experienced pistol shooters in gaining even-better performance scores. *The Cerebellum*, 1-9.

Kraft, A., Kehrer, S., Hagendorf, H., & Brandt, S. A. (2011). Hemifield effects of spatial attention in early human visual cortex. *European Journal of Neuroscience*, *33*(12), 2349-2358.

Kruse, A. A. (2007). Operational neuroscience: Neurophysiological measures in applied environments. *Aviation, space, and environmental medicine*, *78*(Supplement 1), B191-B194.

Kuo, M. F., & Nitsche, M. A. (2012). Effects of transcranial electrical stimulation on cognition. *Clinical EEG and Neuroscience*, *43*(3), 192-199.

Nelson, J. T., McKinley, R. A., Golob, E. J., Warm, J. S., & Parasuraman, R. (2014). Enhancing vigilance in operators with prefrontal cortex transcranial direct current stimulation (tDCS). *Neuroimage*, *85*, 909-917.

Nitsche, M. A., Cohen, L. G., Wassermann, E. M., Priori, A., Lang, N., Antal, A., & Pascual-Leone, A. (2008). Transcranial direct current stimulation: state of the art 2008. *Brain stimulation*, *1*(3), 206-223.

Tecchio, F., Zappasodi, F., Assenza, G., Tombini, M., Vollaro, S., Barbati, G., & Rossini, P. M. (2010). Anodal transcranial direct current stimulation enhances procedural consolidation. *American Journal of Physiology-Heart and Circulatory Physiology*.

Tennison, M. N., & Moreno, J. D. (2012). Neuroscience, ethics, and national security: the state of the art. *PLoS Biol*, *10*(3), e1001289.

Tommasi, V., Prete, G., di Fronso, S., Schinaia, L., Lucafò, C., Tommasi, L. ... & Bertollo, M. (2015). the Effect of trns on Performance: A Pilot Study with a Skilled Air-pistol Shooter. *Biofeedback*, *43*(2), 84-89.

Ukueberuwa, D., & Wassermann, E. M. (2010). Direct current brain polarization: A simple, noninvasive technique for human neuromodulation. *Neuromodulation: Technology at the Neural Interface*, *13*(3), 168-173.