The effects of trans-cranial direct current stimulation intervention on fear: A systematic review of literature

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ARTICLE INFO
Article history:
Received 6 December 2018
Accepted 4 January 2019
Available online xxxx

Keywords:
Anode
Anxiety
Cathode
Trans-cranial brain stimulation
Fear of pain
Fear memory

ABSTRACT
Intensifying fear and fear of pain may lead to some diseases such as panic disorder, phobias, post-traumatic stress disorder (PTSD), anxiety disorders, depression, etc. A number of studies indicated positive effect of transcranial direct current stimulation (tDCS) on controlling fear and some studies did not observe any effect or even negative effect on decreasing fear. Due to lack of consensus in the findings of research, we aimed to systematically review studies, which investigated the effect of tDCS on fear. A literature search was conducted using the databases of PubMed, Science Direct, OVID, CINAHL, PEDro, Cochrane, Scopus and MEDLINE. Fear, fear memory, fear of pain, anxiety, post-traumatic stress disorder, electrical brain stimulation were applied as keywords. The valid assessment scale was used to evaluate the methodological quality of the included studies. The results of this systematic review revealed that the cathodal tDCS (c-tDCS) on the left dorsolateral prefrontal cortex (DLPFC) as compared to anodal tDCS (a-tDCS) could significantly reduce fear and modulate the fear memory. In addition, the findings of this study showed that the c-tDCS has positive effect on behavioural parameters of fear, while it cannot change biochemical parameters of fear during limited sessions of intervention. Application of c-tDCS on the left DLPFC could significantly reduce fear and modulate the fear memory.

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1. Introduction

Fear is a subjective human feeling that is accompanied with some physiological and behavioural responses to an unfamiliar and threatening situation. Fear learning and fear memory are necessary to facilitate survival behaviour in humans and animals in dangerous situations [1,2]. If the fear responses are triggered more often, more intensely and to non-fearful situations they might develop fear-related disorders in person e.g. phobias, panic disorder, post-traumatic stress disorder (PTSD), generalized anxiety disorder, social anxiety disorder or obsessive-compulsive disorder, etc. [2,3]. About 4.7% of the American population suffers from panic disorder, 12.1% from social phobia and 28.8% from other types of anxiety disorders [2,3]. These disorders are associated with significant health care costs and a high burden of disease [4].

Many of the therapeutic techniques focuses on moderation of the fear memory and elimination of fear in humans and animals. In animal studies, pharmacological interventions such as using protein synthesis inhibitors, are used to modify the learned fear which may lead to long lasting effects in modulating fear memories and defensive responses [4,5]. Such invasive interventions have a number of serious side effects such as weight gain, sleepiness, lipid abnormalities and leukopenia and therefore, they cannot be used safely in humans [3]. Moreover, these interventions are associated with high cost.

Using non-invasive brain stimulation techniques such as transcranial direct current stimulation (tDCS) is another method for treatment of fear memories. Using this technique for therapeutic interventions has gained popularity over the past two decades. This technique is painless and non-invasive and is mainly used to modulate the excitability of cortical and subcortical regions of the brain [6,7]. Evidence has shown that tDCS is a safe, practical, and cost-effective technique [8,9]. Recent studies have indicated similar efficacy of tDCS in treatment of depression disorders compared to pharmacological interventions [10]. However, the site of