Official title of the study: Transcranial Direct Current Stimulation (tDCS) in Different psychiatric disorders

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Introduction

Transcranial Direct Current Stimulation (tDCS) is a non-invasive neuromodulation technique that delivers low-intensity direct current (typically 1–2 mA) through scalp electrodes (***Nitsche MA, Paulus W., 2011).***.

Although it does not induce action potentials directly, it modulates cortical excitability and induces plastic changes that can outlast the stimulation period .

Understanding the mechanisms of tDCS is essential to explain its therapeutic potential in various psychiatric disorders.

The dorsolateral prefrontal cortex (DLPFC) is the most frequently targeted region in psychiatric research (***Lefaucheur J-P et al., 2020)***

Advantages

-Non-invasive and safe compared to electroconvulsive therapy (ECT) or deep brain stimulation (DBS) (***Fregni F. et al., 2021***.)..

- Portable and relatively inexpensive equipment. - Can be combined with pharmacological or psychotherapeutic interventions .

-Potential for repeated sessions and home-based supervised (***Bikson M. et al., 2019).***

Applications .

-Flexible targeting of cortical regions based on symptoms (depression, hallucinations, compulsions)

Safety

- Reviews of thousands of sessions confirm safety when following standard parameters (1–2 mA),
- 30–20minutes, ≤40 sessions
- No evidence of structural brain damage ***(Kekic M. et al., 2016)***

Common transient effects:

Tingling, itching, headache, skin redness.

Caution is advised in patients with implanted medical devices, uncontrolled seizures, or unstable neurological conditions

Mechanism of Action of Transcranial Direct Current Stimulation (tDCS) in Psychiatric Disorders.

1. Subthreshold Membrane Polarization

Anodal stimulation slightly depolarizes neuronal membranes, while cathodal stimulation tends to hyperpolarize them.

This does not trigger action potentials but biases neurons toward or away from firing, thereby modulating cortical excitability ***(Qi S. 2024)***

2. Cortical Excitability and Neurotransmitter Balance

tDCS alters cortical excitability by modulating inhibitory and excitatory neurotransmitters (e.g., reducing GABA and modulating glutamate levels).

These shifts contribute to short-term changes in mood, cognition, and behavior ***(Medeiros L.F. 2012).***

3.Synaptic Plasticity (LTP/LTD-like mechanisms(

Repeated stimulation facilitates long-term potentiation (LTP) or long-term depression (LTD)-like effects through NMDA receptor and calcium channel involvement.

This underlies sustained after-effects of tDCS beyond the stimulation session***.(Wang S. 2024).***

4.Neurotrophic Factors and Gene Expression

tDCS enhances BDNF signaling and related molecular pathways, promoting synaptic plasticity and structural remodeling.

This may explain long-lasting therapeutic effects in mood and cognitive disorders***.(Yamada Y.2021).***

5.Network-Level Modulation

tDCS influences large-scale brain networks, including the default mode network (DMN), frontoparietal network, and limbic circuits.

This network reorganization is crucial for psychiatric applications, particularly in depression, anxiety, and psychosis ***(Woods A.J. A. 2016)***

6.Glial and Neurovascular Effects

Evidence suggests modulation of astrocytic activity, neuro-inflammation, and local cerebral blood flow (CBF)

These may indirectly contribute to clinical benefit ***(Liu A. et al. 2018).***

7.Neuromodulator Systems

tDCS impacts dopaminergic, serotonergic, and cholinergic pathways, which are central to psychiatric disorders such as depression, schizophrenia, and addiction ***(Liu A. et al. 2018).***

- **Clincal uses of tDCS in psychiatry :**

Depression (MDD): Anodal stimulation of the left dorsolateral prefrontal cortex (DLPFC) reduces mood symptoms via plasticity, BDNF enhancement, and network rebalancing***.(Loo et al., 2018)***

Schizophrenia: Targeting prefrontal and temporoparietal regions reduces auditory hallucinations and improves cognition through connectivity modulation***. (Koops et al., 2018).***

Anxiety, OCD, PTSD: Modulation of prefrontal–limbic interactions helps regulate hyperactive threat responses and improves executive control.

(*Nitsche MA, Paulus W., 2011).*(*Mondino M. et al., 2015.)*

Insomnia: tDCS shows promise for improving insomnia symptoms and sleep quality, but results are mixed and effect sizes vary across studies.(**Fregni F. et al., 2021).**

Aim of the Work

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Primary aim:

- To evaluate the efficacy and safety of transcranial direct current stimulation (tDCS) in reducing core symptoms of different psychiatric disorders using validated clinical scales.

Secondary aims:

- To assess response and remission rates.
- To evaluate the durability of treatment effects over follow-up.
- To examine effects on cognition, daily functioning, and quality of life.
- To monitor tolerability and adverse events.

Methodology

Ethical Considerations

Approval from the local research and ethical committee, Menoufia University, Egypt, (2025) for the study

- **Informed Consent :**

Written informed consent was obtained from all participants or guardians

Participants must receive full information about the purpose, procedures, potential benefits, and risks of tDCS, with the opportunity to withdraw at any time without penalty.

- **Confidentiality:**

Participant data must be anonymized and securely stored to ensure privacy.

1 - Study Design

A comparative cross-sectional study including five diagnostic groups:

Major Depressive Disorder (MDD), Schizophrenia, Obsessive–Compulsive Disorder (OCD), Generalized Anxiety Disorder (GAD), and Insomnia . Diagnostic assessments followed DSM-5 criteria using structured clinical interviews.

Participants

A total of 325 patients were recruited (65 per group) from psychiatric outpatient clinics between (Month January 2024– to June 2025)

Inclusion Criteria:

- Adults aged 16–65 years, meeting DSM-5 diagnosis, and providing informed consent ***(American Psychiatric Association)***
- Diagnosis confirmed via DSM-5 criteria.
- Stable medication regimen (if applicable) for ≥4 weeks.
- No history of seizures or intracranial metal implants.

Exclusion Criteria:

- Severe neurological conditions (e.g., epilepsy, brain tumors.)
- Pregnancy
- active substance abuse
- severe cognitive impairment, or comorbid psychiatric disorders interfering with assessment.

Sample Size Justification

A sample of 65 subjects per group provides approximately 80% statistical power to detect medium effect sizes (Cohen's d ≈ 0.5) at α = 0.05, according to power calculation guidelines ***(Serdar CC et al).***

2. tDCS Parameters

- Disorder Target Region
- Electrode Montage
- Current Intensity
- Duration Sessions

Depression:

- Montgomery–Åsberg Depression Rating Scale (MADRS) ***(Montgomery SA & Åsberg M .)***
- Left DLPFC (F3) Anode: F3, Cathode: right supraorbital
- 2mA 30-20min
- 20- 10 daily ***(Brunoni et al. 2016)***

Schizophrenia

- Positive and Negative Syndrome Scale (PANSS) ***(Kay SR et al.).***
- Left TPJ (P3) + Left DLPFC (F3)
- Anode: P3, Cathode: F3 (for hallucinations)
- 2 mA 20 min
- 10-15 ***(Brunelin et al. 2012)***.

OCD

- Yale–Brown Obsessive Compulsive Scale (Y-BOCS) ***(Goodman WK et al).***
- SMA (Cz) or OFC (Fp1/Fp2)
- Anode: Cz/Fp1, Cathode: contralateral shoulder
- 2mA 20min

- 20-10 ***(Dinn et al. 2019).***

Anxiety (GAD/PTSD)

- Generalized Anxiety Disorder-7 (GAD-7).
- Right DLPFC (F4) or vmPFC
- Anode: F4, Cathode: left DLPFC (F3)
- 2mA -Session duration: 20–30 minutes per session.
- 10 ***(Shiozawa et al. 2014).***

Insomnia

- Insomnia Severity Index (ISI) — 7 items, sensitive to change; commonly used as primary outcome in tDCS insomnia trials.
- Left DLPFC (F3) or Parietal (Pz)
- Anode: F3/Pz, Cathode: contralateral supraorbital
- 2mA -Session duration: 20–30 minutes per session.
- 10 -12 ***(Frase et al. 2019***)

3- Procedure

Preparation:

- Clean scalp with alcohol to reduce impedance.
- Apply conductive gel and position electrodes using the 10-20 EEG system.
- Use rubber electrodes (5×7 cm) for anodal/cathodal placement.

Stimulation:

Ramp-up current over 30 sec to avoid discomfort.

Monitor for adverse effects (tingling, itching, headache).

Post-Stimulation Assessment:

- Evaluate symptom changes using standardized scales (e.g., HAM-D for depression, Y-BOCS for OCD).
- Repeat sessions 3-5 times per week..

4. Safety and Monitoring

- ***Adverse Effects:***

Mild skin irritation, headache

(rarely seizures—screen high-risk patients.)

- **Contraindications** :

Metallic implants, scalp lesions, epilepsy history.

- **Conclusion**

tDCS is a promising neuromodulatory tool for psychiatric disorders, with varying protocols based on disorder-specific neural targets.

Statistical Analysis

Data were analyzed using SPSS. Descriptive statistics were presented as mean ± SD and frequencies.

Between-group comparisons used ANOVA for continuous variables and Chi-square tests for categorical variables.

Significance was set at $p < 0.05$ with 95% confidence intervals.

Results and Discussion

The data obtained from this study will be tabulated, discussed and compared with other researches and published data when available.

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