Masters Thesis Information Showcase
Fall Semester-2026
Year 2026

Department: Biomedical Engineering
Programme: Masters in Engineering
Specialization: Biomedical Engineering

1	**Title of the Thesis** Assessing gender differences in the role of transcranial direct current stimulation in stress regulation
2	**Abstract** (min 300 to 500 words) Stress is associated with significant alterations in neural activity, cognitive performance, and emotional regulation, making its objective assessment and modulation an important area of research. This study investigated gender differences in stress regulation following bilateral dorsolateral prefrontal cortex (DLPFC) transcranial direct current stimulation (tDCS) using electroencephalography (EEG) power spectral density (PSD), functional connectivity (FC), and behavioral assessment. EEG recordings from 40 healthy young adults (22 males and 18 females; 20–30 years) were obtained during eyes-open (EO) and eyes-closed (EC) resting-state conditions before and after 15 minutes of bilateral DLPFC tDCS. Power spectral density was estimated using Welch's method across the delta, theta, alpha, beta, and gamma frequency bands, while functional connectivity was analyzed to evaluate cortical network organization. Behavioral stress was assessed using the Depression Anxiety Stress Scale (DASS). The results demonstrated significant reductions in stress, anxiety, and depression scores following tDCS. Stress scores decreased from 16.6 ± 4.2 to 13.2 ± 4.4 in males ($p = 0.03$) and from 20.5 ± 3.6 to 15.6 ± 4.7 in females ($p = 0.01$). Anxiety scores decreased from 11.8 ± 5.0 to 7.6 ± 4.1 in males ($p = 0.01$) and from 13.5 ± 3.3 to 8.7 ± 2.3 in females ($p = 0.004$), while depression scores decreased from 11.8 ± 3.8 to 8.5 ± 4.0 in males ($p = 0.02$) and from 11.75 ± 3.4 to 7.5 ± 2.8 in females ($p = 0.05$). EEG analysis revealed elevated frontal theta and beta activity, reduced posterior alpha synchronization, and widespread cortical hyperconnectivity during the pre-stimulation condition, with these abnormalities being more pronounced in males, particularly during the EC resting state. Following tDCS, both genders exhibited normalization of frontal oscillatory activity, restoration of posterior alpha synchronization, and improved functional connectivity characterized by reduced frontal hyperconnectivity and enhanced fronto-parietal integration. Males demonstrated greater neurophysiological modulation due to higher baseline cortical dysregulation, whereas females exhibited relatively more organized cortical activity and stable connectivity patterns both before and after stimulation. These findings suggest that bilateral DLPFC tDCS effectively modulates stress-related neural activity and improves behavioral outcomes, while highlighting important gender-specific differences in cortical responses that may support the development of personalized EEG-guided neuromodulation strategies for stress management.
3	**Impact on SDG#__"** (min 500 words) **SDG 3 – Good Health and Well-being:** This research contributes to **SDG 3 (Good Health and Well-being)** by demonstrating the effectiveness of bilateral dorsolateral prefrontal cortex (DLPFC) transcranial direct current

	stimulation (tDCS) in regulating stress and improving mental well-being. The significant reductions observed in stress, anxiety, and depression scores, together with the normalization of EEG power spectral density and functional connectivity, indicate that tDCS can effectively modulate stress-related brain activity. These findings support the development of non-invasive, EEG-guided neuromodulation techniques for the early assessment and personalized management of stress-related mental health disorders. **SDG 5 – Gender Equality:** This study supports **SDG 5 (Gender Equality)** by emphasizing the importance of gender-specific analysis in neuroscience and mental health research. By comparing male and female neurophysiological responses to stress and tDCS, the study demonstrated distinct patterns of cortical activity and functional connectivity between the two groups. These findings highlight the need to consider biological sex when designing neuromodulation therapies, thereby promoting more inclusive, equitable, and personalized healthcare approaches for both males and females. **SDG 9 – Industry, Innovation and Infrastructure:** This research contributes to **SDG 9 (Industry, Innovation and Infrastructure)** by advancing innovative biomedical technologies for mental healthcare. The integration of EEG signal processing, power spectral density analysis, functional connectivity assessment, and transcranial direct current stimulation provides a comprehensive framework for objective stress evaluation and neuromodulation. The findings offer valuable scientific evidence for the development of next-generation EEG-based diagnostic systems and personalized neurostimulation technologies, fostering innovation in biomedical engineering and digital healthcare.
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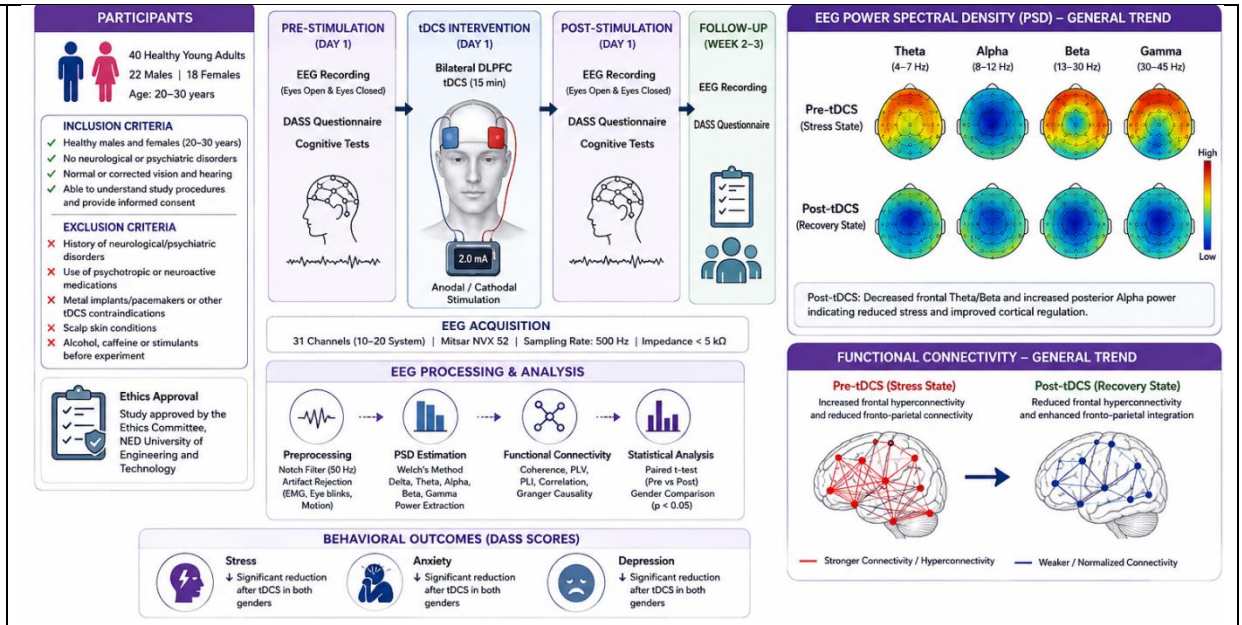
6	**Graphical Abstract**


PARTICIPANTS
40 Healthy Young Adults
22 Males | 18 Females
Age: 20–30 years
INCLUSION CRITERIA
Healthy males and females (20–30 years)
No neurological or psychiatric disorders
Normal or corrected vision and hearing
Able to understand study procedures and provide informed consent
EXCLUSION CRITERIA
History of neurological/psychiatric disorders
Use of psychotropic or neuroactive medications
Metal implants/pacemakers or other tDCS contraindications
Scalp skin conditions
Alcohol, caffeine or stimulants before experiment
Ethics Approval
Study approved by the Ethics Committee, NED University of Engineering and Technology
PRE-STIMULATION (DAY 1)
EEG Recording
(Eyes Open & Eyes Closed)
DASS Questionnaire
Cognitive Tests
tDCS INTERVENTION (DAY 1)
Bilateral DLPFC tDCS (15 min)
2.0 mA
Anodal / Cathodal Stimulation
POST-STIMULATION (DAY 1)
EEG Recording
(Eyes Open & Eyes Closed)
DASS Questionnaire
Cognitive Tests
FOLLOW-UP (WEEK 2–3)
EEG Recording
DASS Questionnaire
EEG ACQUISITION
31 Channels (10–20 System) | Mitsar NVX 52 | Sampling Rate: 500 Hz | Impedance < 5 kΩ
EEG PROCESSING & ANALYSIS
Preprocessing
Notch Filter (50 Hz)
Artifact Rejection (EMG, Eye blinks, Motion)
PSD Estimation
Welch's Method
Delta, Theta, Alpha, Beta, Gamma
Power Extraction
Functional Connectivity
Coherence, PLV, PLI, Correlation, Granger Causality
Statistical Analysis
Paired t-test (Pre vs Post)
Gender Comparison
(p < 0.05)
BEHAVIORAL OUTCOMES (DASS SCORES)
Stress
↓ Significant reduction after tDCS in both genders
Anxiety
↓ Significant reduction after tDCS in both genders
Depression
↓ Significant reduction after tDCS in both genders
EEG POWER SPECTRAL DENSITY (PSD) – GENERAL TREND
Theta (4–7 Hz)
Alpha (8–12 Hz)
Beta (13–30 Hz)
Gamma (30–45 Hz)
Pre-tDCS (Stress State)
Post-tDCS (Recovery State)
High
Low
Post-tDCS: Decreased frontal Theta/Beta and increased posterior Alpha power indicating reduced stress and improved cortical regulation.
FUNCTIONAL CONNECTIVITY – GENERAL TREND
Pre-tDCS (Stress State)
Increased frontal hyperconnectivity and reduced fronto-parietal connectivity
Post-tDCS (Recovery State)
Reduced frontal hyperconnectivity and enhanced fronto-parietal integration
Stronger Connectivity / Hyperconnectivity
Weaker / Normalized Connectivity