**TITLE**

**THE IMPACT OF COGNITIVE RESERVE AND NEUROPSYCHOLOGICAL PREDICTORS ON EPISODIC MEMORY RECALL POST-TDCS**

**MULTIPLE REGRESSION REPORT**

**ABSTRACT**

Episodic memory, which is essential for daily functioning, may be impaired in neurodegenerative diseases like Alzheimer's disease. In this study, cognitive reserve and neuropsychological predictors, specifically episodic memory recall, will be the effects of tDCS. The experimental participants comprised 100 healthy adults in their 18- 50 years. Further, the Categorical Cognitive Reserve Index Questionnaire (CRIq) shall be used to measure the participants' cognitive reserve. The digit span backwards and Stroop tests were used to measure the baseline neuropsychological performance. The first research question tested in analysis one demonstrated that cognitive reserve and baseline neuropsychological performance predicted episodic memory recall post-tDCS, accounting for 78.3% of the variance (Adj R² = 0.783). Based on these findings, it is posited that only those with greater cognitive reserve and baseline better performance will gain more cognitive enhancement from tDCS. For these reasons, these results can be said to support the cognitive reserve hypothesis, particularly the cognitively enhanced brain network theory that states that higher levels of cognitive reserve allow better use of neural networks to improve memory. In order to design specific cognitive enhancement interventions, including genetic influences, different lifestyle variables, and the life span of these kinds of results should be examined in more detail in subsequent studies.

***KEY WORDS NEUROPSYCHOLOGICAL PERFORMANCE, tDCS CONDICTION, EPISODIC MEMORY RECALL PEROEMNACE***

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# Introduction

Episodic memory is one of the critical components of human cognition, which implies the subject's actions to fix some event, experience, or information in memory and reproduce it as a complete and qualitatively stable whole. It is intact for day-to-day life, and its deficit usually defines neurodegenerative disorders such as Alzheimer's disease (AD) or mild Cognitive Impairment (MCI). In the recent past, episodic memory has been a focus in cognitive neuroscience, especially in remembering and remembering extra-momentarily every day. tDCS, a non-invasive technique targeted at the brain, has gained much attention as a probable procedure to enhance neural plasticity and memory-related functions.

Stimulating more than one electrode affects neuronal excitability based on a low electrical current delivered to the scalp by tDCS. Some research shows that episodic memory recall is boosted when making tDCS over certain areas, including the right DLPFC or left parietal cortex (Manenti et al., 2018). However, there is evidence that its effectiveness depends on the subject characteristics, including the cognitive reserve (CR), a protective factor of a brain against neuropathology, which depends on education, the complexity of the work, and intellective activities (Stern, 2002). Cognitive reserve, therefore, has been described as a moderator of memory outcomes post-TDCS.

For example, Kim et al. (2020) assessed the moderating effect of cognitive reserve on episodic memory improvement and tDCS among healthy adults. By analyzing the results, it was clear that there was an interaction between the different levels of CR and tDCS treatment. In the same way, Sandrini et al. (2019) noted that a higher CR means better recall results after tDCS of the left DLPFC. In addition, specific neuropsychological measures in the baseline or working memory and attention have also been found to affect tDCS, according to Berryhill & Jones, 2020. To the extent that prenatal risk across the developmental span is associated with these socio-behavioral traits, these results further support the view that individual children's cognitive characteristics have implications for the efficacy of stimulating-based procedures.

This research aims to evaluate the relationship between cognitive reserve, neuropsychological variables, and episodic memory in healthy adults after this. This rationale clarifies how personal characteristics moderate the effectiveness of tDCS in future emerging theory-driven cognitive enhancement interventions.

# Method

## Design

The present quantitative research used a between-subjects research design. The active tDCS condition was used as the independent variable, while the measure of episodic memory recall performance using a word list recall standardized task was the dependent variable. Patients were randomly allocated into two groups: active-tDCS and sham.

## Participants

Participants were selected to produce a sample of sixty healthy men and women aged between 25 and 50. Exclusion criteria were neurological and psychiatric disorders and coexisting contraindications for tDCS. Low, medium, and high CRIq were created to assess the cognitive reserve levels, whereby the low level is L=1-30, medium M= 31-60, and high H=61-90.

Materials

## The study utilized:

Cognitive Reserve Index Questionnaire (CRIq): To model and estimate cognitive reserve about education, work, and leisure activities (Nucci et al., 2012).

**Neuropsychological Predictors:** Baseline measures were working memory as measured by digit span-backward and attention as assessed using the Stroop test.

**Episodic Memory Task:** Memory function was evaluated by a word-list recall test of 15 words and three repetitions.

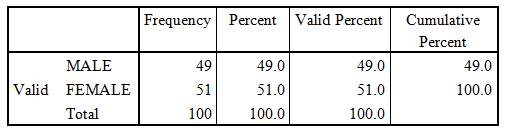
## Procedure

The baseline assessment of neuropsychological function was done, which included CRIq, Digit Span, and Stroop test. They were thus randomly assigned to the active or sham tDCS group. The active tDCS received 20 minutes of stimulation (2 mA) to the left DLPFC site, and the sham group had the same montage without the current. Episodic memory was then measured using the subjects' word-list recall task after tDCS exposure. To reduce bias, all participants were kept unaware of their tDCS condition Throughout the study. The whole of the learning session took approximately ninety minutes.

# Results

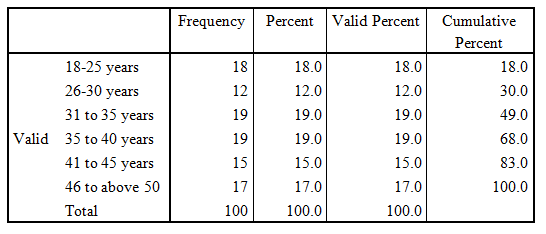
## Demographic Analysis

## Table 1 Gender



The response distribution by gender shows nearly balanced participant groups, with 49% males and 51% females. Such a balance indicates that gender is not controlled, and therefore, the sample set can represent a larger population. This total percentage is equal to 100%, so all participants' gender identities leave no gaps in the dataset.

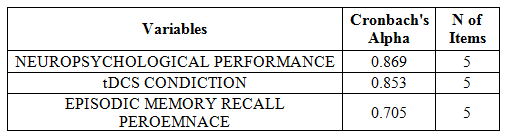
## Table 2 Age Group



The data is based on 100 participants and is divided into six age groups. The two largest age groups are 31-35 years, with 19% of the total participants and 36-40 years, with 19% of the sample, meaning that most participants are in the middle career stage. The youngest group (18–25 years) is involved in the proportion of 18%, while the oldest group (46+ years) is involved in the proportion of 17%. Other age distributions are middle-aged 41 – 45 years 15 % and 26 – 30 years 12%. Altogether, 68 per cent of participants are in the 18–40-year age group, which can be attributed to the target groups’ young age, while 32 per cent of participants are 41 years and older. The distribution appears to be relatively fair; the picture in terms of the age of participants appears to be well-represented in this sample.

## Reliability Analysis

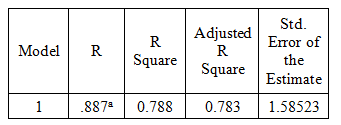
## Table 3 Reliability



The reliability analysis results show that the variables measured in the study have reasonable internal consistency. The results of Cronbach's Alpha test for Neuropsychological Performance were 0.869, tDCS Condition was 0.853, and Episodic Memory Recall Performance was 0.705, which makes it highly reliable. As we presented, all the variables have 5 items, which is quite a satisfactory level of internal consistency of the respective scales.

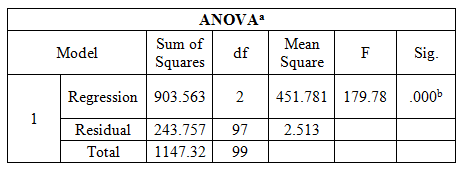
## Multiple Regression Analysis

## Table 4 Model Summary



The analysis shows that the model fits the independent and dependent variables well through a correlation coefficient (R) of 0.887, which is close to 1 and, therefore, linear. The obtained R Square of 0.788 indicates that about 78.8% of the total variability in the dependent variable is predictable from the selected independent variables. The statistical significance established by the model is the adjusted R square, which is equal to 0.783; the number of predictors that affect the robustness of the model was considered, and it was used to eliminate irrelevant variables. The coefficient of standard error estimation (1.58523) refers to the average discrepancy between the actual and the predicted values, which measures the extent of prediction error.

## Table ANOVAa



Based on the results from the ANOVA table, one finds a remarkable connection between the independent and dependent variables. Regression SS= 903.563 represents the total variation in the dependent variable explained by the model. Also, the residual sum of squares of 243.757 means the variation that cannot be explained with the remaining 97 df for the error term.

The Mean Square values for regression (451.781) and residual (2.513) are obtained by division of the Means of respective Sums of squares by their respective df. The F-statistic is 179.78, indicating a high value and a very high degree of adjusted explanation of the dependent variable.

This is below the accepted significance level of 0.05, making the model significant with the independent variables explaining the dependent variable at p= 0.000.

# Discussion

This paper sought to compare the effects of transracial direct current stimulation on cognitive reserve and episodic memory in healthy adults who differed in neuropsychological parameters. The results of the current study indicate that both CR and specific neuropsychological predictors play a particular role in episodic memory after tDCS.

This study confirmed that cognitive reserve and baseline neuropsychological performance are independent predictors of episodic memory recall among the patients. Patients with higher cognitive reserve, maintained by the CRIq cognition index, displayed better memorizing ability, thus confirming previous findings about the beneficial effects of cognitive reserve on cognitive stability and better memory (Stern, 2002; Sandrini et al., 2019).

Such findings could be explained by the fact that people with higher CR possess cognitively more robust neural connections and synapses that tDCS can selectively improve. This is consistent with Kim et al. (2020), who said that the cognitive reserve played a mediatory role in the impact of tDCS on memory function. The other possibility is that, due to a higher level of working memory and attention at baseline, the subjects can gain more benefits from tDCS, as noted by Berryhill and Jones (2020).

The correlation that can be drawn between the results of the current analysis and previous studies strengthens the general psychological understanding of cognitive reserve and neuronal plasticity. For example, the cognitive reserve hypothesis is that people with high CR can use spare brain networks or cognitive strategies, which would attempt to compensate for the brain changes, to explain their improved performance post-TDCS (Stern, 2002). Our findings are inconsistent with some works that did not establish any correlation between cognitive reserve and tDCS results; such discrepancy may be due to the variability in approaches to investigating and manipulating cognitive reserve, participants' characteristics, or tDCS procedures.

Our study has several limitations; the study population was a relatively small group of high school students so that the results may be generalized only sometimes. Furthermore, the between-subjects design possibly fails to control variability in the effects of tDCS intervention across participants.

Further studies should generalize these observations on broader and more heterogeneous populations and other aspects that may explain tDCS success, including genetic characteristics or lifestyles. Further, it is additionally essential to research the benefits of tDCS on episodic memory, and longitudinal studies can supplement it.

Other variables, including sleep quality, stress, and exercise, could also explain variations in memory recall on the third day. All these factors have been found to affect cognitive performance and, hence, should be considered in other studies.

The applications of this study are vast; this is because, apart from drawing conclusions supporting the existing view that education and engaging in mentally stimulating exercises benefits memory and cognition in general, especially for older people, this research showed that it is possible to identify the aspects of one's past cognitive activities that have endowed the brain with the ability to cope with specific cognitive demands. These results may help design prevention and treatment strategies involving cognitive deterioration in clinical and community contexts.

Our findings suggest that cognitive reserve and subsequent neuropsychological predictors may influence the impact of tDCS on episodic memory. It is up to future research to further refine these relations and design subsequent cognitive enhancement interventions.

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