# The role of Transcranial direct current stimulation in patients with moderate cognitive impairment



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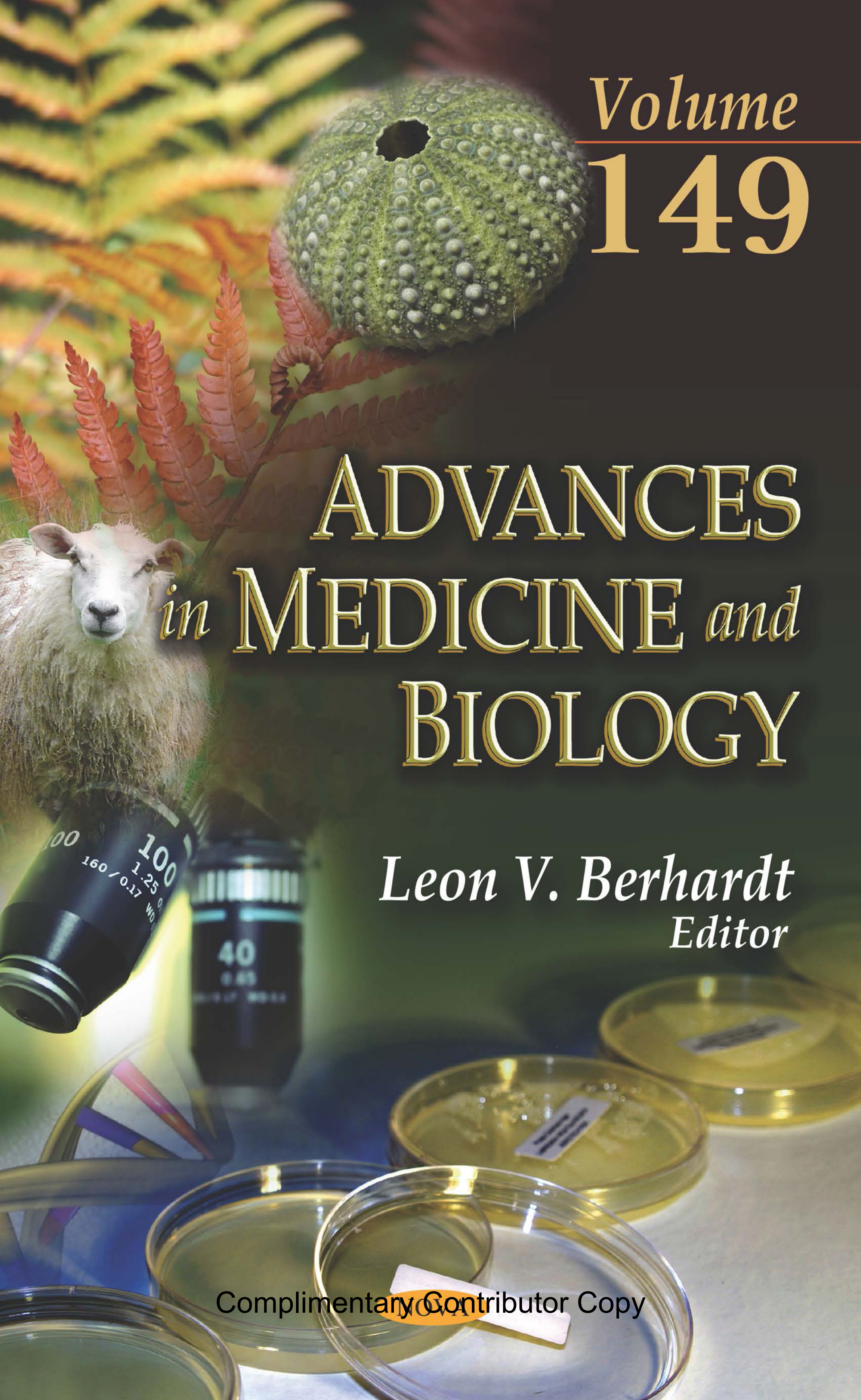

Volume 149

# Advances in Medicine and Biology

Leon V. Berhardt

Editor

# ADVANCES IN MEDICINE AND BIOLOGY

## VOLUME 149

## Library of Congress Cataloging-in-Publication Data

ISBN: 978-1-53616-222-6 (ebook)
ISSN: 2157-5398

*Published by Nova Science Publishers, Inc. † New York*

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In: Advances in Medicine and Biology. V. 149. ISBN: 978-1-53616-221-9
Editor: Leon V. Berhardt 

*Chapter 8*

# THE ROLE OF TRANSCRANIAL DIRECT CURRENT STIMULATION IN PATIENTS WITH MODERATE COGNITIVE IMPAIRMENT

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## ABSTRACT

Cognitive decline comes with a significant change in cognitive performances. This change affects several cognitive domains, such as memory, attention, executive functions, perception, language, and psychomotor functions. The recent confirmation that neurogenesis occurs in the adult brain lead to hypothesize that non-invasive transcranial direct current stimulation (tDCS) might have a therapeutic potential in treating neurodegenerative diseases. The purpose of this study was to evaluate the effect of anodal tDCS on cognitive and neurophysiological functions in

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patients with moderate cognitive impairment (MCI). Ten participants with moderate cognitive impairment underwent ten daily sessions of 2 mA tDCS over the left frontotemporal cortex. A pre-test-post test-follow up design was used to analyze the change in performance. Cognitive and neurophysiological assessments were administered before and after the tDCS sections. Results suggest that tDCS can improve cognitive and neurophysiological performance of patients with moderate cognitive decline.

**Keywords:** cognitive decline, MCI, tDCS, EEG, aging

## INTRODUCTION

Because of several changes in life habits and progress in the medical filed, during the last century, life expectancy has constantly been increasing (Kinsella, He, and Bureau 2009). A longer life expectancy comes with the associated negative side of an increase of degenerative diseases linked to aging (Rocca et al. 2011). Dementia-related diseases (including Alzheimer's disease, different forms of dementia and cognitive decline) are among the most common, and they are causing concerns at different levels because of the very high costs for health care and social systems (Wimo, Jonsson, and Winblad 2006). Moreover, with the numbers of people affected by dementia projected to increase by as much as four times by 2050 (Brookmeyer et al. 2007) finding new ways to approach the problem is becoming more and more relevant.

One promising way of trying to reduce the incidence of the problem is by focusing on the early stages of these diseases, and a way of doing that has been identified is focusing research efforts on mild cognitive impairment (MCI) (Rocca et al. 2011; Eshkoor et al. 2015). MCI can be defined as a condition where an individual experiences a level of deterioration of memory, attention and cognitive functions that is higher than what could be expected for their age and yet they do not meet the clinical diagnostic criteria to be classified as possible Alzheimer Disease (AD) patients (Petersen et al. 2001). MCI has been considered as a potentially interesting condition because recent research has identified it as a transitional stage between the expected cognitive changes of normal aging and AD (Petersen et al. 2001). The relevance of the MCI as a precursor of AD is highlighted and reinforced by the fact that the National Institute on Aging and the Alzheimer's Association organized and promoted a working group that was assigned the task to revise the diagnostic criteria for the symptomatic predementia phase of AD (Albert et al. 2011). The working group identified MCI as a possible precursor of AD and recommended specific guidelines for the diagnosis since, as the authors pointed out (Albert et al. 2011), sharp demarcations between normal cognition and MCI and between MCI and dementia are difficult, and clinical judgment must be used to make a final diagnosis. Having identified MCI as a possible precursor of dementia opens up a promising research path that might try to diagnose symptoms of MCI early on and treat them in order to slow down the progression of the degeneration of cognitive functions.

Because of this promising path, and the relevance of this line of research, several attempts have been made to find possible interventions that could effectively address MCI symptoms and slow down their progression. Preventive interventions have been trying to address risk factors for MCI from different perspectives (Eshkoor et al. 2015), such as focusing on lifestyle changes (Ngandu et al. 2015), like reduction of stress (Johns et al. 2016; Eshkoor et al. 2015), implementation of cognitive (Odawara 2012) and physical exercises (Zhu et al. 2018) into a daily routine, eliminating risky behaviors like smoking (Baumgart et al. 2015) or reducing deficiencies in specific vitamins (Ulamek-Koziol, Czuczwar, and Pluta 2016; Farina et al. 2017) that can also be created by unbalanced diets (Nooyens et al. 2015; Morris et al. 2015). Being regularly involved in creative and social activities also seems to decrease the chances of showing symptoms of MCI by way of enhancing the cognitive reserve (Colombo, Balzarotti, and Greenwood 2018; Colombo, Antonietti, and Daneau 2018).

Even if many studies have been addressing the symptoms of MCI, there is still no evidence that MCI can be effectively treated, even if some interventions report some improvements of the symptoms (Petersen et al.

2001); hence more studies, using new and alternative approaches, are needed.

Noninvasive brain stimulation, like tDCS (transcranial Direct Current Stimulation), has recently emerged as a promising way of treating and possibly reversing some of the symptoms of MCI. tDCS has been proved to improve brain plasticity by positively affecting both cognitive (Oldrati, Colombo, and Antonietti 2018; Colombo et al. 2015) and emotional (Balzarotti and Colombo 2016; Colombo et al. 2019) processes and has been proven to be effective in promoting compensatory mechanism in healthy aging individuals (Cespón et al. 2017). Anodal stimulation (a-tDCS), which increases the brain activation by lowering the threshold required for effective neural firing (Turi, Paulus, and Antal 2012) appears to be a promising way to improve cognition. This is supported by the fact that in cognitive studies, only the anodal effect tends to be consistently observed (Jacobson, Koslowsky, and Lavidor 2012). A recent meta-analysis (Summers, Kang, and Cauraugh 2016) evaluated the effects of anodal tDCS on cognitive and motor performance in healthy older adults. The authors found 25 studies who qualified for inclusion in their meta-analytic review, and the results returned a positive, beneficial effect of a-tDCS on both cognitive a motor tasks. The brain sites most commonly stimulated when addressing cognitive tasks were the frontal and prefrontal cortices. An additional support to the fact that a-tDCS can have a beneficial effect and that these effects are not limited to the target area that is stimulated is provided by a study conducted by Meinzer et al. (2013). The authors used anodal tDCS on the to the left inferior frontal gyrus while also using fMRI equipment on a sample of 20 healthy aging individuals. They measured the effects on performance and task-related brain activity during overt semantic word generation, a task that is negatively affected by advanced age. Their results show how a-tDCS significantly improved performance in older adults up to the level of younger controls and significantly reduced task-related hyperactivity in bilateral prefrontal cortices, the anterior cingulate gyrus.

More evidence of the effectiveness of a-tDCS on clinical population with MCI is needed. Meinzer et al. (2013) explored the effects of a-tDCS on the left inferior frontal cortex during task-related (a semantic word-retrieval task) and resting-state functional magnetic resonance imaging (fMRI) in a sample of eighteen MCI patients, compared to an equivalent sample of healthy individuals. Results supported the hypothesis that a-tDCS exerts beneficial effects on cognition and brain functions in MCI. The authors advocate for more studies using repeated stimulation sessions to test the possibility of reversal of cognitive deficits. A recent study (Murugaraja et al. 2017) followed up on this suggestion and conducted an observational study on the effects of repeated a-tDCS on the left DLPFC. The authors administered 20 minutes of 2mA anodal stimulation for 5 consecutive days on 11 patients with MCI. Cognitive effects of the treatment were measured using the picture memory impairment test (PMIT) immediately and also 1 month after the 5th session of tDCS. All the patients not only improved after the 5 tDCS session, but the improvement was maintained after one month. The study presents some limitations (lack of a sham/control condition and randomization and a simplistic evaluation of the tDCS effect) that call for further data.

Cross-sectional investigations in elderly individuals affected by different levels of cognitive decline have reported associations between EEG spectral parameters (i.e., higher theta activity during rest and lower alpha activity during memory activation) and decreased MMSE scores (Jiang 2005; Onishi et al. 2005; Van der Hiele et al. 2007). Even just focusing on the analysis of the alpha frequency and power can help discriminate among MCI, early Alzheimer's, other forms of dementia, at risk and healthy elderly subjects (Moretti et al. 2004). To be more specific, patients with MCI showed an increase of beta2 power over the right anterior region when compared to a typical healthy aging sample as well as the presence of higher theta at the parietal and temporal area (Fauzan, Amran, and Sciences 2015). EEG data linked to cognitive decline can also be used as a predictor of the onset of dementia (Smailovic et al. 2018), with the key predictors being alpha and theta relative power and mean frequency from left temporo-occipital derivation (T5-O1) (Jelic et al. 2000).

Combining the evidence reported in the literature and discussed above, the main aim of this study was to evaluate the effects of a-tDCS to slow down the progression of MCI using both neurophysiological (MMSE) and neuropsychological data (qEEG).

# METHOD

## Participants

Ten patients were involved in the study. All patients met the criteria for moderate cognitive decline as defined by the Diagnostic and Statistical Manual of Mental Disorders– V (DSM-V). Patients were excluded during a preliminary screening if they had other neuropsychiatric diseases.

The study was conducted according to the Declaration of Helsinki and approved by the university research ethics committee (process approval number 2016-36). Patients and their caregivers (when necessary) gave their informed consent before participation. Demographic information about the sample is reported in Table 1.

**Table 1. Demographic data of participants**

| Participants age | (years) | gender | education (years) | duration of disease (years) |
|---|---|---|---|---|
| 1 | 72 | M | 5 | 3 |
| 2 | 70 | M | 8 | 4 |
| 3 | 63 | M | 5 | 3 |
| 4 | 76 | F | 10 | 2 |
| 5 | 61 | M | 3 | 1 |
| 6 | 71 | F | 8 | 2 |
| 7 | 79 | F | 5 | 3 |
| 8 | 77 | M | 5 | 2 |
| 9 | 72 | F | 7 | 3 |
| 10 | 69 | M | 8 | 3 |

## Materials

Neurocognitive and neurophysiological assessments were used to evaluate the patients.

Patients' level of cognitive impairment was assessed using The Mini-Mental State Exam (MMSE) (Folstein, Folstein, and McHugh 1975), which is commonly used to screen for dementia and includes questions about orientation, attention, recall, and language. The first testing session focuses on different aspects of orientation: orientation to time, to space, as well as personal and family orientation. The second testing session addresses cognitive functions, such as attention, intelligence, memory, language, space cognition, and visual perception.

The neurophysiological assessment has been performed using EEG equipment with 32 acquisition channels. The EEG was recorded in a quiet room, with the subject awake and seated comfortably. The patient was instructed to rest with his/her eyes closed for most of the session. Patients were also instructed to open their eyes for brief periods in order to record reactivity to the alpha rhythm in the occipital cortex.

Nineteen electrodes were positioned according to the 10– 20 International System using an EEG cap. The reference electrode was positioned on FPz while the ground electrode was positioned behind Fz, as reported in previous studies (Formaggio et al. 2008; Storti et al. 2010).

The sampling frequency was 256 Hz, with bandpass filtering between 3 and 60 Hz. A notch filter was used to reject the 50 Hz power line noise.

The recording session lasted 20 minutes for each patient. From each recording, 4 epochs have been selected (3 minutes each and free from artifacts). These epochs have been analyzed using Mathlab software to evaluate activity and peak EEG frequency for beta and theta rhythms and activity, focusing on central and frontal/temporal channels.

The tDCS equipment used in the study was a transcranial direct current stimulator (Omicron-t). For the stimulation sessions, we used two sponge-based electrodes. The dimension of the electrodes was 25 cm2. The anodal electrode was positioned on the subject' s scalp (left frontotemporal lobe, F7-T3) while the reference one was positioned on the right hemisphere

(F8-T4). Electrodes position has been identified through the 10– 20 EEG international system. Anodal tDCS has been administered to patients at an intensity of 2 mA (current density: 2,5 mA/cm2) for 20 minutes, daily, for 10 days.

### Procedure

An ABAA design has been used for this study: pre-test (A), intervention (B), post-test (A' - after the intervention), follow-up (A" – after three months). The intervention was performed daily for 10 days. Both Neuropsychological (qEEG) and neurophysiological (MMSE) assessments were applied in the pre-test, post-test, and follow-up sessions.

Patients kept taking their medication through the duration of the study.

### Statistical Analyses

IBM SPSS version 22 software (IBM, Armonk, NY, USA) was used to perform the statistical analysis. Level of significance was set at $\alpha = 0.05$. The Kolmogorov–Smirnov test ascertained the normal distribution of data. We analyzed differences in task performance as indexed by correct responses in MMSE (and the related subscales). Repeated-measures-ANOVAs (RM-ANOVA) (within-subject factors: "phases" and "subscales") were performed to detect the effects of anodal pre and post tDCS ("time") on cognitive dependent variables. Results are expressed as mean (SD) unless otherwise stated. Bonferroni corrected t-tests were used for post-hoc analysis ($p < 0.01$).

## RESULTS

Subjects tolerated the treatment well, and no negative side effects of the tDCS were reported. Separate analyses of all dependent variables were performed, starting from the global MMSE scores. The effects of brain stimulation on neuropsychological and neurophysiological performances will be presented below.

Focusing on the neuropsychological effects, Table 2 shows mean scores and standard deviations related to the MMSE scale for the 3 phases: pre-test, post-test, and follow-up evaluations.

## Effects of Brain Stimulation on Neuropsychological Activity

Starting from the MMSE scores, a repeated measures ANOVA has been computed, using the different MMSE subscales and the phases as within-subject variables.

**Table 2. MMSE scores in pre-test, post-test and follow-up phases**

| **Test** | **MMSE 1 pre-test** | **MMSE 2 post-test** | **MMSE 3 Follow-up** |
|---|---|---|---|
| | **M (SD)** | **M (SD)** | **M (SD)** |
| MMSE Global Test | 19.25 (3.23) | 25.20 (2.27) | 24.90 (3.34) |
| Temporal Orientation | 2.00 (0.47) | 2.90 (0.31) | 3.00 (0.00) |
| Spatial Orientation | 1.70 (0.48) | 3.00 (0.47) | 2.70 (0.48) |
| Recall | 1.90 (0.56) | 2.70 (0.48) | 2.80 (0.42) |
| Attention and calculation | 2.40 (0.96) | 3.50 (0.85) | 2.90 (0.56) |
| Language | 1.70 (0.42) | 2.00 (0.42) | 1.80 (0.42) |
| Execution | 2.40 (3.00) | 2.70 (0.48) | 3.00 (0.00) |
| Recall 2 | 1.20 (0.42) | 2.40 (0.51) | 2.50 (0.52) |
| Constructive praxia | 1.00 (0.00) | 1.00 (0.00) | 1.00 (0.00) |
| Drawing figure | 0.80 (0.42) | 0.90 (0.31) | 1.00 (0.00) |

A significant main effect of the variable phases emerged, $F(2, 18) = 135.87$, $p < .001$, $d = .82$, as well as a significant interaction effect of the interaction between phases and subscales $F(16, 144) = 4.98$, $p < .001$. The main significant effect means that the MMSE measures improve in the 3 phases, the interaction effect means that in some specific subscales, the effects were significant, while in others, they were not. Figure 1 shows the variations for subscales were significant effects emerged.

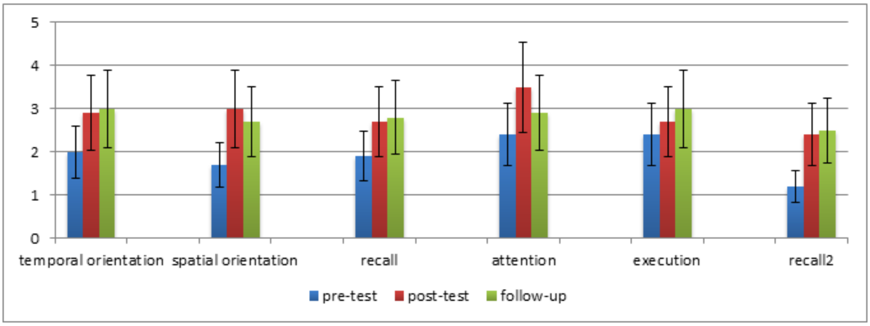


Figure 1. Pre-post-follow-up changes in MMSE subscales.

To better investigate the effects of the neuromodulation on the cognitive improvements of our participants, a series of paired t-test was computed considering the individual subscales of each test.

Considering temporal orientation, the intervention returned a significant effect ($t = 2.90$; $p < 0.01$, $d = .67$), and this result remains stable over time: no differences emerged between post-test and follow-up.

A same trend emerged when considering spatial orientation. Between pre and post test, the intervention returned a significant effect ($t = 3.90$; $p < 0.01$, $d = .77$) and the improvement remained stable over time: no differences emerged between post test and follow-up. A similar result emerged when considering recall, attention, the second recall task an execution subscales. Between pre and post test, the intervention returned a significant positive effect (respectively: $t = 3.75$; $p < 0.01$, $d = .81$; $t = 2,98$, $p < 0.01$, $d = .69$; $t = 2.99$; $p < 0.01$, $d = .82$; $t = 3.90$; $p < 0.01$, $d = .87$) and these improvements remained stable between post test and follow-up.

## Effects of Brain Stimulation on Neurophysiological Activity

To examine the modifications in broad-band frequency representations of alpha and beta oscillations, signals were extracted using the following passbands: 4 – 7 Hz (theta), 9 – 12 Hz (alpha), and 16 – 26 Hz (beta). With their respective transition widths, this gave full width at half-maximum responses of 3.5 – 8 Hz (theta), 7.6 – 13.7 Hz (alpha), and 14 – 29.9 Hz (beta). After this preliminary analysis, a repeated measures ANOVA has been computed, using the three evaluations (pre-test, post-test, and follow-up) as a within-subject variable and the alfa, beta frequency bands as parameters. Mean scores and Standard deviations are reported in Table 3.

**Table 3. Electroencephalographic rhythm (Alpha, Beta) in pre-test, post-test and follow-up phases**

| **Test** | **Experimental group pre-test phase** | **Control group pre-test phase** | **Experimental group pre-test phase** |
|---|---|---|---|
| | **M (SD)** | **M (SD)** | **M (SD)** |
| RhythmAlfa | 9.10 (0.77) | 9.30 (0.42) | 9.82 (0.71) |
| RhythmBeta | 15.39 (1.78) | 17.39 (2.80) | 17.80 (2.71) |

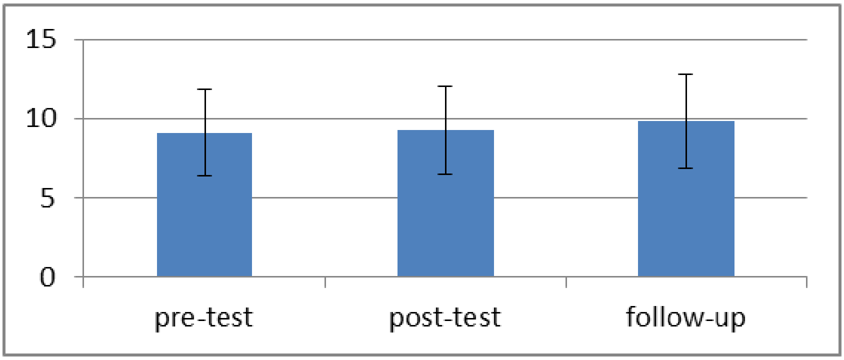


Figure 2. Pre-post-follow-up changes in alpha band.

Focusing on the alpha band, a significant main effect emerged, F (2, 18) = 5.57, $p < .05$, d = .72, and the same was true for beta bands F (2, 18)= 8.43, $p < .01$, d = .84. A paired t–test showed a stable effect between the post-test and the follow-up phases, with no statistically significant effect (Figures 2 and 3).

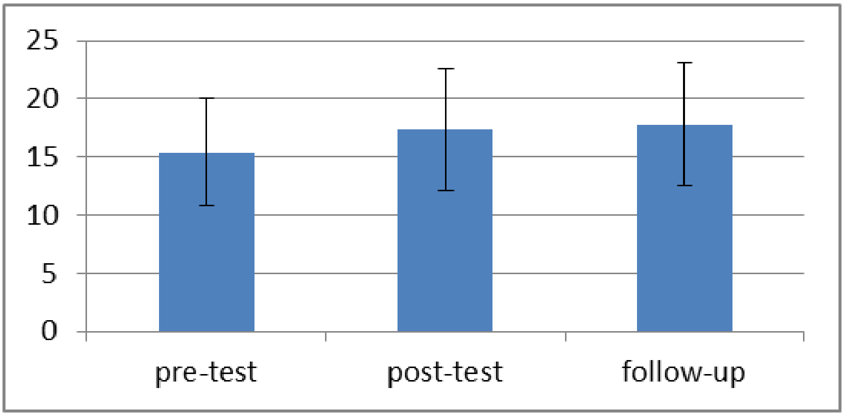


Figure 3. Pre-post-follow-up changes in beta band.

## DISCUSSION

Our study aimed to investigate the effects of a-tDCS on cognitive and neurophysiological functioning in patients diagnosed with MCI. To be more precise, we wanted to evaluate the long term effects of repeated sections of a-tDCS on a cognitive battery assessment (the MMSE) as well as the effects of the same protocols on beta and alpha bands measured with qEEG. This study adds to the literature that explores the effects of a-TDCS on MCI patients, which is very scarce, as discussed in the introduction. If it is true that there are several studies which explored the potential benefits of different tDCS protocols to improve cognitive function of healthy aging individuals (Summers, Kang, and Cauraugh 2016), or to address some symptoms Rett syndrome disease and of Dementia and Alzheimer's disease (Fabio and Caprì 2015; Fabio, Martinazzoli, and Antonietti 2005; Castelli et al. 2013; Fabio, Caprì, et al. 2018; Fabio, Gangemi, et al. 2018; Brunoni et al. 2012; Bystad et al. 2017), studies testing the effects of tDCS repeated sections on a clinical population with MCI are lacking. Given the importance, discussed in the Introduction of MCI as a precursor of different type of dementia, and the relevance of finding treatment options that can prevent MCI to turn into more severe conditions, data on the effectiveness of well-structured tDCS based intervention are essential.

Our results highlight how, after repeated a-tDCS sessions, some specific subtests of the MMSE, as well as alpha and beta band improved. To be more precise, almost all cognitive processes examined by the MMSE showed an increase in patients affected by MCI: temporal orientation test, spatial orientation test, recall, and attention test. These results allow us to hypothesize that repeated sections of a-tDCS can improve cognitive and neurophysiological performance of patients showing symptoms of mild cognitive decline. Our results do not confirm some other findings reported in literature (Bystad et al. 2016) that failed to show an increase in memory performance in Alzheimer's patients, but confirm the positive effects of a-tDCS reported in other studies (Boggio et al. 2012; Gangemi et al. 2017; Gangemi et al. 2018; Fabio et al. 2016; Fabio, Tindara, et al. 2018; Ferrucci et al. 2008). Yes, as previously mentioned, the majority of tDCS clinical trials aimed at assessing the effectiveness of this treatment to reduce cognitive symptoms linked to different forms of dementia focused on AD patients or patients with a diagnosis of dementia. Our study joins the small number of researches that targeted MCI, a newest but potentially critical condition to be treated with tDCS. MCI, as discussed in the introduction, has the potential of being extremely important, since it can be seen as a transitional stage between the expected cognitive changes of normal aging and AD (Petersen et al. 2001). Results from our study confirmed the positive outcomes already reported by a recent study (Murugaraja et al. 2017) who also reported positive effects of repeated sections of a-tDCS in slowing down MCI and also confirmed that these benefits are stable over time. Our results confirm this finding using a more refined neuropsychological assessment of patients' cognitive decline (MMSE), which allowed how to highlight the specific cognitive domain that benefits the most from the tDCS intervention. Our study also added a neurophysiological evaluation of the patients (using qEEG), this assessment was added because of the finding from several cross-sectional studies that have explored relations between EEG and cognitive decline (Pijnenburg et al. 2004; Jiang 2005; Van der Hiele et al. 2007; Bennys et al. 2001; Adler, Brassen, and Jajcevic 2003; Jeong 2004), reporting differences between alpha and beta bands in clinical vs. healthy aging populations. Our data support a positive effect of a-tDCS in improving both alpha and beta bands in our clinical sample, suggesting that the efficacy of the intervention affects both the neuropsychological and neurophysiological level, hence increasing the possible positive influence of tDCS based interventions for patients with MCI.

The present study, even if adds new and relevant clinical data to the exploration of the effects of repeated sections of a-tDCS for patients with MCI, also presents some limitations. One main limitation is the sample size and the lack of a control group. Future studies should replicate these findings by using large-scale randomized controlled studies. Another promising path would be exploring the different effects that tDCS interventions could have on automatic vs. controlled processes, which could potentially be affected differently by MCI progression and by the intervention (Fabio 2017; Vannorsdall et al. 2012; Gladwin, Wiers, and Wiers 2017; Jansma et al. 2001; Fabio, Castriciano, and Rondanini 2015).

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Zhu, Yi., Han, Wu., Ming, Qi., Sheng, Wang., Qin, Zhang., Li, Zhou., Shiyan, Wang., Wei, Wang., Ting, Wu. & Ming, Xiao. (2018). "Effects of a specially designed aerobic dance routine on mild cognitive impairment." *Clinical interventions in aging*, *13*, 1691.

## BIOGRAPHICAL SKETCHES

### *Antonio Gangemi*

**Affiliation:** Department of Clinical and Experimental Medicine, University of Messina, Messina, Italy

**Education:**

- Ph.D. in Cognitive Science, 2018 (University of Messina)
- Master Degree in Psychology, 2017 (University, Italy)
- Bachelor Degree in Neurophisiopathology, 2008 (Messina, Italy)

**Business Address:** Antonio Gangemi, Dipartimento di Medicina Clinica e Sperimentale, Via Bivona, 98121 Messina, Italia

**Research and Professional Experience:**

***Research interests:***

Dr. Gangemi main research interests are linked to cognitive decline and Alzheimer diseases. The main focus is on empowerment of language processes using tDCS.

***Professional experience:***

**Positions and Employment**

2018 – Antonio Gangemi PhD is Neurophysiopathologist at the hospital of Reggio Calabria (Italy). He is also adjunct professor neurophysiological technique of cognitive empowerment.

**Publications from the Last 3 Years:**

***Book chapters:***

[1] Gangemi, A., Fabio, R.A., Caprì, T. & Falzone, A. M. (2017). "Neuroplasticity and Cognitive Empowerment: Relationships and New Methodic Directions". *In Horizons in Neuroscience Research*, *28*, 177-199. New York: Nova Science Publisher.

[2] Gangemi, A., Caprì, T, Fabio R. A., Puggioni, P., Falzone, A. & Martino, G. (2018). "Transcranial Direct Current Stimulation (tDCS) and Cognitive Empowerment for the functional recovery of diseases with chronic impairment and genetic etiopathogenesis". In: *Advances in Genetic Research*, vol. *18*, 179-196. New York: Nova Science Publisher. ISBN: 978-1-53613-264-9.

***Peer reviewed papers:***

[3] Fabio, R. A., Gangemi, A., Caprì, T., Budden, S. & Falzone, A. (2018). "Neurophysiological and cognitive effects of Transcranial Direct Current Stimulation in three girls with Rett Syndrome with chronic language impairments." *Research in Developmental Disabilities, 76*, 76-87.

[4] Fabio, R. A., Caprì, T., Mohammadhasani, N., Gangemi, A., Gagliano, A. & Martino, G. (2018). "Frequency bands in seeing and remembering: comparing ADHD and typically developing children." *Neuropsychological Trends,* 97-116.

[5] Fabio, R. A., Gangemi, A., Nocera, F. & Cardile, S. (2018). "Physical, Cognitive and Environmental Factors in Patients with Moderate and Severe Cognitive Decline. Analysis of Specific Neuropsychological Measures and Frequency EEG Bands." *Journal of Psychiatry and Cognitive Behaviour*: JPCB-146. DOI: 10.29011/2574-7762. 000046.

[6] Caprì, T., Martino, G., Giannatiempo, S., Semino, M. & Fabio, R. A. (2019). "Attention, problem solving and decision making in adult subjects with ADHD." *Journal of Clinical and Developmental Psychology*, *1*, 1-9.

## *Barbara Colombo*

**Affiliation:** Neuroscience Lab; Champlain College, Burlington, VT, US

**Education:**

- M.Sc. in Social Science, 1997, Milan (Italy)
- Ph.D. in Cognitive Psychology, 2006, Milan (Italy)
- M.Sc. in Applied Psychology, 2013, London (UK)

**Business Address:** 163 South Willard Street, Burlington, VT 05401, US

**Research and Professional Experience:**

***Research interests:***

Exploring the role of dorsolateral prefrontal cortex in modulating cognitive and emotional responses to different stimuli by the way of using tDCS (transcranial Direct Current stimulation)

Using neuromodulation to promote empowerment and neurorehabilitation of cognitive and motor functions in different populations

Investigating the role of individual and psychophysiological variable to mediate emotional and behavioral responses

***Professional experience:***

**Positions and Employment**

- June 2014 - Present: *Associate Professor*, Psychology, Champlain College, Burlington, VT, USA.
- February 2008 - June 2014: *Assistant professor*, Psychology, Catholic University of the Sacred Heart, Milano and Brescia, Italy
- 2000 - 2008: *Lecturer and Research assistant* at Catholic University of the Sacred Heart, Milano and Brescia, Italy
- 1998 - 2008: Internships and ongoing collaborations with *Neuropsychology Unit* at Children hospital in Milan, and member of a psychology *private practice* in Milan. Main role: cognitive and neuropsychological assessment and empowerment.

**Professional Memberships**

- 2013 - Member of the British Psychological Society
- 2015 - Member American Psychological Association
- 2015 - Member of American Society of Neurorehabilitation

- 2015 - Member of the Tri-State Learning Collaborative on Aging (aims at helping to build strong communities that support healthy aging through shared learning and collaborative partnerships in Maine, New Hampshire and Vermont)
- 2016- Member of the Society for Neuroscience
- 2014 - 2017 Member of the Steering committee for the Memory Café in Burlington (aims at organizing and promoting a safe and empowering environments for patients with dementia and their caregivers)

**Professional Appointments:**

- June 2014 - Present: *Associate Professor*, Psychology, Champlain College, Burlington, VT, USA.
- February 2008 - June 2014: *Assistant professor*, Psychology, Catholic University of the Sacred Heart, Milano and Brescia, Italy
- 2000 - 2008: *Lecturer and Research assistant* at Catholic University of the Sacred Heart, Milano and Brescia, Italy

**Publications from the Last 3 Years:**

***Book chapters:***

[1] Antonietti, A. & Colombo, B. (2016). "Creative Cognition: How Culture Matters." In *The Palgrave Handbook of Creativity and Culture Research*, (pp. 101-124). Palgrave Macmillan UK.

[2] Antonietti, A. & Colombo, B. (2017). "Discussion of the role of original ideas and background music." *Research Handbook of Innovation and Creativity for Marketing Management*, *223*.

[3] Antonietti, A. & Colombo, B. (2017). "Creativity in advertisement: How advertisements strike people. A critical discussion of the role of insightful ideas and background music." In E. Shiu (ed.), *Research handbook of innovation and creativity for marketing management*, Edward Elgar Publishing, Northampton (MA), 223- 235.

***Peer reviewed papers:***


[4] Caravita, S. & Colombo, B. (2016). "Bullying behavior, youth's disease and intervention: which suggestions from the data for research on bullying in the Brazilian context?" *Jornal de pediatria*, *92*(1), 4-6.

[5] Colombo, B., Balzarotti, S. & Mazzucchelli, N. (2016). "The influence of the dorsolateral prefrontal cortex on attentional behavior and decision making. A t-DCS study on emotionally vs. functionally designed objects." *Brain and cognition*, *104*, 7-14.

[6] Balzarotti, S. & Colombo, B. (2016). "Effects of Unilateral Transcranial Direct Current Stimulation of Left Prefrontal Cortex on Processing and Memory of Emotional Visual Stimuli." *PloS one*, *11*(7), e0159555.

[7] Oldrati, V., Patcelli, J., Colombo, B. & Antonietti, A. (2016). "The role of dorsolateral prefrontal cortex in inhibition mechanism: A study on cognitive reflection test and similar tasks through neuromodulation." *Neuropsychologia*, *91*, 499-508.

[8] Colombo, B. & Antonietti, A. (2016). "The Role of Metacognitive Strategies in Learning Music: A Multiple Case Study." *British Journal of Music Education*, 1-19.

[9] Caravita, S., De Silva, L. N., Pagani, V., Colombo, B. & Antonietti, A. (2017). "Age-Related Differences in Contribution of Rule-Based Thinking toward Moral Evaluations." *Frontiers in Psychology*, *8*, 597.

[10] Balzarotti, S., Biassoni, F., Colombo, B. & Ciceri, M. R. (2017). "Cardiac Vagal Control as a Marker of Emotion Regulation in Healthy Adults: A Review." *Biological Psychology*, *130*, 54-66.

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[12] Colombo, B., Balzarotti, S. & Greenwood, A. (2018). "Using a reminiscence based approach to investigate the cognitive reserve of

healthy aging population." *Clinical Gerontologist*, DOI: 10.1080/ 07317115.2018.1447526.

[13] Colombo, B., Antonietti, A. & Daneau, B. (2018). "The Relationships between Cognitive Reserve and Creativity. A Study on American Aging Population." *Frontiers in Psychology, 9*, 764.

[14] de Oliveira, W. A., Caravita, S. C. S., Colombo, B., Donghi, E., da Silva, J. L., & Silva, M. A. I. (2019). "Self-Justification Processes Related to Bullying among Brazilian Adolescents: A Mixed Methods Study." *Frontiers in Psychology*, 10, 1086

***Books:***

[15] Antonietti, A., Colombo, B. & DeRocher, B. R. (2018). "*Music Interventions for Neurodevelopmental Disorders*." Springer Nature-Palgrave McMillian.

## *Rosa Angela Fabio*

**Affiliation:** Department of Clinical and Experimental Medicine, University of Messina, Messina, Italy

**Education:**

- Ph.D. in Experimental Psychology, 1992 (Rome)
- Specialization Degree in Psychology, 1989 (Milan, Italy)
- Master’s Degree in Philosophy, 1986 (Messina, Italy)
- Certificate in *Structural Cognitive Modifiability*, Bar Ilan University and l’Hadassah-Viso Canada
- Research Institute, Jerusalem (Israel), 29 June – 31 July 1992.
- Primary Certificate *Rational Emotive Therapy*, at I.R.E.T. Verona, March 1999, (Institute for Rational Emotive Therapy, New York) (prof. A. Ellis).

- Advanced Certificate, in *Rational Emotive Therapy*, at I.R.E.T. Verona, October 2000, (from the Institute for Rational Emotive Therapy, New York) (prof. A. Ellis).
- Associated Fellow Certificate, *Rational Emotive Therapy*, at I.R.E.T. Verona, May 2001, (from the Institute for Rational Emotive Therapy, New York) (prof. A. Ellis).

**Business Address:** Fabio Rosa Angela, Dipartimento di Medicina Clinica e Sperimentale, Via Bivona, 98121 Messina, Italia

**Research and Professional Experience:**

***Research interests:***

RA Fabio mainly works in the area of automatic and controlled processes of attention. She is currently carrying out research on various aspects of cognition in gifted, Rett Syndrome and ADHD children. Her main focus is on empowerment of logic, attention and working memory processes.

She follows experimental studies in: Logical reasoning, Attention, Entropy and Cognitive Empowerment; Applications of cognitive issues in the field of teaching, learning, and school instruction; Assessment and empowerment training of thinking skills; Information technologies and cognitive processes.

Rosa Angela Fabio is the author of more than 400 international and national publications including several books.

***Professional experience:***

**Positions and Employment**

2018 - Rosa Angela Fabio PhD is full professor of General Psychology at the Department of Clinical & Experimental Medicine, University of Messina.

2014-2018 - Full Professor of General Psychology at the Department of Cognitive Science and Education, University of Messina.

2009-2014 – Associate Professor of General Psychology at the Department of Cognitive Science and Education, University of Messina.

2009-2014 – non-continuously, coordinator at the faculty of Psychological Science and Technique of the University of Messina.

2005-2009 - Associate professor of General Psychology at the Catholic University of Sacred Heart, Milan.

2002-2005 - Adjunct professor of Empowerment Psychology, and Clinical psychology, Catholic University of Sacred Heart, Piacenza.

2002-2005 - Adjunct professor of Methodology and Statistics for Psychology, University of Milan.

1999-2002 - Adjunct professor of General Psychology, Catholic University of Sacred Heart, Milano.

**Professional Memberships**

- Head of the Cognitive Empowerment Association, Milan, 2000-present day.
- Member of the Italian Association of Psychology, Experimental Section, Rome, 2000-present day

**Publications from the Last 3 Years:**

***Book chapters:***

[1] Gangemi, A., Fabio, R. A., Caprì, T. & & Falzone, A. M. (2017). "Neuroplasticity and Cognitive Empowerment: Relationships and New Methodic Directions." In *Horizons in Neuroscience Research*, *28*, 177-199. New York: Nova Science Publisher.

[2] Fabio, R. A., Cardile, S., Troise, E., Polimeni, S., Germanò E., Di Rosa, G., Siracusano, R., Nicotera, A., Gagliano, A. & Tortorella, G. (2017). "Cognitive empowerment with new technologies improves neuropsychological and Neurophysiological parameters in Rett syndrome." In *Horizons in Neuroscience Research*, *28*, 199-217. New York: Nova Science Publisher.

[3] Townend, G. S., Kaufmann, W. E., Marschik, P. B., Fabio, R. A., Sigafoos, J. & Curfs, L. M. G. (2017). "Cognition, communication and behaviour in individuals with Rett syndrome." In Kaufmann W.E., *Rett Syndrome*, pp. 50-62. London, Mac Keith Press. ISBN: 978-1-909962-83-5.

[4] Fabio, R. A., Caprì, T., Lotan, M., Towey, G. E. & Martino, G. (2018). "Motor abilities are related to the specific genotype in Rett Syndrome." In *Advances in Genetic Research*, vol. 18, 79-108. New York: Nova Science Publisher. ISBN: 978-1-53613-264-9, chapter id 32719.

[5] Gangemi, A., Caprì, T, Fabio R. A., Puggioni, P., Falzone, A. & Martino, G. (2018). Transcranial Direct Current Stimulation (tDCS) and Cognitive Empowerment for the functional recovery of diseases with chronic impairment and genetic etiopathogenesis." In: *Advances in Genetic Research*, vol. 18, 179-196. New York: Nova Science Publisher. ISBN: 978-1-53613-264-9.

[6] Caprì, T. & Fabio, R. A. (in press). "Brain networks related to automatic and controlled processes in ADHD". Nova Publisher editor.

***Peer reviewed papers:***

[7] Fabio, R. A., Billeci, L., Crifaci, G., Troise, E., Tortorella, G. & Pioggia, G. (2016). "Cognitive training modifies frequency EEG bands and neuropsychological measures in Rett syndrome." *Research in Developmental Disabilities*, *54*, 73-85.

[8] Liverta Sempio, O., Fabio, R. A., Tiezzi, P. & Cedro, C. (2016). "Parental and teachers attachment in children at risk of ADHD and with ADHD." *Life span and disability*, XIX, *1*, (2016), 57-77.

[9] Brivitello, U., Nucera, S., Fabio, R. A. & Plebe, A. (2016). "The sweet smell of altruism. Correlations between smells and prosocial behaviour. A short review." Reti, Saperi e Linguaggi – *Italian Journal of Cognitive Science*, *3* (2), 301-316.

[10] Fabio, R. A. (2017). "The study of automatic and controlled processes in ADHD: a reread and a new proposal." *Mediterranean Journal of Clinical Psychology*, *5*, 1, 2-34.

[11] Caprì, T., Foti, A., Fabio, R. A., Pugliese, A. & Martino, G. (2017). "The influence of cognitive factors on pathological gambling." Journal of Gambling studies. APMB - *Atti della Accademia Peloritana dei Pericolanti, Classe di Scienze Medico Biologiche, 105* (2), ISSN 1828-6550.

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[16] Antonietti, A., Caprì, T., Fabio, R. A., Stuart, G., Towey, G., Pugliese, A. & Martino, G. (2018). "The Irrelevant Sound Effect: Testing the Psychological Effects of Sequence Predictability." - *Atti della Accademia Peloritana dei Pericolanti*, *Classe di Scienze Medico Biologiche*, *105* (2), ISSN 1828-6550.

[17] Fabio, R. A. & Towey, G. (2018). "Cognitive and Personality Effects of Regular Practice of Martial Arts, The Journal of Sports Medicine and Physical Fitness". *Jornal of Sports Medicine and Physiological Fitness*-7245.

[18] Martino, G., Catalano, A., Bellone, F., Sardella, S., Lasco, C., Caprì, T., Langher, V., Caputo, A., Fabio, R. A. & Morabito, N. (2018).

"Vitamin D status is associated with anxiety levels in postmenopausal women evaluated for osteoporosis." *Mediterranean Journal of Clinical Psychology*, *6*, 1-16. SSN: 2282-1619

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