

Transcranial Direct Current Stimulation in Neuropsychiatric Disorders

Clinical Principles
and Management

André Brunoni
Michael Nitsche
Colleen Loo
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Foreword

Why write a book on transcranial direct current stimulation (tDCS)? This question is especially relevant in the face of the rapidly increasing numbers of journals, open access publications, wikis and blogs. In parallel to the exponential spread of information sources, information and beliefs also tend to be found in shared virtual spaces, where they are amplified and reinforced. Critical reflection on concurrent and opposing opinions, or a synopsis of such opinions, is underrepresented in such “echo chambers”. This is the case for the general public discourse and may also be true for the reception of scientific findings.

tDCS is a technically extremely simple method and easy to apply. Thus, people can be tempted to build the equipment themselves or try do-it-yourself (DIY) application without any expert guidance—numerous video clips for DIY tDCS on the web are just one form of public sharing of knowledge and convictions about this method that are echoed by other followers. People are also tempted to follow intuitive attitudes or convictions about tDCS, e.g. non-verified dose/parameter response assumptions, hypotheses on the functional anatomy of tDCS effects or a general idea of reinforcing brain functions with no side effects (cognitive enhancement). The 2016 paper “tDCS modulates neuronal activity and learning in pilot training” [1] is just one example where the title immediately and strongly suggests an application in real-world settings. Karl R. Popper’s general rule, however, “that we are not to abandon the search for universal laws and for coherent theoretical system, nor ever give up our attempts to explain causally any kind of event we can describe” [2], which he proposed to be closely associated with the “principle of causality”, should remind us to be careful about making assumptions. Admittedly, though, we often follow associative or correlative relations, particularly when applying insights from neuroscience to clinical situations.

Of course, a single book cannot counterbalance or overrule current trends in a scientific discussion. Moreover dispersed, “open access” pieces of data and information are also extremely valuable in a thorough discussion of scientific findings. Nevertheless, because this book combines a critical amount of data and hypotheses it allows the reader to appraise findings and theories on tDCS and its variants.

Andre Brunoni, Michael Nitsche, Colleen Loo and the other authors, all pioneers and leading experts in the field, have taken a brilliant approach to this endeavour and guide us through the state of the art in tDCS. The different chapters cover tDCS development, related technologies (e.g. transcranial

alternating current stimulation, tACS, or transcranial random noise stimulation, tRNS), physiology and translational research from animal experiments to preclinical studies in humans involving neurocognitive and neuropsychological approaches, electroencephalography and magnetic resonance imaging (MRI). Several chapters cover specific applications ranging from cerebellar and spinal tDCS to different applications in neuropsychiatric disorders. The final part of the book outlines and discusses safety-related, ethical and regulatory issues.

tDCS is part of the armamentarium of non-invasive brain stimulation (NIBS), which constitutes a growing array of techniques such as transcranial magnetic stimulation (TMS), paired associative stimulation (PAS) and transcutaneous vagal nerve stimulation.

Each NIBS technique, but also each variant of tDCS, is a neurophysiologically distinct method. The authors of this book are aware that tDCS is used as a non-focal approach on the most complex organ/system of the human body and that the differential action of tDCS on single neurons or neuronal circuits or glial cells is difficult to predict or target. Dose-response curves often show non-linear functions, which are currently not fully understood. Furthermore, dynamic effects of repeated tDCS administration, which are particularly important for therapeutic applications, still need to be elucidated. The combination of tDCS with psychotherapy and other interventions is currently being tested in pilot studies and is proving to be extremely challenging [3]. Such open methodological fields would provide a large experimental terrain for preclinical studies in cellular and animal models, but studies in this preclinical field are still underrepresented. Thus, the book may stimulate the transfer of research based on clinical or experimental data in humans to the preclinical field of cellular or animal research strategies (reverse translation).

This book is comprehensive and as such valuable. The task of preparing it motivated the editors and authors to move systematically through the field of research and to also cover topics which are not on the main track, e.g. the history of tDCS and ethical and regulatory issues. Consequently the content of chapters may overlap, as a reflection of different perspectives. This book allows the reader to jump between chapters to compare information, hypotheses and views. It is an excellent resource for senior and junior scientists, doctorate students and others to introduce them to this fascinating field of research.

Frank Padberg

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Preface

The clinical interest in non-invasive brain stimulation has grown exponentially over the past 25 years, with the development of non-pharmacological, neuromodulatory techniques such as repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS). TDCS, the youngest sibling of the brain stimulation family, is in fact a “new old technique”. With anecdotal reports of the use of the torpedo fish to treat pain and headache via its electrical discharges during the ancient history, electricity was indeed used in the nineteenth and twentieth centuries to treat several neurologic and psychiatric ailments, usually with sparse scientific foundations. Although more recently, in the 1960s and 1970s, the treatment of some psychiatric disorders was investigated using brain polarization (a technique similar to modern tDCS), the research did not endure—perhaps due to the stigma of electroconvulsive therapy or the concomitant development of pharmacotherapy in that period. TDCS reappraisal only took place in 1998–2000, when two independent European groups showed that the electric currents applied over the motor cortex induced changes in brain excitability. From then onwards, tDCS has been increasingly investigated and has attracted considerable attention in both basic and clinical research settings.

In the present book we aimed to present the main advancements regarding the use of tDCS in neuropsychiatric disorders. The book is divided into three parts. The first part discusses the mechanisms of action of tDCS under different perspectives, which encompass neurophysiological, neuroimaging and neuropsychological studies as well as animal studies and computer-based models. In the second part, state-of-the-art evidence of tDCS use in several neurological and psychiatric disorders is presented. The third and last part of the book discusses different possibilities of the clinical and research use of tDCS, including safety, ethical and regulatory aspects.

This book would not have been produced without the invaluable contribution of leading researchers and scientists of the field. We are grateful and thank these authors for their time and effort in writing informative, insightful and up-to-date chapters. We are also grateful to Springer for supporting our project, particularly Gabriel Natan Pires, the Springer associate editor who encouraged us to edit this book, and Susan Westendorf, the Springer project coordinator responsible for this book production.

We believe that this book will be useful to neurologists, psychiatrists and physicians interested in the potential clinical applications of tDCS. This book will also be of interest for neophytes, who are looking for a primer in

non-invasive brain stimulation. More experienced researchers will also enjoy reading this book as it contains top-quality work written by several tDCS experts. We, the editors, are convinced that *Transcranial Direct Current Stimulation in Neuropsychiatric Disorders: Clinical Principles and Management* will be a captivating bedside book for many researchers in the field—us included.

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