



Review article

A systematic review of the clinical efficacy of transcranial direct current stimulation (tDCS) in psychiatric disorders

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ABSTRACT

Transcranial direct current stimulation (tDCS) is a non-invasive neuromodulation technique, which can be used to selectively disrupt patterns of neural activity that are associated with symptoms of mental illness. tDCS has been implemented in numerous therapeutic trials across a range of patient populations, with a rapidly increasing number of studies being published each year. This systematic review aimed to evaluate the efficacy of tDCS in the treatment of psychiatric disorders. Four electronic databases were searched from inception until December 2015 by two independent reviewers, and 66 eligible studies were identified. Depression was the most extensively researched condition, followed by schizophrenia and substance use disorders. Data on obsessive compulsive disorder, generalised anxiety disorder, and anorexia nervosa were also obtained. The quality of included studies was appraised using a standardised assessment framework, which yielded a median score corresponding to “weak” on the three-point scale. This improved to “moderate” when case reports/series were excluded from the analysis. Overall, data suggested that tDCS interventions comprising multiple sessions can ameliorate symptoms of several major psychiatric disorders, both acutely and in the long-term. Nevertheless, the tDCS field is still in its infancy, and several methodological and ethical issues must be addressed before clinical efficacy can truly be determined. Studies probing the mechanisms of action of tDCS and those facilitating the definition of optimised stimulation protocols are warranted. Furthermore, evidence from large-scale, multi-centre randomised controlled trials is required if the transition of this therapy from the laboratory to the clinic is to be considered.

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1. Introduction

Mental disorders constitute a major public health issue, directly accounting for 7.4% of disease burden worldwide (Murray et al., 2012) and 17.8% in the European Union (Wittchen et al., 2011). They are the leading cause of years lived with disability globally (Whiteford et al., 2013), impacting personal well-being, social relationships and work productivity, and are associated with substantial loss of quality of life (Alonso et al., 2004). Despite an increase in the rate of treatment, psychiatric morbidity has remained relatively stable over the past two decades (Kessler et al.,

2005; Wittchen et al., 2011), thus there is a need to develop novel therapeutic strategies to improve clinical outcomes.

Recent advances in functional neuroimaging have facilitated an improved understanding of the disturbances in neural circuitry that underlie mental disorders (Frangou, 2014; Price and Drevets, 2013). Consequently, there has been increased interest in neuro-modulation methods which can be used to selectively disrupt patterns of neural activity that are associated with symptoms of illness, with the objective of improving behavioural outcomes whilst generating information about disease mechanisms. These emerging brain-directed interventions adhere to an experimental therapeutics approach, which is now widely regarded as the gold-standard strategy for treatment-focused psychiatric research (Insel, 2014; Insel and Gogtay, 2014; Medical Research Council, 2010).

Transcranial direct current stimulation (tDCS) is a non-invasive neuromodulation technique which delivers low-amplitude direct currents to the brain via two surface sponge electrodes (anode and cathode) attached to distinct areas of the scalp with a rubber

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headband (Wagner et al., 2007). The current penetrates the skull and enters the brain from the anode, travels through the tissue, and exits via the cathode (George and Aston-Jones, 2010). tDCS presents several practical advantages over alternative neuromodulation modalities – it has a favourable safety-feasibility profile, offers a convincing placebo, can be applied bilaterally, and is portable and inexpensive.

During the past decade, tDCS has been implemented in numerous trials across a range of patient populations and psychiatric conditions, with a rapidly increasing number of studies being published each year (Fig. 1). This systematic review critically evaluates the clinical efficacy of tDCS in people with mental illness, and is warranted given the limited efficacy of existing therapies, the evidence that psychiatric disorders are neural circuit-based disorders that could benefit from brain-directed interventions, and the appealing characteristics of tDCS in comparison to other forms of neuromodulation. Although several reviews and meta-analyses have previously addressed this topic, the majority have either studied major depression (Berlim et al., 2013; Brunoni et al., 2012a; Kalu et al., 2012; Meron et al., 2015; Shiozawa et al., 2014d) or schizophrenia alone (Mondino et al., 2015c), or used unsystematic search procedures (Brunoni et al., 2012b; Kuo et al., 2014; Tortella et al., 2015) which promote a number of biases (Schmidt and Gotzsche, 2005). To our knowledge, one prior publication has systematically reviewed the therapeutic effects of tDCS across all psychiatric disorders (Mondino et al., 2014). Given the high growth rate of publication in the field, we have provided an up-to-date and comprehensive synthesis of the full evidence base, which is inclusive of all psychiatric conditions and study designs, and which uses a standardised quality assessment.

2. Material and methods

2.1. Selection criteria

Studies in English of any design that investigated the clinical efficacy of tDCS in individuals with psychiatric disorders were eligible for inclusion. Studies of participants with neurological

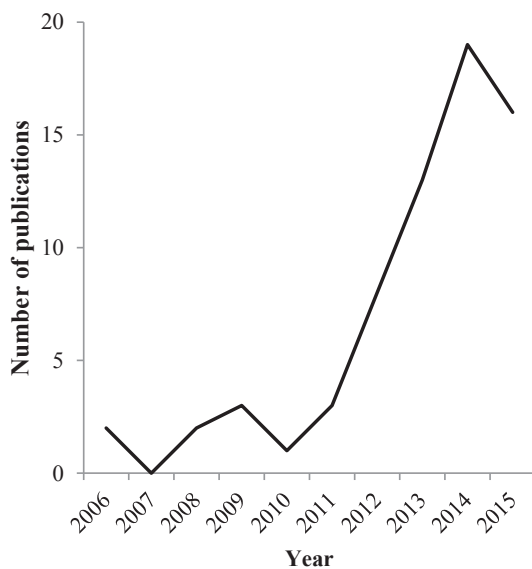


Fig. 1. Number of publications included in this review by year between 2006 and 2015. Note: databases were searched for papers published online or in print until 3rd December 2015.

conditions were excluded, as were those that did not report any symptom outcome variables. Publications were not restricted based on whether details of a Diagnostic and Statistical Manual of Mental Disorders/International Classification of Diseases diagnosis were given, and those involving co-interventions were eligible for inclusion if the effects of tDCS *per se* were discernible.

2.2. Search strategy

Four electronic databases (MEDLINE, Embase, PsycINFO, and CINAHL) were searched (via OvidSP and EBSCOhost) from inception until 3rd December 2015 using the following Medical Subject Headings and keywords: transcranial direct current stimulation, tDCS, and transcranial DC stimulation, in combination with mental disorder, mental illness, psychiatric disorder, psychiatric disease, addict*, anorexi*, anxiety disorder, auditory verbal hallucinations, bipolar disorder, bulimi*, catatonia, craving, dependence, de-personali?ation, depressi*, eating disorder, mania, obsessive compulsive disorder, OCD, panic disorder, personality disorder, phobi*, posttraumatic stress disorder, psychosis, PTSD, and schizophrenia. These searches were supplemented by internet searches and hand-searches of reference lists of relevant papers and reviews. Citation tracking in Web of Science was also performed.

Titles and abstracts of retrieved publications were imported into EndNote, duplicates were removed, and papers that were deemed highly unlikely to be relevant were disregarded. Full-text versions of the remaining articles were then obtained and screened according to the pre-specified eligibility criteria. All papers that did not meet the inclusion criteria were excluded, with the reasons

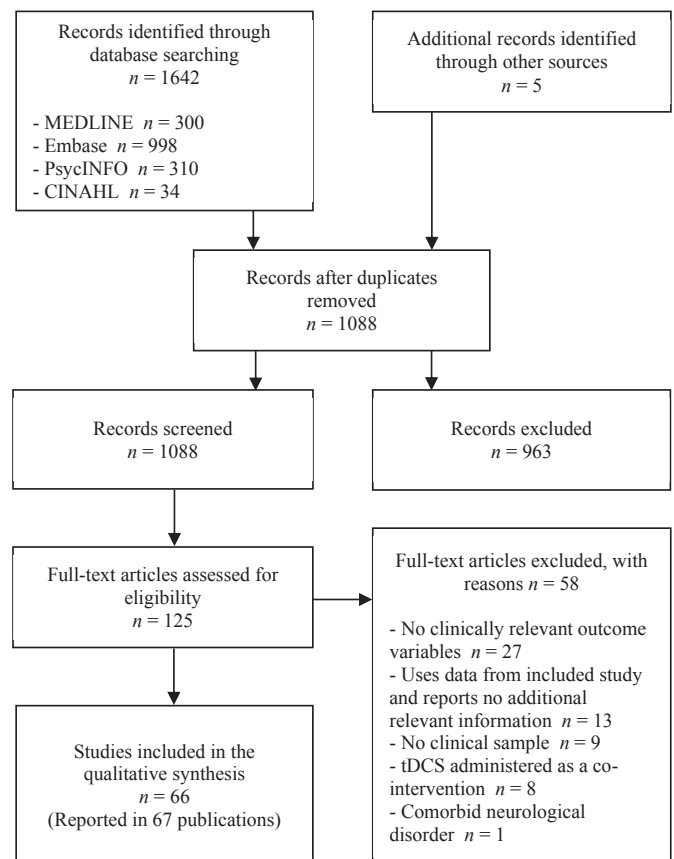


Fig. 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

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