Advancing tDCS in depression: the promise of Neurotwin-based personalized interventions

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Major Depressive Disorder (MDD) represents a significant global health challenge, affecting millions with its complex and heterogeneous nature. Advances in computational neuropsychiatry offer promising avenues for understanding and treating this condition through the mechanistic modeling of neural processes. Our research is based on an agent framework inspired by artificial intelligence to frame the multifaceted character of MDD, where depression is conceptualized as a state of persistently low valence arising from negative world models, dysfunctional objective functions, cognitive deficits, and adverse environmental conditions. This model provides a comprehensive framework that potentially aligns with identified depression biotypes.

Our approach integrates insights from neurobiology, systems neuroscience, and neurophenomenology, focusing on the critical role of neural plasticity in psychological health. Neural plasticity, the brain's ability to modify its connections and behavior in response to new information or environmental changes, is essential for overcoming the maladaptive patterns observed in depression. By leveraging computational models of the brain, or "neurotwins," we explore the potential of transcranial electrical stimulation (tES), specifically Transcranial Direct Current Stimulation (tDCS), as a non-invasive intervention to facilitate the recovery of neural circuits implicated in MDD.

Our work offers a novel perspective on how computational and empirical neuroscience can converge to optimize treatment strategies for MDD, highlighting the promise of tDCS as a complementary or alternative therapeutic modality. Through the application of computational models to tailor and enhance the efficacy of tDCS, we aim to unlock new pathways for the personalized treatment of depression, paving the way for improved outcomes in mental health care.