

# Stimulation of the Prefrontal Cortex Reduces Intentions to Commit Aggression: A Randomized, Double-Blind, Placebo-Controlled, Stratified, Parallel-Group Trial

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Although prefrontal brain impairments are one of the best-replicated brain imaging findings in relation to aggression, little is known about the causal role of this brain region. This study tests whether stimulating the dorsolateral prefrontal cortex using transcranial direct current stimulation (tDCS) reduces the likelihood of engaging in aggressive acts, and the mechanism underlying this relationship. In a double-blind, stratified, placebo-controlled, parallel-group, randomized trial, 81 human adults (36 males, 45 females) were randomly assigned to an active ( $N = 39$ ) or placebo ( $N = 42$ ) condition, and then followed up 1 d after the experiment session. Intentions to commit aggressive acts and behavioral aggression were assessed using hypothetical vignettes and a behavioral task, respectively. The secondary outcome was the perception of the moral wrongfulness of the aggressive acts. Compared with the sham controls, participants who received anodal stimulation reported being less likely to commit physical and sexual assault ( $p < 0.01$ ). They also judged aggressive acts as more morally wrong ( $p < 0.05$ ). Perceptions of greater moral wrongfulness regarding the aggressive acts accounted for 31% of the total effect of tDCS on intentions to commit aggression. Results provide experimental evidence that increasing activity in the prefrontal cortex can reduce intentions to commit aggression and enhance perceptions of the moral wrongfulness of the aggressive acts. Findings shed light on the biological underpinnings of aggression and theoretically have the potential to inform future interventions for aggression and violence.

**Key words:** aggression; moral judgment; prefrontal; transcranial direct current stimulation; violence

## Significance Statement

Aggressive behaviors pose significant public health risks. Understanding the etiology of aggression is paramount to violence reduction. Investigations of the neural basis of aggression have largely supported correlational, rather than causal, interpretations, and the mediating processes underlying the prefrontal–aggression relationship remain to be well elucidated. Through a double-blind, stratified, placebo-controlled, parallel-group, randomized trial, this study tested whether upregulation of the prefrontal cortex reduces the likelihood of engaging in aggression. Results provide experimental evidence that increasing prefrontal cortical activity can reduce intent to commit aggressive acts. They also shed light on moral judgment as one mechanism that may link prefrontal deficits to aggression and, in theory, have the potential to inform future approaches toward reducing aggression.

## Introduction

Prefrontal brain impairment is one of the best-replicated risk factors for aggressive behavior. Evidence from neurological research shows that patients with damage to the frontal cortex exhibit more aggressive behavior (Anderson et al., 1999). In addition to head-injury and lesion studies, the imaging and neuropsychological literature

has documented structural and functional prefrontal deficits in antisocial individuals (Brower and Price, 2001; Yang and Raine, 2009). Findings on the role of the frontal cortex in modulating aggression and violence also extend to sexual offending (Chen et al., 2016).

Within the prefrontal cortex, a meta-analysis of 43 imaging studies found that impairments of the dorsolateral prefrontal cortex (DLPFC) are implicated in antisocial behavior, with a stronger effect for the left ( $d = -0.89$ ) than right ( $d = -0.56$ ) DLPFC (Yang and Raine, 2009). This may be due to the DLPFC's broad connection to functions related to aggression, including moral judgment (Mendez, 2009), that can in turn influence the risk of engaging in aggression, a deduction consistent with the neural moral model of antisocial behavior (Raine and Yang,

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