In the three cases where double blinding was compromised due to the inability of having >1 experimenter at a session, the cases were excluded from analyses. To assess adherence to blinding procedures, James' (James et al., 1996) and Bang's (Bang et al., 2004) blinding indices were calculated using the participants' and blinded experimenters' guesses about group assignment at the end of the experimental session.

Statistical analyses. One-way ANCOVA was used to test group differences in intentions to commit aggression and the behavioral measure of aggression. The following baseline measures were examined as possible covariates: variety of crime throughout the lifetime, aggression, grade point average, trait anxiety, social adversity, psychopathy, the lack of premeditation and sensation-seeking dimensions of impulsivity, and self-control.

In addition to a Self-Report Crime Questionnaire, which asked participants to indicate the number of times they had committed any of 36 criminal and delinquent acts ranging from white-collar and blue-collar offenses (e.g., fraud and shoplifting) to noncriminal, deceptive behaviors (e.g., cheating on an exam), participants' baseline levels of aggression were assessed using the Reactive–Proactive Aggression Questionnaire (Raine et al., 2006). Trait anxiety was assessed using the 20-item Spielberger State-Trait Anxiety Inventory (Spielberger, 1983). A social adversity index was obtained based on responses to 14 items obtained from demographic questionnaires. Items indicating adversity included the following: parent unemployment; mother's low education; father's low education; parental separation or divorce; placement in a foster home, hospital, or other institution during childhood; having ≥5 siblings; born to a teenage mother; a ratio of people per room (including bedrooms, living room, dining room, and kitchen) of ≥1.0; brought up in public housing; parents' use of welfare or food stamps from the government; father or mother had been arrested; father or mother has had problems with alcohol or drugs; father or mother has had physical illness, such as heart or lung problems; father or mother has had mental illness, such as alcoholism, major depression, schizophrenia, or anxiety. To assess psychopathic traits, the short form of the Self-Report of Psychopathy-III questionnaire, comprising 29 items, was administered (Paulhus et al., 2009). Additionally, scores were obtained from the lack of premeditation and sensation-seeking subscales of the short-form version of the UPPS-P Impulsivity Scale [D.R. Lynam, "Development of a Short Form of the UPPS-P Impulsive Behavior Scale (2013), unpublished technical report]. Self-control was assessed using the 13-item Brief Self-Control Scale (Tangney et al., 2004).

Following recommendations, stratification variables and baseline measures associated with the outcomes were adjusted for, while variables with baseline imbalances were not [Committee for Proprietary Medicinal Products (CPMP), 2004; Kahan et al., 2014]. Effect sizes were calculated using partial η squared.

To provide information on a mechanism of action accounting for any effect of tDCS on aggressive intent, change in perceptions of moral wrongfulness was examined using ANCOVA. We tested whether enhanced moral judgment mediated group differences in intent to commit aggressive acts via a bootstrapping approach using the PROCESS macro on SPSS statistics software (IBM; Hayes, 2013). Ten thousand bootstrapped samples were drawn from the original data. The indirect effect of tDCS on intent to commit aggression was calculated as the product of the regression coefficients for the relationship between tDCS and moral judgment and the association between moral judgment and aggressive intent. The percentage mediated, P_M, is expressed as the ratio of the indirect to total effect of treatment group on intention to commit aggression (Ditlevsen et al., 2005; Hayes, 2013). Hypothesis tests were two-tailed. Blinding indices were obtained using STATA version 14.0 (Stata). All other statistical analyses were conducted using SPSS version 24.0 (IBM).

Results

Participant flow and recruitment

Data were analyzed on a total sample of 81 (Fig. 1). No participants were lost to follow-up. There was no evidence of selection bias as no significant differences were observed between participants who were included in the analyses and those who were not ($p > 0.05$; Table 1).

Demographics and adherence to protocol

Baseline distributions of the hypothesized covariates were generally well balanced between the treatment groups. With the exception of social adversity, demographic variables and baseline characteristics did not differ across groups (Table 2). As the James' blinding indices were >0.5 and Bang's blinding indices did not approach 1 or −1, participants were considered to have been blinded successfully on average (Table 3; James et al., 1996; Bang et al., 2004).

Aggression outcomes

Prognostic covariates were determined based on bivariate associations between the hypothesized covariates and outcome measures (Table 4). A one-way ANCOVA controlling for self-report crime and baseline aggression levels revealed a main effect of treatment group on aggressive intent, with the active tDCS group reporting a significantly lower likelihood of engaging in aggression compared with the sham control group ($F_{(1,70)} = 8.40$, $p < 0.01$, $\eta_p^2 = 0.11$; Fig. 2*A*). There were no significant interaction effects between treatment group and sex ($F_{(1,70)} = 0.57$, $p = 0.45$, $\eta_p^2 = 0.01$) and between treatment group and ethnicity ($F_{(1,70)} = 0.01$, $p = 0.92$, $\eta_p^2 < 0.001$). Further analyses revealed that intent to commit both physical assault ($F_{(1,70)} = 5.61$, $p = 0.02$, $\eta_p^2 = 0.07$) and sexual assault ($F_{(1,70)} = 5.64$, $p = 0.02$, $\eta_p^2 = 0.08$) were lower in the active tDCS group (Fig. 2*A*). However, there was no significant group difference in behavioral aggression assessed using the voodoo doll task ($F_{(1,71)} = 1.31$, $p = 0.26$, $\eta_p^2 = 0.02$; Fig. 2*B*). Additional sensitivity analysis conducted on log-transformed and square root-transformed data for the aggression measures yielded substantively similar findings (Fig. 2-1, available at https://doi.org/10.1523/JNEUROSCI.3317-17.2018.f2-1).

Mechanisms accounting for the reduction in intent to commit aggression

ANCOVA also revealed that compared with controls, the active tDCS group perceived aggressive acts as more morally wrong ($F_{(1,71)} = 4.64$, $p = 0.04$, $\eta_p^2 = 0.06$; Fig. 2*C*). In particular, the main effect of treatment group was significant for perceptions of moral wrongfulness regarding sexual assault ($F_{(1,71)} = 6.81$, $p = 0.01$, $\eta_p^2 = 0.09$), but not physical assault ($F_{(1,71)} = 0.96$, $p = 0.33$, $\eta_p^2 = 0.01$). Higher ratings of moral wrongfulness partly mediated the reduction in intention to commit aggressive acts (indirect effect: $b = -0.51$; 95% CI, −1.14 to −0.10; $p < 0.05$). After controlling for perceptions of moral wrongfulness, treatment group was not a significant predictor of aggressive intent (Fig. 3). Moral perception accounted for 31% of the total effect of treatment group on overall aggressive intent.

Further analysis revealed that moral wrongfulness partly mediated the reduction in likelihood of committing sexual assault (indirect effect: $b = -0.34$; 95% CI, −1.11 to −0.03; $p < 0.05$), but not physical assault (indirect effect: $b = -0.32$; 95% CI, −0.89 to 0.10; $p > 0.05$). Perceptions of moral wrongfulness accounted for approximately half ($P_M = 0.56$) of the total effect of treatment group on intent to commit sexual assault. For completeness, sensitivity analyses that included the demographic variables and social adversity as covariates did not substantively change the mediation results (Fig. 3-1, available at https://doi.org/10.1523/JNEUROSCI.3317-17.2018.f3-1).

Adverse events

tDCS was associated with minimal side effects. No major adverse events were reported over the duration of the study. According to Fertonani et al.'s (2010) scale and consistent with other tDCS