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The Relationship Between Cognitive Control and Proactive Aggression: The Moderating Role of Moral Identity

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Abstract

Cognitive control has been recognized as a significant influencing factor of aggressive behavior; however, its relationship with proactive aggression remains controversial, possibly due to the moderating role of moral identity. Experiment 1 manipulated moral identity through priming to investigate its moderating effect on the relationship between cognitive control and proactive aggression. Regression analysis results demonstrated that moral identity moderates the relationship between cognitive control and proactive aggression; specifically, in the moral identity priming group, cognitive control was significantly negatively correlated with proactive aggression, whereas in the moral identity control group, cognitive control and proactive aggression were not correlated. Experiment 2 employed a two-factor between-subjects design, manipulating both moral identity and cognitive control through priming and transcranial direct current stimulation (tDCS), to further examine whether the causal relationship between cognitive control and proactive aggression is moderated by moral identity. Two-way ANOVA results revealed that in the moral identity priming group, individuals' proactive aggression decreased as cognitive control increased; conversely, in the moral identity control group, proactive aggression was unrelated to cognitive control. Therefore, moral identity exerts a moderating effect on the relationship between cognitive control and proactive aggression.

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Response: 1. Using an experimental approach, this study is the first to employ transcranial direct current stimulation (tDCS) to investigate the relationship between cognitive control and proactive aggression, as well as the moderating role of moral identity within this relationship. 2. The study reveals that the controversial relationship between cognitive control and proactive aggression is due to the moderating effect of moral identity. 3. For individuals with low moral identity, cognitive control is not correlated with proactive aggression; however, for those with high moral identity, cognitive control is significantly negatively correlated with proactive aggression, and proactive aggression decreases as activity in brain regions related to cognitive control increases.

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Response: We employed both experimental and questionnaire methods. We conducted manipulation checks on experimental operation results and collected questionnaire data. Before the experimental manipulation, we measured participants’ moral identity and proactive aggression via questionnaires to ensure consistent baselines across different groups. After the experimental manipulation, we performed independent samples t-tests to verify the effectiveness of the experimental manipulation.

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Response: Effect sizes have been reported and analyzed. 95% CIs for statistical analyses have been reported.

5. Please state the planned sample size and actual sample size. If they differ, please explain why. The problem of low statistical power due to insufficient sample size has been widespread in previous psychological research. We recommend explaining in the Methods section the basis for your sample size calculation and determination. Sample size should be determined based on a justified effect size and desired power, with the calculation software or program reported. For rationale and practices regarding sample size planning, see <https://osf.io/5awp4/>

Response: For Experiment 1, based on previous research, the planned sample size calculated using *GPower* was 89 participants; the actual sample size was 106. For Experiment 2, based on previous research, the planned sample size calculated using *GPower* was 90 participants; the actual sample size was 98. The actual sample sizes exceeded the planned sizes to avoid attrition during the study.

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Response: The reporting of p-values meets the requirements.

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Response: In statistical analyses, data from participants who did not complete the entire experiment were excluded and reported in the text. There was no missing data in this analysis. No individual items were deleted when using scales. All measured items and variables were reported in the text.

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Response: This study has been approved by the institution's ethics committee. A scanned copy will be sent to the editorial office email subsequently.

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The Relationship Between Cognitive Control and Proactive Aggression: The Moderating Role of Moral Identity

Cognitive control has been identified as an important factor influencing aggressive behavior, yet its relationship with proactive aggression remains controversial. This may be due to the moderating role of moral identity. Experiment 1 manipulated moral identity using a priming method to investigate its moderating effect on the relationship between cognitive control and proactive aggression. Regression analysis results indicated that moral identity moderates the relationship between cognitive control and proactive aggression. Specifically, in the moral identity priming group, cognitive control was significantly negatively correlated with proactive aggression; in the moral identity control group, cognitive control was not correlated with proactive aggression. Experiment 2 employed a two-factor between-subjects design, manipulating both moral identity and cognitive control through priming and transcranial direct current stimulation (tDCS), to further examine whether the causal relationship between cognitive control and proactive aggression is moderated by moral identity. Two-way ANOVA results revealed that in the moral identity priming group, individuals' proactive aggression decreased as cognitive control increased; in the moral identity control group, proactive aggression was unrelated to cognitive control ability. Therefore, moral identity plays a moderating role in the relationship between cognitive control and proactive aggression.

Keywords: proactive aggression, cognitive control, moral identity, transcranial direct current stimulation

In recent years, incidents such as school bullying and cyber violence have emerged incessantly. Most of these aggressive events involve bullying, verbal abuse, and other behaviors intentionally directed at others without direct provocation or anger, driven by specific interests. These behaviors constitute proactive aggression. Proactive aggression refers to acts of harming others that are proactively initiated by individuals without provocation and with low anger, motivated by instrumental goals to obtain personal benefits or achieve individual objectives, and driven by rational consideration of aggression and conflict resolution between moral inhibition and disinhibition (Babcock et al., 2014; Smeijers et al., 2018; Zhu et al., 2022; Zhu & Wang et al., 2019). It is characterized by purposefulness and premeditation. As a negative behavior that cannot be ignored in contemporary society, proactive aggression not only causes physical harm to victims but also leads to anxiety, depression, and even self-harm and suicidal behaviors (Drachman et al., 2022; Moon & Jang, 2014). Therefore, it is essential to thoroughly investigate the underlying mechanisms of proactive aggression and develop effective interventions.

The cognitive-motivational model of proactive aggression (Zhu et al., 2022) proposes that proactive aggression requires cognitive control. In real life, some criminals demonstrate extraordinary cognitive control and remarkable planning abilities at every stage of their crimes—from carefully orchestrated preludes to

methodical execution and meticulously planned escape strategies. However, the relationship between cognitive control and proactive aggression remains unclear. Multiple studies have found that cognitive control is negatively correlated with proactive aggression (Cen et al., 2022; García-Vázquez et al., 2020; Hecht & Latzman, 2018) and can significantly negatively predict proactive aggression (Cen et al., 2022). However, other research indicates that control ability is positively correlated with or unrelated to proactive aggression (Hecht & Latzman, 2018; Rathert et al., 2011). This inconsistency may be due to the presence of certain moderating variables.

Social-cognitive theory of moral identity suggests that moral identity plays an indispensable role in the transformation process between moral cognition and individual behavior. Strong moral identity can enhance the accessibility of personal self-regulatory cognitive structures and moral self-schemas (Aquino et al., 2009; Lapsley & Hill, 2009), thereby further promoting prosocial behavior and resisting aggressive and antisocial behavior (Hertz & Krettenauer, 2016). Previous researchers have found that individuals with higher moral identity are more likely to have their moral self-schemas activated and possess stronger abilities in information processing and moral behavior (Higgins & Tory, 1996). Similarly, to maintain high self-consistency between external behavioral performance and moral identity, individuals with high moral identity are more likely to perceive stronger moral obligations and consider others' suffering during social interactions (Aquino et al., 2007; Winterich et al., 2009). Therefore, they are also more likely to recruit cognitive control resources to avoid aggressive behavior (Aquino et al., 2007; Wang et al., 2017; Zeng et al., 2020). According to the definition and characteristics of proactive aggression and the relevant cognitive-motivational model, proactive aggression results from the interaction of instrumental motivation, moral inhibition, and moral disengagement motivation. Cognitive control flexibly regulates individual decision-making processes based on current goals, such as inhibiting or regulating instrumental motivation or moral inhibition motivation (Zhu et al., 2022; Zhu & Wang et al., 2019; Zhu & Zhou et al., 2019). When conflicts arise between self-interest and moral costs: individuals with high moral identity have moral inhibition motivation in a dominant position, so they recruit cognitive control systems to timely adjust and control their states (Ridderinkhof et al., 2004) to suppress impulses for personal gain and avoid proactive aggression. Individuals with low moral identity may prioritize personal interests, recruiting cognitive control resources primarily for moral emotion and cognitive regulation and reconstruction—that is, moral disengagement (Zhu et al., 2022)—to rationalize their aggressive behavior. In this case, stronger cognitive control may 反而 make individuals more likely to engage in proactive aggression rather than inhibit it. Moreover, moral identity has been extensively confirmed in research to interact with other factors and influence individuals' moral behavior. Therefore, the controversial relationship between cognitive control and proactive aggression may be due to the moderating role of moral identity. Accordingly, Experiment 1 manipulated moral identity using a priming method to investigate its moderating effect on the relationship between

cognitive control and proactive aggression. Experiment 2 further examined the moderating role of moral identity in the causal relationship between cognitive control and proactive aggression by manipulating both moral identity and cognitive control through priming and transcranial direct current stimulation.

With technological advancements, transcranial direct current stimulation (tDCS) has been widely applied in cognitive control research. Previous findings indicate that the dorsolateral prefrontal cortex (dlPFC) is the brain region responsible for conflict control. Consequently, many studies have applied anodal stimulation to the dlPFC to investigate inhibitory control and found that anodal tDCS to the dlPFC produces higher activation levels in inhibition-related tasks (Verveer et al., 2020; Weidler et al., 2022; Wiegand et al., 2019). Moreover, the left dlPFC plays a critical role in proactive inhibition and can significantly improve individual performance in control tasks (Boudewyn et al., 2020; Verveer et al., 2020; Zhou & Xuan, 2018). Researchers have found that during Flanker task performance, participants receiving anodal stimulation to the left dlPFC showed significantly improved inhibitory control compared to those receiving sham stimulation (Karuza et al., 2016). Additionally, scholars have found that brain regions associated with the Simon effect are primarily concentrated in the left frontal lobe, particularly related to dlPFC activity (Zhang et al., 2014). Therefore, in this study, the left dlPFC was selected as the tDCS stimulation site to manipulate cognitive control and examine the impact of altered cognitive control on proactive aggression at different moral identity levels.

Based on existing literature, the research hypotheses are as follows: Moral identity moderates the relationship between cognitive control and proactive aggression. Specifically, when moral identity is at low or neutral levels, cognitive control is positively correlated or uncorrelated with proactive aggression; when moral identity is high, moral inhibition dominates, and cognitive control is negatively correlated with proactive aggression. Second, only when moral identity is high can increased cognitive control reduce proactive aggression.

Experiment 1

Method

Participants Using G*Power 3.1 with an effect size of 0.25, significance level $\alpha = 0.05$, and statistical power $1-\beta = 0.80$, the calculated required sample size was 89 participants (Cohen, 1988). We subsequently recruited 112 university students and randomly assigned them to moral identity priming and control groups. Four participants were excluded for suspecting the experimental scenario, and two were excluded for misunderstanding the game rules during interviews, leaving 106 valid participants (48 males, 58 females; mean age = 19.78, SD = 1.62).

Materials (1) Simon Task

The Simon task program was written using Psychopy 2021. Experimental materials consisted of red and blue solid squares presented randomly on the left or right side of the screen, comprising four conditions: blue square on left, red square on left, blue square on right, and red square on right (Song et al., 2018). The task began with instructions explaining the rules, followed by practice trials requiring 90% accuracy before proceeding to the formal task. The formal task included 160 trials divided into two blocks of 80 trials each (four stimulus types, each presented 20 times, with no more than three consecutive identical stimulus types). The trial procedure is shown in Figure 1 [Figure 1: see original paper]. Half of the participants pressed ‘f’ for blue and ‘j’ for red; the other half pressed ‘f’ for red and ‘j’ for blue.

(2) Moral Identity Manipulation Task

We used a common moral identity priming paradigm (Li et al., 2013; Wu, 2014). In Task 1, participants were presented with nine moral trait words (priming group) or nine neutral words (control group) and asked to generate synonyms to the best of their ability; if unable to think of synonyms, they copied the original words. After completing Task 1, participants proceeded to Task 2, spending several minutes thinking about these words, selecting at least four as keywords, and recalling and writing about personal experiences (one or more events) with a minimum of 60 characters. Wu’s (2014) effectiveness questionnaire (Task 3) was used to verify the priming effect, with participants rating the extent to which their writing reflected their identity as a student, team member, etc. on a 7-point scale (1 = “very small” to 7 = “very large”).

Additionally, Aquino and Reed’s (2002) Moral Identity Questionnaire was administered pre-manipulation. This 10-item scale includes internalization and symbolization dimensions and measures personal moral identity level (e.g., “Being someone who has these characteristics would make me feel good”). It demonstrates good reliability and validity among Chinese students (Wang et al., 2017). Items are rated on a 5-point scale (1 = “strongly disagree” to 5 = “strongly agree”), with higher scores indicating higher moral identity (see Appendix for details).

(3) Reward-Interference Task

Participants were informed they would compete in a button-pressing speed contest with another participant to examine how competitive environments affect reaction speed to sounds and movements. Before the experiment, the experimenter explained the instructions, guided participants through the game interface, and provided five practice rounds to familiarize them with the game flow. After confirming their understanding of the rules, participants entered a network connection interface to begin the formal game. The game featured two roles (A and B), randomly assigned by the system (in reality, all participants were Role A). Role A could choose whether to interfere with Role B’s signal tone using corresponding noise levels (weak or strong interference), while Role B could not use noise to interfere (Zhu & Wang et al., 2019; Zhu et al., 2022).

The task comprised 60 trials with the following procedure (see Figure 2 [Figure 2: see original paper]):

- 1) **Matching Phase:** At the start of each round, the system rematched opponents (Role B). After successful matching, a fixation cross “+” appeared to alert participants to focus attention.
- 2) **Decision Phase:** A reward amount (1-15 yuan) appeared randomly at the top of the screen, representing the winner’s prize for that round’s button-pressing contest. “No interference” and interference options (“weak interference” or “strong interference”) were presented simultaneously on the left and right sides of the bottom screen, with positions randomized. Participants responded by pressing ‘f’ for the left option and ‘j’ for the right option.
- 3) **Button-Pressing Contest:** A “+” appeared first to alert attention, followed by a white light (no response required). Upon hearing a “beep” signal, participants pressed the spacebar as quickly as possible within 2 seconds. If faster than the opponent, the white light turned green (win); if slower, premature, or no response, it turned red (loss). A 2-second feedback phase followed, informing participants of the round outcome and winnings (Zhu & Wang et al., 2019; Zhu et al., 2022).

In the proactive aggression task (Zhu & Wang et al., 2019; Zhu et al., 2022), we preset winning probabilities: 90% when selecting strong noise interference, 70% for weak interference, and 30% when choosing no interference. Participants’ final compensation comprised a base payment plus average winnings from the game. We recorded the frequency of different noise interference levels selected and calculated an interference mean score as the proactive aggression index.

Procedure One week before the formal experiment, participants completed the moral identity questionnaire and underwent sound threshold measurement to determine appropriate sound intensity for the subsequent reward-interference task.

During the formal experiment, the experimenter first introduced the procedure, obtained informed consent, confirmed compensation, and collected participant registration information. Participants then completed a simple button-pressing task (the Simon task), followed by random assignment to moral identity priming or control groups to complete the moral manipulation tasks. Subsequently, they performed the reward-interference task and finally participated in a debriefing interview.

Data Processing For moral identity questionnaires, valid responses were entered into SPSS 26.0 after checking for random or missing responses. For Simon task data, trials with reaction times less than 0.2 s or greater than 1.5 s were excluded (Song et al., 2018). Mean reaction times for congruent and incongruent conditions were calculated from valid correct trials. The Simon effect was computed by subtracting mean reaction time in congruent trials from that in incongruent trials (Tang et al., 2018), with larger values indicating poorer con-

trol ability (Cheng, 2020). To more intuitively interpret its relationship with proactive aggression, the Simon effect was multiplied by -1 to create a new variable named “cognitive control,” serving as the cognitive control ability index (Cheng, 2020).

For reward-interference task data, participants with fixed identical key responses were excluded (none occurred in this study). Scores were calculated as: no interference = 0, weak interference = 1, strong interference = 2. The interference mean score = (frequency of no interference \times 0 + frequency of weak interference \times 1 + frequency of strong interference \times 2) / 60, serving as the proactive aggression index.

Results

Manipulation Check To verify the effectiveness of moral identity manipulation, independent samples t-tests were conducted on moral identity questionnaire scores collected pre-manipulation and effectiveness questionnaire scores collected post-manipulation (see Figures 3 [Figure 3: see original paper] and 4 [Figure 4: see original paper]). Results showed no significant difference in pre-manipulation moral identity scores between the priming group ($M = 3.85$, $SD = 0.49$) and control group ($M = 3.82$, $SD = 0.54$), $t(104) = 0.26$, $p = 0.797$, Cohen’s $d = 0.05$, $1-\beta = 0.06$. Post-manipulation moral identity scores were significantly higher in the priming group ($M = 5.83$, $SD = 1.26$) than in the control group ($M = 3.20$, $SD = 1.74$), $t(104) = 8.90$, $p < 0.001$, Cohen’s $d = 1.73$, $1-\beta = 1.00$. These results demonstrate effective moral identity manipulation.

Additionally, independent samples t-tests on pre-manipulation proactive aggression questionnaire scores showed no significant difference between the priming group ($M = 1.10$, $SD = 0.16$) and control group ($M = 1.10$, $SD = 0.15$), $t(104) = 0.97$, $p = 0.334$, Cohen’s $d = 0.19$, $1-\beta = 0.16$, indicating consistent baseline proactive aggression levels between groups.

Differences Between Moral Priming and Control Groups in the Cognitive Control-Proactive Aggression Relationship To examine whether moral identity moderates the relationship between cognitive control and proactive aggression, linear regression analysis was conducted. Results showed an R^2 of 0.15, adjusted R^2 of 0.12, $1-\beta = 0.94$, and a significant regression equation, $F = 5.786$, $p = 0.001$. The main effect of moral identity manipulation was significant, $p < 0.001$; the main effect of cognitive control was significant, $p = 0.016$; and the interaction between moral identity and cognitive control was significant, $p = 0.032$ (see Table 1).

Table 1 Analysis of Variance for Multiple Regression Equation

Using moral identity as a moderator, slope analysis revealed (see Figure 6 [Figure 6: see original paper]) that in the moral identity control group, cognitive control did not significantly affect proactive aggression, $p = 0.298$, 95% CI =

[-2.616, 8.368], which includes zero. In the moral priming group, cognitive control significantly affected proactive aggression, $p = 0.018$, 95% CI = [-6.785, -0.662], which does not include zero. These findings indicate that moral identity moderates the relationship between cognitive control and proactive aggression: cognitive control is uncorrelated with proactive aggression in the control group, while proactive aggression decreases as cognitive control ability increases in the priming group.

Discussion

Experiment 1 manipulated moral identity to activate participants' moral identity self-schemas, dividing them into moral identity manipulation and control groups to investigate the role of moral identity in the relationship between cognitive control and proactive aggression at the behavioral level. Results demonstrated that moral identity moderates this relationship: cognitive control was significantly negatively correlated with proactive aggression in the moral identity priming group but uncorrelated in the control group, supporting Hypothesis 1.

Aquino et al.'s moral identity theory (Aquino et al., 2009) and Anderson and Bushman's (2002) General Aggression Model provide a reasonable explanation for the moderating role of moral identity. When facing rewards, most people find it difficult to resist temptation, and the desire for monetary rewards is natural. However, some individuals choose not to aggress even when they know their actions will not be discovered or punished. This self-regulation is largely influenced by internal moral standards. Individuals with high moral identity typically abide by laws, regulations, and social moral norms, and are better able to restrain themselves from making statements or engaging in behaviors that may violate moral principles (Chen & Li, 2016). Higher moral identity increases the likelihood of moral self-schema activation and enhances information processing and moral behavioral capacities. Strong moral identity enhances the accessibility of personal self-regulatory cognitive structures and schemas (Lapsley & Hill, 2009), promoting prosocial behavior and resisting aggressive and antisocial behavior (Hertz & Krettenauer, 2016). Therefore, in the control group where moral self-schemas were not yet activated, reward motivation was dominant when facing incentives. Individuals may not need to recruit control resources to maintain consistency between their behavior and internal standards, resulting in a non-significant correlation between cognitive control and proactive aggression. In contrast, individuals in the priming group with high moral identity had activated moral schemas, prioritized morality, and set maintaining moral standards as their goal. Cognitive control resources then helped individuals achieve this moral goal, reducing proactive aggression. These findings provide empirical support for the social-cognitive model of moral identity and the General Aggression Model.

Experiment 1 only manipulated moral identity to examine the correlational relationship between cognitive control and proactive aggression at different moral

identity levels. Experiment 2 built upon Experiment 1 by using tDCS to intervene in brain regions related to cognitive control, further investigating the moderating role of moral identity in the causal relationship between cognitive control and proactive aggression.

Experiment 2

Method

Participants Based on previous research (Wu et al., 2020), G*Power 3.1 was used with an effect size of 0.30, significance level $\alpha = 0.05$, and statistical power $1-\beta = 0.80$ to calculate a required sample size of 90 participants (Cohen, 1988). We recruited 100 university students and randomly assigned them to moral identity priming and control groups. Two participants were excluded for not completing the entire experiment, leaving 98 valid participants (48 males, 50 females; mean age = 20.31, SD = 1.81).

Experimental Design A 2 (tDCS stimulation: anodal/sham) \times 2 (manipulation group: moral identity priming/control) between-subjects design was employed. tDCS was used to stimulate cognitive control brain regions (left dlPFC), with the anodal stimulation group serving as the cognitive control enhancement group and the sham stimulation group as the control group. Independent variables were cognitive control and moral identity; the dependent variable was proactive aggression.

Materials and Procedure Materials and procedures were largely identical to Experiment 1, with the addition of continuous tDCS stimulation throughout the experimental tasks. We used Neuroelectronics' Starstim 8 5G stimulator. Based on the EEG 10-20 system coordinates, the anodal stimulation site was F3, with the reference electrode at Fp2 (see Figure 7 [Figure 7: see original paper]). Participants in the anodal stimulation group received 1.5 mA direct current stimulation for 30 minutes, with 30-second ramp-up and ramp-down periods, delivered through a pair of 8 cm² circular sponge electrodes. Participants in the sham stimulation group had sponge electrodes fixed at the same positions and received sham stimulation—1.5 mA current for only the initial 30-second ramp-up and final 30-second ramp-down periods.

Experimental Procedure One week before the formal experiment, participants completed the moral identity questionnaire. At the beginning of the formal experiment, the experimenter introduced the procedure, confirmed compensation, and obtained informed consent. The formal experiment proceeded as follows:

- 1) Sound threshold measurement to determine appropriate sound intensity for the reward-interference task.
- 2) Completion of the Simon task.
- 3) Random assignment to moral identity priming or control groups to complete

the manipulation writing task.

4) Random assignment of participants in each manipulation group to anodal or sham tDCS groups. After fitting the tDCS cap and setting parameters, participants read the reward-interference task rules and practiced for 10 minutes before stimulation. At minute 11 of stimulation, they began the formal reward-interference task, followed by another Simon task.

5) Debriefing interview.

Data Analysis Data processing and index calculation were identical to Experiment 1. To verify tDCS stimulation effectiveness, paired samples t-tests were planned on reaction times for incongruent trials in the Simon task within each moral identity group, comparing pre- and post-stimulation performance. A 2 (tDCS stimulation: anodal/sham) \times 2 (manipulation group: moral identity priming/control) ANOVA was planned to further investigate the relationship between cognitive control and proactive aggression under different moral identity conditions.

Results

Manipulation Check To ensure effective moral identity manipulation, independent samples t-tests were conducted on pre-manipulation moral identity questionnaire scores and post-manipulation effectiveness questionnaire scores (see Figures 8 [Figure 8: see original paper] and 9 [Figure 9: see original paper]). Results showed no significant difference in pre-manipulation moral identity scores between the priming group ($M = 3.90$, $SD = 0.44$) and control group ($M = 3.85$, $SD = 0.43$), $t(96) = -0.61$, $p = 0.547$, Cohen's $d = 0.12$, $1-\beta = 0.09$. Post-manipulation moral identity scores were significantly higher in the priming group ($M = 4.84$, $SD = 1.75$) than in the control group ($M = 2.96$, $SD = 1.58$), $t(96) = -5.58$, $p < 0.001$, Cohen's $d = 1.13$, $1-\beta = 1.00$, indicating successful moral identity manipulation.

To verify tDCS stimulation effectiveness, paired samples t-tests on reaction times for incongruent trials in the Simon task were conducted separately for anodal and sham stimulation groups within each moral identity condition (see Figures 10 [Figure 10: see original paper] and 11 [Figure 11: see original paper]). In the moral identity priming group, participants receiving sham tDCS showed no significant difference between pre-stimulation ($M = 0.48$, $SD = 0.07$) and post-stimulation ($M = 0.47$, $SD = 0.06$) incongruent trial reaction times ($p = 0.373$, Cohen's $d = 0.19$, $1-\beta = 0.14$). However, participants receiving anodal tDCS showed significantly lower post-stimulation ($M = 0.46$, $SD = 0.05$) than pre-stimulation ($M = 0.49$, $SD = 0.07$) reaction times, $p = 0.005$, Cohen's $d = 0.63$, $1-\beta = 0.83$.

In the moral identity control group, participants receiving sham tDCS showed no significant difference between pre-stimulation ($M = 0.48$, $SD = 0.07$) and post-stimulation ($M = 0.46$, $SD = 0.07$) reaction times ($p = 0.102$, Cohen's $d = 0.34$, $1-\beta = 0.36$). However, participants receiving anodal tDCS showed

significantly lower post-stimulation ($M = 0.45$, $SD = 0.05$) than pre-stimulation ($M = 0.48$, $SD = 0.06$) reaction times, $p = 0.011$, Cohen's $d = 0.57$, $1-\beta = 0.76$. These results demonstrate effective anodal/sham tDCS stimulation.

To verify that effects were not confounded by moral identity manipulation, independent samples t-tests on incongruent trial reaction times were conducted between priming and control groups within anodal and sham conditions before and after stimulation. No significant differences were found (all $ps > 0.05$), indicating that tDCS effectively enhanced cognitive control without being influenced by moral identity manipulation.

Additionally, independent samples t-tests on pre-manipulation proactive aggression questionnaire scores showed no significant difference between the priming group ($M = 1.06$, $SD = 0.77$) and control group ($M = 1.06$, $SD = 0.13$), $t(104) = 0.31$, $p = 0.758$, Cohen's $d = 0.06$, $1-\beta = 0.06$, indicating consistent baseline proactive aggression levels before manipulation and stimulation.

Effects of Enhanced Cognitive Control on Proactive Aggression at Different Moral Identity Levels To further verify the moderating role of moral identity, a 2 (tDCS stimulation: anodal/sham) \times 2 (manipulation group: moral identity priming/control) ANOVA was conducted with proactive aggression scores as the dependent variable. Results showed no significant main effect of moral identity manipulation, $F(1, 94) = 0.85$, $p = 0.358$; a significant main effect of tDCS stimulation, $F(1, 94) = 6.53$, $p = 0.012$; and a significant interaction between tDCS stimulation and moral identity group, $F(1, 98) = 6.88$, $p = 0.010$ (see Table 2).

Table 2 Analysis of Variance for Effects of Moral Identity and Cognitive Control on Proactive Aggression

Simple effects analysis based on the ANOVA (see Figure 13 [Figure 13: see original paper]) revealed that under moral identity priming conditions, tDCS stimulation had a significant effect, $F(1, 94) = 13.42$, $p < 0.001$. Participants receiving anodal tDCS showed significantly lower proactive aggression scores than those receiving sham stimulation, with a difference of 0.43^{***} (sham minus anodal). Under moral identity control conditions, tDCS stimulation had no significant effect, $F(1, 94) = 0.002$, $p = 0.962$, with no significant difference between anodal and sham groups. These findings indicate that moral identity moderates the relationship between cognitive control and proactive aggression: cognitive control is uncorrelated with proactive aggression in the control group, while negatively correlated in the priming group, with proactive aggression decreasing as cognitive control increases.

Discussion

Building on Experiment 1, Experiment 2 confirmed the moderating role of moral identity in the relationship between cognitive control and proactive aggression.

Using tDCS to stimulate cognitive control brain regions (left dlPFC), we examined the impact of enhanced cognitive control on proactive aggression at different moral identity levels. Results showed that under moral identity priming, proactive aggression decreased as cognitive control increased, whereas under control conditions, proactive aggression was unrelated to cognitive control ability. These findings replicate Experiment 1 and support our hypotheses. They are also consistent with previous research showing that the dlPFC is crucial for integrating internal and external information and maintaining this information in conflict situations to accomplish goal-directed behaviors, with the left dlPFC playing a key role in proactive inhibition (Boudewyn et al., 2020; Verveer et al., 2020; Zhou & Xuan, 2018). The dlPFC flexibly adjusts inhibition targets based on goals. After moral identity priming, individuals' moral self-schemas are activated, making moral conduct and maintaining moral standards primary goals. At this point, the dlPFC's main objective is to suppress irrelevant stimuli to achieve this goal, so enhanced left dlPFC activity in the moral identity priming group reduces proactive aggression. In the control group, where moral schemas remain unclear, individuals face conflicts between instrumental motivation and moral inhibition motivation after being tempted by rewards, constantly weighing the maintenance of morality against personal gain without a clear goal. Therefore, even when cognitive control is enhanced in the control group, no reduction in proactive aggression is observed.

General Discussion

This study investigated whether moral identity moderates the relationship between cognitive control and proactive aggression through two experiments. Experiment 1 manipulated moral identity and demonstrated its moderating role: cognitive control was uncorrelated with proactive aggression in the control group but significantly negatively correlated in the priming group. Building on Experiment 1, Experiment 2 simultaneously manipulated both moral identity and cognitive control, further examining whether the causal relationship between cognitive control and proactive aggression is moderated by moral identity. Results again verified the moderating role and found that in the priming group, proactive aggression decreased as activity in the cognitive control-related brain region (dlPFC) increased, while no relationship existed in the control group. These findings support our hypotheses and provide further evidence and explanation for the inconsistent relationship between cognitive control and proactive aggression.

Typically, people find it difficult to resist reward temptations, and the desire for monetary rewards is natural. The cognitive-motivational model and conflict monitoring theory provide strong theoretical support for understanding individuals' decision-making processes when facing reward temptations (Zhu & Wang et al., 2019; Zhu & Zhou et al., 2019; Botvinick et al., 2001). When facing potential rewards, the brain's instrumental motivation system and moral motivation system are simultaneously activated and jointly process and integrate information.

Instrumental motivation focuses on achieving personal goals and obtaining benefits, while moral motivation emphasizes the moral correctness of behavior and responsibility toward others or society. During this process, individuals must consider both maximizing personal interests and weighing whether the behavior aligns with their moral standards. When individuals have high moral identity, they are more inclined to adhere to their moral principles and set maintaining moral standards as their behavioral goal. They then recruit control resources to resolve motivational conflicts to achieve this goal. When control ability is strong, individuals are more likely to successfully overcome irrelevant goals and achieve their behavioral objectives. After moral identity activation, individuals' moral schemas become more accessible, making maintaining moral standards more likely to become behavioral motivation. Therefore, when processing conflicts between instrumental and moral motivations, they treat instrumental motivation as interference and work to overcome it, choosing not to engage in proactive aggression. This produces the phenomenon where stronger control ability leads to less proactive aggression. Conversely, individuals without activated moral identity may have confused behavioral goals—some focusing on obtaining benefits, others on maintaining morality—making the relationship between enhanced cognitive control and proactive aggression non-significant. These results again verify our hypothesis that moral identity moderates the relationship between cognitive control and proactive aggression, providing empirical support for Experiment 1.

Additionally, in Experiment 2, we used tDCS to specifically apply anodal stimulation to the left dlPFC to enhance cognitive control. We further subdivided both moral identity priming and control groups into anodal and sham tDCS subgroups. Results showed that in both moral identity manipulation groups, only the anodal stimulation groups showed enhanced cognitive control, while sham groups showed no significant change. Moreover, only in the moral identity priming group did increased cognitive control reduce proactive aggression. These results again verify the moderating role of moral identity. The dlPFC, as a crucial brain region, coordinates and processes complex cognitive tasks, especially when facing conflicts and decision-making needs. It can flexibly adjust based on current goals. By applying anodal tDCS, we activated and strengthened this region's function, thereby improving cognitive control ability. As described, individuals in the moral identity priming group, although facing conflicts between instrumental and moral inhibition motivations in the proactive aggression task, had maintaining moral standards as their primary goal. Therefore, they treated instrumental motivation as interfering information, and enhanced control ability strengthened inhibition of this motivation, reducing proactive aggression.

Based on these two studies, we can see that individuals' decision-making processes when facing reward temptations involve complex psychological processing with interactions and 博弈 between instrumental and moral motivations. Individuals' moral identity levels and control abilities play key roles in this process, jointly influencing whether they choose to engage in proactive aggression. Therefore, in understanding and preventing proactive aggression, simply enhancing

cognitive control does not necessarily reduce proactive aggression; the role of moral identity cannot be ignored. When individuals' goal is to obtain personal benefits, enhanced cognitive control may even increase aggression levels. Only when individuals set maintaining moral standards as their behavioral goal does enhancing cognitive control reduce proactive aggression. Consequently, when developing intervention programs for students' proactive aggression, we must comprehensively consider multiple factors including motivational structure, moral identity level, and control ability. For individuals with different moral identity levels, personalized intervention strategies should be developed to more effectively reduce aggression. For high moral identity individuals, the focus should be on enhancing cognitive control. Modern technological methods such as tDCS combined with cognitive training can be used to strengthen students' cognitive control. This combination of physical stimulation and cognitive training can more precisely target students' brain neural networks, improving their cognitive efficiency and self-control. Through periodic or follow-up training, we can monitor students' progress in real-time and adjust training protocols based on feedback to achieve optimal results. For low moral identity individuals, the priority should be enhancing their moral identity. Parents and teachers play crucial roles in this process. In family settings, parents can guide children to establish correct values and moral views through daily teachings, cultivating their moral emotions. In classroom settings, teachers can create positive moral atmospheres through themed class meetings and group counseling activities, allowing students to experience the power of morality in collective settings. In summary, only by simultaneously enhancing cognitive control and moral identity can proactive aggression be effectively reduced.

Limitations and Future Directions

First, regarding participant selection, this study only used university students, which limits the generalizability and applicability of the findings. Primary and secondary school students are at critical stages of cognitive development, and their cognitive characteristics and developmental trajectories may differ significantly from university students. Therefore, to more comprehensively and deeply understand the role of moral identity in the relationship between cognitive control and proactive aggression, future research should explore more diverse populations, including primary and secondary school students and special populations, to draw more generalizable conclusions.

Second, regarding methodology, this study primarily relied on behavioral measures from experimental tasks to assess cognitive control and proactive aggression, which involves certain subjectivity and limitations. To address this deficiency, future research could introduce more objective and precise measurement methods. For example, combining tDCS with near-infrared spectroscopy to measure physiological indicators during task performance could more objectively assess changes in cognitive control and occurrences of proactive aggression. Moreover, different individuals may have varying sensitivity to tDCS intervention—

some may be more sensitive to current stimulation while others may not feel obvious effects. These differences may influence subsequent responses. Future tDCS intervention studies should consider adding questionnaires to collect information about side effects and subjective experiences, controlling for response biases through analysis of these aspects and developing personalized intervention protocols based on individual sensitivity.

Finally, regarding experimental design, due to the situational setup of the reward-interference task, this study employed a between-subjects design. However, this design may not fully reveal individual internal differences in proactive aggression after enhanced cognitive control. To more deeply explore this issue, future research should improve experimental design, enhance task situational authenticity, and consider using within-subjects designs. Longitudinal follow-up training could investigate individual internal differences and patterns of change in proactive aggression after cognitive control enhancement.

Conclusion

Moral identity plays a moderating role in the relationship between cognitive control and proactive aggression. In the moral identity control group, cognitive control is uncorrelated with proactive aggression; in the moral identity priming group, cognitive control is significantly negatively correlated with proactive aggression for individuals with high moral identity, and proactive aggression decreases as activity in cognitive control-related brain regions increases.

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ABSTRACT

Proactive aggression is one of the common anti-social behaviours in the life which brings a lot of negative impacts and consequences in people's lives. Although cognitive control has been identified as an important influence on aggressive and antisocial behaviour, the association between cognitive control and proactive aggression remains controversial. We speculate that this may be due to the presence of moral identity as a moderator. Therefore, the present study aimed to investigate whether moral identity plays a moderating role in the relationship between cognitive control and proactive aggression.

Study 1 recruited 106 college students and divided them into the moral identity initiation and control groups by experimental manipulation, using linear regression analyses to investigate whether moral identity plays a moderating role in the relationship between cognitive control and proactive aggression. Based on the results of Study 1, Study 2 used a between-subjects design of 2 (tDCS stimulation: active /sham) \times 2 (manipulation group: moral identity initiation/control), recruiting 98 undergraduate students and assigning them randomly to the active stimulation and sham stimulation groups. Study 2 used transcranial direct current stimulation (tDCS) to apply stimulation to brain regions of cognitive control (left dlPFC) and employed a two-way ANOVA to further investigate the impact of enhanced cognitive control on proactive aggression behavior at different levels of moral identity.

The results of Study 1 indicated that moral identity plays a moderating role in the relationship between cognitive control and proactive aggression; specifically, in the moral identity activated group, cognitive control was significantly negatively correlated with proactive aggression; in the moral identity controlled group, there was no correlation between cognitive control and proactive aggression. Study 2 validated the findings of Study 1 once again and found that the effect of enhanced cognitive control on proactive aggression behaviours differed across levels of moral identity. In the moral identity-initiated group, individuals' proactive aggression decreased with enhanced cognitive control; in the moral identity-controlled group, individuals' proactive aggression was irrelevant to cognitive control.

Conclusion: Moral identity plays a moderating role in the relationship between cognitive control and proactive aggression. Specifically, cognitive control is significantly and negatively related to proactive aggression at high levels of moral identity, and the individual's proactive aggression decreases as cognitive control increases. While in the moral identity control group, there was no correlation between cognitive control and proactive aggression.

Keywords: proactive aggression, cognitive control, moral identity, transcranial direct current stimulation

Appendix 1: Moral Identity Questionnaire (Measure of Moral Identity) (Excerpt)

The following lists nine words that can describe a person's characteristics: caring, compassionate, etc. Please circle the number that best reflects your actual situation (Aquino & Reed, 2002; Wu, 2014).

Appendix 2: Moral Identity Manipulation (Excerpt)

This study is anonymous, and results are for scientific research only. Please carefully fill in your personal information and answer each question objectively and truthfully.

Please try your best to think of synonyms for the following words. If you cannot think of similar meanings, carefully copy the presented words.

Moral Identity Priming Group:

Examples: just, diligent, kind, honest, helpful, etc.

Moral Identity Control Group:

Examples: computer, mobile phone, key, car, pen, etc.

Please spend a few minutes thinking about these words, select at least four as keywords (no fewer than 4), and write about your personal experiences related to them (one or more events). Imagine these words are closely related to your life, which will help you complete the task. Total word count should be at least 60 characters (Li et al., 2013; Wu, 2014).

Based on the content from the previous task, please answer the following questions (excerpt).

1-7 indicates the degree to which the following statements match your actual situation. Please check the corresponding number.

To what extent does what you wrote reflect that you are a student?

Very small 1 — 2 — 3 — 4 — 5 — 6 — 7 Very large

To what extent does what you wrote reflect that you are a team member?

Very small 1 — 2 — 3 — 4 — 5 — 6 — 7 Very large

Appendix 3: Interview Outline (Excerpt)

Hello, to better improve our game, we need to conduct an interview with you lasting about 5 minutes. The interview will be recorded. Is that okay?

Questions based on participants' specific situations:

First, check how they made their choices.

Question 1: What factors influenced your choice to interfere with the other player in the game?

Question 2: What considerations were behind your choices between interfering and not interfering?

(Ask follow-up questions based on specific situations, such as: Were you conflicted? Why?)

Question 3: What feelings did you have during the game?

Question 4: What do you think the other player is feeling right now?

Question 5: Please briefly evaluate your opponent.

Question 6: How would you rate your engagement level in this experiment?
50% or below 60%

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv — Machine translation. Verify with original.