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Toward controlling of a pandemic: How self-control ability influences willingness to take the COVID-19 vaccine

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ABSTRACT

What influences people's vaccine attitudes and intentions in the combat against the COVID-19 pandemic? Extending beyond health factors, the present research examines whether non-health-specific factors—such as one's self-control ability—influence individual attitudes toward vaccination. Drawing on the social psychology literature, we propose that self-control, which is often associated with adherence to social norms and with engagement in socially desirable behaviors, can lead to more favorable attitudes toward vaccines. Study 1 provided correlational evidence for our theoretical perspective that students scoring high on trait self-control expressed less vaccine hesitancy than students scoring low on self-control. Employing a more representative population, Study 2 examined the relationship with behaviors. It was found that non-student adults with higher self-control strength levels were more likely to accept vaccine appointments opportunities than those with lower self-control strength levels. Using an experimental design, Study 3 found that participants exerting a high level of effort for attentional self-control in the incongruent Stroop task condition showed lower COVID-19 vaccine acceptance than participants in the congruent condition. In sum, our research provides the first experimental evidence that high self-control can have a reliable impact on individual perceptions of vaccination.

1. Introduction

The COVID-19 pandemic represents an unprecedented time and uncovers one of the greatest challenges in modern history (Yang & Wang, 2020). This rapidly changing global health issue is affecting nearly every aspect of our lives such as economic devastation, political disruption, and social strife (Li & Cao, 2021; Lipscy, 2020; McKee & Stuckler, 2020). Recently, the vaccination effort around the world has offered the hope of achieving herd immunity against the new coronavirus disease (Malik et al., 2020). Though high global vaccination rates seem to move people closer to normal life, vaccine hesitancy, which refers to delay in acceptance or fears about safety and efficacy of vaccines (Dubé et al., 2015), has risen sharply in multiple communities. Research has shown that individuals express vaccine hesitancy due to various reasons, which include the misinformation spread by the anti-vaccine movement (Poland & Jacobson, 2001), Andrew Wakefield's infamous case about the relationship between vaccine and autism (Deer, 2011), and vaccine scandal and crisis in public confidence (Han et al., 2019).

In the past few decades, much evidence has shown that a range of health-related factors such as health condition, illness perception, and distrust of health experts are associate with vaccination inclination (Brewer et al., 2017; Donadiki et al., 2014; Erawan et al., 2021). For example, using nationally representative general population samples of Ireland and the United Kingdom, Murphy et al. (2021) found that participants showing more COVID-19 vaccine resistance were less likely to read authoritative texts about pandemics than vaccine accepting respondents. However, the existing literature has neglected to investigate the role of non-health-specific variables in vaccine hesitancy. The current studies focused on an underexplored yet important individual difference factor, namely, self-control ability, in vaccine attitudes and intentions. Self-control (or self-regulatory ability) refers to the self's conscious efforts to override and alter its incipient pattern of responses, including behaviors, emotions, and thoughts (Baumeister et al., 2007; Baumeister & Exline, 1999). It increases human being's ability to accommodate a broad range of physical, social, and cultural environments (Groß, 2021; Tangney et al., 2004). For example, the dieter abstains from food cravings and gaining from weight, the addict recovers

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from alcohol and substance abuse, and the students eliminates distractions and overcomes procrastination. Thus, one of the most prominent characteristics of self-control is to thwart and prevent behavior when motivations clash (e.g., a food temptation conflicts with the desire to live a healthy life) (Baumeister & Vohs, 2007).

A recently burgeoning body of research has investigated the association between self-control and personal and social health behavior in the context of COVID-19. For example, Schnell & Krampe (2020) found that individuals who exercised a higher degree of self-control showed substantially less COVID-19 stress and general mental distress. Recent contributions in the literature have demonstrated that self-control also plays a significant role in promoting health behavior in response to the COVID-19 pandemic (Kokkoris & Stavrova, 2021; Martarelli et al., 2021; Tu et al., 2021). For example, Wolff et al. (2020) found that high trait self-control was associated with adherence to behavioral recommendations by health experts, and it also buffered the negative effect of perceived difficulty of abiding by health and safety guidelines. Along the same line, Rodriguez et al. (2021) showed that individuals differences in self-control were positively related to compliance with guidelines during the COVID-19 global pandemic, such that people with high self-control reported less stockpiling. Overall, these findings highlight the importance of self-regulatory ability in controlling selfish impulses and in promoting prosocial behaviors in the context of COVID-19.

Since protection and protecting others are typical forms of socially desirable behaviors, we propose that individuals scoring high on trait self-control might express less vaccine hesitancy than those scoring low on self-control. A recent article offers preliminary evidence consistent with our hypotheses. Betsch et al. (2018) found that there was an inverse (but weak) link between vaccine hesitancy and behavioral control ($r = -0.21$). However, Betsch and colleagues only used self-report assessment instruments of vaccine hesitancy for infectious viral illness such as measles or pertussis in German participants. We provide conceptual replications of these findings using more ecologically valid behaviors of vaccine hesitancy in the context of the new coronavirus disease, but, more important, we offer causal evidence for the role of self-regulation ability in shaping individual perceptions of COVID-19 vaccination.

Specifically, the present research offers three important contributions to the existing literature. To begin with, despite previous research documenting the influence of self-control on health-related behaviors such as compliance with preventive measures during the COVID-19 pandemic (Rodriguez et al., 2021), limited research to date has examined the role of self-control in vaccine attitudes and behavior. Second, the vast majority of existing studies on vaccine hesitancy almost relies heavily upon self-report data. However, there might be a striking association between vaccine intentions and vaccine behavior in the real-life context (daCosta DiBonaventura & Chapman, 2005). The current research examined willingness to take the COVID-19 vaccine with a behavioral measure, or at the least, with a dependent variable that closely represents actual behavior. Finally, although countless studies have documented psychological consequences of self-control such as reducing risk for delinquency and increasing positive health behaviors (Hagger, 2014; Piquero et al., 2016), the evidentiary basis of self-control has been criticized and questioned in recent years. By revealing the effect of self-regulatory ability on vaccine-related perceptions in Chinese people, we shed light on the cognitive outcome of self-control in non-WEIRD (western, educated, industrialized, rich, and democratic) populations (Henrich et al., 2010).

Two lines of reasoning related to prosocial motivation and social norm adherence suggest that high self-control leads to more positive attitudes toward COVID-19 vaccinations. First, a body of literature indicates that self-control ability plays a significant role in behaving prosocially to others (Joosten et al., 2015; Li et al., 2019). The new coronavirus disease presents people many self-control conflicts. On the one hand, vaccinated individuals may experience potential side-effects such as a sore arm, a mild fever or body aches, or even blood clot in some rare cases. Although risk of vaccination is insignificant with respect to the public health benefiting from stopping the circulation of the virus, personal inconvenience, costs, and worries arise from immunization may make people more reticent to take the vaccine (Day, 2006). On the other hand, as the proportion of a community that is vaccinated against the new coronavirus disease grows, the individual benefits of getting vaccinated for members of the community decline, because people are protected against the disease (Verelst et al., 2018). Thus, adherence to health behaviors surrounding the COVID-19 pandemic is self-control demanding and is typically correlated with aversive experiences such as refusing to take the vaccine due to side effects or taking advantage of others' vaccinations (Brooks et al., 2020; Wolff et al., 2020).

Social evolutionary theories suggest that self-control has evolved as a way to restrain impulses and override tempting desires when there is a conflict between public health concerns and individual self-interest (Baumeister & Exline, 1999). The COVID-19 pandemic has shown us that individual liberty and freedom to govern themselves are not an absolute state of affairs against the basic needs of all persons (Gostin & Wiley, 2020). Many public health experts warn that individuals who can be vaccinated and turn down COVID-19 vaccination are selfish and put other people's health and lives at risk (Couto et al., 2021). In a recent study, Rieger (2020) found that priming with beliefs about altruism can significantly increase people's willingness to get vaccinated against COVID-19. One stream of research on altruistic behavior is the work on the social and cognitive consequences of self-control. For example, Kocher et al. (2017) provided evidence for the notion that self-control may help individuals overcome an impulse to act in self-interest and increase their cooperative behavior in social dilemmas. This pattern of results suggests that a strong self-regulatory ability can function to overcome egoistic beliefs or selfish state behavior for the sake of the group's interests as a whole. Applying this logic into the domain of public health, self-control may have the same detrimental effects on the reckless and selfish behavior in the context of COVID-19 such as free riding on the vaccination decisions of others. Thus, strong self-regulation may result in reduced hesitancy and stronger intentions.

The second reason that self-control capacity leads to more COVID-19 vaccine favorability is that high self-control facilitates more normative behavior. Social norms, the unwritten rules or standards that members of a particular social group or culture implicitly recognize, direct and guide individuals' cognition, emotion, and behavior (Cialdini et al., 1991). An emerging line of research has explored how social norms influence public willingness to get vaccinated against COVID-19 (Lau et al., 2019). In a recent study conducted by Sinclair and Agerström (2021), it was found that conveying strong (compared to weak) norms can significantly increase young people's willingness to take the vaccine and reduce their vaccine hesitancy. Based on the findings that social norms exert a powerful influence on vaccination, people with high trait self-control who demonstrate more compliance with social norms should be more likely to modify vaccination intention and behavior to help others in the community.

To empirically test our hypothesis, we conducted three complementary studies employing multiple methods (correlational survey and experimental design), multiple populations (university students and community sample), and multiple rating sources (self-report and behavioral outcome). Study 1 consisted of a cross-section survey which examined the association between trait self-control and vaccination attitudes in a sample of Chinese university students. Using a more diverse sample and behavioral measure, Study 2 examined whether participants with higher self-control strength levels would be more likely to accept vaccine appointments opportunities than those with lower self-control strength levels. Study 3 aimed to establish the causal link between self-control and individual attitudes toward vaccination. Specifically, we used the color Stroop task to manipulate the exertion of self-control and investigated its effect on vaccination attitudes.

2. Study 1

2.1. Method

2.1.1. Participants

Participants included 201 individuals (115 females, men) with a mean age of 20.2 (SD = 1.9) years. They were recruited from the campus of a medium-sized university in central China. Each research participant was compensated 5 RMB on completion of the study. As a solution to minimize the possibility of false positives due to the opportunistic exploitation of researcher degrees of freedom, we did not perform any statistic tests until the collection of all data sets was terminated. All participants had not obtained a vaccine against COVID-19 when the study took place.

2.1.2. Materials and procedure

Participants were informed that the study concerned individuals' attitudes toward some vaccination issues. They completed a questionnaire package that contained two blocks of measures: self-control and vaccination attitudes and two ostensively unrelated tasks (personality test and language disambiguation task) which were used to hide the true purpose of the study. The presentation order of these four blocks was randomized across subjects to avoid order effects. After completing the task, the participants answered a debriefing question about the true purpose of the study.

Participants' self-control was gauged with the 13-item Brief Trait Self-control Scale (Tangney et al., 2004). Sample items included "*I am good at resisting temptation*" and "*People would say that I have iron self-discipline*". Participants indicated their responses on a 5-point scale, ranging from 1 (*Not at all like me*) to 5 (*Very much like me*). The internal reliability of this measure was high, Cronbach alpha = 0.82.

To measure the intention to take COVID-19 vaccine, a two-item version of vaccine intention scale (Huynh & Senger, 2021) was included in the study. The items were: 1) "*How likely is it that you would get a Corona Virus (COVID-19) shot if one were available?*"; and 2) "*If you were faced with the decision to get a Corona Virus (COVID-19) shot today, how likely is it that you would do so if one were available?*". Responses were given on a 7-point Likert scale, ranging from 1 (*not at all likely*) to 7 (*extremely likely*). The internal reliability of this measure was high, Cronbach alpha = 0.87.

2.2. Results and discussion

No participants suspected a relation between self-regulation ability and their COVID-19 vaccine intentions and thus the statistical analysis was run on all participants. As expected, higher self-control ($M = 3.01$, $SD = 0.93$) was associated with a strong intention to get a COVID-19 vaccine ($M = 5.05$, $SD = 1.59$), $r = 0.60$, $p < .001$, 95% confidence interval [CI] = [0.5034, 0.6818]. Specifically, Chinese university students who scored higher on the Brief Trait Self-control Scale showed more positive attitudes toward vaccination with COVID-19 than those scored lower on this scale. This relationship remained significant after controlling for age and gender (all $ps < 0.001$).

As the first test of our theoretical perspective, we offered preliminary evidence for the notion that self-control was positively associated with individual attitudes toward vaccination in a Chinese student population. Note that Study 1 has several limitations. First, as an initial test of this hypothesized association, Study 1 only included a sample of Chinese university students which may not represent the general population at large. Thus, we sampled a more diverse population in Study 2. Second, all variables in Study 1 were self-reported that might lead to common method bias. It is likely that self-reported vaccination intention can dramatically diverge from vaccination behavior (daCosta DiBonaventura & Chapman, 2005). To address this limitation, we measured vaccination intention with a dependent variable that is close to behavior in Study 2.

3. Study 2

3.1. Method

3.1.1. Participants

The experiment took place between March and April 2021. Participants included 224 individuals (128 females, 96 males) with a mean age of 33.4 ($SD = 10.9$) years. 78 participants had received a COVID-19 vaccination and 146 participants had not when the study took place. They were recruited from a big shopping mall in southwest China. It was an indoor shopping center, anchored by department stores that sold different kinds of merchandise, including food, jewelry, clothes, watches, and household supplies to the general public. Each research participant was compensated 10 RMB on completion of the study. As a solution to minimize the possibility of false positives due to the opportunistic exploitation of researcher degrees of freedom, we did not perform any statistic tests until the collection of all data sets was terminated. All participants had not obtained a vaccine against COVID-19 when the study took place.

3.1.2. Materials and procedure

All participants provided written informed consent on research participation. Due to the ethical challenges of conducting a study examining the actual vaccination behavior (e.g., getting participants vaccinated in the study), we focused on a behavioral choice that appeared real. An experimenter asked pedestrians walking alone in a large shopping center if they would take part in a short and simple psychology test in exchange for monetary rewards. The research assistant was instructed to walk around the shopping center and to look for potential participants. If participants agreed to take the survey, they were asked to complete the questionnaires about trait self-control of interest (Cronbach alpha = 0.80). Subsequently, they were instructed to complete two unrelated questionnaires about a personality test and a language disambiguation task as Study 1.

Upon completion of the questionnaire package, the experimenter asked if they had obtained the COVID-19 vaccine. People who responded *Yes* were thanked and paid for their participation. If participants responded *No*, the experimentalist said:

Thank you for your help with the survey. Here is 10 yuan as compensation for your time and efforts in the study. Ahh, actually I forgot to tell you that our college has some cooperation with hospitals and thus we can book a coronavirus (COVID-19) vaccination appointment at community pharmacy for you. Would you like to accept this offer?

We did not have actual vaccination appointments slots for participants. Although it is impossible for us to know how participants viewed the veracity of the experiment's cover story, it created a real situation which required them to make a behavioral choice. After participants expressed their vaccination attitudes, they were then thanked and debriefed about the true nature of the study.

3.2. Results and discussion

No participants suspected a relation between self-regulation ability and their COVID-19 vaccine intentions and thus analysis was run on all participants. The experimenter revealed the true purpose of the study and that the appointment opportunity did not exist after the last data set had been collected. Eighty-six or 58.90% of participants accepted the appointment opportunities for their jabs, while sixty or 41.10% of participants declined the appointment opportunities for their jabs. This difference was statistically different from a 50%–50% split, $\chi 2$ (1, $N = 146$) = 4.63, $p = .03$, Cramer's Phi = 0.18. As expected, unvaccinated participants who accepted vaccination appointments opportunities showed a higher level of self-control ($M = 3.65$, $SD = 0.59$) than participants who declined vaccination appointments opportunities ($M = 3.27$, $SD = 0.63$), t (144) = 3.66, $p < .001$, $d = 0.61$, 95% confidence

interval [CI] = [0.1749, 0.5851]. We also compared levels of self-control between vaccinated individuals and unvaccinated people who accepted vaccination appointments opportunities. The results showed that the vaccinated individuals ($M = 3.84$, $SD = 0.48$) showed a higher level of self-control than those who intended to vaccinate, t (162) = 2.86, p = .005, $d = 0.45$, 95% confidence interval [CI] = [0.0744, 0.4056].

In Study 2, we sought to conceptually replicate the findings of Study 1 with a larger, more diverse sample from another location in China. Critically, we observed the same relationship in a behavioral decision. However, both Studies 1 and 2 are purely correlational. There is no way to determine the causal direction of the relationship. It is possible that self-control is the cause of positive attitudes toward vaccination against COVID-19. An alternative explanation is that getting vaccinated increase people's self-control resources. To determine the causal direction between these two variables, Study 3 adopted an experimental design.

4. Study 3

4.1. Method

4.1.1. Participants

Participants included 160 individuals (87 females, 73 males) with a mean age of 19.7 ($SD = 1.5$) years. They were recruited from a medium-size university in central China. Each research participant was compensated 10 RMB on completion of the study. As a solution to minimize the possibility of false positives due to the opportunistic exploitation of researcher degrees of freedom, we did not perform any statistic tests until the collection of all data sets was terminated. All participants had not obtained a vaccine against COVID-19 when the study took place.

4.1.2. Materials and procedure

Participants first provided informed consent and were then informed that researchers were interested in their performance on a perceptual-cognitive judgment task. We randomly assigned participants to either a congruent or an incongruent Stroop condition which was modeled after Singh and Göritz (2018) and Li et al. (2019). A recent meta-analytic review indicated that this modified color Stroop task is effective for impairing participants' subsequent self-control performance on another control-demanding task (Dang, 2018). In the Stroop task, participants were required to identify the displayed color of words, while fully ignoring the actual meaning of the words. Stimuli consisted of the Chinese words "red," "green," "yellow" and "blue" displayed in one of these four colors. In the congruent Stroop condition, the semantic meaning of the word was consistent with the displayed color patch (e.g., "RED" displayed in red). In the incongruent Stroop condition, the semantic meaning of the word and the displayed color patch did not match (e.g., "RED" displayed in blue).

The experiment composed of 100 trials conditions with an equal distribution of colors. The participants were asked to respond by moving the mouse cursor on one of four buttons below the stimulus area and clicked the left button. The buttons were labeled "red," "green," "blue," or "yellow" in black text color which were randomized for each subject. The word was presented and remained on the screen until the participant responded by naming the color. The feedback on whether each response had been correct or wrong was displayed on the screen for 500 ms.

After completing the color Stroop task, participants were administered a posttest questionnaire that included two manipulation check items. First, the participants assessed the difficulty of the Stroop task on a 5-point scale. Second, they indicated on a 7-point rating scale (1 = *disagree strongly*, 4 = *neither agree nor disagree*, 7 = *agree strongly*) the degree to which they inhibited their habitual tendency to select the dominant responses in the task (Boucher & Kofos, 2012; Inzlicht et al., 2014). Next, the experimenter asked whether participants would accept a vaccination appointment opportunity as in Study 2. Finally, we thoroughly debriefed participants via a funneled debriefing procedure and thanked them for their participation.

4.2. Results and discussion

No participants suspected a relation between the Stroop task and their COVID-19 vaccine intentions and thus analysis was run on all participants. Results indicated that participants in the incongruent Stroop task condition perceived the task as more effortful and difficult ($M = 2.95$, $SD = 0.78$) than participants in the congruent Stroop task condition ($M = 2.30$, $SD = 0.66$), t (158) = 5.69, $p < .001$, $d = 0.91$, 95% confidence interval [CI] = [0.4244, 0.8756]. Moreover, participants in the incongruent Stroop task condition reported that they overrode a dominant response ($M = 3.10$, $SD = 0.69$) more than participants in the congruent condition ($M = 1.70$, $SD = 0.75$), t (158) = 12.29, $p < .001$, d = 1.96, 95% confidence interval [CI] = [1.1750, 1.6250]. Thus, these findings suggest that the incongruent Stroop task indeed required a higher level of self-control.

In the congruent Stroop task condition, fifty or 62.5% of participants accepted the appointment opportunities for their jabs, while thirty or 37.50% of participants declined the appointment opportunities for their jabs. This difference was statistically different from a 50%–50% split, χ^2 (1, $N = 80$) = 5.00, $p = .025$, Cramer's Phi = 0.25. In the incongruent Stroop task condition, thirty-two or 40.00% of participants accepted the appointment opportunities for their jabs, while forty-eight or 60.00% of participants declined the appointment opportunities for their jabs. This difference was not statistically different from a 50%–50% split, χ^2 (1, N = 80) = 3.20, $p = .07$, Cramer's Phi = 0.20. Critically, there were significant differences in the number of participants accepting vaccination appointment opportunities between the two conditions as revealed by a binary logistic regression, Wald χ2(1, $N = 160$) = 7.96, $p = .005$, odds ratio = 2.50, 95% CI = [1.323, 4.724]. Such findings suggest that exerting self-control subsequently hindered vaccine acceptability and decreased people's intention to get a vaccine.

5. General discussion

In the past few decades, a sizable literature has shown that self-control plays a functional role in encouraging prosocial acts and normative behaviors (Baumeister & Exline, 1999; Baumeister & Vohs, 2007; Stavrova & Kokkoris, 2017). Extending beyond these findings, the current research obtained robust evidence that individual differences in self-control can influence perceptions of vaccination against the COVID-19 pandemic. Using a correlational study which collected data from Chinese university students, Study 1 found that self-control ability was positively associated with vaccine acceptance. Employing a more diverse population and assessing vaccination intention behaviorally, Study 2 provided further support for our theoretical perspective that people with a higher level of self-control were more likely to receive a vaccine than people with a lower level of self-control. Study 3 established the causal link between self-control and vaccination intention. We provided experimental evidence that participants' intention to vaccinate would decrease after completing the incongruent Stroop task which required the exertion of self-control to suppress an urge to choose a dominant response.

The present research presents several notable contributions. First, we contribute to an incipient but rapidly growing literature on factors which are related to vaccine-related perceptions and attitudes. Evolutionary research suggests that harsh and unpredictable environments set up conflicts between personal desires and social constraints (Hofmann et al., 2012). In this process, self-control has evolved as an effective strategy to handle those clashes that human beings face (Baumeister & Vohs, 2007). Consistent with this theoretical perspective, we found that self-control exerted a positive effect on increasing the likelihood of accepting COVID-19 vaccination. This is possibly because self-control can significantly increase norm compliance and promote more socially

desirable behaviors. Thus, our findings advance the literature by showing that enhancing self-control may act as a buffer against anti-vaccination attitudes and free riding (i.e., benefiting from herd immunity without receiving the vaccine) in the context of the COVID-19 pandemic.

In addition, the results showed that exerting self-control subsequently decreased individuals' intention to vaccinate. This is possibly because self-regulation ability is needed to bring behavior into line with social conventions (Muraven & Baumeister, 2000). However, one important stream of self-control research regarding the effect dubbed ego-depletion, the phenomenon that exerting self-control in one domain depletes a limited supply of willpower to another control-demanding task, is grappling with a replication crisis (Hagger et al., 2016). In a preregistered, multi-laboratory project, Vohs et al. (2021) found that initial exertion of self-control had no detectable effect on subsequent self-regulatory performance. Yet, the researchers also found that the depletion effect was more pronounced for participants reporting more fatigue. One remark directed to the critiques is that some self-control manipulations do not require expending considerable efforts in overriding their incipient responses (Baumeister et al., 2018). To address this issue, Study 3 included two manipulation check items to assess the task difficulty and how participants fought against a dominant response. This successful manipulation may help produce a more reliable effect.

Second, the current inquiry is one of the first to assess vaccination attitudes behaviorally. The existing literature regarding vaccination intention almost heavily depends on momentary self-report and hypothetical situations. These methods are understandable since it would be impractical and ethically controversial to get participants vaccinated in the study. However, some research suggests that individuals' vaccination intention in hypothetical situations is not synonymous with their behavior in real-life contexts (daCosta DiBonaventura & Chapman, 2005). If so, previous findings regarding self-reported vaccination intention will become less meaningful. To answer the call from Reynolds et al. (2006) who encouraged social psychologists to study action-relevant outcomes, we examined vaccination intention with a dependent variable that is close to behavior in Study 2. The results showed that participants with higher self-control were more likely to accept appointment opportunity than participants with lower self-control. This finding supports the relationship found in self-reports and hypothetical context as shown in Study 1. Yet, these results must be interpreted cautiously because although we assessed participants' behavioral choice, they did not actually receive a vaccine.

Finally, our results have some practical implications for the optimization of vaccination strategies. To the extent that self-control strengthens individuals' intention to receive a COVID-19 vaccine, interventions that yield an enhancement in self-regulation ability may be employed to increase vaccination intentions among individuals. In a meta-analysis conducted by Gollwitzer and Sheeran (2006), it was found that forming an implementation intention can effectively in increasing self-control, which in turn promoting the initiation of health-protective and disease-preventive behaviors. Thus, an implementation intention plan, which links a behavior with a public health context, such as "if I get vaccinated, I will protect myself and other people", can be used to encourage voluntary vaccination.

While the present research has several strengths and established the effectiveness of self-control in vaccination acceptance, it also has a set of limitations that should be addressed in future studies. First, our sample was not obtained via probability sampling and cannot achieve a best match with the quota criteria of a nationally representative sample in terms of gender, age, geographic region and other demographic information. In addition, although our study showed generalizability by sampling a cross-section of society, one limitation is that the research was all implemented in China. On the positive side, our participants were culturally and economically diverse in comparison to WEIRD populations in most psychology literature (Henrich et al., 2010). In contrast, the negative side of overreliance on Chinese samples may limit the generalizability of study results. Since coronavirus disease situations and vaccination programs are different in each country, it would be informative to replicate our research findings in other countries.

Second, it is reasonable to expect that the current studies would subject to social desirability bias in which participants may over report their socially favorable attitudes such as self-control ability. Additionally, while the present research revealed the effect of self-control on vaccination inclination, future studies could explore potential mediating mechanisms underpinning the results. The two mediators discussed above, altruistic orientation and norm adherence, have been shown to increase people intention to vaccinate. Such possibilities warrant future investigations.

Third, although we present evidence that self-regulation ability is associated with the observed effects, the small percentage of variance explained by self-control alone indicates that other variables about study participants are likely important. Future research can integrate these other sources of variance and build relatively sophisticated statistical models such as a multiple regression test to better understand psychological roots of vaccine hesitancy and resistance.

Finally, the current study only used the color Stroop task to manipulate the exertion of self-control. Prior work has provided dramatic evidence for the effectiveness of this intensive procedure (Dang, 2018). However, there are a wide range of manipulation techniques from simple online tests to time-costly in-person tests. To substantially increase the replicability of our findings, it would be meaningful to use different measures to investigate whether the exertion of self-control can produce weaker or stronger effects on vaccination attitudes.

CRediT authorship contribution statement

Yu Cao: Conceptualization, Methodology, Data curation, Validation, Writing – review & editing. **Heng Li:** Conceptualization, Writing – original draft.

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