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Training Self–Other Distinction: Effects on Emotion Regulation, Empathy, and Theory of Mind

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Navigating our social environment requires the ability to distinguish ourselves from others. Previous research suggests that training interventions have the potential to enhance the capacity for self–other distinction (SOD), which then may impact various sociocognitive domains, including imitation–inhibition, visual perspective taking, and empathy. Importantly, empirical research on the role of SOD in emotion regulation remains scarce. In this study, we aim to investigate the impact of training SOD on emotion regulation and also replicate findings on empathy and the attribution of mental states to others. Using a pre–post design, participants (N = 104) were assigned to either the imitation–inhibition or general inhibitory control training. Compared to general inhibitory control training, participants trained to inhibit imitation displayed a significant increase in posttest emotion regulation levels compared to pretest levels, indicating that imitation–inhibition training increased self-reported emotion regulation. Notably, emotional interference remained unaffected by either form of training. Both training interventions resulted in diminished self-reported empathic concern, while only general inhibitory control training led to a reduction in personal distress. Moreover, neither type of training had an impact on self-reported perspective taking or theory of mind performance. This study provides novel empirical evidence of the positive impact of imitation–inhibition training on emotion regulation. Furthermore, our findings make significant contributions to the advancement of research in this area and offer further support for the advantages of behavioral training as a methodological approach to studying sociocognitive abilities.

Keywords: training social cognition, emotion regulation, empathy, self–other, imitation–inhibition

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Being able to distinguish between our own intentions and those of others is essential for navigating the social environment (Jeannerod, 2003). This capacity, known as self–other distinction (SOD; Brass et al., 2009; Santiesteban, White, et al., 2012), plays a crucial role in various perceptual, motor, and cognitive functions. At the perceptual level, SOD allows us to accurately represent our body, including its characteristics and limits. This perceptual clarity forms the basis for our spatial awareness and sense of self in the physical world (Jeannerod, 2003). At the motor level, SOD is instrumental in our capacity to adapt our behavior to different contexts. It enables us to distinguish our actions from those generated by others, facilitating coordinated interactions in social settings (Brass et al., 2009; Jeannerod, 2003). At the mental representation level, SOD enables us to differentiate between our beliefs, desires, and intentions and those of others, facilitating effective navigation of the social world (Jeannerod, 2003). Hence, SOD serves as the foundation for a wide range of facets of human cognition and behavior. Indeed, a deeper understanding of this mechanism can enhance our comprehension of sociocognitive functioning and its impairments, potentially leading to misattributions of mental and affective states and inappropriate responses during social interactions (Shaw et al., 2020).

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Previous research underscores the vital role of SOD in numerous sociocognitive abilities associated with self-processing (Brass et al., 2009). One of these abilities is imitation, involving the intentional replication of observed actions from others (Jeannerod, 2006). During imitation, the processing of these actions triggers the activation of neural representations akin to those involved when personally experiencing them (Rizzolatti & Craighero, 2004). This neural activation engages internal motor representations in the observer (Brass & Heyes, 2005). However, within social contexts, not all observed actions should be automatically imitated. Thus, to effectively inhibit imitation, we must be able to distinguish between internally generated motor representations and those activated by observing others (Brass et al., 2009). The imitation–inhibition task (Brass et al., 2000; Cracco et al., 2018) is a well-established experimental paradigm to assess SOD. In this task, participants are required to move their fingers to respond to a target while simultaneously observing finger movements. The key index measured in this task is thought to reflect an individual's ability to inhibit the tendency to automatically imitate another's action, which in turn requires the enhancement of mental representations of the self while inhibiting representations of the other (Brass et al., 2009; Santiesteban, White, et al., 2012).

It has been suggested that perspective taking and theory of mind (ToM) are sociocognitive processes related to SOD. Perspective taking involves our capacity to distance ourselves from our own viewpoint and adopt that of others (Epley et al., 2004). Experimental studies have manipulated participants' visual experiences to encourage the adoption of an alternative perspective, resulting in conflicts with their own viewpoints and longer response times on experimental trials compared to control trials (Schurz et al., 2013). This conflict has been interpreted as the activation of the SOD mechanism (Keysar et al., 2000; Samson et al., 2010). On the other hand, ToM refers to the ability to comprehend one's own mental states and those of others, providing insight into another person's thoughts and intentions (Happé et al., 2017). In fact, SOD might be an important element of ToM, as it enables us to distinguish our own mental states from those shared with others. In an experimental study, Santiesteban, White, et al. (2012) hypothesized that training in imitation–inhibition would enhance visual perspective taking and ToM. They observed that imitation–inhibition training improved the SOD process and enhanced performance in perspective taking but not in ToM (Santiesteban, White, et al., 2012). This finding provided evidence that the same SOD mechanism underlies imitation–inhibition and perspective taking.

Another sociocognitive ability that might be linked to SOD is empathy (Happé et al., 2017). Empathy refers to experiencing an affective state similar to that of another person, caused by observing or imagining their state (Singer & Lamm, 2009). An extensive body of literature has suggested that empathy for pain can serve as a proxy for the neurobiological mechanisms underlying empathy (Decety & Lamm, 2006; Singer & Lamm, 2009). For instance, by using transcranial magnetic stimulation, Avenanti et al. (2005) found a significant decrease in the amplitudes of motor-evoked potentials (MEPs) corresponding to the specific muscle observed being penetrated. This reduction in MEP is thought to reflect corticospinal empathy, a form of empathy that involves an automatic simulation of another person's pain, activating similar neural processes as when experiencing pain oneself (Minio-Paluello et al., 2009). It has also been suggested that in order to empathize with another individual, we need to differentiate between our own affective state and that of the other (Little et al., 2023). Thus, the SOD mechanism may reduce the personal distress involved in understanding these emotions (Lamm et al., 2016). According to a recent integrative approach proposed by Thompson et al. (2019), SOD plays a key role in the cognitive processes required for empathizing with others (Thompson et al., 2019). In line with a previous study (Santiesteban, White, et al., 2012), de Guzman et al. (2016) found that participants trained to increase SOD, compared to those trained to decrease SOD, demonstrated facilitated corticospinal empathy as evidenced by reduced MEP amplitudes when observing pain applied to another person's hand versus observing touch (Experiment 1). Furthermore, participants trained to increase SOD reported enhanced explicit empathy, as measured by a self-report questionnaire, following the SOD training (Experiment 2). These results provided evidence that training SOD within the motor level (imitation–inhibition) can lead to transfer effects in other domains (e.g., empathy). However, these findings raise the question of whether the effects on empathy are unique to the SOD training used or if other types of executive function training could also enhance empathic abilities.

It has been proposed that SOD is implicated in comprehending both personal and others' emotions (Lamm et al., 2016; Shaw et al., 2020). SOD is believed to form the foundation for recognizing and managing emotions. The term "emotion regulation" encompasses a range of processes that enable us to effectively manage our emotions (Gross, 2015). It holds significant implications for social functioning and emotional well-being (Livingstone & Srivastava, 2012). More recently, a close relationship between the cognitive processes underlying emotion regulation and empathy has been proposed. An integrative framework states that the emotional state experienced by an observer, resulting from empathic processes, could potentially be influenced by the regulatory mechanisms employed to control both our own emotions and the emotions of those around us (Thompson et al., 2019). Specifically, it has been suggested that the cognitive processes involved in empathy, including the SOD mechanism, share common component processes with reappraisal (i.e., reframing the meaning of a situation to change its emotional impact; Gross, 2015), which represents a form of emotion regulation (Thompson et al., 2019). Recently, Thompson et al. (2024) examined the relationship between processes related to empathy and self-reported emotion dysregulation using behavioral and self-report measures. They found that higher visual perspective-taking ability, measured by an eye-tracking-based measure (the "Director Task," Keysar et al., 2000), was associated with lower levels of self-reported emotion dysregulation. Therefore, this finding suggests that cognitive empathy processes may facilitate emotion regulation. However, the precise nature of the cognitive control involved in emotion regulation, whether it represents a specific mechanism of SOD or a more general inhibitory control mechanism, remains unclear.

The present study aims to investigate the effect of imitation–inhibition training on emotion regulation, empathy, and ToM. Two types of training will be conducted: imitation–inhibition training (to increase SOD) and Stroop-like training (to increase general inhibitory control). The effects of imitation–inhibition training are expected to be specific to abilities dependent on self–other processing, such as imitation–inhibition, emotion regulation, empathy, perspective taking, and ToM. Given the aforementioned literature, we expect observing higher levels of sociocognitive abilities posttraining compared to pretraining in the imitation–inhibition training group. Additionally, we expect that any such effect, if present, will be less pronounced in the Stroop-like training group. Previous research has demonstrated that interventions in one sociocognitive domain (e.g., imitation–inhibition) can yield transfer effects on other domains (e.g., empathy and visual perspective taking). This study aims to build on previous work by examining whether imitation–inhibition or Stroop-like training improves sociocognitive abilities, incorporating a more intricate design that incorporates 3-day training sessions. Furthermore, this is the first empirical study that incorporates emotion regulation as a potential target of this training. Our hypothesis is that imitation–inhibition training will increase emotion regulation, empathy, and ToM, consequently leading to higher sociocognitive performance in the posttraining measurements compared to pretraining. Additionally, we expect that the magnitude of change (post–pre) will be higher in the imitation–inhibition training group compared to the Stroop-like training group.

Method

Participants

Initially, 126 adults without any psychiatric or neurological diagnosis were recruited. However, 22 participants had to be excluded for not finishing the last session of the experiment. As such, our final sample consisted of 104 healthy adults from Chile, aged 18–38 years ($M_{\text{age}} = 24.75$ years, $SD_{\text{age}} = 4.92$ years, females = 72). Participants were randomly assigned to imitation–inhibition (N = 51) or Stroop-like training (N = 53) groups. Groups did not differ in terms of age, $t(102) = -0.526$, $p = .599$, or gender, $\chi^2(1) = 1.309$, $p = .253$. Participants were recruited online through social media groups on Facebook and Instagram. The inclusion criteria for the study were (a) being between the ages of 18 and 40 years old, (b) having normal or corrected-to-normal vision, and (c) not having a current diagnosis of a psychiatric or neurological disorder. All participants enrolled in this study were fluent in Spanish. An a priori power analysis was conducted using G*Power Version 3.1.9.7 (Faul et al., 2007, 2009) for sample size estimation. To detect a medium effect size (Cohen's $d = 0.50$) with 80% power at $\alpha = .05$ (one-tailed) in an independent sample t test, the required sample size was 51 participants per group (N = 102). Thus, the obtained sample size of N = 104 is adequate to achieve the main objective of the study. All participants provided written informed consent and received 5,000 CLP (approx. €5) as compensation. Ethical approval was granted by the Ethics Committee of the Universidad de Talca (No. 30-2021).

Transparency and Openness

The data and materials are available in the Open Science Framework at https://osf.io/mwby4/?view_only=00260fcc1137459e923c158a3e1665db. This study's design and its analysis were not preregistered. We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. Data were analyzed using R Version 4.0.0 (R Core Team, 2022) and the package "ggplot2" Version 3.4.2 (Wickham, 2016). Additionally, we conducted Bayesian analyses using JASP (https://jasp-stats.org/; van Doorn et al., 2021; Wagenmakers, Love, et al., 2018; Wagenmakers, Marsman, et al., 2018).

Procedure

The entire online study was programmed using the jsPsych library (Version 6.1.0) and ad hoc plugins (Westfal et al., 2021) using a JavaScript framework for creating behavioral experiments (de Leeuw, 2015). The experiment was hosted on the online platform Cognition.run (see https://www.cognition.run/). Participants attended on 5 consecutive days, with each session occurring 24 hr after the previous one. On the first day of the study, participants were asked to complete a series of demographic questions, followed by two self-report questionnaires: the Interpersonal Reactivity Index (IRI) and the Difficulties in Emotion Regulation Scale (DERS), as well as three experimental tasks: the emotional Stroop task, the imitation–inhibition paradigm, and the Faux Pas Recognition Test. Participants received training (~30 min) on the second, third, and fourth days, with each training session preceded by a daily questionnaire on their sleep hours, stress levels, and other related factors (see Supplemental Materials). Finally, on the fifth day, participants were asked to complete the same questionnaires and tasks as on Day 1. For each session, a research assistant sent an email with the links to the tasks and questionnaires, and participants were required to respond at the same time as the previous session to ensure a 24-hr interval between each session.

Trainings

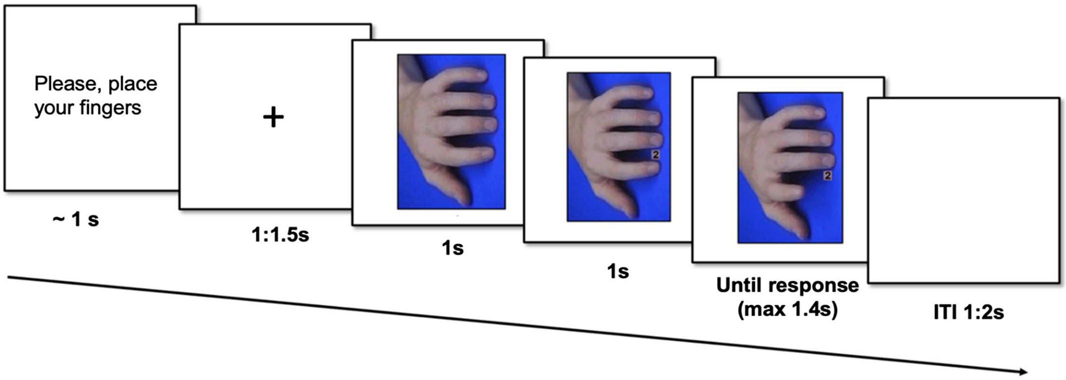
Imitation–Inhibition Training

In the imitation–inhibition training (to increase SOD; Santiesteban, White, et al., 2012), participants were required to perform the opposite finger-lifting movement to that observed in a mirrored hand displayed on a computer screen (see Figure 1). For example, when the stimulus hand on the screen showed an index finger being lifted, participants had to lift their middle finger, and when the stimulus hand on the screen showed a middle finger being lifted, participants had to lift their index finger. The training took approximately 30 min. To mitigate the potential interference from spatial compatibility effects, the finger actions observed were executed by a left hand rotated clockwise (+90°) from the participants' point of view.

Stroop-Like Training

In the Stroop-like training (to increase general inhibitory control; Santiesteban, White, et al., 2012), participants were presented with the same stimulus hand on the screen as in the imitation–inhibition training; however, the hand was static (see Figure 2). Before the start of every block, the participants were instructed to imagine wearing a red or green ring on their index or middle finger. The participants were asked to lift the finger with the opposite color ring to the color of the stimulus on the screen. For example, when a red rhombus appeared between the fingers of the stimulus hand on the screen, participants should lift their "green" finger, that is, the one with the green ring. The color of the rings

Figure 1
Example of a Trial From the Imitation–Inhibition Training



Note. In this training, participants were first asked to press their index finger down on the "G" key and their middle finger down on the "H" key. Next, following a fixation cross, a static left hand was presented for 1,000 ms before the onset of an irrelevant number, either 1 or 2, along with a finger-lifting movement. Participants were asked to lift their index finger when the middle finger of the stimulus hand was lifted and to lift their middle finger when the index finger of the stimulus hand was lifted. ITI = intertrial interval. See the online article for the color version of this figure.

was counterbalanced on each block on a within-subjects basis. The training took approximately 30 min.

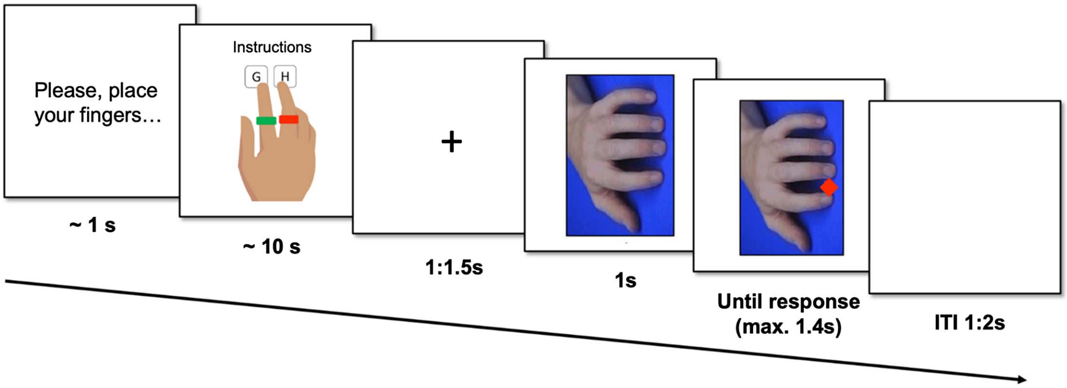
Test of Social Cognition

Emotional Stroop Task

In this task, colored words were presented individually to the participants, and their task was to identify the color of each word as quickly and accurately as possible (see Figure 3). The words were drawn from three categories of different valence: neutral words (e.g., chair), positive emotional words (e.g., joy), and negative emotional words (e.g., blood). The participants were instructed to respond with the key associated with the color (red, green, or yellow). A total of 225 trials (75 negative, 75 positive, and 75 neutral) were presented in five blocks of 45 trials each in a pseudorandomized order, such that no more than two trials of the same type were presented in succession.

The list of words was originated from a pilot study in which participants ($n = 21$; $M_{\text{age}} = 18.6 \pm 0.81$ years, 17 females) rated 150 words on valence and arousal using 10-point rating scales. Twenty-five negative words (e.g., depressed, suffering; valence -8.68 ± 0.35; arousal 7.72 ± 0.34), 25 positive words (e.g., happiness, thankful; valence 8.53 ± 0.36; arousal 7.59 ± 0.37), and 25 neutral words (e.g., door, table; valence 0.28 ± 0.32; arousal 0.56 ± 0.25) were chosen for the emotional Stroop task

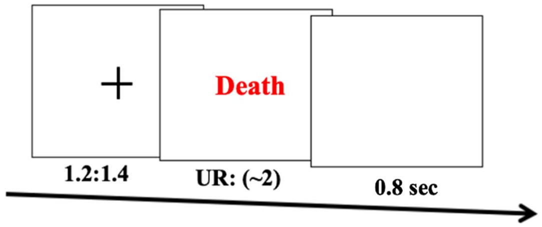
Figure 2
Example of a Trial From the Stroop-Like Training



Note. Participants were asked to press their index finger down on the "G" key and their middle finger down on the "H" key. Next, following a fixation cross, a static left hand was presented for 1,000 ms before the onset of a red or green rhombus, along with a static left hand. Participants were asked to lift the "red finger" (the finger with a red ring) when a green rhombus appeared and to lift their "green finger" when a red rhombus appeared on the screen. ITI = intertrial interval. See the online article for the color version of this figure.

Figure 3

Example of a Trial From the Emotional Stroop Task



Note. The participants were asked to respond to the color (red, green, or yellow) of the presented word. This word could have a neutral valence, positive emotional valence, or negative emotional valence. UR = until response. See the online article for the color version of this figure.

(see Supplemental Materials). To assess differences in arousal between the word groups, a Bonferroni-corrected t test was conducted. The results revealed that there was no significant difference in arousal between the positive and negative word groups, Bonferroni-corrected t test $t(72) = 1.48$, $p = .43$; however, both the positive and negative words were found to be more arousing than the neutral words, negative versus neutral: $t(72) = 77.69$, $p < .01$; positive versus neutral: $t(72) = 76.22$, $p < .01$.

Imitation–Inhibition Task

The imitation–inhibition task was used to assess the control of imitative responses. At the beginning of the imitation–inhibition task (Brass et al., 2000, 2001), participants were instructed to press down the "G" and "H" keys on a keyboard using their right index and middle fingers (see Figure 2). Once their fingers were in place, the task started. The trial began with a fixation cross displayed on the center of the screen for 1–1.5 s, followed by an image of a hand resting for 1 s. Then, a number (1 or 2) appeared between the two fingers, and one of the fingers lifted up (either the index or middle finger). The participants were instructed to lift their index finger for number 1 and their middle finger for number 2. The image stayed on the screen until the participant responded or for 1.4 s, whichever came first. After a variable period of 1–2 s, the next trial began. The observed finger movements could either match (congruent trials) or not match (incongruent trials) the instructed finger movements, and there was also a "neutral" condition where a number was displayed but no finger movement occurred. To eliminate the effects of spatial orientation, the observed hands were rotated relative to the surface. There were a total of 240 randomized trials, with 80 trials in each condition (congruent, incongruent, and neutral).

Faux Pas Recognition Test

The Faux Pas Recognition Test is a widely used measure of ToM (Baron-Cohen et al., 1999; Stone et al., 1998). The test aims to evaluate the ability to recognize situations where someone unintentionally expresses something inappropriate that can be harmful or offensive to another person. This test consists of a series of 20 short stories: 10 stories with a Faux Pas in which a character inadvertently commits a social error or *faux pas*, and the other 10 serve as control stories. The order of presentation for the faux pas and control stories is randomized. Following each story, there are eight questions that correspond to the variables considered in this assessment: (a) Faux Pas Detection (cognitive ToM), (b) Person Identification (cognitive ToM), (c) Understanding Inappropriateness (cognitive ToM), (d) Intentions (cognitive ToM), (e) Belief (cognitive ToM), (f) Empathy (affective ToM), and (g) and (h) Control Questions, which evaluate comprehension of the story. For this study, we used the Spanish adaptation by De Achaval (2010) and followed the scoring system proposed by Stone et al. (1998; see https://docs.autismresearchcentre.com/tests/FauxPas_Adult.pdf). Participants were awarded 1 point for each correct answer, with higher scores indicating a better understanding of the *Faux Pas*.

The IRI

IRI is a self-report questionnaire that measures an individual's empathy and ability to understand and respond to the feelings of others (Davis, 1983). The Chilean version of the IRI used in this study (Fernández et al., 2011) comprises 28 items designed to assess four facets of empathy: perspective taking (IRI PT), empathic concern (IRI EC), personal distress (IRI PD), and fantasy (IRI PS). The IRI PT subscale measures the ability to adopt another person's point of view, while the IRI EC subscale measures the tendency to experience compassion and concern for others. The IRI PD subscale measures the degree to which an individual feels anxious or uncomfortable when confronted with another's negative emotions, and the IRI PS measures the tendency to identify with fictional characters and emotionally invest in their experiences. A high score in one of the subscales indicates a greater tendency toward empathy in that specific facet of empathy. In the present study, the IRI demonstrated good internal consistency reliability at pretest (Cronbach's $\alpha = .80$) and posttest (Cronbach's $\alpha = .83$).

The DERS

DERS is a measure of emotional dysregulation and has been used as a tool for investigating emotion regulation abilities in adults (Gratz & Roemer, 2004). The Chilean version of the DERS (Guzmán-González et al., 2014), used in this study, comprises 25 items designed to assess five dimensions of emotion regulation: nonacceptance of emotional responses, difficulty engaging in goal-directed behavior, impulse control difficulties, lack of emotional awareness, and lack of emotional clarity. The overall score, referred to as the DERS total score, can be calculated, with high scores indicating greater difficulties in managing emotions effectively. In the present study, the DERS total score demonstrated excellent internal consistency reliability at pretest (Cronbach's $\alpha = .93$) and posttest (Cronbach's $\alpha = .95$).

Data Analysis

Prior to the statistical analysis, all extreme reaction times (RTs) and questionnaire scores identified using the interquartile range (IQR) method were discarded (IQR, Tukey, 1977). In the emotional Stroop task, RTs that were above 3,000 ms or below 200 ms (0.06%), as well as RTs of incorrect responses (2.78%), were removed. In the imitation–inhibition task, we followed the procedures outlined by Westfal et al. (2021), removing trials with RTs shorter than 100 ms (0.01%) and eliminating any erroneous trials (3.76%). We also removed RTs below and above 3 *SDs* of the participant's mean (1.39%). Each participant's mean average RTs for congruent and incongruent trials were computed, along with the calculation of a congruency effect (incongruent RTs minus congruent RTs). Additionally, we calculated the proportion of errors (PE) for congruent and incongruent trials. Based on previous studies, we decided to compute inverse efficiency (IE) scores and focus on them for subsequent analysis, as both RTs and PE showed a similar pattern of effects (Bruyer & Brysbaert, 2011). The IE is calculated as the RTs divided by the proportion of correct trials [RTs/(1 − PE)] (Bruyer & Brysbaert, 2011; see also Hogeveen & Obhi, 2013). IE scores are frequently recommended to account for trade-offs between speed and accuracy (Liesefeld & Janczyk, 2019). In situations where there is a trade-off between speed and accuracy, the IE effect helps to adjust for variations in the proportion of incorrect responses. IE is measured in milliseconds (ms), similar to RTs, but it provides an estimate of the time taken for accurate responses.

Data normality was evaluated with the Shapiro–Wilk test, and appropriate parametric and nonparametric analyses were selected accordingly. First, to compare differences among training sessions, the RTs and accuracy data were analyzed using a Friedman test, followed by post hoc analysis with Wilcoxon signed-rank tests. Second, to compare the differences within groups in every sociocognitive measure, Wilcoxon signed-rank tests were performed. Additionally, we examined whether the magnitude of increase or decrease differed between the two types of training. We calculated a pre-/postdifference score (post–pre) for each group and then conducted an independent sample *t* test. A Wilcoxon rank-sum test was conducted to ensure no significant differences between the pretraining values of the two training groups. All analyses were conducted using R Version 4.0.0 (R Core Team, 2022). Additionally, we performed Bayesian independent sample *t* tests to evaluate the likelihood of favoring the one-sided, directed alternative hypotheses regarding the distinct effects of imitation–inhibition training on emotion regulation, empathy, and attribution of mental states to others compared to the null hypothesis (H0: There is no difference in the effects between imitation–inhibition training and Stroop-like training). We tested a specific alternative hypothesis for each sociocognitive ability (i.e., H1). We conducted Bayesian analyses using JASP (https://jasp-stats.org/; van Doorn et al., 2021; Wagenmakers, Love, et al., 2018; Wagenmakers, Marsman, et al., 2018). JASP default priors were used as the model for H1.

Results

Training

RTs

We observed that during the imitation–inhibition training, the RTs decreased monotonically from Session 1 to Session 3, $\chi^2(2) = 45.5$, $p < .001$; dashed line, left side of Figure 4. Similarly, in the Stroop-like training, the RTs consistently decreased from Session 1 to Session 3, $\chi^2(2) = 15.2$, $p < .001$; dashed line, right side of Figure 4.

Accuracy

We observed that the imitation–inhibition training significantly improved behavioral performance from 92% to >95% after three training sessions, $\chi^2(2) = 7.48$, $p = .024$; solid line, left side of Figure 4. Post hoc analysis with Wilcoxon signed-rank tests revealed that accuracy reached an asymptote from the second to the third training session, $W = 358$, $p = .239$. In the Stroop-like training, accuracy significantly improved monotonically from 84% to >90% after three sessions, $\chi^2(2) = 10.0$, $p = .007$; solid line, right side of Figure 4. Post hoc analysis with Wilcoxon signed-rank tests revealed that accuracy reached an asymptote from the second to the third training session, $W = 316$, $p = .304$.

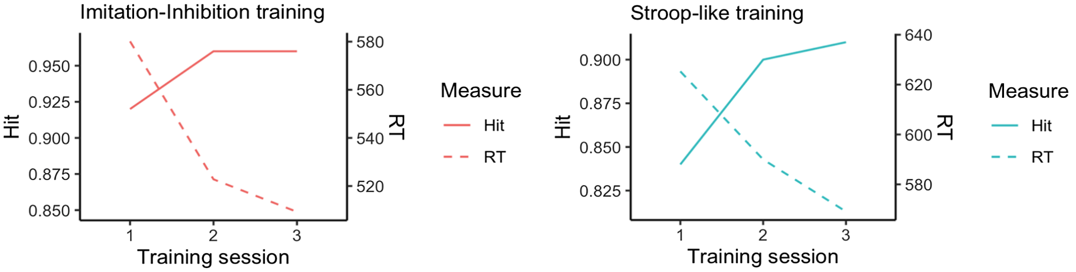
Imitation–Inhibition Task

After removing RTs outliers (1.39%) and excluding erroneous trials (3.76%), a total of 103 participants were distributed between the two training conditions: imitation–inhibition training ($N = 50$) and Stroop-like training ($N = 53$). Groups differed in terms of pretraining IE congruency effect ($U = 1{,}739$, $p = .006$, effect size $r = 0.27$). Specifically, the pretraining IE congruency effect was higher for the imitation–inhibition group (*Mdn* = 45.55, IQR = 52.45) compared to the Stroop-like training group (*Mdn* = 26.50, IQR = 38.20).

The analysis of the IE congruency effect revealed a significant decrease of the IE congruency effects from pretraining to posttraining for both the imitation–inhibition training group (pre: *Mdn* = 45.55, IQR = 52.45; post: *Mdn* = 33.95, IQR = 32.93, Wilcoxon signed-rank test: $W = 886.5$, $p = .016$, effect size $r = 0.34$)

Figure 4

Behavioral Results of Each Training



Note. Both the imitation–inhibition training group and the Stroop-like training group maintained accuracy (Hit) above 90%, while their RTs consistently decreased. RTs = reaction times. See the online article for the color version of this figure.

and the Stroop-like training group (pre: *Mdn* = 26.50, IQR = 38.20; post: *Mdn* = 17.30, IQR = 31.50, *W* = 989.5, *p* = .015, effect size *r* = 0.33; see Figure 5A).

To compare the difference between the groups in mean change of the IE congruency effect, we computed a post–pre difference score (Δ) and performed an independent *t* test with a directional hypothesis that the imitation–inhibition training would lead to an increased SOD, as indicated by a lower congruency effect (i.e., lower IE scores) compared to the Stroop-like training (H1: Imitation–inhibition training increases the SOD, resulting in lower IE scores; imitation–inhibition training < Stroop-like training).

We observed no difference in the ΔIE congruency effects between the training groups, imitation–inhibition: *M* = –18.20, *SD* = 46.12; Stroop-like: *M* = –12.89, *SD* = 43.76, *t*(102) = −0.598, *p* = .275, Cohen's *d* = −0.12; see Figure 5B. To further investigate this directed hypothesis, we conducted a Bayesian independent samples *t* test using JASP (JASP Team, 2023). Under the null hypothesis, we expect an effect size of 0. Thus, we define H_0: $\delta = 0$. Under the alternative hypothesis, we expect a negative effect; that is, H_1: $\delta < 0$. We found a Bayes factor for the null of $\mathrm{BF}_{-0} = 2.869$, which means that the observed data are approximately 2.9 times more likely under H_0 than under H_1. In sum, these data provide anecdotal evidence in favor of H_0.

Explicit Emotion Regulation: DERS

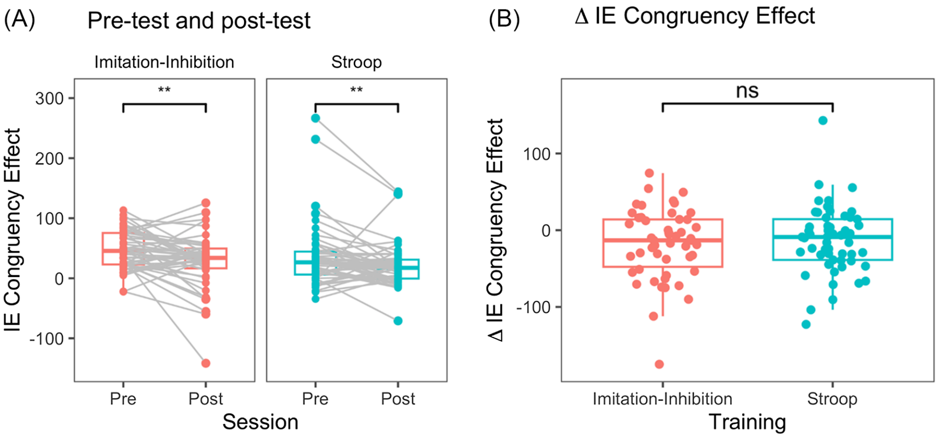
Figure 6 shows DERS total scores for each training group. After removing outliers and excluding incomplete data, a total of 101 participants were distributed between the two training conditions: imitation–inhibition (*N* = 49) and Stroop-like (*N* = 52). Groups did not differ in terms of pretraining DERS total scores (imitation–inhibition: *Mdn* = 54.0, IQR = 21.0; Stroop-like: *Mdn* = 50.0, IQR = 22.50, *U* = 1,298, *p* = .873, effect size *r* = 0.019). There was a significant decrease in scores from pretest DERS total score to posttest DERS total score for the imitation–inhibition group, pre: *M* = 53.45, *SD* = 13.86; post: *M* = 50.38, *SD* = 13.01, *t*(48) = 3.564, *p* ≤ .001, Cohen's *d* = 0.51. However, no significant difference was observed for the Stroop-like group (pre: *M* = 54.15, *Mdn* = 50.0, IQR = 22.50; post: *M* = 53.25, *Mdn* = 48.0, IQR = 35.25, *W* = 739.5, *p* = .207, effect size *r* = 0.19; see Figure 6A). These findings indicate that only the imitation–inhibition training reduced participants' total scores on the DERS, which suggests that imitation–inhibition training increased self-reported emotion regulation.

To compare the difference between the groups in mean change in the DERS total scores, we computed a post–pre difference score (Δ) and performed an independent *t* test with a directional hypothesis that the imitation–inhibition training would lead to an enhanced emotion regulation, as indicated by a lower ΔDERS total score, compared to the Stroop-like training (H1: Imitation–inhibition training enhances emotion regulation, resulting in lower ΔDERS total score; imitation–inhibition training < Stroop-like training).

The analysis of the ΔDERS total score revealed a significant difference between the training groups, with the imitation–inhibition group exhibiting a lower value (*M* = –3.061, *SD* = 6.01) compared to the Stroop-like training group, *M* = –0.904, *SD* = 5.83; *t*(99) = −1.829, *p* = .035, Cohen's *d* = 0.364; Figure 6B. To further investigate this directed hypothesis, we conducted a Bayesian independent samples *t* test using JASP (JASP Team, 2023). Under the null hypothesis, we expect an effect size of 0. Thus, we define H_0: $\delta = 0$. Under the alternative hypothesis, we expect a negative effect; that is, H_1: $\delta < 0$. We found a Bayes factor of $\mathrm{BF}_{-0} = 1.759$, which means that the observed data are approximately 1.76 times

Figure 5

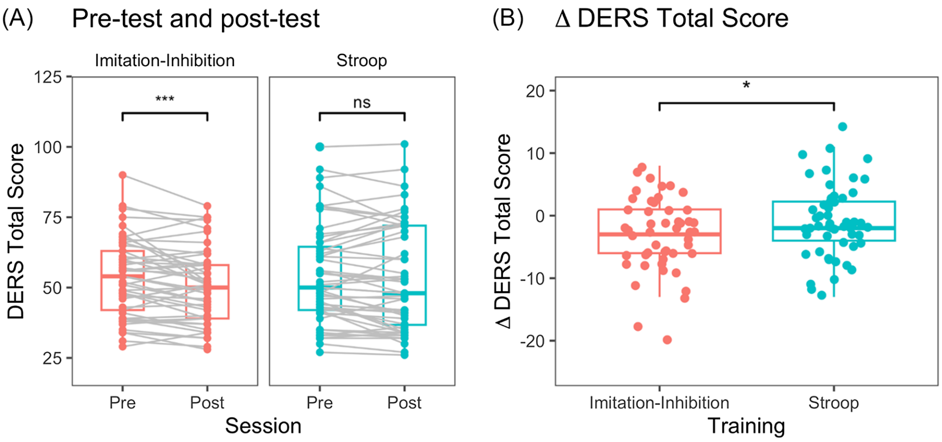
Performance of Each Training Group on the Imitation–Inhibition Task



Note. Panel A: The pretest and posttest IE congruency effect congruency effect (IE Incongruent-IE Congruent) for both training groups. Panel B: A comparison of the Δ (post–pre) IE congruency effect for the two training groups. The median of each data distribution is indicated by the center line located in the middle of the box, while the interquartile range (IQR) is represented by the box, with the lower quartile representing the 25th percentile and the upper quartile representing the 75th percentile. IE = inverse efficiency; ns = not significant. See the online article for the color version of this figure.
** *p* < .01.

Figure 6

DERS Total Scores for Each Training Group



Note. Panel A: Pretest and posttest DERS total scores for both training groups, which illustrate that DERS total scores decreased following imitation–inhibition training. Panel B: ΔDERS total score through boxplots for both the imitation–inhibition and Stroop-like training groups. DERS = Difficulties in Emotion Regulation Scale; ns = not significant. See the online article for the color version of this figure.

* $p < .05$. *** $p < .001$.

more likely under H_1 than under H_0. These data provide anecdotal evidence in favor of H_1; that is, imitation–inhibition training enhanced self-reported emotion regulation by reducing DERS total scores.

Implicit Emotion Regulation: The Emotional Stroop Task

Figure 7 shows RTs data from the emotional Stroop task. After removing outliers (0.06%) and excluding erroneous trials (2.78%), a total of 104 participants were distributed between the two training conditions: imitation–inhibition ($N = 51$) and Stroop-like ($N = 53$). Groups did not differ in terms of pretraining emotional Stroop effect (ESE: RTs negative-RTs neutral) RTs (imitation–inhibition: *Mdn* = 13.90, IQR = 38.65; Stroop-like: *Mdn* = 9.10, IQR = 24.25, $U = 1325.5$, $p = .866$, effect size $r = 0.017$). The results of the analysis of the ESE revealed that there was no significant change in RTs from the pretest to the posttest for both the imitation–inhibition group (pre: *Mdn* = 13.90, IQR = 38.65; post: *Mdn* = 5.40, IQR = 17.10, Wilcoxon signed-rank test: $W = 729$, $p = .539$, effect size $r = 0.09$) and the Stroop-like group (pre: *Mdn* = 9.10, IQR = 24.25; post: *Mdn* = 4.17, IQR = 23.0, Wilcoxon signed-rank test,

Figure 7

Performance of Each Training Group on the Emotional Stroop Task

Note. Panel A: Pretest and posttest ESE for both training groups illustrate that ESE (negative-neutral, RT) did not increase following either the Stroop-like training or the imitation–inhibition training. Panel B: A comparison of the ΔESE RTs for the two training groups. RT = reaction time; ns = not significant. See the online article for the color version of this figure.

$W = 835$, $p = .292$, effect size $r = 0.145$; see Figure 7A). These results indicate that neither the imitation–inhibition nor the Stroop-like training were able to reduce emotional interference.

To compare the difference between the groups in mean change in the ESE, we computed a post–pre difference score (Δ) and performed an independent t test with a directional hypothesis that the imitation–inhibition training would lead to an increased implicit emotion regulation, as indicated by a lower ESE (i.e., lower RTs), compared to the Stroop-like training (H1: Imitation-inhibition training increases implicit emotion regulation, resulting in lower ESE RTs; imitation–inhibition training < Stroop-like training). The results indicated a nonsignificant difference between the training groups, imitation–inhibition: $M = -2.96$, $SD = 27.83$; Stroop-like: $M = -6.40$, $SD = 28.15$, $t(102) = 0.628$, $p = .734$, Cohen's $d = 0.123$; see Figure 7B. To further investigate this directed hypothesis, we conducted a Bayesian independent samples t test using JASP (JASP Team, 2023). Under the null hypothesis, we expect an effect size of 0. Thus, we define H_0: $\delta = 0$. Under the alternative hypothesis, we expect a negative effect; that is, H_1: $\delta < 0$. We found a Bayes factor of $BF_{0-} = 7.296$, which means that the observed data are approximately 7.3 times more likely under H_0 than under H-. These data provide moderate evidence in favor of H0.

Empathic Concern

Figure 8 shows empathic concern (IRI EC) scores for each training group. After removing outliers and excluding incomplete data, a total of 102 participants were distributed between the two training conditions: imitation–inhibition ($N = 50$) and Stroop-like ($N = 52$). Groups did not differ in terms of pretraining IRI EC scores (imitation–inhibition: $Mdn = 22.0$, IQR = 5.75; Stroop-like: $Mdn = 21.0$, IQR = 6.0, $U = 1{,}450$, $p = .317$, effect size $r = 0.12$). The analysis of the empathic concern IRI EC scores revealed a significant decrease in scores from pretest to posttest for both the imitation–inhibition group (pre: $Mdn = 22.0$, IQR = 5.75; post: $Mdn = 20.0$, IQR = 6.0, $W = 695$, $p = .007$, effect size $r = 0.39$) and the Stroop-like group, pre: $M = 20.1$, $SD = 4.17$; post: $M = 19.3$, $SD = 4.12$, $t(51) = 2.505$, $p = .015$, Cohen's $d = 0.35$; see Figure 8A.

Next, we compared the difference between the groups in the Δ IRI EC score with a directional hypothesis that the imitation–inhibition training would lead to a better empathic concern, as indicated by a greater ΔIRI EC score, compared to the Stroop-like training (H1: Imitation–inhibition training increases empathic concern, resulting in higher ΔIRI EC score; imitation–inhibition training > Stroop-like training). The analysis revealed a nonsignificant difference in the Δ IRI EC score between the training groups, imitation–inhibition: $M = -0.94$, $SD = 2.46$; Stroop-like: $M = -0.78$, $SD = 2.27$, $t(100) = -0.323$, $p = .626$, Cohen's $d = -0.06$; see Figure 8B.

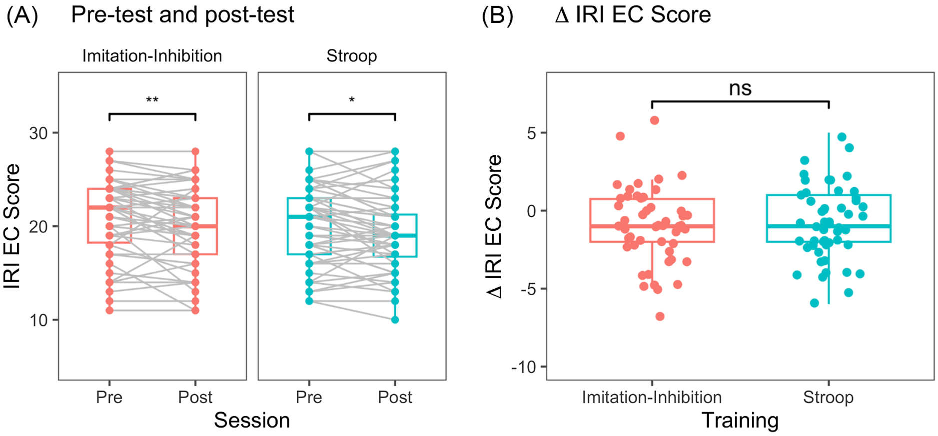
To further investigate this directed hypothesis, we conducted a Bayesian independent samples t test using JASP (JASP Team, 2023). Under the null hypothesis, we expect an effect size of 0. Thus, we define H0: $\delta = 0$. Under the alternative hypothesis, we expect a positive effect; that is, H1: $\delta > 0$. We found a Bayes factor of $BF_{0+} = 6$, which means that the observed data are approximately 6 times more likely under H0 than under H1. These data provide moderate evidence in favor of H0.

Perspective Taking

Figure 9 shows perspective-taking (IRI PT) scores for each training group. After removing outliers and excluding incomplete data, a total of 103 participants were distributed between the two training conditions: imitation–inhibition ($N = 51$) and Stroop-like ($N = 52$). Groups did not differ in terms of pretraining IRI PT scores, imitation–inhibition: $M = 18.94$, $SD = 4.09$; Stroop-like: $M = 19.44$, $SD = 3.77$, $t(101) = -0.647$, $p = .519$, Cohen's $d = -0.13$. The analysis of the IRI PT scores revealed no significant differences in scores from pretest to posttest for either of the

Figure 8

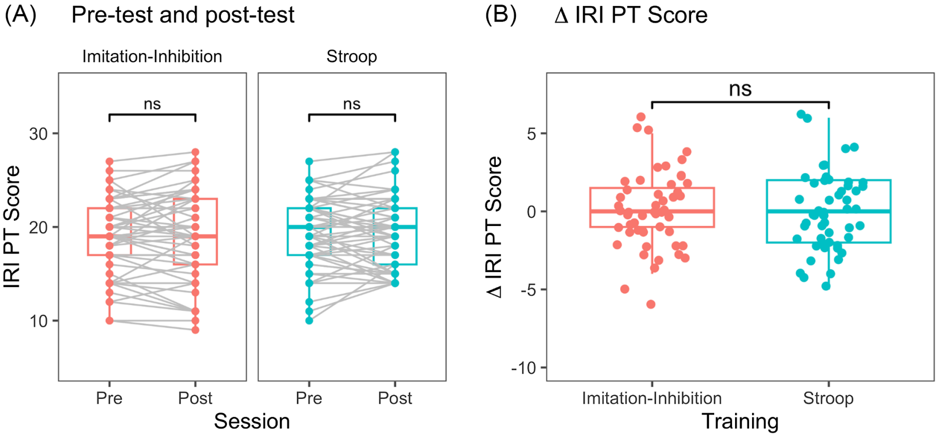
IRI EC Scores for Each Training Group



Note. Panel A: Pretest and posttest IRI EC scores for both training groups, which illustrate that IRI scores decreased following both the imitation–inhibition and the Stroop-like training. Panel B: A comparison of the ΔIRI EC score for the two training groups. IRI = Interpersonal Reactivity Index; EC = empathic concern; ns = not significant. See the online article for the color version of this figure.
* $p < .05$. ** $p < .01$.

Figure 9

IRI PT Scores for Each Training Group



Note. Panel A: Pretest and posttest IRI PT scores for both training groups. Panel B: A comparison of the ΔIRI PT score for the two training groups. IRI = Interpersonal Reactivity Index; PT = perspective taking; ns = not significant. See the online article for the color version of this figure.

groups: imitation–inhibition group, pre: $M = 18.94$, $SD = 4.09$; post: $M = 19.02$, $SD = 4.79$, $t(50) = -0.230$, $p = .819$, Cohen's $d = -0.03$; Stroop-like group, pre: $M = 19.44$, $SD = 3.77$; post: $M = 19.42$, $SD = 3.81$, $t(51) = 0.056$, $p = .955$, Cohen's $d = 0.008$; Figure 9A.

Next, we compared the difference between the groups in the Δ IRI PT score with a directional hypothesis that the imitation–inhibition training would lead to an enhanced perspective taking, as indicated by a greater ΔIRI PT score, compared to the Stroop-like training (H1: Imitation–inhibition training increases perspective taking, resulting in higher ΔIRI PT score; imitation–inhibition training > Stroop-like training). The analysis revealed a nonsignificant difference in the Δ IRI PT score between the training groups, imitation–inhibition: $M = 0.08$, $SD = 2.44$; Stroop-like: $M = -0.02$ $SD = 2.45$, $t(101) = 0.202$, $p = .42$, Cohen's $d = 0.040$; see Figure 9B.

To further investigate this directed hypothesis, we conducted a Bayesian independent samples t test using JASP (JASP Team, 2023). Under the null hypothesis, we expect an effect size of 0. Thus, we define H0: $\delta = 0$. Under the alternative hypothesis, we expect a positive effect; that is, H1: $\delta > 0$. We found a Bayes factor of $BF_{0+} = 4.10$, which means that the observed data are approximately 4 times more likely under H0 than under H1. These data provide moderate evidence in favor of H0.

Personal Distress

Figure 10 shows personal distress (IRI PD) scores for each training group. No data was removed after preliminary checks for missing data or outliers. Thus, a total of 104 participants were distributed between the two training conditions: imitation–inhibition ($N = 51$) and Stroop-like ($N = 53$). Groups did not differ in terms of pretraining IRI PD scores, imitation–inhibition: $M = 12.80$, $SD = 5.61$; Stroop-like: $M = 13.08$, $SD = 5.14$, $t(102) = -0.257$, $p = .797$, Cohen's $d = -0.05$. The analysis of the IRI PD scores revealed a nonsignificant decrease in scores from pretest to posttest for the imitation–inhibition group, pre: $M = 12.80$, $SD = 5.61$; post: $M = 12.49$, $SD = 4.84$, $t(50) = 0.785$, $p = .436$, Cohen's $d = 0.11$. However, a significant decrease from pretest to posttest was observed for the Stroop-like group, pre: $M = 13.08$, $SD = 5.14$; post: $M = 11.28$, $SD = 5.88$, $t(52) = 5.444$, $p \leq .00$, Cohen's $d = 0.11$; Figure 10A. These findings indicate that Stroop-like training decreased self-oriented personal distress feelings.

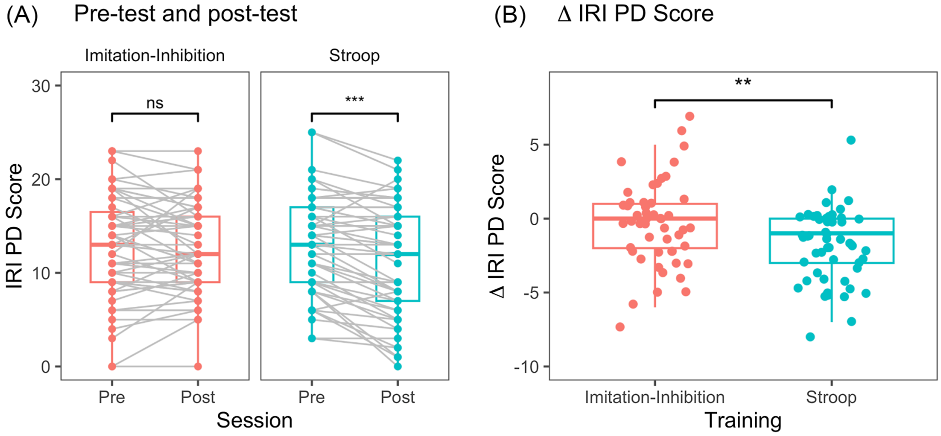
Next, we compared the difference between the groups in the Δ IRI PD score with a nondirectional hypothesis (two-tailed; H1: imitation–inhibition training ≠ Stroop-like training). The analysis of the ΔIRI PD scores between the groups revealed a significant difference between the training groups, with the Stroop-like training exhibiting a lower value ($M = -1.79$, $SD = 2.40$) compared to the imitation–inhibition training, $M = -0.31$, $SD = 2.85$, $t(102) = 2.86$, $p < .01$, Cohen's $d = 0.56$; Figure 10B. To further investigate this nondirectional hypothesis, we conducted a Bayesian independent samples t test using JASP (JASP Team, 2023). We found a Bayes factor of $BF_{10} = 7.445$, which means that the observed data are approximately 7.5 times more likely under H_1 than under H_0. In sum, these data provide moderate evidence in favor of H_1; that is, Stroop-like training effectively reduced feelings of personal distress.

Faux Pas Recognition Test

Figure 11 shows Faux Pas Total (ratio) scores for each training group. After removing outliers and excluding incomplete data, a total of 100 participants were distributed between the two training conditions: imitation–inhibition ($N = 49$) and Stroop-like ($N = 51$). Groups did not differ in terms of pretraining Faux Pas Total score, imitation–inhibition: $M = 0.60$, $SD = 0.10$; Stroop-like: $M = 0.62$, $SD = 0.09$, $t(98) = -0.7$, $p = .8$, Cohen's $d = -0.139$. The analysis of the Faux Pas Total score revealed no significant differences in scores from pretest to posttest for either of the groups: imitation–inhibition group, pre: $M = 0.60$, $SD = 0.10$; post: $M = 0.61$,

Figure 10

IRI PD Scores for Each Training Group



Note. Panel A: Pretest and posttest IRI PD scores for both training groups, which illustrate that IRI PD scores decreased only after the Stroop-like training. Panel B: A comparison of the ΔIRI PD scores for the two training groups. IRI = Interpersonal Reactivity Index; PD = personal distress; ns = not significant. See the online article for the color version of this figure.

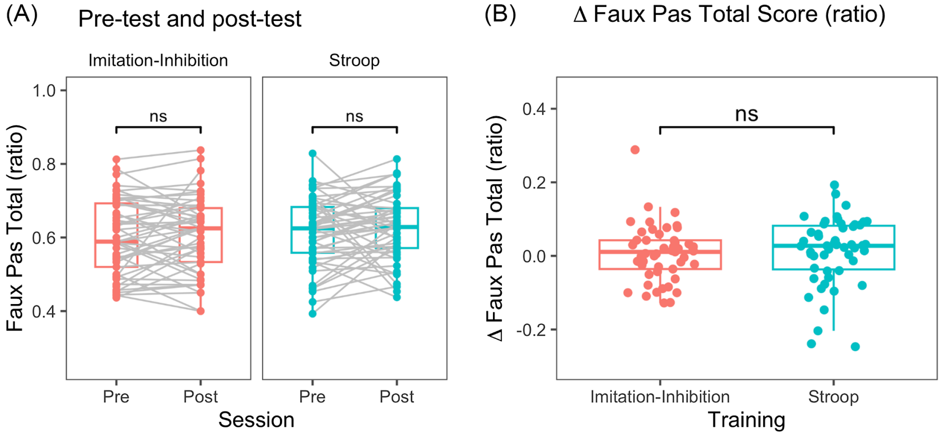
** $p < .01$. *** $p < .00$.

SD = 0.10, $t(48) = -0.6$, $p = .6$, Cohen's $d = -0.08$; Stroop-like group, pre: $M = 0.62$, $SD = 0.09$; post: $M = 0.63$, $SD = 0.11$, $t(50) = -0.9$, $p = .4$, Cohen's $d = -0.131$; Figure 11A.

Next, we compared the difference between the groups in the ΔFaux Pas Total score with a directional hypothesis that the imitation–inhibition training would lead to an increased ToM, as indicated by a greater ΔFaux Pas Total score, compared to the Stroop-like training (H1: Imitation–inhibition training increases ToM, resulting in higher ΔFaux Pas Total score; imitation–inhibition training > Stroop-like training). The analysis revealed a nonsignificant difference in the Δ Faux Pas Total score between the training groups, (imitation–inhibition: *Mdn* = 0.01, IQR = 0.08; Stroop-like: *Mdn* = 0.03, IQR = 0.12, $U = 1{,}073$, $p = .89$, effect size $r = 0.122$; see Figure 11B). These results indicate that neither the imitation–inhibition nor the Stroop-like training was able to improve the attribution of mental states to others. To further investigate this directed hypothesis, we conducted a Bayesian independent samples *t* test using JASP (JASP Team, 2023). Under the null hypothesis, we expect an effect size of 0. Thus, we define H0: $\delta = 0$. Under the alternative hypothesis, we expect a positive effect; that is, H1: $\delta > 0$. We found a Bayes factor of $BF_{0+} = 6.015$ which means that the observed data are approximately 6 times more likely under H0 than under H1. In sum, these data provide moderate evidence in favor of H0.

Figure 11

Faux Pas Total Scores (Ratio) for Each Training Group



Note. Panel A: Pretest and posttest IRI PT scores for both training groups. Panel B: A comparison of the ΔFaux Pas Total score (ratio) for the two training groups. IRI = Interpersonal Reactivity Index; PT = perspective taking. See the online article for the color version of this figure.

Discussion

In this study, we investigated the effects of training to inhibit the tendency to imitate the actions of others on socioaffective abilities. We used two types of training: imitation–inhibition training and Stroop-like training. Our analysis yielded five key findings. First, both types of training improved the control of imitation. Second, participants who received training in imitation–inhibition showed enhanced self-reported emotion regulation, as observed 24 hr after the completion of a 3-day training period. We observed this improvement compared to the Stroop-like training group. Third, emotional interference remained unchanged following both types of training. Fourth, both training paradigms resulted in decreased self-reported empathic concern, while only Stroop-like training led to a reduction in personal distress. Moreover, neither type of training had an impact on self-reported perspective taking or ToM performance. In the next section, we will examine the current findings, emphasizing their theoretical significance, constraints, and avenues for future research.

Our first finding was that both imitation–inhibition training and Stroop-like training enhanced the control of imitation. This finding aligns with the results of a previous study by Santiesteban, White, et al. (2012) that shows that both forms of training improved the control of imitation. Altogether these findings suggest that imitation–inhibition training and Stroop-like training can increase self–other processes in the motor domain. However, an alternative interpretation could be that the observed enhancement in SOD in both types of training paradigms arises from the similarity in terms of stimuli used in the experimental tasks, supporting the generalist view that imitation–inhibition is mediated by the same kind of cognitive process as general inhibitory control (e.g., Cooper et al., 2013; Heyes, 2011). In our study, although the Stroop-like training did not involve finger-lifting actions (biological movement), participants did respond to red or green rhombi between the index and middle finger of a stationary hand. This was designed to control for the social aspect of the imitation–inhibition training, while keeping the stimuli as similar as possible in both training types. However, we adapted the original training paradigm used in Santiesteban, White, et al. (2012) to an online format, which required participants to remember the imaginary ring color of the finger instead of wearing a sticker on the knuckle. This modification likely increased the task's reliance on working memory compared to the imitation–inhibition training. To mitigate this, we provided a color-finger mapping reminder at the beginning of each block, significantly reducing working memory load. However, we acknowledge that participants still needed to remember the ring's color during each trial, imposing some cognitive demand. Despite this, these two types of training, similar in their surface characteristics, potentially enhanced SOD at the motor level similar to what was observed by Santiesteban, White, et al. (2012). In a broader context, these findings are also intriguing in relation to ongoing debates regarding the precise contribution of specific neurocognitive mechanisms associated with social cognition and domain-general mechanisms related to cognitive control in the imitation–inhibition (Darda & Ramsey, 2019). On the one hand, it has been proposed that the inhibition of imitation relies on a multiple demand network associated with stimulus–response compatibility tasks, rather than a social cognition specialized network (see Darda & Ramsey, 2019, for a meta-analysis). However, previous neuroimaging studies (e.g., Brass et al., 2009; Spengler et al., 2009) and recent neurostimulation studies have provided evidence into the involvement of a domain-specific network of social cognition associated with the ToM network (Hogeveen et al., 2015; Nobusako et al., 2017; Santiesteban, Banissy, et al., 2012; Santiesteban et al., 2015; Sowden & Catmur, 2015). These recent findings suggest an active contribution of sociocognitive processes to the inhibition of automatic imitation, rather than relying solely on executive functions. However, it is crucial to approach the interpretation of this evidence with caution due to its limited basis in a few studies. Therefore, to gain a deeper understanding of the role of domain-general processes in imitation–inhibition, conducting additional research using neurostimulation methods may offer insights into the neurocognitive mechanisms causally involved in imitation–inhibition.

Our second finding was that only imitation–inhibition training increased self-reported emotion regulation. This improved self-report emotion regulation after imitation–inhibition training (but not after Stroop-like training) suggests that the capacity for SOD can be seen as a crucial component of emotion regulation, functioning as a cognitive process that enables individuals to make inferences about another person's emotional state and how it relates to their own. This, in turn, has a significant impact on shaping their emotional response. This finding not only contributes to our understanding of how strengthening SOD can improve sociocognitive performance, as supported by previous research (de Guzman et al., 2016; Santiesteban, White, et al., 2012), but it also holds particular relevance in the study of difficulties in emotion regulation observed in clinical populations. Recent research has highlighted challenges in emotion regulation among individuals with impaired SOD, such as those with autism spectrum conditions (Berkovits et al., 2017), borderline personality disorder (De Meulemeester et al., 2021), and psychosis spectrum symptoms (Assaf et al., 2022), among others. Therefore, our findings underscore a vital connection between SOD and effective emotion regulation, suggesting that interventions aimed at improving SOD may have therapeutic potential for individuals facing emotional regulation challenges. To the best of our knowledge, this study presents the first evidence of the impact of imitation–inhibition training on emotion regulation. Taken together, these findings suggest that imitation–inhibition training enhances emotion regulation abilities and may potentially improve emotion regulation in clinical populations.

Our third finding was that emotional interference (i.e., the degree to which cognitive control was influenced by emotional stimuli compared to neutral stimuli) as measured by the emotional Stroop task is unaffected by either form of training. The emotional Stroop task is a widely employed measure to assess attentional mechanisms toward emotional stimuli (Kappes & Bermeitinger, 2016). Interestingly, our findings indicate that neither the imitation–inhibition training nor the Stroop-like training fully accounted for the attentional processing demands of the emotional Stroop task. Moreover, although previous studies have suggested that individuals with enhanced emotion regulation abilities would exhibit reduced levels of emotional interference effects compared to those with lesser regulation abilities (e.g., Koole & Rothermund, 2011; Zhang & Lu, 2012), our findings do not provide support for this assumption. Instead, we propose that there was no training effect on the emotional Stroop task because the task did not require a distinction between self and other. Specifically, the "affective content" of the emotional Stroop task was not directed toward either the self or the other.

Our fourth finding revealed significant influences on empathy following the training. Firstly, both imitation–inhibition training and Stroop-like training were found to decrease self-reported empathic concern (EC). EC refers to the feeling of concern and sympathy toward others, leading to altruistic actions (Eisenberg et al., 2010). According to the framework proposed by Coll et al. (2017), empathy is a state that arises as a consequence of two main components: emotion identification and affect sharing. Emotion identification refers to the ability to accurately infer and recognize the emotional state experienced by another person. On the other hand, affect sharing refers to the degree to which attributing an affective state to another person elicits a similar state within oneself. According to this framework, EC may reflect a balance of these two components, accurately identifying and understanding the emotional states of others, leading to a more other-focused empathic response. It has been proposed that to truly experience empathy, an individual must perceive the pain of another, share that emotional state, and consciously recognize that it is distinct from their own personal experience (Singer & Klimecki, 2014; Singer & Lamm, 2009). According to this assumption, enhancing EC requires strengthening representations of others while inhibiting self-representations. Therefore, the decrease in EC may indicate an enhancement of self-representations and inhibition of other representations, similar to the imitation–inhibition (Cook, 2014). Moreover, our results in the imitation–inhibition group of lower EC (a component of affective empathy) and higher emotion regulation are broadly consistent with those reported by Thompson et al. (2022), who found that individuals with higher trait affective empathy exhibited increased difficulties with emotion regulation. Additionally, it has been proposed that empathy entails the sharing of painful emotions and comprehending the emotions of others is rooted in an embodied simulation process based on one's own emotional experiences (Lamm et al., 2016). Therefore, the EC may be indicative of an improved self–other distinction, as opposed to an overlap between self and other representations necessary for experiencing and sharing the emotions of others (Gallese, 2007; Gallese et al., 2004; Keysers & Gazzola, 2006). It is essential to acknowledge, as previously noted, that the study by de Guzman et al. (2016) on the impact of imitation–inhibition training on empathy utilized two distinct measures: self-report questionnaires and a task involving painful stimuli while measuring MEPs. This methodological distinction introduces a potential confounding variable when interpreting the findings. Specifically, when participants were exposed to painful stimuli, it is conceivable that they experienced emotions such as avoidance or discomfort, thinking, "I would not like that to happen to me," rather than truly empathizing with the isolated body part. Consequently, the observed differential amplitude of MEPs in response to painful stimuli could potentially signify a reaction to an aversive stimulus rather than genuine empathy (see, for instance, Granovsky et al., 2019). Another aspect of empathy that we explored was personal distress (PD), which refers to a self-oriented and aversive emotional response characterized by discomfort when one perceives or encounters the distress of others (Eisenberg et al., 2010). It has been suggested that the ability to accurately distinguish between self and others is crucial in preventing the onset of PD (Decety & Lamm, 2011). This SOD allows individuals to maintain a clear boundary between their own emotions and those of others, enabling empathetic responses without becoming overwhelmed by PD. According to Coll et al. (2017), PD may represent a more limited form of affect sharing, experiencing emotional overarousal without accurately identifying the specific emotions. Our results indicated that only Stroop-like training led to a reduction in self-reported PD suggesting that imitation–inhibition training alone was insufficient to decrease PD. Although it is natural to assume that a stronger SOD would result in lower PD (Lamm et al., 2016), our findings suggest that cognitive processes beyond SOD seem to regulate PD. For instance, individuals may employ disengagement coping strategies such as distraction or avoidance behaviors to mitigate PD (e.g., Hofmann & Hay, 2018; Waugh et al., 2020), indicating that self–other processes alone may not be sufficient in reducing feelings of PD. Taken together, these results challenge the straightforward interpretation of the role of SOD in empathy. Therefore, further investigation and careful consideration of alternative methods (e.g., MEP) are necessary to gain a comprehensive understanding of empathy-related responses to painful stimuli and the underlying role of SOD.

In the context of empathy, we also examined the impact of training on self-reported perspective taking, which refers to the ability to adopt the perspectives of others and understand their point of view (Davis, 1983; Keysar et al., 2000). However, neither imitation–inhibition training nor Stroop-like training showed a significant effect on self-reported perspective taking. This finding suggests that neither type of training alone is capable of influencing perspective taking as measured by the IRI. This result seems to contradict previous findings that training to inhibit imitation can enhance visual perspective taking as measured by the Director Task (Santiesteban, White, et al., 2012). However, it is important to note that self-report perspective taking and visual perspective taking involve different underlying mechanisms and information processes.

Our fifth finding shows that ToM performance remained unaffected by both types of training. ToM refers to the ability to attribute mental states to self and others (Premack & Woodruff, 1978). The attribution of mental states to others is a crucial aspect of social cognition that involves understanding and inferring the thoughts, beliefs, and emotions of individuals around us (Happé et al., 2017). This ability is closely linked to the concept of SOD. The original proposal by Brass et al. (2009) suggested that the neural network activation observed during imitation–inhibition tasks exhibited similarities to the activation observed during ToM tasks. They proposed that this shared activation may indicate a common process known as SOD, which plays a crucial role in both imitation–inhibition and ToM. Drawing from the self–other control theory (Brass et al., 2009; Spengler et al., 2009), we hypothesized that training in imitation–inhibition would result in an improvement in the attribution of mental states to others. Our results did not support this prediction, as neither the imitation–inhibition training nor the general inhibitory control had an impact on the attribution of mental states to others. These findings align with a previous study (Santiesteban, White, et al., 2012) that reported a lack of a transfer effect from imitation–inhibition training to the mental stories condition of a ToM task. Although it seems that the attribution of mental states to others may not share a common SOD process with imitation–inhibition, it is conceivable that a ceiling effect limited our ability to observe a differential effect from the training on this task. As a result, the task lacked the necessary sensitivity to identify enhanced performance in ToM exhibited by the imitation–inhibition group. Santiesteban, White, et al. (2012) suggested that the absence of a training effect in the ToM task might be attributed to the difference in "online" versus "offline" requirements between the imitation–inhibition task and the ToM task. In the ToM task, "online" SOD is unnecessary, unlike in the imitation–inhibition task where there is conflict between the intentions of the participant to perform their own intentions to follow the instructions (just follow the numbers) and representations of the other (hand on the screen performing a finger movement and ignoring the "other" hand). In the context of the ToM task, when participants "put themselves in the mental shoes of the character," the need to actively control representations of self and other is minimized, unlike in the imitation–inhibition task, where SOD is explicitly demanded. This distinction in task requirements may potentially account for the differing outcomes observed between the two tasks and highlights the importance of considering the specific cognitive demands and processes involved in each task when interpreting the results (Cook, 2014). It is important to note that we employed the Faux Pas Recognition Test (Baron-Cohen et al., 1999; Stone et al., 1998), a ToM task that has been widely used to examine social cognitive abilities in various clinical populations, including individuals with frontal damage and autism spectrum disorders. Therefore, it is conceivable that the impact of training interventions on the attribution of mental states to others in neurotypical individuals may be limited or insufficient. These findings suggest that additional factors or approaches may be necessary to effectively enhance the normal functioning of attributing mental states to others (e.g., Baimel et al., 2015). Taken together, the ToM task employed in this study appears to be more sensitive to clinical populations rather than neurotypical individuals. This observation may help explain the lack of training effects on the attribution of mental states to others.

Limitations and Future Directions

The present study has several limitations that need acknowledgment. Firstly, it was conducted in an online setting, with participants completing computer-based tasks from their homes. This format may have introduced confounding factors, such as variations in environmental conditions and distractions at participants' locations. However, it is noteworthy that online studies using the imitation–inhibition task have shown comparable behavioral effects in effect size and reliability to in-person conditions (Westfal et al., 2021). These findings suggest that online research can be a viable and effective approach for studying imitation–inhibition. Another limitation is the number of statistical tests conducted, including some one-tailed tests, which increases the Type I error rate. To address this concern, we employed Bayesian analysis, which provides several advantages over traditional frequentist methods like *t* tests (Kruschke, 2013). Bayesian analysis generates complete distributions of credible values for key parameters, such as effect sizes, group means and differences, standard deviations, and normality assessments. Additionally, the Bayesian decision rule allows for accepting the null hypothesis when the credible estimates have high precision. By leveraging these advantages of the Bayesian framework, we aimed to reinforce the reliability of our inferences despite the multiplicity of tests performed. A limitation to consider is the emotional Stroop task used in our study. The word list in this task was not evenly matched in terms of letter and syllable counts, despite piloting with a small group of undergraduate students. This mismatch could introduce confounding factors, affecting the task's validity. Future studies should aim to improve the emotional Stroop task's design by carefully matching words based on letters and syllables, enhancing its reliability and validity as an inhibitory control measure. Another limitation relates to the Faux Pas Recognition Test. Valuable for assessing social cognition, this lengthy task (approximately 30 min) may have caused participant fatigue, potentially impacting their performance, especially toward the end of the test. An additional constraint is our reliance on self-report measures for evaluating empathy and emotion regulation. These measures are inherently subjective and could be influenced by factors like social desirability. Moreover, the sociocognitive measures employed primarily focused on trait-level characteristics rather than state-level features. According to Schmitt and Blum (2020), traits are enduring patterns of thoughts, feelings, and behaviors that remain consistent across situations, vary among individuals, and remain stable over time. In contrast, states are temporary patterns tied to specific situations at a given moment, varying based on the circumstances a person encounters. Therefore, it might be surprising that we found effects on the IRI and DERS scales, which are thought to rely on trait-level measures rather than state-level measures. However, it is possible that the training effects led to pre–post differences in offline social cognition rather than online social cognition (Schilbach, 2014). According to the framework proposed by Schilbach (2014), the offline social cognition involves the observer's point of view when there is no conflict between self and other representations, and it leans toward slower and more reflective processing. On the other hand, online social cognition refers to the interactor's point of view, depending on quick, instinctive judgments and resembling real-time social interaction. Our finding of training effects on offline social cognition (similar to trait-level features) rather than online social cognition (similar to state-level features) may be expected if we consider this study did not resemble real-time social interaction and relied more on offline measures. We acknowledge this limitation and suggest that future studies should incorporate measures of online social cognition to better capture the potential effects of the training on state-level social cognitive processes. Additionally, future research should explore whether the benefits of imitation–inhibition training depend on "online" or "offline" task processing. Lastly, our reliance on participants from Chile limits the generalizability of our findings. To enhance cross-cultural applicability, future research should include a diverse, multinational sample.

Conclusion

This study aimed to examine the effects of imitation–inhibition training on emotion regulation, empathy, and ToM. This study provides novel empirical evidence demonstrating that participants trained in imitation–inhibition increased self-reported emotion regulation compared to a group trained in general inhibitory control. Furthermore, both training interventions resulted in diminished self-reported empathic concern, while only inhibitory control training led to a reduction in personal distress. Moreover, neither type of training had an impact on self-reported perspective taking, and ToM performance remained unaffected as well. The current findings suggest that the same SOD process may underlie both the ability to inhibit imitation and emotion regulation. More importantly, they hold potential significance for both theoretical models and clinical interventions.

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