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ORIGINAL PAPER

Training the Moral Self: An 8-Week Mindfulness Meditation Program Leads to Reduced Dishonest Behavior and Increased Regulation of Interoceptive Awareness

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Abstract

Objectives Recent meta-analyses suggest that mindfulness meditation may enhance prosocial behavior, while evidence regarding moral behavior is still scarce. We combined a randomized controlled mindfulness training design with an ecologically valid moral decision-making task (Temptation to Lie Card Game; TLCG), in which participants were tempted to deceive an opponent to increase their monetary payoff.

Method TLCG and self-report measures (in the domains of attention regulation, body awareness, emotion regulation, and change in the perspective of the self) were administered to participants who underwent the mindfulness meditation training (experimental group, $n = 44$) or were waitlisted (control group, $n = 25$) twice: before and after the 8-week training.

Results Concerning moral decision-making, we observed a significant effect involving condition, time, and group. Trained participants deceived significantly less in the post-training as compared with the pre-training phase ($p = 0.03$), while untrained ones showed no significant change ($p = 0.58$). In the self-reports, significant effects involving time and group were found for the Multidimensional Assessment of Interoceptive Awareness (MAIA-2) in Self-Regulation, Attention Regulation, Body Listening, and for the Five Facet Mindfulness Questionnaire (FFMQ) in Non-Reactivity to inner experience. Trained participants showed a time-related increase in all subscales scores, while untrained ones did not. Finally, a moderation analysis revealed a significant interaction between weekly mindfulness meditation training minutes and MAIA-2 Attention Regulation (post-training) on moral behavior change.

Conclusions Our preliminary results suggest that mindfulness meditation practice decreases self-serving dishonest behavior and increases awareness of one's bodily and emotional state. In particular, the amount of mindfulness meditation practice predicted moral behavior change in practitioners who reported the highest regulation of attention towards internal bodily signals.

Preregistration This study is not preregistered.

Keywords Mindfulness meditation · Moral decision-making · Dishonest behavior · Reward · Resistance to temptation · Interoceptive awareness

Although mindfulness meditation has been classically investigated in the domain of individual functioning (e.g., attention, cognitive, or emotional control), recent studies began to investigate whether the beneficial effects of mindfulness practice can extend individual boundaries, reaching the domain of social and moral functioning. In the Buddhist tradition, mindfulness meditation has been used as a tool to promote wholesome actions, virtuous and prosocial qualities. Consistently, several recent studies found that mindfulness meditation increases prosocial outcomes like helping (Berry et al., 2018; Condon et al., 2013; Lim et al., 2015) and charitable (Chen & Jordan, 2020; Hafenbrack et al., 2020; Iwamoto et al., 2020) behavior. Recent

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meta-analyses reported positive effects of mindfulness practice on prosocial outcomes (Berry et al., 2020; Donald et al., 2019). In particular, it is described that mindfulness-only interventions increased compassionate helping (but not instrumental or generosity-related) behavior and reduced prejudice and retaliation (Berry et al., 2020). However, some studies reported opposite findings, namely that mindfulness meditation reduced charitable (secular mindfulness only; Chen & Jordan, 2020) and prosocial (Poulin et al., 2021) behavior. Furthermore, the employment of reward-based tasks hinders the dissociation between enhanced other-oriented motivation and decreased monetary reward salience in studies investigating the effects of mindfulness meditation on prosocial behavior (Feruglio et al., 2022).

Evidence regarding the effects of mindfulness on moral behavior is still scarce. Previous studies investigating the association between dispositional mindfulness and morality showed that dispositional mindfulness was negatively related with both impulsivity and moral disengagement (Georgiou et al., 2020); positively related with moral sensitivity, moral identity, and prosocial tendencies (Xiao et al., 2020); predicted moral responsibility, but not moral judgment (Small & Lew, 2021); and was associated with reduced cheating behavior (Ruedy & Schweitzer, 2010). Moreover, other investigations indicated that mindfulness-based trainings induced improvements in moral cognition, e.g., embracing a more objective point of view instead of a subjective perspective in moral reasoning (Pandey et al., 2018; Shapiro et al., 2012).

The above-mentioned studies suggest that mindfulness meditation may promote moral behavior. Interestingly, a series of studies investigated whether enhanced emotion regulation and decreased emotional reactivity typically associated with mindfulness meditation trainings could have detrimental consequences in the moral domain. Schindler et al. (2019) employed short breathing mindfulness exercises and assessed reparative intentions or behaviors after a condition in which participants may have caused (or not) harm to another individual. In 2 out of 5 studies, the authors found weaker reparative intentions in the mindfulness group with respect to the control one (Schindler et al., 2019). Also, Hafenbrack et al. (2022) investigated the role of focused-breathing mindfulness meditation in affecting guilt-driven reparative behaviors. They found that mindfulness meditation reduced state guilt (Experiment 1) and reparative behaviors after guilt-inducing situations (Experiments 2a–2c). Also, they showed that (reduced) guilt mediated the negative effect of mindfulness meditation on reparative behavior (Experiments 3a and 3b) and that state mindfulness specifically weakened the association between guilt and reparative behaviors (Experiment 4). Finally, they found that reparative behavior increased more after loving kindness meditation with respect to focused-breathing meditation (Experiment 5) due to enhanced other-focus in the former type of practice (Hafenbrack et al., 2022). Schindler and Pfattheicher (2023) manipulated guilt and tested whether trait mindfulness affected prosocial behavior (Study 2), but found no evidence for a positive link between the two, suggesting that dispositional mindfulness may affect socio-moral behavior by means of more complex mechanisms (Schindler & Pfattheicher, 2023).

Crucially, it is not possible to draw firm conclusions from many of the above-mentioned studies as they mostly employed self-reports, hypothetical scenarios, or one-shot behavioral assessments instead of measuring actual behavior in a morally relevant context across multiple trials (see also Schindler & Friese, 2022). Recently, Du et al. (2023) employed a harm aversion moral decision-making task in which participants were required to establish a tradeoff between money for themselves and unpleasant electric shocks to another person. They found that an 8-week mindfulness training prevented the decline of moral preferences over time (i.e., the moral slippery slope effect; Garrett et al., 2016) in the training group, as compared with the control group. Also, they revealed that the mechanism through which mindfulness training prevents the moral slippery slope effect is by reducing the increase in the motivation to obtain money at the cost of harming another individual (Du et al., 2023).

A recent psychological and neuroscientific model (Sevinc & Lazar, 2019) proposed that heightened awareness of external and internal phenomena, resulting from enhanced activity in the salience network (Sevinc et al., 2017) and in the insular cortex (Young et al., 2018) after mindfulness-based training, may enhance the ability to detect morally relevant information and promote the emergence of socio-moral behavior. Accordingly, mindfulness-based trainings were shown to enhance interoceptive awareness, i.e., the ability to identify, access, understand, and respond appropriately to bodily signals (Craig, 2002). On the link between interoception and moral behavior, some authors found that heightened attention towards internal body sensations can shift behavior towards immoral outcomes, e.g., taking riskier and egoistic decisions (Ditto et al., 2006; Mancini et al., 2011; Williams et al., 2016); conversely, other studies showed that higher interoceptive abilities are linked to increased social connection (Arnold et al., 2019), moral identity (Scattolin et al., 2022), and more altruistic behavior (Piech et al., 2017). Recently, Vabba et al. (2022) investigated whether individual differences in the capacity to read signals from inside (interoception) and outside (exteroception) the body predicted participants' moral behavior, in conditions where their reputation was at risk or not. The authors found that cardiac interoception (but not visual exteroception) modulated moral behavior: low interoceptive participants told less egoistic lies when their reputation was at risk, while high cardiac interoceptive participants did not change their behavior depending on the reputation risk conditions (Vabba et al., 2022). Thus, whether being aware of the body and its internal signals biases moral decisions towards dishonesty or honesty remains to date an open question.

Measuring actual moral preferences may be challenging. Self-reports have issues related to social desirability and poor reliability due to retrospective reporting, while in moral dilemmas or tasks that measure behavioral intentions individuals make hypothetical judgments that are not associated with real consequences (Thielmann et al., 2020; van de Groep & Van Woudenberg, 2022). Notably, employing economic games or decision-making tasks have several advantages, as the possibility to make numerous decisions, allowing repeated and multiple assessments over time. Also, participants interact (or believe to interact) with other individuals, resembling the context in which typically moral behavior unfolds, i.e., daily social interaction. Further, participants' decisions entail direct or indirect consequences for oneself and others (e.g., the division of sums of money determines the actual payoff of both players), making them good proxies for real-life decisions. Consistently, the number of prosocial choices made in a revised version of the Altruism-Antisocial's (AlAn) game—a paradigm that requires weighing self-interest and other-harm over multiple trials—has been recently found to correlate with psychopathic trait scores (Sakai et al., 2023).

Behaviors that violate moral norms can take many forms. A specific type is deception, a social behavior in which one individual deliberately attempts to persuade another to accept something as true even if they know it to be false (Abe, 2009; Ganis & Keenan, 2009; Ponsi et al., 2021). Behaviors like deception (Mazar et al., 2008) or promise-breaking (Calluso et al., 2018) often involve a conflict between the temptation to obtain some benefit and the desire to conform to personal and socio-moral norms. Notably, a recent study found that self-serving dishonesty is associated with activity in both the dorsolateral prefrontal cortex and the orbitofrontal cortex, suggesting that both inhibitory control and valuation processes may be concurrently at play in moral decision-making (Globig et al., 2023). Proneness to deceive others can be influenced by several variables, such as moral dispositional traits (Panasiti et al., 2011, 2014), social reputational risk (Panasiti et al., 2011, 2016; Vabba et al., 2022), social stereotypes and status (Azevedo et al., 2017; Schepisi et al., 2020), moral emotions (Parisi et al., 2021), body ownership (Scattolin et al., 2022), and emotional and cognitive intelligence (Pittarello et al., 2018).

To further expand research on this topic, here we combined a randomized controlled mindfulness training design with an ecologically valid moral decision-making task (Temptation to Lie Card Game), in which participants are tempted to deceive an opponent to increase their monetary payoff. Specifically, we compared participants who took part in an 8-week mindfulness meditation course with a wait-list control group, assessing their moral decision-making and self-reported measures twice, before and after the training. Self-reports aimed at measuring attention regulation, body awareness, emotion regulation, and change in the perspective of the self, that is, the mechanisms through which mindfulness meditation is thought to exerts its effects (Hölzel et al., 2011).

Method

Participants

Participants were recruited among 125 Italian university students interested in attending a course of introduction to mindfulness meditation offered as part of the psychological assistance and support service of the University of Udine (Italy). The participation to the experimental study was not mandatory. All the students were randomly assigned to one of three groups (block randomization): two of them, which together constituted the experimental group, started the meditation course in April 2021 and one (the wait-list control group) started in June 2021. A total of 69 students (14 males, age range 20–53 years, $M_{age} = 26.29 \pm 7.31$) distributed in the three groups took part in the study and were tested in a laboratory-like, online study because of the restrictions imposed by the COVID-19 pandemic in Italy (pre-training testing: from 22 March to 13 April 2021; post-training testing: from 28 May to 10 June 2021). Participants underwent the mindfulness meditation training or were waiting to be enrolled. The experimental group ($n = 44$) consisted of two sub-groups ($n = 20$ and $n = 24$) that attended the mindfulness meditation training during the same period and with the same instructors, in different days of the week. Independent samples T-tests revealed that the two sub-groups did not differ in terms of age ($M_{\text{Sub-group1}} = 26.29 \pm 7.68$, $M_{\text{Sub-group2}} = 23.75 \pm 3.02$; $t = 1.39$, $df = 42$, $p = 0.17$, $d = 0.42$) years of education ($M_{\text{Sub-group1}} = 15.46 \pm 2.28$, $M_{\text{Sub-group2}} = 14.60 \pm 1.27$; $t = 1.50$, $df = 42$, $p = 0.14$, $d = 0.45$) number of completed training sessions ($M_{\text{Sub-group1}} = 7.42 \pm 0.88$, $M_{\text{Sub-group2}} = 7.15 \pm 1.14$; $t = 0.88$, $df = 42$, $p = 0.39$, $d = 0.27$) amount of weekly mindfulness meditation practices at home carried out during the 8 weeks ($M_{\text{Sub-group1}} = 123.96 \pm 34.29$ min, $M_{\text{Sub-group2}} = 114.00 \pm 51.93$ min; $t = 0.76$, $df = 42$, $p =$

0.45, d = 0.23), or average temporal distance between the experimental sessions ($M_{Sub\text{-}group1}$ = 66.63±4.28 days, $M_{Sub\text{-}group1}$ = 67.90±3.55 days; t = -1.06, df = 42, p = 0.30, d = -0.32). For this reason, they were treated as a single group for the subsequent statistical analyses.

One participant was excluded from the analysis for not completing at least 50% of the mindfulness training (4 out of 8 sessions), leaving 43 participants in the experimental group. The final sample was composed of 68 Italian participants (14 males, age range 20–53 years, M_{age} = 26.38±7.33, $M_{education}$ = 14.99±1.84 years, see Fig. 1 for participant flow chart and Table 1 for demographic information). The two groups did not differ in terms of age (t = -1.69, df = 66, p = 0.10, d = -0.42) and years of education (t = 0.63, df = 66, p = 0.53, d = 0.16).

Participants obtained the mindfulness meditation training course free of charge and were compensated with gift cards with a value of €10 for their performance in the moral decision-making task (see the "Moral Decision-Making" section for additional details). The study was performed in accordance with ethical standards of the 1964 Declaration of Helsinki after obtaining informed consent from each participant.

Procedure

Participants were presented with the moral decision-making task and the self-report measures twice, once in the first experimental session (pre-training time) and once in the second experimental session (post-training time, average temporal distance of 66.90 days, SD = 4.41, min = 52 days, max = 75 days, $M_{experimental}$ = 67.12, $SD_{experimental}$ = 3.98, $M_{control}$ = 66.52, $SD_{control}$ = 5.12; t = 0.54, df = 66, p = 0.59, d = 0.14).

Between the two sessions, participants belonging to the experimental group took part in an 8-week mindfulness meditation training, while the control participants did not.

Participants were instructed to perform the task in a quiet room and to complete all the experimental phases using their personal computer. The experiment was programmed and run by means of the software Psytoolkit (Stoet, 2010, 2017), which allows to run psychological experiments through the user's browser. The experiment was divided into three phases: in the first phase, participants reported their demographic data; in the second phase, they performed the moral decision-making task; and in the third phase, they were asked to respond to self-report measures.

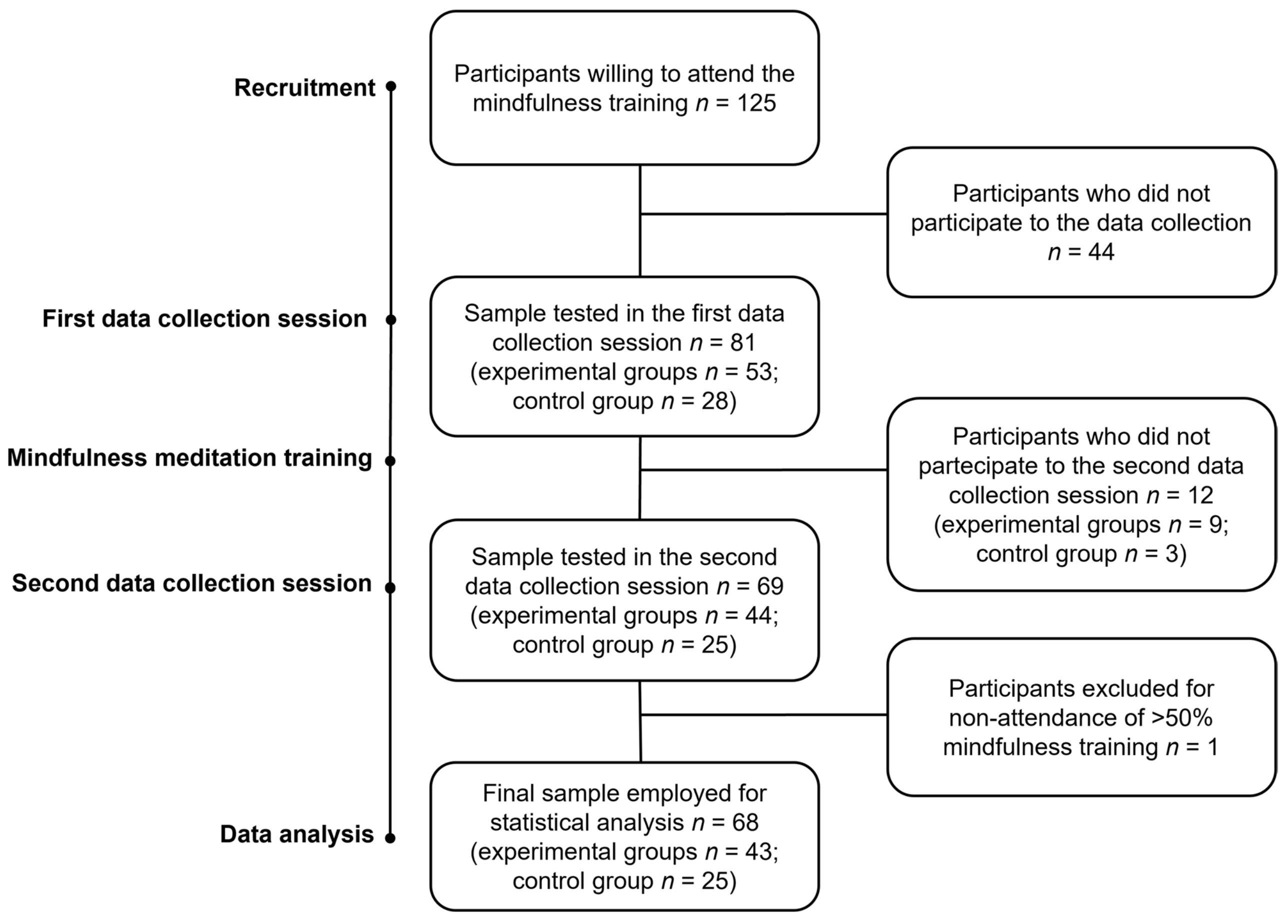

Fig. 1 Participant flow chart. The graphical representation shows the progression of participants through different phases of the study, from recruitment phase to data analysis

Table 1 Demographic and descriptive information of self-report scores, reported for the experimental and the control group

	Experimental group ($n = 43$) Mean±*SD* (%) [Cronbach's α, McDonald's ω]	Control group ($n = 25$) Mean±*SD* (%) [Cronbach's α, McDonald's ω]
	Demographic information	
Age	25.26±6.12 years	28.32±8.84 years
Age range	20–53 years	20–52 years
Gender	8 male (18.60%)	6 male (24.00%)
Education	15.09±1.94 years	14.80±1.68 years
	Descriptive information of self-report scores	
FFMQ Acting With Awareness	T0: 25.16±6.78 [0.92, 0.92] T1: 26.42±5.98 [0.91, 0.91]	T0: 23.88±6.23 [0.89, 0.90] T1: 23.64±5.60 [0.90, 0.90]
FFMQ Describing	T0: 24.91±6.90 [0.93, 0.93] T1: 26.79±7.00 [0.95, 0.95]	T0: 25.64±7.27 [0.93, 0.94] T1: 26.92±6.86 [0.94, 0.94]
FFMQ Observing	T0: 28.14±5.40 [0.78, 0.80] T1: 29.37±4.39 [0.74, 0.75]	T0: 27.24±4.73 [0.76, 0.78] T1: 26.36±5.15 [0.83, 0.84]
FFMQ Non-Judging Inner Exp.	T0: 24.56±6.60 [0.88, 0.88] T1: 26.93±6.96 [0.93, 0.93]	T0: 24.72±6.70 [0.87, 0.88] T1: 24.92±6.29 [0.90, 0.91]
FFMQ Non-Reactivity Inner Exp.	T0: 17.98±4.31 [0.83, 0.83] T1: 21.23±4.29 [0.87, 0.87]	T0: 17.56±3.82 [0.74, 0.75] T1: 18.04±3.22 [0.67, 0.65]
FFMQ Total Score	T0: 120.74±20.54 [0.92, 0.92] T1: 130.74±19.75 [0.93, 0.93]	T0: 119.04±19.42 [0.91, 0.91] T1: 119.88±16.59 [0.90, 0.91]
ERQ Cognitive Reappraisal	T0: 4.96±1.17 [0.84, 0.85] T1: 5.50±0.84 [0.81, 0.80]	T0: 5.01±0.99 [0.79, 0.78] T1: 5.26±0.90 [0.87, 0.88]
ERQ Expressive Suppression	T0: 3.65±1.42 [0.79, 0.82] T1: 3.42±1.45 [0.83, 0.84]	T0: 3.52±1.61 [0.86, 0.86] T1: 3.43±1.42 [0.75, 0.78]
MAIA-2 Attention Regulation	T0: 2.06±0.89 [0.83, 0.84] T1: 2.97±0.76 [0.81, 0.83]	T0: 1.93±0.97 [0.90, 0.91] T1: 2.05±0.85 [0.88, 0.87]
MAIA-2 Body Listening	T0: 2.18±1.04 [0.82, 0.83] T1: 2.93±1.02 [0.84, 0.85]	T0: 2.15±1.09 [0.81, 0.82] T1: 2.11±1.03 [0.83, 0.83]
MAIA-2 Emotional Awareness	T0: 3.59±0.92 [0.78, 0.77] T1: 3.87±0.79 [0.82, 0.81]	T0: 3.34±0.92 [0.77, 0.80] T1: 3.04±0.80 [0.85, 0.85]
MAIA-2 Not Distracting	T0: 2.22±0.72 [0.62, 0.63] T1: 2.36±0.77 [0.76, 0.77]	T0: 2.45±0.75 [0.65, 0.70] T1: 2.31±0.80 [0.81, 0.82]
MAIA-2 Noticing	T0: 3.40±0.72 [0.44, 0.46] T1: 3.45±0.75 [0.66, 0.68]	T0: 3.35±0.93 [0.69, 0.70] T1: 3.38±0.94 [0.70, 0.71]
MAIA-2 Not Worrying	T0: 2.22±1.24 [0.89, 0.89] T1: 2.42±1.05 [0.88, 0.89]	T0: 2.44±1.05 [0.85, 0.86] T1: 2.34±0.93 [0.84, 0.84]
MAIA-2 Self-Regulation	T0: 2.15±1.13 [0.86, 0.87] T1: 3.13±0.86 [0.81, 0.81]	T0: 2.50±0.90 [0.73, 0.73] T1: 2.11±0.87 [0.84, 0.85]
MAIA-2 Trusting	T0: 2.88± 1.28 [0.89, 0.90] T1: 3.39±1.01 [0.84, 0.84]	T0: 2.84±1.44 [0.93, 0.94] T1: 2.79±1.17 [0.88, 0.88]
MIS Internalization	T0: 4.57±0.50 [0.84, 0.86] T1: 4.52±0.56 [0.85, 0.86]	T0: 4.45±0.43 [0.64, 0.69] T1: 4.46±0.38 [0.41, 0.42]
MIS Symbolization	T0: 2.91±0.91 [0.85, 0.84] T1: 3.02±0.85 [0.84, 0.85]	T0: 3.07±0.52 [0.40, 0.41] T1: 3.20±0.75 [0.80, 0.82]

T0 refers to pre-training time, while T1 refers to post-training time

Self-reports' acronyms are the following: *FFMQ* Five Facet Mindfulness Questionnaire, *ERQ* Emotion Regulation Questionnaire, *MAIA-2* Multidimensional Assessment of Interoceptive Awareness, *MIS* Moral Identity Scale

Mindfulness Meditation Training

Participants in the experimental group attended the 8-week Mindfulness Oriented Meditation (MOM; Crescentini et al., 2014; Fabbro & Muratori, 2012; Matiz et al., 2018) program. In its structure, the program is similar to the Mindfulness-Based Stress Reduction course, one the most widespread mindfulness program developed by Kabat-Zinn (2003). The MOM training was delivered online and was organized into eight weekly group sessions of 2 hr. Each session included a short teaching on topics concerning mindfulness (such as being in the here and now, the autopilot mode, decentering from mental states), a guided mindfulness meditation practice of 30 min, and a final discussion about participants' experience and questions. The meditation practice was the same throughout the course and was divided into three parts: 10 min of paying attention to the breath (anapanasati), 10 min of paying attention to bodily sensation (body scan), and 10 min of equanimous observation of all mental states such as thoughts, emotions, and sensations (open awareness). After the first meeting, participants were given an audio file with the same guided meditation and were asked to practice daily at home.

Measures

Moral Decision-Making

In order to measure spontaneous moral decision-making, we employed the Temptation to Lie Card Game task (TLCG; Azevedo et al., 2017; Panasiti et al., 2011, 2014, 2016; Scattolin et al., 2022; Vabba et al., 2022), a zero-sum two-card card game between two players: the Player (P) and the Opponent Player (OP). All participants were Ps and interacted with one anonymous OP. After the fixation point was displayed, symbols representing the points at stake in that round were presented (i.e., one or two stars for low-value rounds and three or four stars for high-value ones). Participants were told that a different amount of points was associated to each round without knowing the exact monetary value; this prevented participants to compute trial-by-trial the exact amount of gains and losses and to avoid crossover effects. Then, covered cards were shown and the OP had to choose one of them (left or right card): the ace of hearts was the winning card, while the ace of spades was the losing one. The position of the ace of hearts/spades cards on screen (left or right) was counterbalanced across the experiment. The card chosen by the OP became framed in green and the remaining card went to the P. Crucially, the OP was not able to see the outcome of such choice and P's task was to communicate the outcome to the OP. In the case the OP picked the ace of spades, P faced a favorable outcome (i.e., P was supposed to win and OP was supposed to lose), while in the case the OP picked the ace of hearts, P faced an unfavorable outcome (i.e., P was supposed to lose and OP was supposed to win). However, P could either accept the outcome of the game (truth) or change it (lie). In the favorable outcome, P could tell the truth to their own advantage (self-gain truth) or lie to reverse the outcome to OP's advantage (other-gain lie), while in the unfavorable outcome, P could tell the truth to OP's advantage (other-gain truth) or lie to reverse the outcome to their own advantage (self-gain lie). Importantly, the points at stake were assigned to the player who won the round. Participants in the role of P responded by pressing the A or L keys, corresponding to the choice of assigning and showing the OP the left or the right card, respectively. After the decision, P was presented with the feedback about decision outcome (e.g., "You lied, you won"). Each trial consisted of the following timed sequence of elements: (1) fixation cross (300 ms), (2) information about the reward magnitude (1500 ms), (3) covered cards (random time from 1500 to 3000 ms), (4) P's decision outcome and OP's decision phase (up to 10 s), (5) P's decision feedback (1500 ms), and (6) inter-trial interval (1500 ms) (see Fig. 2 for the schematic representation of the TLCG).

Participants were informed that both players would have been compensated with book vouchers whose monetary value was computed as follows: a fixed amount of €5 and an additional bonus to be split between the two players depending on the amount of points collected throughout the experiment by each of them (i.e., the more the points, the higher the split of the bonus). Participants knew that their decision would have entailed real monetary consequences for both them and the OP. Unbeknown to the participants, the payoff was not dependent on the amount of points collected during the task, but they all received book vouchers worth €10 (€5 for participation and €2.5 for each TLCG task). Since participants may have known each other and they were not simultaneously tested, no debriefing regarding deception was made at the end of the second experimental session (post-training). However, they were informed that they could contact the experimenters for further explanations, if needed.

The task was composed by 48 total trials (6 trials per condition depending on the combination among favorable/unfavorable outcome condition, low/high reward, and left/right positioning of the chosen card). Before the actual task, participants completed 12 practice trials (8 without a decision time limit and 4 with the decision time limit set to 10 s, as in the subsequent TLCG task) in which they were informed they were playing against an algorithm. After the practice trials, participants were told that they would play the card game against a real opponent and that they had to wait before proceeding. In order to increase the credibility of the procedure, participants received a message from one of the experimenters communicating that also the other player completed the practice trials and was ready to continue with the game. In this occasion, the experimenters checked whether participants correctly understood the instructions of the game by asking if they needed further explanations. Unbeknown to the participants, the opponent did not exist, and they played against an algorithm that won the round half of the time and lost it the other half.

Immediately after the end of the TLCG, participants' involvement and guilt were assessed by means of two rating questions ("How involved did you feel in the game?", "How guilty did you feel during the game?"). Participants were asked to rate their involvement and guilt on visual analogue scales ranging from 1 (Not at all involved/guilty) to 100 (Completely involved/guilty). The involvement rating has been introduced as an indirect measure of study suspicion (as in previous studies employing the TLCG: Panasiti et al., 2016; Scattolin et al., 2023; Schepisi et al., 2020) to avoid asking participants whether they believed in the existence of the opponent player, since this could have induced doubts about the truthfulness of the social interaction.

Self-Report Measures

The self-report questionnaires aimed at evaluating participants in the following domains (Hölzel et al., 2011): attention regulation, emotion regulation, body awareness, and change in the perspective of the self (in particular, the moral self).

The *Five Facet Mindfulness Questionnaire* (FFMQ; Baer et al., 2006; Giovannini et al., 2014) is a self-report questionnaire that evaluates the five distinct facets of mindfulness. It is composed of 39 items and 5 subscales: Observing (attending to sensory stimuli that derive from both external sources and the body), Describing (labeling internal experiences with words), Acting with awareness (ongoing attention and awareness to present activity and experience), Non-judging of inner experience (non-evaluative attitude towards one's thoughts and emotions while focusing on inner experiences), and Non-reactivity to inner experience (ability to not react or being overwhelmed by distressing thoughts and emotions). Each item requires an answer on a 5-point Likert scale, from 1 (*Never or very rarely true*) to 5 (*Very often or always true*). Nineteen out of 39 items were reverse scored. The score in each subscale is obtained from the sum of the items belonging to that category. The total score is obtained from the sum of all 39 items. Higher scores represent higher levels of mindfulness and self-awareness in that specific facet or in general.

The *Emotion Regulation Questionnaire* (ERQ; Balzarotti et al., 2010; Gross & John, 2003) is a self-report questionnaire that measures individual differences in emotion regulation strategies. It is composed of 10 items and 2 subscales: Cognitive Reappraisal (cognitive change of the meaning of emotional stimuli or situations aimed at reducing emotional responding) and Expressive Suppression (inhibition of ongoing emotion-expressive behavior). Each item requires an answer on a 7-point Likert scale, from 1 (*Strongly disagree*) to 7 (*Strongly agree*). The score in each subscale is obtained from the average of the items belonging to that category. Higher scores represent greater use of that specific emotion regulation strategy.

The *Multidimensional Assessment of Interoceptive Awareness* (MAIA-2; Calì et al., 2015; Mehling et al., 2018) is a state-trait questionnaire that measures multiple dimensions of interoceptive awareness. It is composed of 37 items and 8 subscales: Noticing (awareness of uncomfortable, comfortable, and neutral body sensations), Not-Distracting (tendency not to ignore or distract oneself from sensations of pain or discomfort), Not-Worrying (tendency not to worry or experience emotional distress with sensations of pain or discomfort), Attention Regulation (ability to sustain and control attention to body sensations), Emotional Awareness (awareness of the connection between body sensations and emotional states), Self-Regulation (ability to regulate distress by attention to body sensations), Body Listening (active listening to the body for insight), Trusting (experience of one's body as safe and trustworthy). Each item requires an answer on a 6-point Likert scale, from 0 (*Never*) to 5 (*Always*). Nine out of 37 items were reverse scored. The score in each subscale is obtained from the average of the items belonging to that category. Higher scores indicate stronger interoceptive skills in that domain.

The *Moral Identity Scale* (MIS; Aquino & Reed, 2002) presents participants with the description of a person with characteristics associated with moral probity, such as fair, honest, etc. They are then told to keep such as person in mind as they decide the extent to which they agree with 10 statements. MIS measures the salience of integrity and moral values within a person's character and it is composed of 10 items and 2 subscales: Internalization (the degree to which the moral traits are relevant to the self-concept) and Symbolization (the degree to which individuals define their moral selves in reference to social groups and outward image). Each item requires an answer on a 5-point Likert scale, from 1 (*Strongly disagree*) to 5 (*Strongly agree*). Two out of 10 items were reverse scored. The score in each subscale is obtained from the average of the items belonging to that category. Higher scores indicate stronger private (Internalization) and public (Symbolization) moral identity.

Internal reliability for each psychometric scale and subscale, in pre- and post-training time, and for each group, was estimated with Cronbach's α (alpha) and McDonald's ω (omega) (Table 1). Results involving subscales with issues in internal consistency reliability, as signaled by values of Cronbach's α and McDonald's $\omega < 0.70$ (McNeish, 2018; FFMQ Non-reactivity to inner experience, MAIA-2 Noticing, MAIA-2 Not-Distracting, MIS Internalization, MIS Symbolization) will be interpreted with caution.

Data Analyses

Numbers are reported with two decimal points, apart from *p* values in tables which are expressed with three decimal points for better approximation to exact values.

Moral Decision-Making

We employed the R package *lme4* v1.1-26 (Bates et al., 2015) to perform multilevel generalized linear mixed-effects models (GLMMs). GLMMs allow for the modeling of binary outcomes (e.g., decision to lie or to tell the truth) for repeated

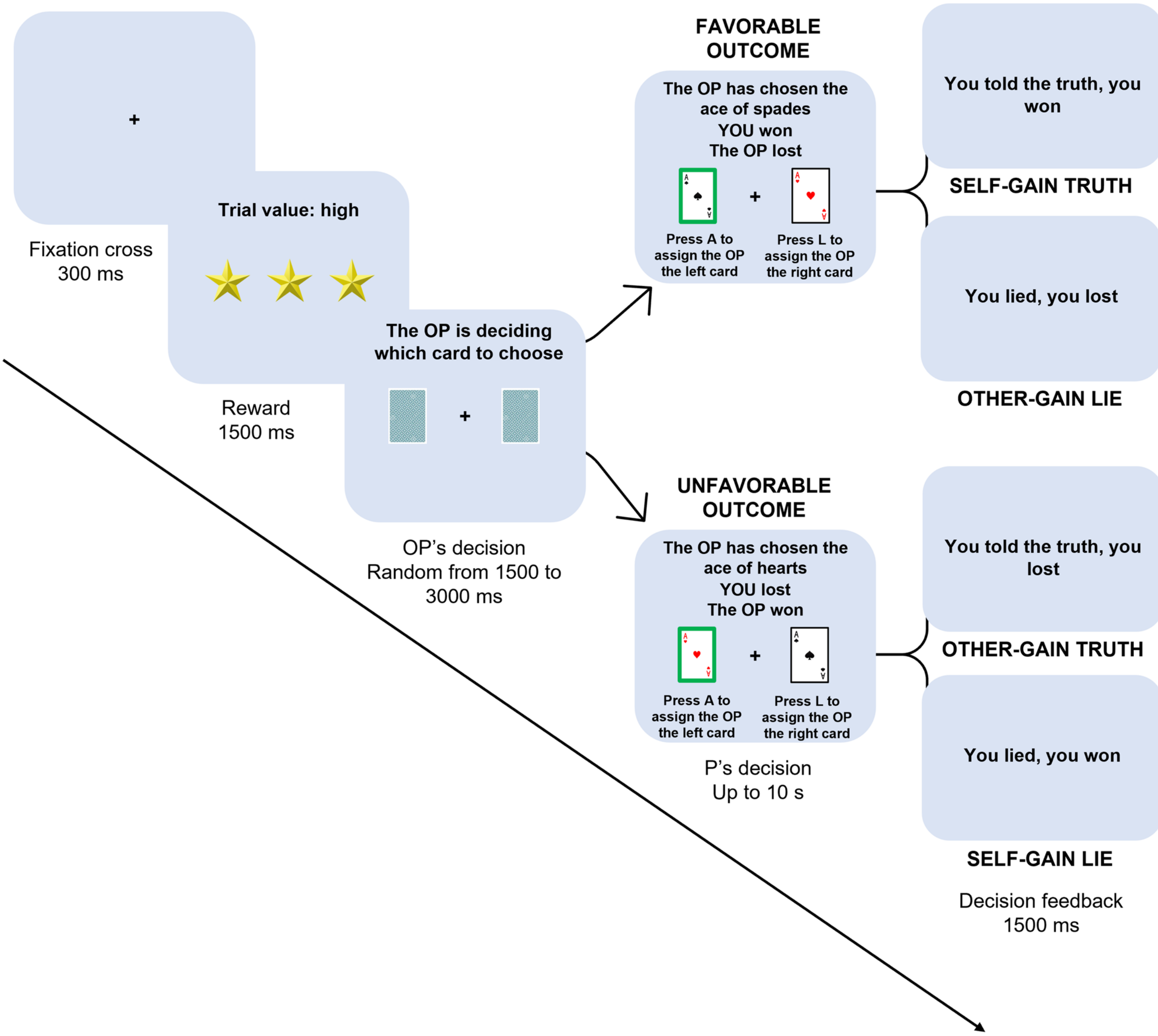

Fig. 2 Schematic representation and timeline of the TLCG task, in which reward magnitude was manipulated. The number of stars could range from 1 to 4: 1 and 2 stars signalled a low value trial, while 3 and 4 stars signalled a high value trial. P, participant; OP, opponent player. In the **Favorable Outcome** condition, the OP chose the losing card (i.e., ace of spades) and the P was supposed to win. In the **Unfavorable Outcome** condition, the OP chose the winning card (i.e., ace of hearts) and the P was supposed to lose

measures and to incorporate both fixed and random effects in the regression model (Pinheiro & Bates, 2000). Statistical analyses have been conducted on single trials data (total number of observations across all trials = 6528) with the *glmer* function. We modelled the probability to deceive the OP (dependent variable, Decision: 0 = Truth, 1 = Lie) given the following categorical predictors (independent variables): Condition (Unfavorable Outcome, Favorable Outcome), Reward (Low, High), Group (Experimental, Control), Time (Pre-training, Post-training), and their reciprocal interactions.

The fixed effects structure included the main effect of each predictor and all the reciprocal interactions. The random effects structure was determined by selecting the most parsimonious random structure using principal component analysis (PCA; lme4 function *rePCA*). PCA was run on the model with the maximum random structure (i.e., the model including the highest-order within-subject interaction—in our case the triple interaction Condition by Reward by Time—as random slope over participants (Barr, 2013) to test for overparameterization (Bates et al., 2015). In each model, by-subject random effects that explained a near-zero amount of variance (< 0.02) were removed. The employed regression model structure in the Wilkinson-Rogers notation was the following:

$$\text{Decision} \sim \text{Condition} * \text{Reward} * \text{Group} * \text{Time} + (\text{Condition} + \text{Condition} : \text{Reward} + \text{Condition} : \text{Time} + \text{Condition} : \text{Reward} : \text{Time} \mid \text{Subject})$$

Data analysis has been performed with the open software R (R Core Team, 2021), R version 4.0.4 (2021-02-15). Conditional and marginal R^2 were computed with the *report_performance* function (R package *report*; Makowski et al., 2023). Reported main effects and interactions are based on type III Wald chi-square test (function *Anova*, R package *car*; Fox & Weisberg, 2019) run on the selected model. Beta values and 95% confidence intervals were computed using a Wald z-distribution approximation, estimated with the function *report_table* (R package *report*; Makowski et al., 2023). Post-hoc comparisons were performed with the function *emmeans* (R package *emmeans*; Lenth, 2021) with false discovery rate (FDR) correction. Predicted probabilities were computed with the function *ggpredict* (R package *ggeffects*; Lüdecke, 2018). Predicted probabilities can be interpreted as the predicted probability that the outcome y (the dependent variable Decision, where 1 = Lie and 0 = Truth) is 1 for a given value of predictor x (e.g., Condition). *ggpredict* computes predicted values for all possible levels of the categorical predictors (i.e., Condition, Reward, Time, and Group) and returns predicted probabilities (also called conditional effects) conditioned on the reference level of each categorical predictor (in our case: Condition = Unfavorable Outcome; Reward = Low; Time = Pre-training; Group = Experimental). In order to provide effect size statistics, odds ratio was computed for each significant main effect or interaction using the *standardize_parameters* function (exponentiate = TRUE; R package *parameters*; Lüdecke et al., 2020). Odds ratio has also been computed for each post-hoc contrast using the *emmeans* function (type = response; R package *emmeans*; Lenth, 2021). Student's t-tests have been performed on averaged data with the software JASP (JASP Team, 2023).

We performed separate Shapiro-Wilk tests for the rating questions in each Time (Pre-training, Post-training) and Group (Experimental, Control) to check whether they followed a normal distribution. Since all p-values of the tests were less than $\alpha = 0.05$, the self-report scores were assumed to be not-normally distributed. Consequently, rating questions have been analyzed by means of analyses of variance using aligned rank transformed data by means of the function *art* (R package ARtool; Kay et al., 2021). In fact, the aligned-rank transform (ART) allows for non-parametric analyses of variance even in factorial designs (Wobbrock et al., 2011). The Bartlett's tests of homogeneity of variance have been performed with the function *bartlett.test*. The two-way repeated measures ANOVAs have been performed with the function *anova*, by using the following formula: Rating score ~ Group * Time + Error (Subject/Time).

Best linear unbiased predictors (BLUPs; Bates & Pinheiro, 1998) used as dependent variable in the moderation analyses have been extracted using the *coef* function in R, which returns the fixed effect of the interaction plus the by-subject random effect (Schepisi et al., 2020). Moderation analyses were conducted with the R package *process* (Hayes, 2022). Bootstrapping was employed to estimate robust confidence intervals (number of samples = 5000). Plots were created using the *ggplot* function (R package *ggplot2*; Wickham, 2016).

Self-Report Measures

Descriptive information for each subscale score, including Cronbach's α and McDonald's ω, are reported in Table 1. We performed separate Shapiro-Wilk tests for all self-report scores in each Time (Pre-training, Post-training) and Group (Experimental, Control) to check whether they followed a normal distribution. Since all p values of the tests were greater than $\alpha = 0.05$, the self-report scores were assumed to be normally distributed. Two-way repeated measures ANOVAs with Time (Pre-training, Post-training) as a within-subject factor and Group (Experimental, Control) as between-subject factor were conducted on each self-report measure separately.

The Shapiro-Wilk tests have been performed with the R function *shapiro.test*. The two-way repeated measures ANOVAs have been performed with the function *aov_car* (R package: *afex*; Singmann et al., 2023), by using the following formula: Self-report score ~ Group * Time + Error (Subject/Time). Post-hoc comparisons were performed with the function *emmeans* (R package *emmeans*; Lenth, 2021) with false discovery rate (FDR) correction. The Bartlett's tests of homogeneity of variance have been performed with the function *bartlett.test*. Estimated marginal means (EMMs) were computed with the *ggemmeans* (R package *ggeffects*; Lüdecke, 2018) function. Cohen's d has been computed for each post-hoc contrast using the *eff_size* function (R package *emmeans*; Lenth, 2021). Plots were created using the *ggplot* function (R package *ggplot2;* Wickham, 2016).

Results

Moral Decision-Making

The results of the type III Wald chi-square test run on the regression model can be found in Table 2. The model's total

Table 2 Analysis of deviance table (type III Wald χ^2 test) and effect size (odds ratio)

Effects	χ^2 ($df = 1$)	Beta	z	LLCI	ULCI	p	Odds ratio (*OR*)
Intercept	4.02	−1.39	−2.00	−2.75	−0.03	0.045*	0.25
Condition	10.91	−2.64	−3.30	−4.21	−1.07	< 0.001***	0.07
Reward	10.67	1.53	3.27	0.61	2.44	0.001**	4.60
Time	5.54	−1.22	−2.35	−2.24	−0.20	0.019*	0.29
Group	1.84	−1.57	−1.36	−3.83	0.70	0.175	0.21
Condition × Reward	11.63	−2.92	−3.41	−4.59	−1.24	< 0.001***	0.05
Condition × Time	4.01	1.36	2.00	0.03	2.70	0.045*	3.91
Reward × Time	0.00	−0.01	−0.01	−0.98	0.97	0.990	0.99
Condition × Group	3.93	2.59	1.98	0.03	5.16	0.047*	13.36
Reward × Group	0.01	−0.08	−0.11	−1.58	1.42	0.913	0.92
Time × Group	5.78	2.04	2.40	0.38	3.70	0.016*	7.70
Condition × Reward × Time	0.05	0.22	0.22	−1.77	2.22	0.827	1.25
Condition × Reward × Group	0.08	−0.38	−0.28	−3.05	2.30	0.783	0.69
Condition × Time × Group	8.51	−3.21	−2.92	−5.36	−1.05	0.004**	0.04
Reward × Time × Group	1.02	−0.80	−1.01	−2.34	0.75	0.313	0.45
Condition × Reward × Time × Group	0.90	1.55	0.95	−1.64	4.74	0.342	4.69

Effects of Condition, Reward, Time, Group, and their reciprocal interactions on participants' tendency to deceive the opponent during the TLCG

Significance: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

LLCI lower limit confidence interval, *ULCI* upper limit confidence interval

number of observations is 6528, while the residual degrees of freedom are 6476 ($n - k$, where $k = 52$, which correspond to the number of parameters estimated in the GLMM). Overall, the model's total explanatory power is substantial (conditional $R^2 = 0.82$, i.e., the proportion of variance explained by both the fixed and random effects) and marginal R^2 (i.e., the proportion of variance explained by the fixed effects) is of 0.15. The GLMM run on decisions taken during the TLCG revealed effects of Condition, Reward, and Time. These main effects indicate that participants lied more: (i) in the unfavorable outcome (predicted probability (*pp*) = 0.20, 95% *CI* [0.06, 0.49]) than in the favorable outcome (*pp* = 0.02, 95% *CI* [0.01, 0.04]) condition; (ii) for high (*pp* = 0.53, 95% *CI* [0.22, 0.82]) than low (*pp* = 0.20, 95% *CI* [0.06, 0.49]) reward; in the pre-training (*pp* = 0.20, 95% *CI* [0.06, 0.49]) than in the post-training (*pp* = 0.07, 95% *CI* [0.01, 0.29]) time.

We also found significant interactions of Condition by Reward, Condition by Time, Condition by Group, Time by Group, and Condition by Time by Group. Since the two-way interactions Condition by Time, Condition by Group, and Time by Group were qualified by a higher order interaction, we described and analyzed only the three-way interaction Condition by Time by Group.

FDR-corrected post-hoc comparisons computed on the two-way interaction Condition by Reward (Table 3) showed that overall participants made more self-gain than other-gain lies, both for low ($pp_{\text{self-gain lies}} = 0.20$, 95% $CI_{\text{self-gain lies}}$ [0.06, 0.49]; $pp_{\text{other-gain lies}} = 0.02$, 95% $CI_{\text{other-gain lies}}$ [0.01, 0.04], $p = 0.03$) and for high ($pp_{\text{self-gain lies}} = 0.53$, 95% $CI_{\text{self-gain lies}}$ [0.22, 0.82]; $pp_{\text{other-gain lies}} = 0.00$, 95% $CI_{\text{other-gain lies}}$ [0.00, 0.01], $p < 0.001$) reward conditions (Fig. 3, Panel a). Further, reward magnitude seemed to play a role in modulating participants' self- and other-oriented moral decision-making. On the one

Table 3 Post-hoc pairwise comparisons and effect size (odds ratio) relative to the Condition × Reward interaction

Contrast	Estimate	*SE*	z ratio	p	Odds ratio (*OR*)
Unfavorable Low – Favorable Low	1.46	0.66	2.23	0.026*	4.32
Unfavorable Low – Unfavorable High	−1.28	0.35	−3.65	<.001***	0.28
Unfavorable Low – Favorable High	2.79	0.66	4.24	<.001***	16.25
Favorable Low – Unfavorable High	−2.75	0.60	−4.56	<.001***	0.06
Favorable Low – Favorable High	1.33	0.35	3.80	<.001***	3.76
Unfavorable High – Favorable High	4.07	0.70	5.85	<.001***	58.62

Post-hoc *p*-values were FDR corrected for 6 tests. Significance: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

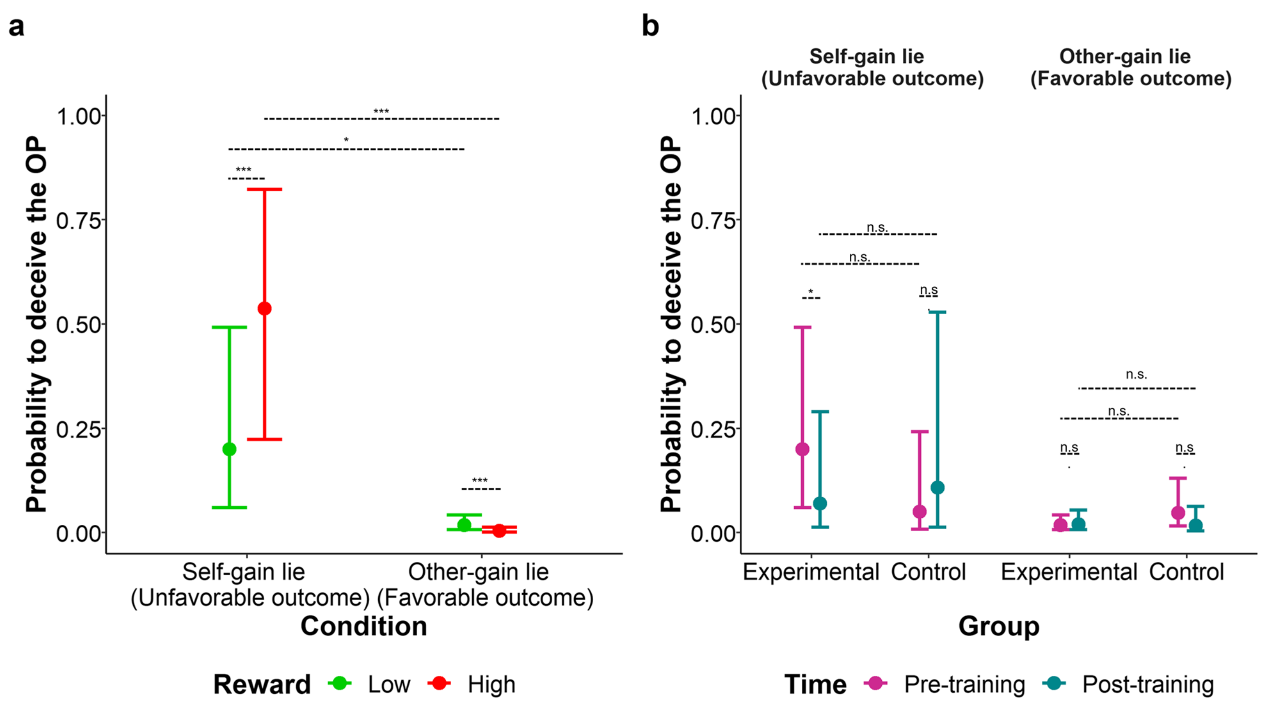

Fig. 3 Probability to lie to the opponent in the TLCG derived from the two-way interaction Condition × Reward (**a**) and the three-way interaction Condition × Time × Group (**b**). Error bars represent confidence intervals

hand, participants made more self-gain lies in the high relative to the low reward condition ($p < 0.001$). On the other hand, participants made more other-gain lies in the low relative to the high reward condition ($p < 0.001$).

FDR-corrected post-hoc comparisons computed on the three-way interaction Condition by Time by Group (Table 4) showed that, in the pre-training time, the two groups did not differ in the propensity to make both self-gain ($p = 0.22$) and other-gain lies ($p = 0.33$). Interestingly, the analyses also indicate that, in the unfavorable outcome condition, the experimental group showed a decrease in self-gain lies in the post-training ($pp = 0.07$, 95% CI [0.01, 0.29]) compared to the pre-training time ($pp = 0.20$, 95% CI [0.06, 0.49]) ($p = 0.03$; see Fig. 3, panel b). The control group showed no modulation of time on the amount of self-gain lies in the unfavorable outcome condition ($pp_{\text{pre-training}} =$ 0.05, 95% $CI_{\text{pre-training}}$ [0.01, 0.24]; $pp_{\text{post-training}} = 0.11$, 95% $CI_{\text{post-training}}$ [0.01, 0.52]; $p = 0.58$). Neither the experimental group ($pp_{\text{pre-training}} = 0.02$, 95% $CI_{\text{pre-training}}$ [0.01, 0.04]; $pp_{\text{post-training}} = 0.02$, 95% $CI_{\text{post-training}}$ [0.01, 0.05]; $p = 0.62$) nor the control group ($pp_{\text{pre-training}} = 0.05$, 95% $CI_{\text{pre-training}}$ [0.02, 0.13]; $pp_{\text{post-training}} = 0.02$, 95% $CI_{\text{post-training}}$ [0.00, 0.06]; $p = 0.40$) showed a time-related change in the propensity to make other-gain lies in the favorable outcome condition. Despite the experimental group showed a reduction in the propensity to lie to the opponent, in the post-training phase, the two groups did not differ in the amount of both self-gain ($p = 0.99$) and other-gain lies ($p = 0.99$).

To perform an intent-to-treat analysis, we performed the main GLMM analysis including the 13 participants who have been previously removed. The critical three-way interaction Condition by Time by Group is significant (χ^2 ($df =$ 1) = 7.66, $p < 0.01$, beta = −2.92, 95% CI [−4.98, −0.85]) and yielded the same results.

To focus on the main effect of Time, in both the experimental and control groups, we also performed Student's t-tests by comparing the percentage of self-gain lies in the pre-training phase with the same percentage in the post-training phase, in each group separately. The pre-training ($M = 43.61$, $SD = 37.08$, $SE = 5.65$) and the post-training ($M = 34.49$, $SD = 36.61$, $SE = 5.58$) percentages of self-gain lies were significantly different from each other ($t(42) = 2.70$, $p = 0.01$, $d = 0.41$) in the experimental group. On the contrary, the pre-training ($M = 36.49$, $SD = 34.51$, $SE = 6.90$) and post-training ($M = 41.01$, $SD = 37.40$, $SE = 7.48$) percentages of self-gain lies were not significantly different from each other ($t(24) = -0.78$, $p = 0.45$, $d = -0.16$) in the control group. We also compared the temporal evolution of other-gain lies. The pre-training ($M = 6.04$, $SD = 10.97$, $SE = 1.67$) and the post-training ($M = 9.33$, $SD = 15.46$, $SE = 2.36$) percentages of other-gain lies were not significantly different from each other ($t(42) = -1.79$, $p = 0.08$, $d = -0.27$) in the experimental group. Similarly, the pre-training ($M = 10.65$, $SD = 16.47$, $SE = 3.30$) and post-training ($M = 10.71$, $SD = 15.82$, $SE = 3.16$) percentages of other-gain lies were not significantly different from each other ($t(24) = -0.02$, $p = 0.98$, $d = -0.00$) in the control group.

Table 4 Post-hoc pairwise comparisons and effect size (odds ratio) relative to the Condition × Time × Group interaction

Contrast	Estimate	*SE*	*z* ratio	*p*	Odds ratio (*OR*)
Unfavorable Pre-training Experimental – Favorable Pre-training Experimental	4.10	0.74	5.56	<.001***	60.25
Unfavorable Pre-training Experimental – Unfavorable Post-training Experimental	1.22	0.45	2.71	0.027*	3.40
Unfavorable Pre-training Experimental – Favorable Post-training Experimental	3.85	0.68	5.63	<.001***	46.85
Unfavorable Pre-training Experimental – Unfavorable Pre-training Control	1.61	1.10	1.47	0.221	4.99
Unfavorable Pre-training Experimental – Favorable Pre-training Control	3.30	0.83	3.97	<.001***	27.15
Unfavorable Pre-training Experimental – Unfavorable Post-training Control	1.19	1.27	0.94	0.466	3.28
Unfavorable Pre-training Experimental – Favorable Post-training Control	3.84	0.89	4.31	<.001***	46.58
Favorable Pre-training Experimental – Unfavorable Post-training Experimental	−2.87	0.87	−3.31	<.01**	0.06
Favorable Pre-training Experimental – Favorable Post-training Experimental	−0.25	0.41	−0.62	0.6243	0.78
Favorable Pre-training Experimental – Unfavorable Pre-training Control	−2.49	0.97	−2.58	0.032*	0.08
Favorable Pre-training Experimental – Favorable Pre-training Control	−0.80	0.65	−1.22	0.329	0.45
Favorable Pre-training Experimental – Unfavorable Post-training Control	−2.91	1.16	−2.51	0.032*	0.05
Favorable Pre-training Experimental – Favorable Post-training Control	−0.26	0.73	−0.35	0.808	0.77
Unfavorable Post-training Experimental – Favorable Post-training Experimental	2.62	0.87	3.01	0.012*	13.77
Unfavorable Post-training Experimental – Unfavorable Pre-training Control	0.38	1.20	0.32	0.808	1.47
Unfavorable Post-training Experimental – Favorable Pre-training Control	2.08	0.97	2.14	0.060	7.98
Unfavorable Post-training Experimental – Unfavorable Post-training Control	−0.04	1.37	−0.03	0.994	0.96
Unfavorable Post-training Experimental – Favorable Post-training Control	2.62	1.02	2.56	0.032*	13.70
Favorable Post-training Experimental – Unfavorable Pre-training Control	−2.24	0.99	−2.27	0.049*	0.11
Favorable Post-training Experimental – Favorable Pre-training Control	−0.55	0.69	−0.80	0.543	0.58
Favorable Post-training Experimental – Unfavorable Post-training Control	−2.66	1.18	−2.25	0.049*	0.07
Favorable Post-training Experimental – Favorable Post-training Control	−0.01	0.76	−0.01	0.994	0.99
Unfavorable Pre-training Control – Favorable Pre-training Control	1.69	0.96	1.77	0.127	5.44
Unfavorable Pre-training Control – Unfavorable Post-training Control	−0.42	0.59	−0.71	0.579	0.66
Unfavorable Pre-training Control – Favorable Post-training Control	2.23	0.90	2.49	0.032*	9.34
Favorable Pre-training Control – Unfavorable Post-training Control	−2.11	1.13	−1.88	0.106	0.12
Favorable Pre-training Control – Favorable Post-training Control	0.54	0.50	1.07	0.397	1.72
Unfavorable Post-training Control – Favorable Post-training Control	2.65	1.14	2.32	0.047*	14.19

Post-hoc *p*-values were FDR corrected for 28 tests. Significance: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 5 Repeated measures analysis of variance table (aligned rank transformed data) and effect size (η_p^2)

Effects	*F* (1,67)	*p*	η_p^2
Involvement			
Group	1.09	0.299	0.02
Time	22.69	<0.001***	0.25
Group × Time	0.53	0.467	0.01
Guilt			
Group	0.14	0.714	0.00
Time	15.82	<0.001***	0.19
Group × Time	0.24	0.626	0.00

Effects of Group, Time, and their reciprocal interaction on participants' involvement and guilt ratings, made immediately after the TLCG

Significance: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

η_p^2 Partial Eta Squared (PES)

Regarding rating questions, the two-way repeated measures ANOVAs (Table 5) revealed a significant main effect of Time for both involvement and guilt ratings, but no significant effects for the main effect of Group and the Group by Time interaction. In addition, since the two groups had unequal sample sizes, we performed a Bartlett's test with multiple independent variables (rating score ~ interaction (Group, Time) that showed homogeneity of variances for both engagement (Bartlett's *K*-squared = 1.25, $df = 3$, $p = 0.74$) and guilt (Bartlett's *K*-squared = 2.18, $df = 3$, $p = 0.54$) ratings. For both involvement and guilt ratings, the pre-training scores ($M_{\text{involvement}} = 60.73$, $SD_{\text{involvement}} = 30.75$; $M_{\text{guilt}} = 36.06$, $SD_{\text{guilt}} = 33.44$) were higher with respect to the post-training ones ($M_{\text{involvement}} = 46.20$; $SD_{\text{involvement}} = 31.07$; $M_{\text{guilt}} = 22.70$, $SD_{\text{guilt}} = 28.22$), but this difference is equally distributed across both the experimental and the control groups.

Table 6 Repeated measures analysis of variance table (type III) and effect size (η_p^2 and η^2_G)

Effects	F (1,66)	MSE	p	η_p^2	η^2_G
MAIA-2 Self-Regulation					
Group	2.54	1.39	0.116	0.037	0.028
Time	5.94	0.46	0.018*	0.083	0.022
Group × Time	32.22	0.46	<0.001***	0.328	0.108
MAIA-2 Attention Regulation					
Group	7.43	1.19	0.008**	0.101	0.083
Time	30.05	0.28	<0.001***	0.313	0.081
Group × Time	17.25	0.28	<0.001***	0.207	0.048
MAIA-2 Body Listening					
Group	3.40	1.70	0.070	0.049	0.039
Time	8.62	0.46	0.005**	0.116	0.027
Group × Time	10.70	0.46	0.002**	0.139	0.034
FFMQ Non-Reactivity to Inner Experience					
Group	4.20	24.51	0.044*	0.060	0.046
Time	13.68	8.06	<0.001***	0.172	0.049
Group × Time	7.55	8.06	0.008**	0.103	0.028

Effects of Group, Time, and their reciprocal interaction on participants' MAIA-2 Self-regulation, MAIA-2 Attention Regulation, MAIA-2 Body Listening, and FFMQ Non-Reactivity to Inner Experience subscale scores

Significance: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

η_p^2 Partial Eta Squared (PES), η^2_G Generalized Eta Squared (GES)

Self-Report Measures

The results of the two-way repeated measures ANOVAs can be found in Table 6. We found significant Time by Group interactions for the following dependent variables: MAIA-2 self-regulation, MAIA-2 attention regulation, MAIA-2 body listening, and FFMQ non-reactivity to inner experience subscales.

FDR-corrected post-hoc comparisons (Table 7) indicate that the experimental group showed an increment in the post-training time with respect to the pre-training one in all subscales scores: (all $p < 0.001$). MAIA-2 self-regulation (Fig. 4, Panel a), MAIA-2 attention regulation (Fig. 4, Panel b), MAIA-2 body listening (Fig. 4, Panel c), FFMQ non-reactivity to inner experience (Fig. 4, Panel d). The control group showed no modulation of time on the subscales scores (all $p > 0.05$). Also, the experimental group post-training scores were significantly higher with respect to the control ones in all subscales scores (all $p < 0.01$). The pre-training scores of the experimental and the control group were not significantly different (all $p > 0.05$), indicating that the time-related increase shown by trained participants could be reasonably ascribed to the mindfulness meditation training.

Since the two groups had unequal sample sizes, we performed a Bartlett's test with multiple independent variables (*subscale score* ~ interaction(Group, Time) that showed homogeneity of variances for MAIA-2 self-regulation (Bartlett's K-squared = 4.09, $df = 3$, $p = 0.25$), MAIA-2 attention regulation (Bartlett's K-squared=2.09, $df = 3$, $p = 0.55$), MAIA-2 body listening (Bartlett's K-squared = 0.14, $df = 3$, $p = 0.99$), and FFMQ non-reactivity to inner experience (Bartlett's K-squared = 2.90, $df = 3$, $p = 0.41$), since all $p > 0.05$. The two-way repeated measures ANOVAs performed on the other employed self-report scores (i.e., other subscales of FFMQ and MAIA-2, ERQ and MIS) did not show significant two-way Time by Group interactions (all $p > 0.05$).

For the self-report measures significantly modulated by Time in the experimental group, we also estimated the effect sizes of training-related changes relative to the control group. Effect sizes were computed as Cohen's d = (M_ExpPost-M_ExpPre)/[(1/2)(SD_ExpPre+SD_ExpPost)] - (M_ControlPost-M_ControlPre)/[(1/2)(SD_ControlPre+SD_ControlPost)], that is the mean differences in the experimental group, divided by their pooled standard deviation, minus the same measure in the control group (Bornemann et al., 2014; Cohen, 1988). The effect sizes ranged from medium (FFMQ-Non-reactivity to Inner Experience: 0.62; MAIA-2 Body Listening: 0.77) to large (MAIA-2 Attention Regulation: 0.98), and very large (MAIA-2 Self-Regulation: 1.43, see Fig. 4, Panel e).

Moderation Analyses

For each participant of the experimental group, we extracted the individual-specific slope of the Condition by Time significant interaction (best linear unbiased predictors, BLUPs; Bates & Pinheiro, 1998). The Condition by Time interaction BLUPs referred to the strength of the effect shown by the experimental group, i.e., the tendency to decrease self-gain lies in the post-training with respect to the pre-training time.

In order to test whether the behavioral changes shown by the experimental group were related to the changes in the self-report measures and in the amount of practice training they made during the 8 weeks, we performed four moderation analyses in which the dependent variable was the Condition by Time interaction BLUPs (i.e., how much the self-gain deceptive behavior was reduced in the post- compared to the pre-training phase), the independent variable was the weekly mindfulness meditation training minutes reported by the participants and the moderator variables were the self-report measures which showed a time-related change in the experimental group (one for each analysis: MAIA-2 Attention Regulation, MAIA-2 Self-regulation, MAIA-2 Body Listening, FFMQ Non reactivity to inner experience) in the post-training time. The moderation analyses were performed on averaged data.

Table 7 Post-hoc pairwise comparisons and effect size (Cohen's *d*) relative to the Time × Group interactions of MAIA-2 Self-Regulation, MAIA-2 Attention Regulation, MAIA-2 Body Listening, and FFMQ Non-Reactivity to Inner Experience subscale scores

Contrast	*EMM*	*SE*	*t*-ratio	*p*	*d*
MAIA-2 Self-Regulation					
Pre-training Experimental – Post-training Experimental	−0.98	0.15	−6.69	<0.001***	−1.44
Pre-training Experimental – Pre-training Control	−0.35	0.27	−1.32	0.230	−0.52
Pre-training Experimental – Post-training Control	0.04	0.24	0.18	0.862	0.06
Post-training Experimental – Pre-training Control	0.63	0.25	2.53	0.028*	0.93
Post-training Experimental – Post-training Control	1.02	0.22	4.69	<0.001***	1.50
Pre-training Control – Post-training Control	0.39	0.19	2.04	0.069	0.58
MAIA-2 Attention Regulation					
Pre-training Experimental – Post-training Experimental	−0.91	0.12	−7.95	<0.001***	−1.71
Pre-training Experimental – Pre-training Control	0.13	0.23	0.58	0.674	0.25
Pre-training Experimental – Post-training Control	0.01	0.21	0.04	0.967	0.02
Post-training Experimental – Pre-training Control	1.05	0.22	4.77	<0.001***	1.97
Post-training Experimental – Post-training Control	0.92	0.20	4.62	<0.001***	1.73
Pre-training Control – Post-training Control	−0.13	0.15	−0.84	0.610	−0.24
MAIA-2 Body Listening					
Pre-training Experimental – Post-training Experimental	−0.75	0.15	−5.12	<0.001***	−1.10
Pre-training Experimental – Pre-training Control	0.03	0.27	0.12	0.906	0.05
Pre-training Experimental – Post-training Control	0.07	0.26	0.28	0.906	0.11
Post-training Experimental – Pre-training Control	0.78	0.26	2.98	0.008**	1.15
Post-training Experimental – Post-training Control	0.82	0.26	3.20	0.006**	1.21
Pre-training Control – Post-training Control	0.04	0.19	0.21	0.906	0.06
FFMQ Non-Reactivity to Inner Experience					
Pre-training Experimental – Post-training Experimental	−3.26	0.61	−5.32	<0.001***	−1.15
Pre-training Experimental – Pre-training Control	0.42	1.04	0.40	0.828	0.15
Pre-training Experimental – Post-training Control	−0.06	1.01	−0.06	0.950	−0.02
Post-training Experimental – Pre-training Control	3.67	1.02	3.59	0.002**	1.29
Post-training Experimental – Post-training Control	3.19	0.99	3.23	0.004**	1.12
Pre-training Control – Post-training Control	−0.48	0.80	−0.60	0.828	−0.17

Post-hoc *p*-values were FDR corrected for 6 tests for each subscale. Significance: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. *EMM* estimated marginal mean, *SE* standard error, *d* Cohen's *d*

The results of the moderation analysis with MAIA-2 Attention Regulation (post-training time) as moderator variable can be found in Table 8. The overall model was statistically significant ($R = 0.47$, $R^2 = 0.22$, $MSE = 2.54$, $F(3,39) = 3.69$, $p = 0.020$). There was a significant main effect of weekly mindfulness meditation training minutes ($p = 0.026$) and a non-significant main effect of MAIA-2 Attention Regulation on Condition by Time interaction BLUPs ($p = 0.064$).

The moderation analysis also revealed a significant interaction (R^2change $= 0.13$, $F(1,39) = 6.49$, $p = 0.015$) between the moderator variable MAIA-2 Attention Regulation (post-training time) (mean-1*SD* = 2.22, mean = 2.97, mean+1*SD* = 3.73) and the independent variable on Condition by Time interaction BLUPs. The standardized slope for the effect of weekly mindfulness meditation training minutes was significant when MAIA-2 Attention Regulation was one *SD* above the mean ($\beta = 0.02$, $t = 2.47$, $SE = 0.01$, $p = 0.018$, $LLCI = 0.00$, $ULCI = 0.04$), but not at the mean ($\beta = 0.01$, $t = 0.83$, $SE = 0.01$, $p = 0.409$, $LLCI = -0.01$, $ULCI = 0.02$) and one *SD* below the mean ($\beta = -0.01$, $t = -1.41$, $SE = 0.01$, $p = 0.167$, $LLCI = -0.03$, $ULCI = 0.01$, see Fig. 5). As shown in Fig. 5, as the MAIA-2 Attention Regulation scores increased, the strength of the relationship between weekly mindfulness meditation training minutes and Condition by Time interaction BLUPs increased.

The moderation analyses with MAIA-2 Self-regulation, MAIA-2 Body Listening, and FFMQ Non reactivity to inner experience in the post-training time as moderator variables presented no significant interaction effects with the independent variable weekly mindfulness meditation training minutes (all $p > 0.05$).

Discussion

In this study, we investigated the effects of an 8-week mindfulness meditation training on spontaneous moral decision-making during an online card game in which participants faced the temptation to deceive an opponent to

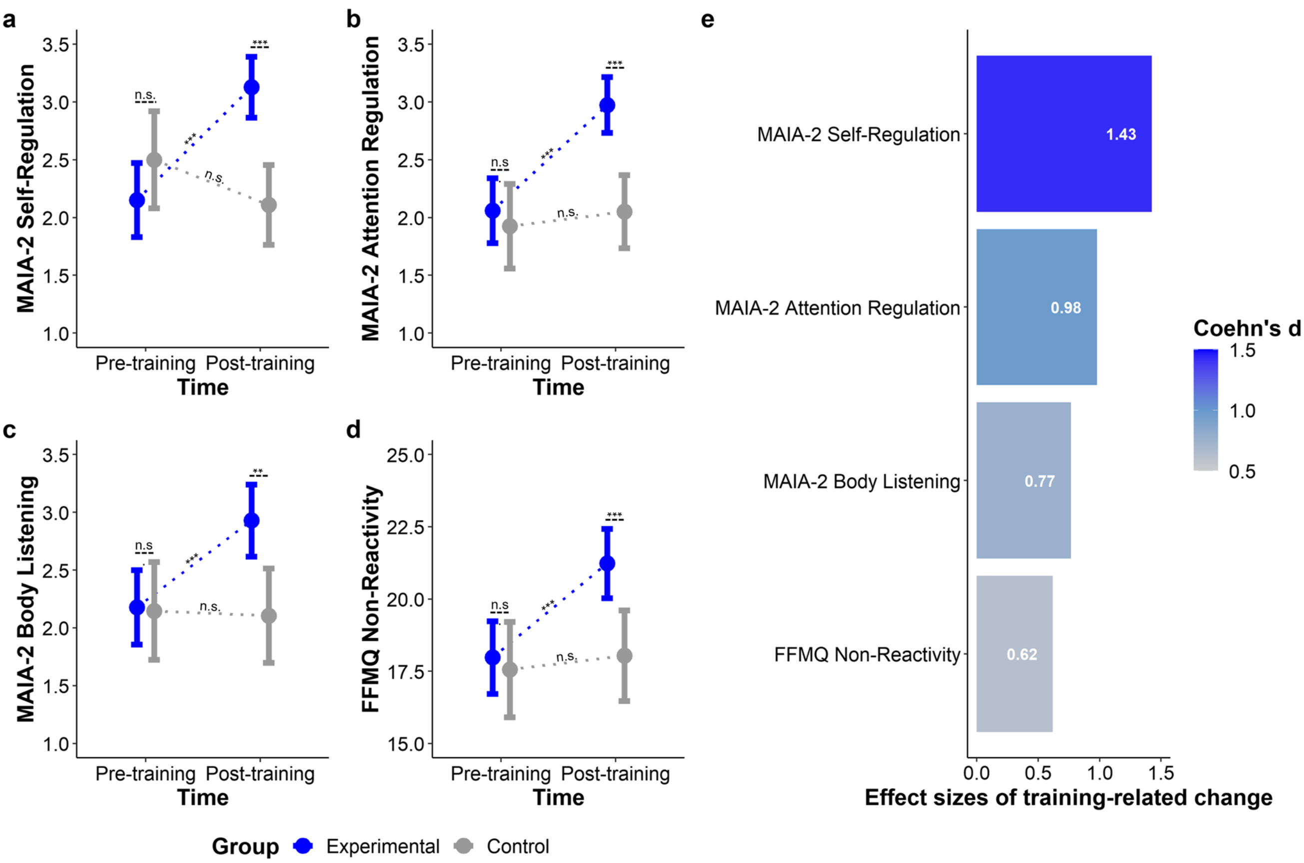

Fig. 4 Estimated marginal means (EMMs) of the self-report questionnaires scores derived from the two-way interaction Time × Group for MAIA-2 Self-Regulation (**a**), MAIA-2 Attention Regulation (**b**), MAIA-2 Body Listening (**c**), and FFMQ Non-reactivity to Inner Experience (**d**) subscales. Error bars represent confidence intervals. Effect sizes (Cohen's *d*) of training-related change relative to the control group (**e**)

increase their monetary payoff. In line with previous studies, we found that participants were more likely to deceive for self-gain than for the gain of the opponent (Azevedo et al., 2017; Panasiti et al., 2011, 2014, 2016; Schepisi et al., 2020; Vabba et al., 2022). Interestingly, reward magnitude played a role in modulating participants' self- and other-oriented moral decisions: participants made more self-gain lies when the reward at stake was high as compared to low, and conversely, they made more other-gain lies when the reward at stake was low as compared to high (as in Scattolin et al., 2022). Crucially, we found that trained participants showed a time-related reduction in the propensity to make self-gain lies, while the controls showed no modulation. Neither the experimental nor the control group showed a time-related change in the propensity to make other-gain lies. Therefore, mindfulness meditation practitioners showed a decrease in the tendency to favor themselves over the opponent when supposed to

Table 8 Moderation analysis results, in which predictor: weekly Mindfulness Meditation training minutes, moderator: MAIA-2 Attention Regulation (Post-training time), dependent variable: Condition × Time interaction BLUPs

	β	*SE*	*t*	*p*	*LLCI*	*ULCI*	BootMean	Boot*SE*	Boot*LLCI*	Boot*ULCI*
Constant	5.86	3.30	1.77	0.084	−0.83	12.54	6.33	4.66	−1.45	17.65
Weekly training minutes	−0.06	0.03	−2.32	0.026	−0.12	−0.01	−0.07	0.04	−0.16	−0.00
MAIA-2 Attention Regulation (T1)	−2.13	1.12	−1.90	0.064	−4.38	0.13	−2.20	1.68	−6.02	0.77
Interaction	0.02	0.01	2.55	0.015	0.00	0.04	0.02	0.01	0.00	0.06

Significance: ****p* < 0.001, ***p* < 0.01, **p* < 0.05

BootLLCI lower limit of the bootstrap confidence interval, *BootULCI* upper limit of the bootstrap confidence interval

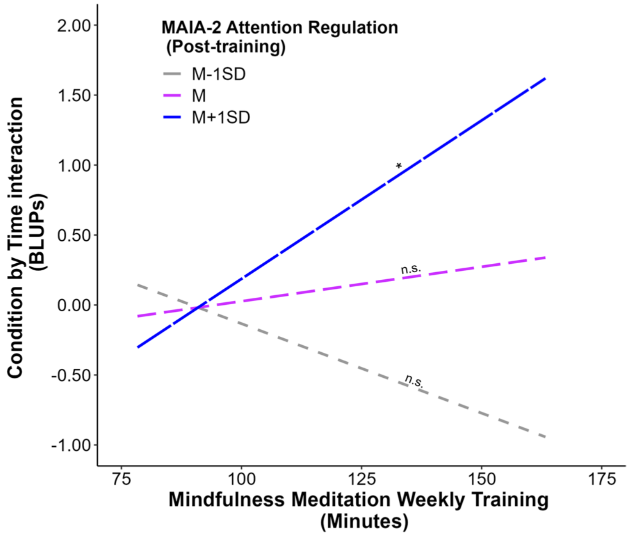

Fig. 5 Linear relationship between Condition × Time interaction BLUPs and weekly mindfulness meditation training minutes, moderated by the MAIA-2 Attention Regulation scores in the post-training time (experimental group)

lose (self-gain lies), but they did not present an increase in the tendency to favor the opponent over themselves when supposed to win (other-gain lies). These results are consistent with previous evidence showing that mindfulness meditation improve self-regulation (Friese & Hofmann, 2016; Kaunhoven & Dorjee, 2017; Tang et al., 2007), self-control (Bowlin & Baer, 2012; Friese et al., 2012), reward reactivity (Garland et al., 2014, 2019; Papies et al., 2015; Westbrook et al., 2013), and reduce impulsivity (Dixon et al., 2019; Hendrickson & Rasmussen, 2013, 2017; Yao et al., 2017). Therefore, we propose that higher resistance to temptation and self-control in mindfulness meditation practitioners could contribute to make them accept the unfavorable outcome, with fewer attempts to change it. With respect to the favorable outcome, the lack of increase in other-gain lies could be linked to phenomena like loss aversion (i.e., the tendency to dislike losses more than equivalent gains; Kahneman & Tversky, 1979) and endowment effect (i.e., the tendency to overvalue something over which ownership has been already established, respect to something that is not owned yet; Kahneman et al., 1991), which, to our knowledge have not found to be modulated by mindfulness meditation yet (but see Maymin & Langer, 2021).

Previous studies employing self-report measures or hypothetical moral scenarios showed that mindfulness seems to have beneficial effects on morality (Georgiou et al., 2020; Pandey et al., 2018; Ruedy & Schweitzer, 2010; Shapiro et al., 2012; Small & Lew, 2021; Xiao et al., 2020). Further, mindfulness training seems to prevent the decline of moral preferences over time by reducing the increase in the motivation to obtain money at the cost of harming another individual (Du et al., 2023). Crucially, other studies report that enhanced emotion regulation and decreased emotional reactivity typically associated with mindfulness meditation could have negative consequences in the moral domain, by weakening the feelings of guilt in mindfulness meditation practitioners. In our study, we have measures of emotion regulation (ERQ Cognitive Reappraisal and Expressive Suppression subscales) and guilt (rating question), but our results suggest that there was not a significant increase in emotion regulation or a decrease in guilt that could be ascribed to the mindfulness meditation training. However, evidence derived from studies in which actual behavior is measured in morally relevant contexts is still scarce. Our study provides preliminary evidence showing that mindfulness meditation reduces spontaneous self-serving in an ecologically valid social scenario.

With respect to self-reported interoceptive awareness, we found that the mindfulness training enhanced participants' abilities to direct and control their attention to bodily sensations (Attention Regulation), to actively listen to them (Body Listening), and to use them to regulate distress (Self-regulation). Importantly, these interoceptive subcomponents represent the regulatory aspects of interoceptive awareness, through which individuals recognize, organize, interpret, and respond to bodily sensations (Mehling, 2016). In line with our findings, Bornemann et al. (2014) reported that a 3-month intervention based on daily practices of "Body Scan" and "Breath Meditation" improved the regulatory aspects of interoceptive awareness, and that the largest change-related effect sizes have been found for Self-Regulation, Attention Regulation, and Body Listening (Bornemann et al., 2014). Similarly, D'Antoni et al. (2022) indicated that a 7-week MOM training increased interoceptive awareness in the Self-Regulation, Body Listening, and Not Worrying MAIA-2 subscales (D'Antoni et al., 2022). Further, de Lima-Araujo et al. (2022) recently found that a 3-day mindfulness training specifically impacted interoceptive sensibility (but not interoceptive accuracy) and that the training and control group presented a significant between-group difference only in the Attention Regulation subscale (de Lima-Araujo et al., 2022).

We also found that the mindfulness meditation training enhanced participants' self-reported non-reactivity to distressing thoughts and emotions (FFMQ Non-Reactivity to Inner Experience). This facet, together with Non-Judging, represents the tendencies to assume a nonattached or nonevaluative stance towards what is observed, respectively (i.e., the mindfulness "how" skills) (Eisenlohr-Moul et al., 2012). Importantly, previous studies reported that Non-Reactivity predicted more efficient emotion regulation (Hill & Updegraff, 2012), was positively related to reappraisal of emotional experience (Iani et al., 2019) and mediated the relationship between behavioral inhibition and emotion dysregulation (Reese et al., 2015). Furthermore, Non-Reactivity seemed to decrease automatic emotional responding to negative stimuli through interoception, as reflected by a reduced anterior insula activation under stress (Paul et al., 2013).

By means of moderation analyses, we also tested whether the behavioral changes in the TLCG shown by the experimental group were predicted by the amount of weekly meditation practice training and by the self-report measures which showed a significant time-related modulation. We found that more minutes spent on weekly mindfulness meditation training produced greater moral behavior change, only in practitioners who reported the highest scores of MAIA-2 Attention Regulation in the post-training time. In other words, we showed that the effect of weekly training minutes on moral behavioral change was moderated by the ability to regulate interoceptive attention (in particular, the effect was significant for participants who scored 1 *SD* above the mean, but not at the mean and 1 *SD* below it). This finding is consistent with previous studies indicating that there is a relationship between the frequency of meditation practice and increased self-reported interoceptive awareness (Bornemann et al., 2014) and mindfulness skills (Cebolla et al., 2017; Soler et al., 2014).

Explicit awareness of visceral and bodily signals is typically reflected in the activity of the right anterior insula (Critchley et al., 2004). Accordingly, an 8-week mindfulness meditation training has been found to alter the functional plasticity of the middle and anterior insula, pivotal regions for the cortical representations of interoceptive attention (Farb et al., 2013). Importantly, increased insula response to an interoceptive attention task following a mindfulness training is associated with increased self-reported interoceptive awareness (body trusting; Datko et al., 2022). Also, attentional control seems to regulate the effects of emotion on moral judgments, suggesting that emotional and attentional processes may interact in affecting people's moral behavior (van Dillen et al., 2012). Our results indicate that spontaneous moral behavior may be influenced by the amount of meditation training, only in participants who reported the highest regulation of attention towards internal bodily states. This would be in agreement with bodily feedback theories according to which bodily responses play a pivotal role in the experience of emotions and, consequently, in human behavior guidance (Crone et al., 2004; Damasio et al., 1991; Dunn et al., 2006; James, 1884; Porciello et al., 2023; Schacter & Singer, 1962). In particular, interoceptive accuracy seems to moderate the extent to which bodily signals influence emotion experience and decision making (Dunn et al., 2010). Notably, good cardioception is associated with more advantageous choices in the Iowa Gambling task (Werner et al., 2009), to more profitable risk-taking in the financial markets (Kandasamy et al., 2016) and the absence of anticipatory bodily responses impairs decision-making in patients with ventromedial prefrontal cortex lesions (Bechara et al., 1997, 2000). Also, other studies found a relationship between both the generation (Sokol-Hessner et al., 2009) and the access (Sokol-Hessner et al., 2015) to internal bodily signals with the loss aversion phenomenon. These findings may be consistent with a value-based model of decision-making (Rangel et al., 2008), in which internal bodily signals act as weights for assigning values to different choice options. Accordingly, recent findings suggest that bodily arousal influences reward-guided decision-making by means of interoceptive coding mechanisms in the frontal cortex (Fujimoto et al., 2021). The role of internal signals as valuation cues may also be explained by the partial overlap among brain areas involved in interoception and decision-making, like dorsal anterior cingulate cortex (dACC), orbitofrontal cortex (OFC), anterior insular cortex, hypothalamus, and amygdala (Craig, 2009; Critchley et al., 2004)

Crucially, our paradigm required participants to take decisions in a social context where choices simultaneously entail monetary consequences for both the decisor and the opponent. A study in which Buddhist meditators and control participants played the role of responders in the Ultimatum Game (UG) showed that the former group behaved more rationally than the latter group, accepting unfair offers in more than 50% of the trials. fMRI revealed that the two groups activated a different brain network: meditators presented activation primarily in areas dedicated to interoception and emotion (mid- and posterior insula and ventral posterior thalamus), while controls activated areas involved in social cognition and theory of mind (medial prefrontal cortex, anterior cingulate cortex, superior temporal sulcus). Crucially, ROI analysis in bilateral anterior insula revealed that in controls its activation predicted the rejection of unfair offers, while in meditators it did not. This finding suggests that meditators may have uncoupled the negative emotional response triggered by unfair offers by attending to internal states (as indexed by posterior insula activation) (Kirk et al., 2011). Some studies investigated the effect of bodily signals on social decision-making; some of them found that salient bodily states increase the emergence of a self-centered stance, reducing prosocial behavior. Mancini et al. (2011) reported that painful (interoceptive) stimuli delivered during the UG decreased fair offers in the proposers and increased the acceptance rate in the responders (Mancini et al., 2011). Similarly, the presentation of one's own heartbeat sounds during the UG affected feeling of unfairness in response to unfair splits and the frequency of unfair offers in the proposers (Lenggenhager et al., 2013). Recently, Vabba et al. (2022) found that high cardiac interoceptors were more consistent in their deceptive behavior and did not change it according to the social reputational risk that was associated with it (Vabba et al., 2022). On the contrary, Piech et al. (2017) found that participants' interoceptive sensitivity to their own heartbeat predicted altruistic behavior measured as monetary generosity in the Dictator Game across two experiments (Piech et al., 2017).

Recently, Arnold et al. (2019) proposed two different mechanisms for linking interoception to social connection: the "*enhanced emotional discernment hypothesis*" and the "*attentional switching hypothesis*". According to the former, the enhanced ability to detect bodily signals enriches emotional experience that, in turn, may facilitate the understanding of others' emotions and one's own empathic responses. The latter hypothesis proposes instead that interoception facilitates social connection by means of the ability to flexibly shift between interoceptive (emotional and bodily signals) and exteroceptive (social) attention (Arnold et al., 2019). In addition, Piech et al. (2017) proposed that heightened interoceptive sensitivity may enhance the representation of recipients' distress, increasing participants' altruistic behavior. In line with this idea, several studies reported a self-decentering effect driven by mindfulness meditation (Chiarella et al., 2020; Logie & Frewen, 2015; Stewart et al., 2018; Trautwein et al., 2016).

In conclusion, we presented preliminary evidence suggesting that mindfulness meditation training reduced practitioners' tendency to spontaneously deceive other individuals to increase their monetary payoff, in an ecologically valid moral decision-making task. Further, we showed that the higher amount of mindfulness meditation practice produced a reduction in self-serving dishonest behavior, only in practitioners who reported the highest ability to regulate attention towards internal bodily signals. The present preliminary evidence supports the hypothesis that heightened awareness of mental and physiological phenomena may promote moral behavior (Sevinc & Lazar, 2019).

Limitations and Future Directions

This study has some limitations. One is the lack of preregistration, the practice of designing and describing the theoretical foundations and the experimental and analytical methods prior to data collection. Other issues regard convenience sampling (i.e., a non-probability sampling method where data is collected from an easily accessible and available population) and the employment of the waitlist control condition. Both these issues were related to recruitment and methodological issues due to COVID-19 lockdown restrictions. An additional limitation regards the lack of a direct measure of study suspicion; this could represent a potential threat to internal validity. Another limitation is the employment of self-report measures to assess interoceptive awareness and the lack of neurophysiological measures taken during the moral decision-making task. Particularly, the employment of interoceptive tasks (e.g., Heartbeat Counting Task; Schandry, 1981) coupled with cardiac activity recording, could have provided additional information on participants' interoception. Since interoceptive accuracy (Vabba et al., 2022), autonomous nervous system activity (Panasiti et al., 2016), and motor readiness ERP (Panasiti et al., 2014) may affect moral decision-making in the TLCG, future studies also need to include the measurement of neurophysiological activity to better understand the complex relationship between awareness of non-motoric bodily signals (Villa et al., 2022; Fusco et al., 2021), (dis) honest behavior and mindfulness meditation. Future research should also fulfil Open Science practices (Open Science Collaboration, 2015) like pre registration or registered reports to improve theoretical development and methodological assessment. Also, mindfulness research will benefit from the employment of active control conditions like sham meditation to rule out placebo effects (Van Dam et al., 2018). In addition, the employment of direct measures of study suspicion could further increase the internal validity of future studies on the topic.

Our findings may be interpreted in terms of different psychological and neurophysiological processes affected by mindfulness practice (e.g., enhanced self-restraint, ability to access one's own or others' internal states, interoceptive-exteroceptive attention switching, or reduced reward salience). Future studies are needed to clarify the specific involvement of these processes in the reduction of dishonest behavior entailing detrimental (monetary) consequences for other individuals.

Use of Artificial Intelligence AI was not used.

Author Contributions Susanna Feruglio: conceptualization, methodology, software, investigation, data curation, writing—original draft. Maria Serena Panasiti: conceptualization, methodology, writing—review and editing, supervision, funding acquisition. Cristiano Crescentini: conceptualization, methodology, writing—review and editing, supervision, funding acquisition. Salvatore Maria Aglioti: conceptualization, writing—review and editing, supervision, funding acquisition. Giorgia Ponsi: conceptualization, methodology, software, formal analysis, investigation, data curation, writing—original draft, visualization, supervision, project administration, funding acquisition.

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Data Availability All data are available at the Open Science Framework (https://osf.io/d9bz7/).

Declarations

Ethics Statement The study was approved by the Institutional Review Board of the Department of Psychology, Sapienza University of Rome (protocol number: 0000796).

Informed Consent This study was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki.

Conflict of Interest The authors declare no competing interests.

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