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Socio-cognitive training impacts emotional and perceptual self-salience but not self-other distinction

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ABSTRACT

Training to inhibit imitative tendencies has been shown to reduce self-other interferences in both automatic imitation and perspective taking, suggesting that an enhancement of self-other distinction is transferrable from the motor to the cognitive domain. This study examined whether socio-cognitive training specifically enhances self-other distinction, or rather modulates self-salience, that is, the relative attentional priority of information pertaining to the self-perspective over information pertaining to the other person's perspective. Across two experiments, participants trained on one day to either imitate, inhibit imitation, inhibit control stimuli, or they were imitated. On the following day they completed a visuo-tactile affective perspective-taking paradigm measuring both self-other distinction and emotional self-salience, and a shape matching paradigm measuring perceptual self-salience. Results indicate no significant or consistent impact of training on self-other distinction performance, but reveal an increased emotional and perceptual self-salience following training to inhibit imitative tendencies. Together, these findings raise the question whether socio-cognitive training improves performance via enhanced self-other distinction, and invite to consider self-salience as a complementary angle to explain the past, present, and future findings on self-other distinction.

1. Introduction

We often track what other people do, think, and feel while we also do, think, and feel. This ability to co-represent our own and others' mental experiences requires the ability of *self-other distinction*, which enables us to tease apart the representations pertaining to each respective person, preventing biases and confusions in our understanding of others as well as of ourselves (Lamm, Bukowski, & Silani, 2016). Specifically, in case of absent or insufficient self-other distinction, our judgements of what another person intends to do, feels, or thinks are interfered by our own mental states and thus cause biased, slower, and/or inaccurate judgements, which are referred to as *egocentric* interference, bias, or intrusions. Conversely, our representations of other people' actions, feelings, or thoughts can interfere with our own actions, feelings, and thoughts, which cause *altercentric* interference, bias or intrusions or even personal distress in particular cases when we confuse the other person's intense negative affect as if it were our own. Hence, self-other distinction is a central ability for accurate and efficient performance in a large range of social situations.

Santiesteban et al. (2012) devised a socio-cognitive training protocol intended to enhance self-other distinction which consisted of counter-imitating observed finger movements. This training resulted in improved performance on two measures tapping into self-other distinction: automatic imitation and visual perspective taking. Improved self-other distinction in imitation was measured through the extent of reduced susceptibility to imitative tendencies that interfere with the execution of instructed action plans (Brass, Bekkering, & Prinz, 2001; Brass, Bekkering, Wohlschla, & Prinz, 2000). Concretely, seeing another person lifting her/his index finger interferes with the participants' action plan and thus performance at lifting their own middle finger diminishes because they tend to imitate the other person's movements. These altercentric interferences due to imitation are

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regulated by self-other distinction and have thus been used as a proxy for self-other distinction capacity (e.g., Tomova et al., 2014). Improved self-other distinction in perspective taking (Director task; Keysar, Barr, Balin, & Brauner, 2000) was measured through the extent of reduced interference in performance at judging what another person wants when the participants' own private knowledge was conflicting with the other person's knowledge. Failure to regulate the interference leads to inaccurate self-projections of private knowledge onto the other person's knowledge. These egocentric interferences due to self-projection can be regulated by self-other distinction and have thus been used as a proxy for self-other distinction capacity as well (e.g., Tomova et al., 2014). In Santiesteban et al. (2012), the altercentric interference in imitation and the egocentric interference in perspective taking were smaller following training to counter-imitate another person's finger movements in comparison to two other control training conditions, which consisted of training to imitate the other and a non-social inhibition training. It must be noted that imitating the other can equally be regarded as a socio-cognitive training although it is not intended to enhance self-other distinction. In the present study the socio-cognitive training refers to the counter-imitation. The present work aimed to conceptually replicate and extend these findings in the affective domain by exploiting an affective perspective-taking task (also referred to as an emotional egocentricity task), called the Affective touch task (Silani, Lamm, Ruff, & Singer, 2013), and a perceptual matching task, called the Shape-matching task (Sui & Humphreys, 2012). The Affective touch task (also referred to as a visuotactile empathy paradigm) requires to rate how good/bad another person or oneself feels in two kinds of situations: when both persons simultaneously feel the same way (congruent trials) or when they feel opposite feelings (incongruent trials; e.g. one disgusted, the other pleased). Self-other distinction is measured through the extent of reduction in the rated emotional intensity (less positive or less negative) from the congruent self-other feelings situations to the incongruent self-other feelings situation. Specifically, the egocentric bias is the extent to which our own emotion biases our judgment of the other person's emotion, causing the other person's emotion to be perceived as less positive or less negative following that our own emotion is negative or positive, respectively. The altercentric bias is the extent to which the spontaneously inferred emotional state of the other person biases our judgment of our own feeling, causing it to be less intense. In this task the egocentric and altercentric biases are merged to form a single measure of self-other distinction. The perceptual matching task requires from the participants to verify the accuracy of learnt arbitrary shape–label pairings (e.g., self – triangle, best friend – square, and stranger – circle) as fast and accurately as possible (see Fig. 2). This task does not measure self-other distinction but relative self-salience, which is the extent to which information about the self is prioritized over other information. Our main aim was to examine whether the socio-cognitive training specifically enhanced self-other distinction, or whether it instead modulated relative self-salience, a factor often confounded with self-other distinction.

Recent work in perspective taking has set out to decompose the multiple dimensions underlying perspective-taking performance (Bukowski, 2014, 2018; Bukowski & Samson, 2017; Bukowski, Silani, Riva, Tomova, & Lamm, 2016) and has highlighted that altercentric and egocentric biases can be caused and resolved either by (1) self-other distinction itself, that is, the handling of the conflict between the self- and other person's representations and its resulting interference, or by (2) relative self-salience (also named self-other priority), that is, how attention is distributed between information pertaining to the self-perspective versus the other person's perspective, in other words, the extent of relative self-prioritization of information. In the context of perceptual tasks, the latter dimension is also referred to as *self-salience* (Sui & Humphreys, 2012; Sui, Liu, Mevorach, & Humphreys, 2013). To illustrate the deconstruction into two dimensions, consider that an individual showing a strong egocentric bias is often interpreted as having poor self-other distinction, but the strength of the egocentric bias might actually be driven by a strong self-salience. This individual may have normally functioning self-other distinction but prioritize his/her self-perspective so much that the self-projection becomes strong and hard to regulate. Similarly, a strong altercentric bias might reflect a low self-salience, that is, a relatively high prioritization of information about the other person, rather than poor self-other distinction. In order to signify poor self-other distinction, both strong egocentric and altercentric interferences/biases must be observed, which would indicate that both self-projection and altercentric computation are hard to regulate and thus point towards a problem in their common underlying regulatory mechanism: self-other distinction. Conversely, an individual showing a small egocentric or altercentric bias is often interpreted as having good self-other distinction, but the interference that needs to be regulated might be minor or absent if the individual strongly prioritized, respectively, the other person's or self-perspective.

Dissociating the self-other distinction and relative self-salience dimensions has proven useful to better understand the impact of emotions (Bukowski & Samson, 2016), sleep deprivation (Deliens et al., 2017), individual differences in empathic and imitative tendencies (Bukowski & Samson, 2017, 2021) and, more importantly, to examine specifically the self-other distinction mechanisms (Bukowski et al., 2020). Critically, in order to be able to dissociate these two dimensions, the social cognition paradigm needs to measure performance on *self-trials*, that is, requiring to process one's own mental state, and *other-trials*, that is, requiring to process another person's mental state within the same paradigm. This allows (1) to measure both the altercentric and egocentric interferences (on self-trials and other-trials, respectively) to calculate the shared (or overall) extent of interference, which reflects self-other distinction irrespective of the perspective taken, and (2) to measure performance differences between self-trials and other-trials, which indicates self-salience when self-trials are better performed than other-trials (see Fig. 1 and Fig. 2). In the study of Santiesteban et al. (2012), the automatic imitation task has only self-trials (i.e., participants are asked to disregard the other person's hand and to focus on the superimposed cue they see) and thus captures only an altercentric interference whereas the visual perspective-taking task (i.e., the Director's task) has only other-trials (i.e., participants must focus exclusively on what the Director wants and can see) and thus captures only the egocentric interference. Hence, the tasks previously used by Santiesteban et al. (2012) cannot ascertain whether their socio-cognitive training effects reflect a modulation of self-other distinction or of self/other-salience. Importantly, another study reported improved empathy following the same socio-cognitive training, using two types of empathy measures devoid of task-demands to enforce self-other distinction (de Guzman, Bird, Banissy, & Catmur, 2015). The first measure was corticospinal activity when observing physical pain inflicted to another person (while the participant's emotional state was neutral), and the second measure was the change in scores on a self-report questionnaire of empathic behaviours. Thus, the first measure was tapping into low-level empathy processes based on action-perception coupling mechanisms and enabling self-other affect sharing rather than self-other distinction (Lamm et al., 2016). Therefore, this finding suggests that the socio-cognitive training modulated self-salience in a context where the two persons did not feel conflicting emotions. The second measure is a self-report of tendencies that is strongly influenced by motivational aspects such as how often one cares or spontaneously shares another person's affect (Reniers, Corcoran, Drake, Shryane, & Völlm, 2011); which suggests as well that the socio-cognitive training modulated the self-salience rather than self-other distinction. These two findings of de Guzman and colleagues support the possibility that the effects of socio-cognitive training increased the prioritization of perceptual information pertaining to the other person's affect, that is, the training may reduce self-salience rather than enhance self-other distinction performance.

Based on these considerations, the present work was designed to disambiguate two opposing hypotheses, and thus to deepen our understanding of how the social cognition training devised by Santiesteban

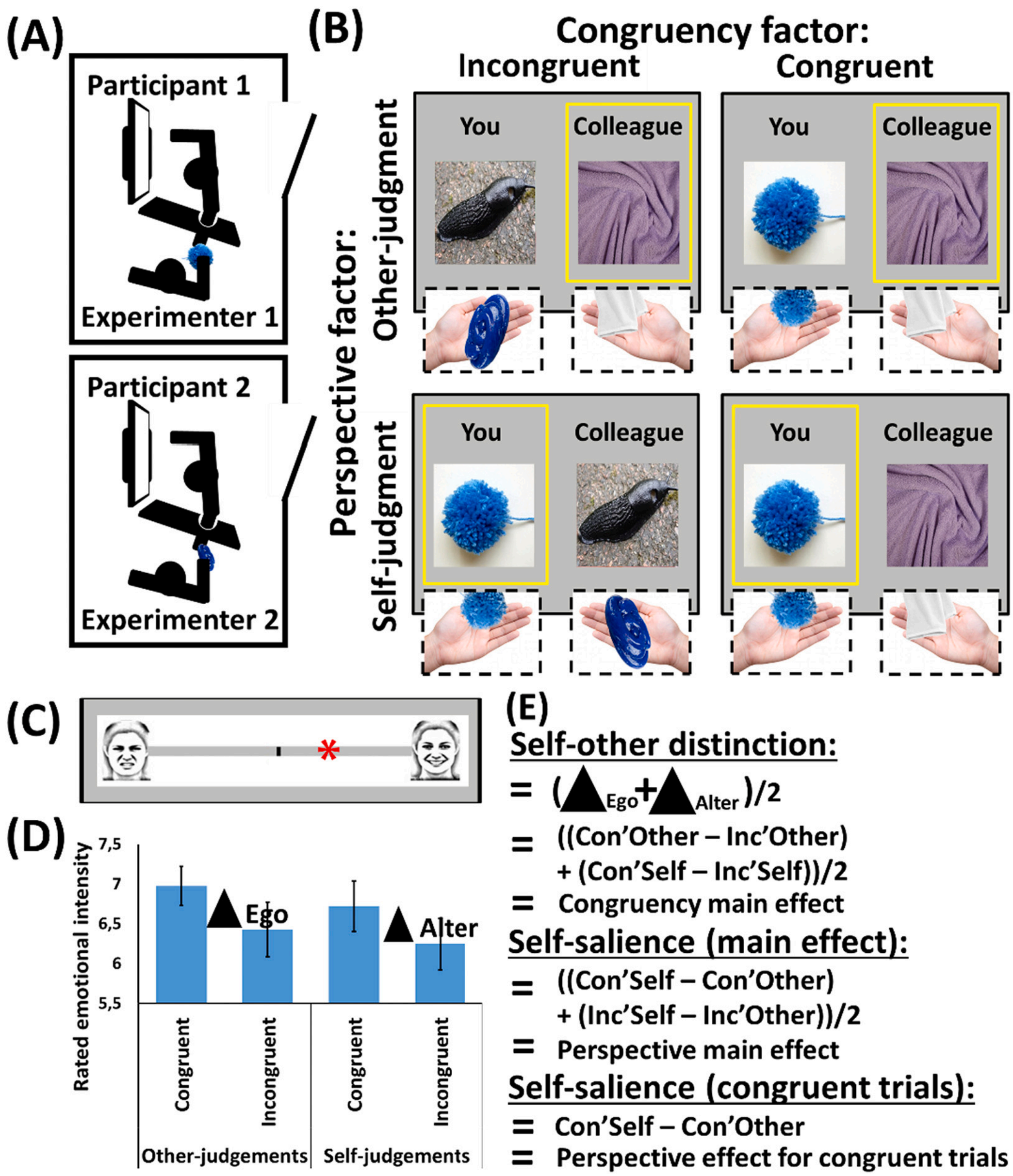

Fig. 1. The Affective touch task. Setup (A): two paired participants received visuotactile stimuli where their left hand was touched behind a curtain by inert materials imitating the visual stimulus under the label 'You'. Design (B): Participants were instructed to judge either how they feel or how their colleague feels (Perspective factor) and their respective affective experiences could either be congruent (same valence: both pleasant or both unpleasant) or incongruent (opposite valence; Congruency factor). (C) Feeling judgements were rated with a visual analogue scale ranging from very unpleasant to very pleasant. (D) Emotional intensity ratings with 95% confidence intervals across the four within-subject conditions (Perspective x Congruency) extracted from the combined experiments 1 and 2, which capture the extent of egocentric and altercentric interferences along with the main scores (E) of self-other distinction and self-salience.

et al. (2012) impacts socio-cognitive performance. While the first hypothesis posited that the training specifically impacted self-other distinction, the second predicted that the training specifically impacted the relative self-salience. In order to examine both self-other distinction and self-salience, we used a relatively novel affective perspective-taking paradigm, the Affective touch task (Silani et al., 2013), allowing to dissociate both dimensions, and a perceptual shape-matching task capturing self-salience but not self-other distinction (Sui & Humphreys, 2012). According to the first hypothesis, we predicted that, in comparison to the two control training groups (i.e., imitation and inhibitory-control groups), the group who completed the social cognition training (i.e., the imitation-inhibition group) would show less interference (i.e., bias) caused by the conflict between self-experienced emotions and the emotions of another person, which corresponds to a smaller reduction in emotional intensity of the ratings in the affective perspective-taking paradigm (see Fig. 1).

If the second hypothesis were true, we predicted that the group who completed the social cognition training would show a lower level of relative self-salience than the control training groups on both the Shape-matching task and the Affective touch task. In the Shape-matching task, we predicted that the performance advantage for self-pairing in the socio-cognitive training group would be lower than those in the two other control training groups. In the Affective touch task, we predicted that the self-salience in emotional intensity in the socio-cognitive training group would be lower than in the two other groups; which means that the superiority in emotional intensity ratings of the self-trials over the other-trials will be lower. This self-salience in emotional intensity can be calculated in two ways: (1) By using the main effect of perspective, which merges congruent and incongruent perspective conditions, to look at the overall difference between self- versus other-judgements and (2) the effect of perspective specific to congruent perspectives trials, that is when there is no conflict between the self-experienced emotion and the emotion experienced by the other. While examining the main effect of perspective is warranted because the self-salience is likely to influence the processing of both congruent and incongruent trials, there are theoretical and empirical arguments supporting the examination of specifically the congruent trials (Bukowski & Samson, 2017; Ramsey, Hansen, Apperly, & Samson, 2013; Samson et al., 2010). Concretely, it is theorized that congruent trials tap more into bottom-up perceptual processes grounded in perception-action

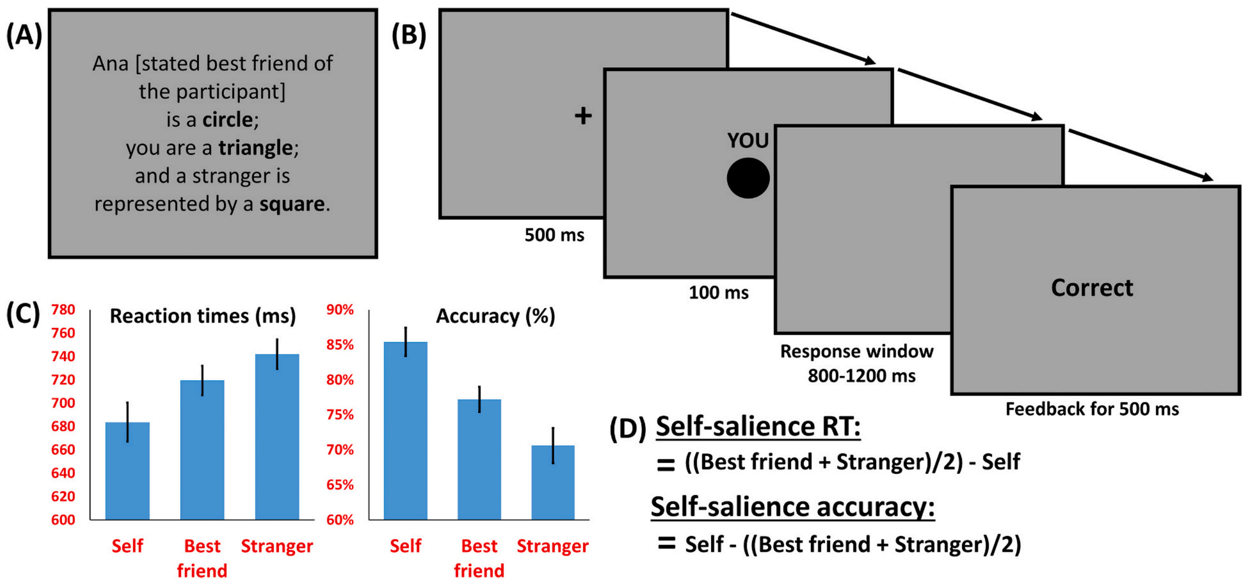

Fig. 2. The Shape-matching task. (A) Participants learned three arbitrary label-shape pairings and trained for 12 trials. (B) In each trial a correct or incorrect label-shape pairing is shortly displayed following which participants judged whether the pairing is correct via a "yes"/"no" key response and a feedback on the response followed. (C) Performance in terms of reaction times (left) and accuracy (right) and 95% confidence intervals for the respective pairings extracted from the combined experiments 1 and 2, which shows a consistent self-pairing performance advantage. (D) Calculation formula for the self-salience on reaction times and accuracy.

coupling mechanisms, whereas incongruent trials rather tap into top-down processes in charge of detecting and handling the perspectives conflict and the resulting self-other interference, such as cognitive control and self-awareness (Bukowski, Tik, et al., 2020; Decety & Jackson, 2004; Lamm et al., 2016; Ramsey et al., 2013; Samson et al., 2010). Hence, the perspective effects on congruent and incongruent trials can be opposite, such as in the dot visual perspective-taking paradigm, where a significant interaction between congruency and the perspective taken is observed and translates into participants performing better at other-judgements trials for congruent trials but better at self-judgements for incongruent trials (Samson et al., 2010). In the same vein, it was recently found that self-salience measured with the perspective effect on congruent trials (and not on incongruent trials) predicted lower scores on the Empathy Quotient, a questionnaire measure of empathy (Bukowski, Ahmad Kamal, Bennett, Rizzo, & O'Tuathaigh, 2020). Interestingly, the same congruency by perspective interaction was reported in the Affective touch paradigm as well (Silani et al., 2013) but to date no study has ever measured self-salience in affective perspective-taking (except this unpublished work: Bukowski et al., 2016), and thus no study examined congruent trials in affective perspective-taking to better capture self-salience. At last, it must be reminded that the findings of de Guzman et al. (2015) suggest a modulation of relative self-salience on empathy measures devoid of incongruent trials. Consequently, based on the aforementioned theoretical and empirical background, we predicted that, if socio-cognitive training affects self-salience, the imitation-inhibition group would have lower self-salience in emotional intensity than in the control training groups, which would manifest in the main effect of perspective (overall difference between self- and other-trials) and/or with the self-salience calculated with the effect of perspective specific to congruent trials. Altogether, there is evidence supporting each hypothesis (self-other distinction vs. self-salience) and each prediction (smaller congruency effect vs. smaller self-salience, especially for congruent trials).

In addition to conceptually replicating and disentangling the specificity of the training effects, our study examined whether self-other distinction is a cross-domain mechanism by testing the impact of the socio-cognitive training on self-other distinction in empathy. Empathy is typically defined as the ability to feel for and understand another person's affective state. How the socio-cognitive training influences the 'feeling' facet of empathy has already been examined with two empathy measures devoid of task-demands to enforce self-other distinction (de Guzman et al., 2015). The 'understanding' facet of empathy is however best captured with measures tapping into self-other distinction as it requires awareness and thus understanding of the discrepancy between our own emotional state and another person's emotional state. In line with the findings of Santiesteban et al. (2012) indicating beneficial training impacts in two social cognitive domains (automatic imitation and visual perspective taking), we hypothesized that the training would also be beneficial for self-other distinction in empathy, that is, in the affective domain. Therefore, we predicted that we could replicate the findings of Santiesteban et al. (2012) and find a higher self-other distinction performance in the socio-cognitive training group than in the two other control training groups.

Self-salience is also measured across various domains (Cunningham, Turk, Macdonald, Macrae, & Neil Macrae, 2008; Rogers, Kuiper, & Kirker, 1977; Sui, Humphreys, & He, 2012) and it is still unclear whether self-salience is a domain-general phenomenon. Recent evidence, however, supports opposing hypotheses: one study (Nijhof, Shapiro, Catmur, & Bird, 2020) revealed no association between self-salience in the Shape-matching task and an attentional blink task, whereas another study (Bukowski & Samson, 2021) reported that participants characterized by strong self-salience in visual perspective taking also showed the smallest altercentric interference in an automatic imitation task. The present study examined self-salience in two domains via the Shape matching task and the Affective touch task and we predicted that, if the training specifically influenced self-salience, then self-salience should be influenced in the same direction in both tasks.

Finally, the socio-cognitive training itself, if proved to reliably impact social-cognition performance, offers interesting insights in how performance can be improved. Specifically, the training consists in counter-imitating another person's finger movements for 40 min 24 h prior to a testing phase, and includes two between-subject control training conditions: an imitation session where participants actively imitate the other person's finger movements and an inhibitory control session where participants are required to select a counter-intuitive response (i.e., press blue button for red stimulus and vice-versa). Comparisons with respect to the inhibitory control session allow to partially control for training effects on domain-general executive functions and to address the question as to whether self-other distinction training affects domain-specific cognitive mechanisms or domain-general cognitive mechanisms. Addressing this issue relates to a pressing and much debated concern as recent studies have highlighted a major and so far underestimated role of domain-general executive functions in automatic imitation and perspective taking (Cracco et al., 2018; Darda, Butler, & Ramsey, 2020; Darda & Ramsey, 2019; Qureshi & Monk, 2018; Qureshi, Monk, Samson, & Apperly, 2020).

In summary, this study examined whether and how a socio-cognitive training based on counter-imitation impacts self-other distinction in empathy (or affective perspective taking). Based on the Shape-matching task and the two-dimensional design of the Affective touch task, we were able to test two competing hypotheses concerning the specificity of the training effects: a specific impact on self-other distinction leading to lower altercentric and egocentric biases, versus a specific impact on self-salience leading to lower prioritization of self-related stimuli (over stimuli pertaining to the other person).

The present study consisted of two experiments with an identical procedure (except for experiment 1 that had an additional and novel training condition) in order to reliably examine the impact of the socio-cognitive training on self-other distinction and self-salience. Participants were first trained, and after 24 h (as in Santiesteban et al., 2012) they completed the Affective touch and the Shape matching tasks. In addition, dispositional empathy was assessed on day 1 and mood state was assessed right before starting the Affective touch task. Experiments 1 and 2 were conducted at the University of Vienna, at the Faculty of Psychology and complied with local ethical regulations and the Declaration of Helsinki (2013, latest revision). The raw and processed data can be found online on https://osf.io/pcv3u/. None of the methods, procedures, and analyses were pre-registered. The methods and results of two experiments are presented separately and followed by a results section where datasets from the two experiments are collapsed.

2. Experiment 1

2.1. Material and methods

2.1.1. Sample

Only female participants were recruited for consistency with previous work (Riva, Triscoli, Lamm, Carnaghi, & Silani, 2016; Silani et al., 2013) and to increase statistical homogeneity, given sex/gender differences on the Affective touch task had been documented as well (Tomova et al., 2014). Any past or present psychiatric condition was an exclusion criterion, including specifically a phobia for insects or fish (as the Affective touch task has such stimuli). Right-handedness was an inclusion criterion. We ran a power analysis using the training effect size ($\eta_p^2 = 0.12$) reported for the Director perspective-taking task for the interaction between the between-subject effect of training group and the within-subject effect of trial type (i.e., control/congruent views versus experimental/incongruent views between the participant's and the director's perspectives) in the study of Santiesteban et al. (2012; the only published study that used socio-cognitive training before the conduction of the present study). The analysis conducted with G*Power 3.1 ($\alpha = 0.05$, $1\text{-}\beta = 0.95$, 4 groups, 2 repeated measurements) indicated a requirement of at least 9 participants per group that has been changed to 33 participants per group, thus 132 participants.[1] After exclusion of 8 participants due to dropouts or data loss caused by technical problems, the final sample consisted in 90 participants ($M_{age} = 21.58$; $SD_{age} = 3.71$) randomly distributed between 4 training groups: the imitation ($N = 24$), imitation-inhibition ($N = 26$), and control-inhibition ($N = 18$) as in Santiesteban et al. (2012) and a fourth novel training "be-imitated" group ($N = 22$) inspired from a study showing the impact of participants' finger movements being imitated on empathy (De Coster, Andres, & Brass, 2014). Further exclusions or missing data specific to particular measures are further described in the Results section. With 90 participants, the achieved power (i.e., 1-β) to detect the expected effect was 0.83. Given the insufficient sample size, this experiment is underpowered to replicate the expected effect of training on socio-cognitive measures with a power of 0.95. Participants received a course credit with the psychology bachelor curriculum in return for their participation.

2.1.2. Procedure

All participants came to the laboratory twice, on two consecutive days, and were tested in pairs. They were contacted prior to their first session on day 1 and provided with the general information about the study to ensure they fit inclusion criteria and to schedule an appointment paired with another participant. Both participants followed the same procedure. Upon arrival on day 1, participants received further information about the procedure, their related rights and they provided their informed consents. Then they were split over two separate but adjacent rooms. The participants completed one of the four socio-cognitive training procedures followed by two self-report questionnaires (Interpersonal Reactivity Index, IRI; the cognitive empathy subscale of the Empathy Quotient, cEQ). On the next day (day 2, 24 h after the training) participants again received information about the tasks to follow and provided their informed consents before entering the separated test rooms. Then they completed: (1) the training for the Affective touch task, (2) Positive and Negative Affect Scale (PANAS), (3) the Affective touch task, and (4) the shape matching task. At last, participants were debriefed separately.

2.1.3. Materials

2.1.3.1. Socio-cognitive training. The socio-cognitive training was devised from Santiesteban et al. (2012) by adapting the 'automatic imitation' task, a stimulus-response matching task measuring how the task-irrelevant finger lifting of another person on screen interferes with participants' own finger lifting in response to numeric cues (Brass et al., 2001). Specifically, the instructions of the original automatic imitation task were changed to form: (1) a "imitation" group where the participants had to imitate the other person's finger lifting, (2) an "imitation-inhibition" group where participants had to lift the opposite finger of the other person's finger lifting (i.e., the participant's index finger when the other person's middle finger was being lifted, and vice-versa), (3) an "imitation-control" group where participants had to lift the key with opposite color of the sticker's color superimposed on the static hand (e.g., they had to lift a finger from the red key when a green sticker appears on screen), and (4) a "be-imitated" group where participants were instructed to lift either their index or middle finger and to observe their finger lifting being imitated by the other person's identical finger. The last condition is a novel addition to the original socio-cognitive training and was motivated by the finding of enhanced empathic response to another person's pain when being imitated by another person with the same automatic imitation materials (De Coster et al., 2014). The hand stimuli were identical to those used in Santiesteban et al. (2012), that is, where hands were rotated in a way that the displayed finger movements were orthogonal to response finger movements in order to limit – albeit not entirely control for – the influence of spatial compatibility. For all 4 training conditions, participants completed 6 blocks of 72 trials, which lasted about 40 min.

2.1.3.2. Affective touch task. The Affective touch task (also known as the visuo-tactile empathy task or emotional egocentricity task), developed by Silani et al. (2013), measures participants' ratings of the

[1] The required sample size was calculated via the partial eta square according to the default but inadequate parameters of G*Power, this user error led us to underestimate the required sample size. We thank Reviewer 2 for pointing out this issue.

pleasantness or unpleasantness of visuotactile stimulations that two paired participants receive simultaneously (see Fig. 1). Participants received distinct tactile stimulations and were informed via a screen about what each participant was being touched with. Right after the stimulation, they were instructed to rate either the other participant's emotional state or their own emotional state on a scale ranging from very unpleasant to very pleasant. Critically, in half of the trials both participants experienced similarly valenced emotional states (congruent; both pleasant or unpleasant stimulations) whereas in the other half of the trials they experienced an opposite emotional state (incongruent; one received a pleasant, the other an unpleasant stimulation). The rated target and the similarity of emotional states formed two orthogonal factors: the target perspective to take (self vs. other) and the congruency between the two participants' emotional experiences (congruent vs. incongruent). Congruent and incongruent trials are mixed within two blocks, one block during which participants are instructed to systematically rate only the other person's emotional state and one block during which participants rate only their own emotional state. Each block consisted of 40 trials and each trial had the following sequence: (1) A fixation cross displayed on screen (range: 1800–5850 ms); (2) three seconds of pleasant (e.g., a rose or a feather) or unpleasant (e.g., a worm or a slug) tactile stimulations alongside with two pictures (400 × 400 pixels) depicting each participant's touch stimulus and a headline "You" or "Your colleague" above the respective pictures; (3) a two-second time window to rate the intensity and valence of the target person's emotional state via a finger touch on the screen over a visual analogue scale where the top-end was a manikin face expressing pleasantness and the bottom-end was a face expressing unpleasantness. The rating scale was continuous and ranged from −10 to indicate maximal unpleasantness to +10 to indicate maximal pleasantness. Participants were informed that the materials they were touched with were innocuous and inert but they were instructed to imagine the emotional state as if the target was touched by the depicted stimulus. The order of the trials was pseudo-randomized to avoid that the valence or the congruency is identical across more than two consecutive trials and the block order (i.e., self-perspective then other-perspective or vice-versa) was counter-balanced across subjects. Before starting the task, participants were familiarized with the task via a practice block of 30 trials (10 pleasant, 10 unpleasant, 10 neutral) in which they received and rated visuo-tactile stimuli solely from the self-perspective (there was no picture of the other person's stimulus). This block allowed the participants to get a first-hand experience with all visuo-tactile stimulations before having to imagine how it would feel for another person. The whole task lasted about 25 min (see Silani et al., 2013 for further details on the task).

In line with previous studies using the Affective touch task (Bukowski, Tik, et al., 2020; Riva et al., 2016; Silani et al., 2013), the ratings of unpleasant trials were expected below zero (down to −10) and thus multiplied by −1 to be merged with the ratings of pleasant trials (where ratings are positive up to 10) in order to conduct analyses of emotion intensity irrespective of the valence of the trials.

The main effect of congruency captures self-other distinction performance by measuring the extent to which the ratings of the target person's emotional state are drawn towards the irrelevant person's emotional state when their emotional states are incongruent, which is quantified as less intense (i.e., closer to zero) ratings in the incongruent condition than in the congruent condition. The ratings difference (i.e., for each participant, median[2] rating in congruent condition minus median rating incongruent condition) was therefore the index of self-other distinction performance.

The main effect of perspective captures the relative salience of the self-experienced emotions over the other person's emotional experiences by measuring the extent to which the ratings were further away from zero (more pleasant or unpleasant) when rating the self-experienced emotion than when rating the other person's emotion. The rating difference (i.e., for each participant, median rating in self-experienced emotion condition minus median rating in the other person's emotion condition) was therefore the index of emotional self-salience.

Lastly, an interaction between congruency and perspective can be decomposed either in terms of egocentric and altercentric biases (or interference) when measuring self-other distinction performance separately for other person's perspective and self-perspective conditions, respectively, or in terms of perspective salience expressed separately for congruent and incongruent trials.

2.1.3.3. Shape matching task. The shape matching task is a perceptual matching task devised by Sui et al. (2012) measuring the extent participants are better (faster and more accurate) at verifying whether a shape (triangle, square, or circle) corresponds to the label "you", "your best friend", or "unfamiliar person" (see Fig. 2). The shape-label correspondence, or pairing, has been learned via instructions and trained during a 12 trials practice block. Following a 500-ms fixation cross, one of the three shapes was presented along with one of the three labels for 100 ms following which participants had 800 to 1200 ms to press either of two keys to indicate whether the presented shape and label matched or mismatched. A 500-ms feedback was then presented ("Correct", "Incorrect", "Too late!"). Performed average accuracy was displayed at the end of each of the three blocks of 60 trials. Shape and label matched in half of the trials in the self, friend, and stranger conditions. Shape-label pairings were randomly determined at the beginning of the task. As in the original task, mean RT and rate of correct responses were analyzed only for matching trials (no effect is found on the mismatching trials) to examine performance difference between the label-shape parings. Perceptual salience of the self (i.e., self-salience) is calculated by the extent of being more efficient at verifying the shape associated with the self than at verifying the other two pairings (friend and stranger). The task lasted about 20 min.

2.1.3.4. PANAS. The Positive and Negative Affect Scale (Watson, Clark, & Tellegen, 1988) is a self-report mood scale with 10 items assessing positive emotions and 10 items assessing negative emotions ranging from 1 "Not at all or a very little" to 5 "Extremely". Separate scores are computed by summing the ratings of the positive and negative items, respectively, and by subtracting the two scores (positive – negative). Participants' mood was tested before beginning of the Affective touch task but after the practice trials.

2.1.3.5. IRI. The Interpersonal Reactivity Index (IRI) is a self-report questionnaire assessing four dimensions of empathy across 4 subscales of 7 items ranging from 1 "Does not describe me at all" to 5 "Describes me very well". The Perspective-Taking (PT) subscale refers to everyday tendencies to consider the perspective of other people. The Fantasy (FS) subscale assesses the individual's tendencies to identify themselves with fictional characters in movies, books, etc. The Empathic Concern (EC) subscale measures the tendencies to feel concern and compassion for others. The Personal Distress (PD) subscale measures the tendencies to feel anxious or discomfort while observing the distress of others.

2.1.3.6. Cognitive Empathy Quotient. The Empathy Quotient is a 60-item self-report instrument used for measuring empathy in adults (Baron-Cohen & Wheelwright, 2004) that consists of 40 empathy-related items and 20 distractor filler items. The items are scored on a 4-point scale ranging between *strongly agree* and *strongly disagree*. Lawrence, Shaw,

[2] Medians were used instead of means (as in previous own work) because the majority of the participants in both experiments have produced at least one rating opposite to the expected valence (e.g., rating as unpleasant a trial that should be rated as pleasant), which excessively influences the mean but not the median.

Baker, Baron-Cohen, and David (2004) identified three factors: cognitive empathy, emotional reactivity and social skills. In this experiment only the cognitive empathy subscale (cEQ) comprising 11 items from EQ was used.

2.1.4. Design and analyses

This study aimed to examine the impact of socio-cognitive training developed by Santiesteban et al. (2012) on two socio-cognitive behavioural tasks, the Affective touch and Shape-matching tasks, in order to test two competing hypotheses regarding the impact of the imitation-inhibition training in comparison to two other control training conditions, the imitation and inhibitory-control conditions and a novel training condition, that is, the be-imitated condition. The first hypothesis was that the imitation-inhibition training enhances self-other distinction performance and the second hypothesis was that the imitation-inhibition training modulates self-salience.

Self-other distinction was measured with the Affective touch task, where the congruency effect, that is, the extent of reduction in median rating from the congruent condition to incongruent condition (which is equivalent to averaging the egocentric and altercentric biases), was expected to be significantly lower in the imitation-inhibition group than the other three training groups (see Fig. 1). This prediction is tested via an a priori planned comparison via three *t*-tests for independent samples comparing the size of the congruency effect in the imitation-inhibition group against the three other groups.

Self-salience was measured both with the Affective touch task and the Shape-matching task. For the Affective touch task, self-salience in the imitation-inhibition group (i.e., the extent of the average rating of emotional intensity was higher in the self-judgment condition than the other-judgment condition) was expected to significantly differ from the other three training groups (see Fig. 1). We predicted that this difference in emotional intensity between self- and other-judgements would manifest on the main effect of perspective and probably more strongly on the congruent trials. These predictions were tested via a priori planned comparisons via two sets of three *t*-tests for independent samples comparing the size of the perspective difference in the imitation-inhibition group against the three other groups; one set of t-tests was conducted on the overall difference between self- and other-judgements while the other was conducted on the self-other judgements difference in congruent trials. For the Shape-matching task, self-salience in the imitation-inhibition group, that is, the extent of performance advantage either in terms of RT or accuracy for the shape associated to the self over the average performance for the shapes associated with the best friend and the stranger, was expected to significantly differ from the other three training groups (see Fig. 2). This prediction is tested via an a priori planned comparison via three *t*-tests for independent samples comparing the size of the self-shape performance advantage in the Imitation-inhibition group against the three other groups.

These a priori planned comparisons are preceded by an omnibus ANOVA for each dependent variable (i.e., median rating of emotional intensity for the Affective touch task and RT and accuracy for the Shape-matching task), both with Training as a between-subject factor. In the Affective touch task, the ANOVA for repeated measures uses the Congruency (congruent vs. incongruent condition) and the Perspective (self-judgment vs. other-judgment) as within-subject factors where an interaction between Congruency and Training would support a modulation of self-other distinction by the training type and an interaction between Perspective and Training would support a modulation of main effect self-salience by the training type. A triple interaction Perspective by Congruency by Training could support a self-salience modulation by training specifically for congruent trials. In the Shape-matching task, the Shape (self vs. best friend vs. stranger) is the within-subject factor where an interaction between Shape and Training would support a modulation of self-salience by the training type.

2.2. Results

2.2.1. Group differences

Group differences in age and scores of the IRI, cEQ, and PANAS were inspected across the 4 groups by performing one-way ANOVAs with group as between-subject factor. Age data of 9 participants was missing whereas questionnaire data of 3 participants (4 for PANAS) was missing. The ANOVA did not reveal any significant differences between training groups [for age (F(3,82) = 1.274, p = .289), IRI perspective-taking (F(3,88) = 0.406, p = .749), IRI fantasy (F(3,88) = 0.632, p = .596), IRI empathic concern (F(3,88) = 1.386, p = .253), IRI personal distress (F(3,85) = 0.340, p = .799), IRI global score (F(3,88) = 0.948, p = .421), cEQ (F(3,88) = 0.481, p = .697), PANAS positive affect (F(3,87) = 0.335, p = .800), PANAS negative affect (F(3,87) = 1.060, p = .371) and PANAS global score (F(3,87) = 1.422, p = .242)].

2.2.2. Affective touch task

Rates of erroneous valence ratings (i.e., negative ratings, which indicates rating in the valence opposite to those instructed; M = 0.051, SD = 0.095) of two participants were at chance level (50% chance getting the right valence) and were thus excluded from analyses. Participants were thus distributed as follows: imitation-inhibition group: 25; imitation group: 24; inhibitory-control: 17; be-imitated group: 22.

2.2.2.1. Omnibus ANOVA. The repeated-measures ANOVA of the ratings revealed a significant main effect of congruency F(1,84) = 14.490, $p < .001$, $\eta_p^2 = 0.147$, with a lower median emotional intensity in the incongruent emotions condition, a non-significant main effect of perspective F(1,84) = 1.008, p = .318, $\eta_p^2 = 0.012$, and a non-significant congruency by perspective interaction, F(1,84) = 1.271, p = .263, η_p^2 = 0.015 (see Fig. 3 upper panel). These findings replicate previous studies (Bukowski, Tik, et al., 2020; Silani et al., 2013). We found a non-significant congruency by training interaction, F(3,84) = 0.803, p = .496, $\eta_p^2 = 0.028$, indicating no difference in the extent of the self-other distinction bias across training groups, a marginally significant perspective by training interaction, F(1,84) = 2.387, p = .075, η_p^2 = 0.079, indicating a trend for a difference in the extent of the emotional self-salience across training groups, and a non-significant congruency by perspective by training interaction, F(3,84) = 0.542, p = .655, η_p^2 = 0.019. There was no significant main effect of training groups over empathic performance, F(3,84) = 0.542, p = .655, $\eta_p^2 = 0.019$.

2.2.2.2. Planned comparisons. In order to directly test the hypothesized impact of imitation-inhibition training on self-other distinction, we conducted three planned contrasts to compare the congruency effect (i.e., the extent of overall bias and thus self-other distinction) of the imitation-inhibition group to the other training groups. The congruency effect in the imitation-inhibition group (M = 0.385, SD = 0.748) was not significantly different from those in the be-imitated group (M = 0.233, SD = 0.724, t(84) = 0.503, p = .617, d = 0.21, *95% CI* [−0.450, 0.755]), inhibitory-control group (M = 0.391, SD = 0.884, t(84) = 0.019, p = .985, d = 0.01, *95% CI* [−0.654, 0.641]), and imitation group (M = 0.623, SD = 1.522, t(84) = 1.039, p = .302, d = 0.20, *95% CI* [−0.897, 0.281]).

In order to directly test the hypothesized impact of imitation-inhibition training on self-salience, we conducted three planned contrasts to compare the two perspective effects (i.e., whether the mean ratings of emotional intensity were higher for self- than other-judgements as a main effect, and then for congruent trials only) of the imitation-inhibition group to the three other training groups. The perspective *main* effect in the imitation-inhibition group (M = 0.319, SD = 1.152) was significantly higher than the be-imitated group (M = −0.598, SD = 1.205, t(84) = 2.130, p = .036, d = 0.79, *95% CI* [0.061, 1.774]), marginally significantly higher than the inhibitory-control group (M = −0.557, SD = 1.177, t(84) = 1.892, p = .062, d = 0.75,

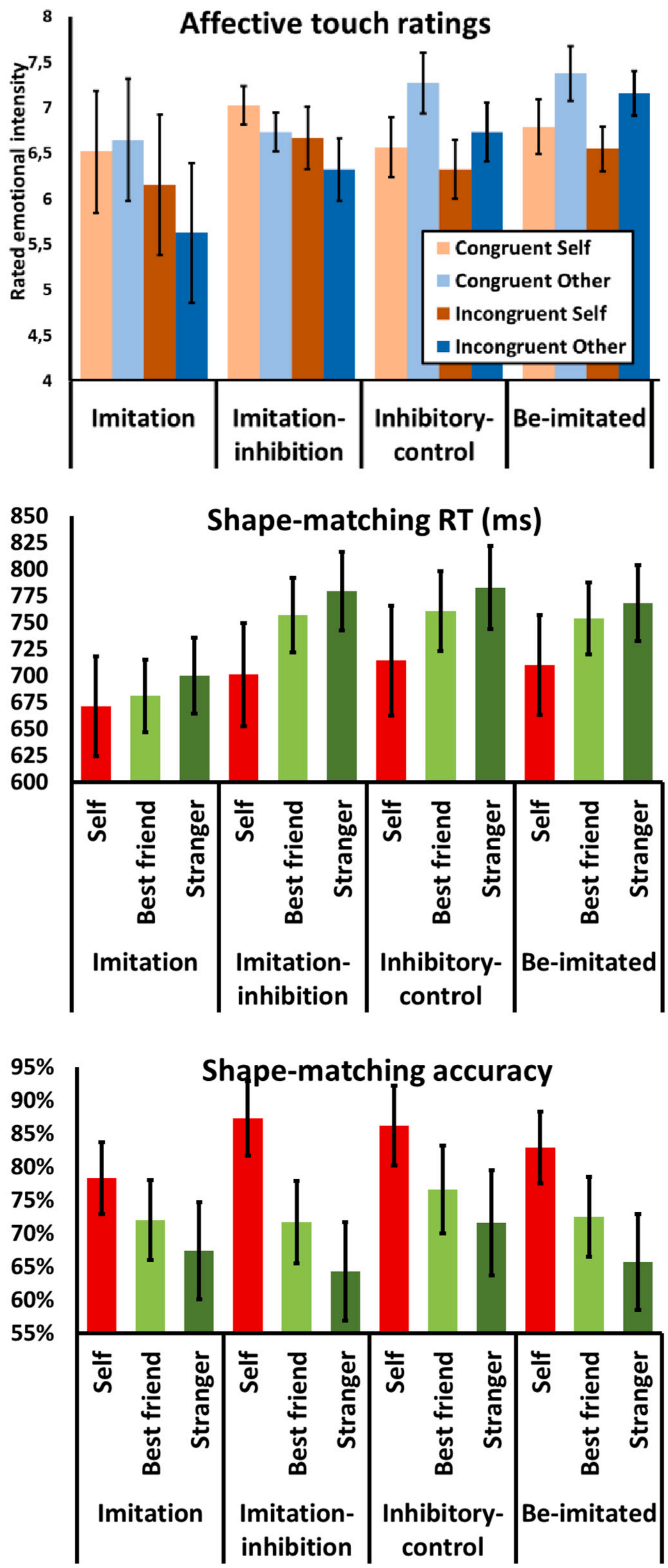

Fig. 3. Impact of socio-cognitive training types on empathic and shape-matching performance in experiment 1. *Upper panel*: Rating intensities when judging the self- and other person's emotional state when emotions are congruent and incongruent. Errors bars indicate pairwise within-subject 95% confidence interval. *Middle panel*: Reaction times to verify matching shape-label parings for shapes associated with the self, the best friend, and a stranger. Errors bars indicate 95% confidence interval. *Lower panel:* Accuracy percentages to verify matching shape-label parings for shapes associated with the self, the best friend, and a stranger. Errors bars indicate 95% confidence interval.

95% CI [−0.045, 1.797]), and not significantly different from the imitation group ($M = 0.199$, $SD = 2.062$, $t(84) = 0.285$, $p = .776$, $d = 0.07$, *95% CI* [−0.717, 0.957]).

The perspective effect on congruent trials in the imitation-inhibition group ($M = 0.295$, $SD = 1.103$) was significantly higher than the be-imitated group ($M = -0.587$, $SD = 1.420$, $t(84) = 2.343$, $p = .022$, $d = 0.69$, *95% CI* [0.133, 1.631]) and the inhibitory-control group ($M = -0.707$, $SD = 1.290$, $t(84) = 2.474$, $p = .015$, $d = 0.83$, *95% CI* [0.197, 1.807]), and not significantly different from the imitation group ($M = 0.128$, $SD = 1.340$, $t(84) = 1.149$, $p = .254$, $d = 0.14$, *95% CI* [−0.309, 1.155]).

2.2.3. Shape matching task

Rates of correct responses ($M = 0.666$, $SD = 0.165$) of 22 participants were at chance level (50% chance getting the right response; cut-off rate of 0.56 for 95% confidence that performance is above chance) and were thus excluded from analyses. Participants were thus distributed as follows: imitation-inhibition group: 16; imitation group: 17; inhibitory-control: 14; be-imitated group: 17.

2.2.3.1. Omnibus ANOVA. The repeated-measures ANOVA conducted on the reaction times (RT) indicated the assumption of sphericity was violated, χ^2 (2) = 28.254, $p < .001$, and thus, a Greenhouse-Geisser correction was used (see Fig. 3, middle panel). The ANOVA revealed a significant main effect of shapes, $F(1.45,60) = 29.079$, $p < .001$, $\eta_p^2 = 0.326$, with RT for the self being fastest and RT for stranger being the slowest, and a non-significant shape by training interaction, $F(5.06,60) = 1.271$, $p = .286$, $\eta_p^2 = 0.060$. There was a significant main effect of training groups, $F(3,60) = 3.178$, $p = .030$, $\eta_p^2 = 0.137$, with faster RT in the imitation group.

The repeated-measures ANOVA conducted on the accuracy rates indicated the assumption of sphericity was violated, χ^2 (2) = 19.479, $p < .001$, and thus, a Greenhouse-Geisser correction was used (see Fig. 3, lower panel). The ANOVA revealed a significant main effect of shapes, $F(1.56,60) = 33.269$, $p < .001$, $\eta_p^2 = 0.357$, with the highest accuracy for the self and lowest for the stranger, and a non-significant shape by training interaction, $F(4.68,60) = 0.873$, $p = .497$, $\eta_p^2 = 0.042$. There was no significant main effect of training groups, $F(3,60) = 1.062$, $p = .372$, $\eta_p^2 = 0.050$.

2.2.3.2. Planned comparisons. In order to directly test the hypothesized impact of imitation-inhibition training on self-salience, for RTs then accuracy rates, we conducted 3 planned contrasts to compare the self-shape performance advantage (i.e., the extent the performance is better for the shape associated with the self over the average performance of the shapes associated with the best friend and the stranger) of the imitation-inhibition group to the three other training groups.

For RTs, the self-shape performance advantage in the imitation-inhibition group ($M = 67.027$, $SD = 83.263$) was significant higher than in the imitation group ($M = 18.920$, $SD = 46.483$; $t(60) = 2.131$, $p = .037$, $d = 0.71$, *95% CI* [2.940, 93.273]) but did not differ from the inhibitory-control ($M = 57.575$, $SD = 59.784$; $t(60) = 0.398$, $p = .692$, $d = 0.13$, *95% CI* [−38.003, 56.907]) nor the be-imitated groups ($M = 51.139$, $SD = 64.768$; $t(60) = 0.704$, $p = .484$, $d = 0.21$, *95% CI* [−29.278, 61.055]).

In terms of accuracy rates, the self-shape performance advantage in the imitation-inhibition group ($M = 0.193$, $SD = 0.153$) was significantly higher than in the imitation group ($M = 0.086$, $SD = 0.095$; $t(60) = 2.386$, $p = .020$, $d = 0.84$, *95% CI*[0.017, 0.197]) but did not differ from those in inhibitory-control ($M = 0.121$, $SD = 0.135$; $t(60) = 1.538$, $p = .129$, $d = 0.50$, *95% CI [*−0.0218, 0.167]) and be-imitated groups ($M = 0.138$, $SD = 0.127$; $t(60) = 1.218$, $p = .228$, $d = 0.39$, *95% CI [*−0.035,0.144]).

2.3. Intermediary discussion

The data collected so far suggests that the socio-cognitive training has no reliable impact on empathic performance and shape matching performance. However, while the impact on self-other distinction was clearly non-significant (all p's > 0.300) and of small effect size at best (all Cohen d's < 0.22), the impact on self-salience shows a consistent pattern consisting in having numerically the highest self-salience in the imitation-inhibition group as measured with both the Affective touch and Shape-matching tasks. However, the extent self-salience in the imitation-inhibition group is higher than in the other groups is variable in terms of statistical significance (p values ranging from 0.254 to 0.015) and effect sizes (Cohen d values ranging from 0.14 to 0.84). If these preliminary results were confirmed it would question the initial finding of Santiesteban et al. (2012) according to which perspective-taking performance was improved following imitation-inhibition due to enhanced self-other distinction. Aiming to replicate these preliminary findings with a larger sample size, we ran a second experiment with the identical procedure. However, due resources constrains and since findings from this condition could not be compared with the study of Santiesteban et al. (2012), we decided to not replicate the be-imitated condition.

3. Experiment 2

3.1. Material and methods

3.1.1. Sample

As in experiment 1, only female participants were recruited. Any past or present psychiatric condition, including specifically a phobia for insects or fishes, was an exclusion criterion. Right-handedness was an inclusion criterion. Sample size was initially aimed to triple the required sample size (initially computed as 9 participants per group but corrected to 33 participants per group and 99 in total, see footnote 1), and thus 111 healthy adults were recruited, with a final sample of 109 participants ($M_{age} = 21.58$; $SD_{age} = 3.71$) after exclusion of two dropouts. The sample was randomly distributed between 3 training groups: the imitation ($N = 37$), imitation-inhibition ($N = 36$), and control-inhibition ($N = 36$) as in Santiesteban et al. (2012). Further exclusions or missing data specific to particular measures are further described in the Results section. Participants received a course credit with the psychology bachelor curriculum in return for their participations.

3.1.2. Materials and procedure

Procedure and material are identical to experiment 1 except for the absence of the be-imitated training condition.

3.2. Results

3.2.1. Group differences

Group differences in age and scores of the IRI, cEQ, and PANAS were inspected across the three priming groups by performing one-way ANOVAs with the training group membership as between-subject factor. Age data and questionnaires data of two participants (one for cEQ) was missing. The ANOVA revealed non-significant difference between training groups for age ($F(2,107) = 1.583$, $p = .210$), IRI perspective-taking ($F(2,107) = 0.427$, $p = .654$), IRI fantasy ($F(2,107) = 0.636$, $p = .531$), IRI empathic concern ($F(2,107) = 0.034$, $p = .967$), IRI global score ($F(2,107) = 0.364$, $p = .696$), cEQ ($F(2,108) = 0.248$, $p = .781$), PANAS positive affect ($F(2,107) = 1.013$, $p = .367$), and PANAS global score ($F(2,107) = 1.309$, $p = .274$). The training groups significantly differed for IRI personal distress ($F(2,107) = 3.403$, $p = .037$) and PANAS negative affect ($F(2,107) = 3.439$, $p = .036$). Post-hoc analyses with Bonferroni correction for multiple comparisons show that personal distress in the imitation group ($M = 19.865$, $SD = 4.097$) is lower than in the imitation-inhibition ($M = 21.943$, $SD = 4.646$, $p = .068$, $d = 0.47$) and inhibitory-control groups ($M = 22.111$, $SD = 3.487$, $p = .042$, $d = 0.59$) whereas negative affect in the imitation-inhibition group ($M = 19.371$, $SD = 10.778$) is higher than in the imitation ($M = 14.162$, $SD = 8.358$, $p = .024$, $d = 0.59$) and inhibitory-control groups ($M = 15.750$, $SD = 6.124$, $p = .158$, $d = 0.59$). Given these group differences, the results on empathic and shape matching performance are presented with personal distress and negative affect as covariates.

3.2.2. Affective touch task

Inspection of rates of erroneous valence ratings ($M = 0.027$, $SD = 0.049$) showed that no participant performed at chance level (50% chance getting the right valence) and thus none was excluded from analyses. However, data went missing due to technical failures for 7 participants. Participants were thus distributed as follows: imitation-inhibition group: 33; imitation group: 35; inhibitory-control: 34.

3.2.2.1. Omnibus ANOVA. The repeated-measures ANOVA of the ratings revealed a significant main effect of congruency, $F(1,99) = 26.570$, $p < .001$, $\eta_p^2 = 0.212$, with a lower median emotional intensity in the incongruent emotions condition, a significant main effect of perspective, $F(1,99) = 6.756$, $p = .011$, $\eta_p^2 = 0.064$, and a non-significant congruency by perspective interaction, $F(1,99) = 0.530$, $p = .468$, $\eta_p^2 = 0.005$ (see Fig. 4, upper panel). These findings replicate previous studies (Bukowski, Tik, et al., 2020; Silani et al., 2013).

We found a non-significant congruency by training interaction, $F(2,99) = 2.086$, $p = .130$, $\eta_p^2 = 0.040$, a non-significant perspective by training interaction, $F(2,99) = 0.793$, $p = .455$, $\eta_p^2 = 0.016$, and a significant congruency by perspective by training interaction, $F(2,99) = 3.130$, $p = .048$, $\eta_p^2 = 0.059$.

We decomposed the triple interaction by first running the same ANOVA but separately each perspective (other-judgements and self-judgements) then separately for each level of congruency (congruent and incongruent perspectives).

The ANOVA conducted on other-judgements trials revealed a significant main effect of congruency, $F(1,99) = 16.048$, $p < .001$, $\eta_p^2 = 0.137$, indicating the presence of an egocentric bias, a non-significant congruency by training interaction, $F(2,99) = 1.228$, $p = .297$, $\eta_p^2 = 0.024$, and a marginally significant main effect of training, $F(2,99) = 2.972$, $p = .056$, $\eta_p^2 = 0.056$. The ANOVA conducted on self-judgements trials revealed a significant main effect of congruency, $F(1,99) = 20.649$, $p < .001$, $\eta_p^2 = 0.173$, indicating the presence of an altercentric bias, a significant congruency by training interaction, $F(2,99) = 3.862$, $p = .024$, $\eta_p^2 = 0.072$, and a non-significant main effect of training, $F(2,99) = 0.530$, $p = .590$, $\eta_p^2 = 0.011$. An exploratory post-hoc analysis on the altercentric bias with the training group as between-subject factor was conducted to decompose the congruency by training interaction. With a Bonferroni correction for multiple comparisons, the altercentric bias was significantly higher in the imitation-inhibition group ($M = 1.083$, $SD = 1.789$) than in the imitation ($M = 0.276$, $SD = 1.027$, $p = .034$) and marginally significantly higher than in the inhibitory-control group ($M = 0.385$, $SD = 0.898$, $p = .088$).

The ANOVA conducted on the incongruent trials revealed a significant main effect of perspective, $F(1,99) = 5.513$, $p = .021$, $\eta_p^2 = 0.053$, a non-significant perspective by training interaction, $F(2,99) = 0.800$, $p = .452$, $\eta_p^2 = 0.016$, and a marginally significant main effect of training, $F(2,99) = 2.618$, $p = .078$, $\eta_p^2 = 0.050$. The ANOVA conducted on the congruent trials revealed a significant main effect of perspective, $F(1,99) = 5.493$, $p = .021$, $\eta_p^2 = 0.053$, a non-significant perspective by training interaction, $F(2,99) = 2.073$, $p = .131$, $\eta_p^2 = 0.040$, and a non-significant main effect of training, $F(2,99) = 0.798$, $p = .453$, $\eta_p^2 = 0.016$.

To account for group differences in negative affect and personal distress, the first omnibus repeated measures ANOVA was reanalysed with negative affect and then with personal distress as covariates of no interest. Including negative affect as covariate slightly reduced the statistical significance of the triple interaction ($p = .069$), did not affect the

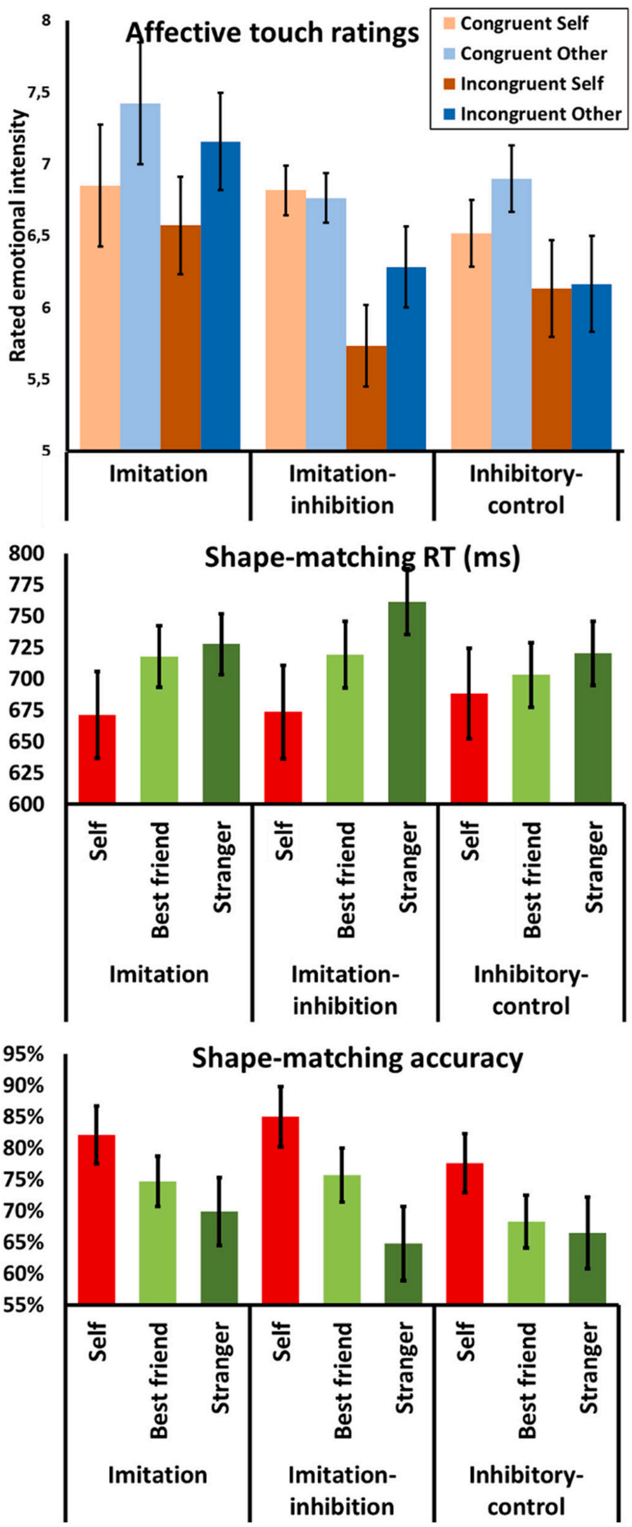

Fig. 4. Impact of socio-cognitive training types on empathic and shape-matching performance in experiment 2. *Upper panel*: Rating intensities when judging the self- and other person's emotional state when emotions are congruent and incongruent. Errors bars indicate pairwise within-subject 95% confidence interval. *Middle panel*: Reaction times to verify matching shape-label parings for shapes associated with the self, the best friend, and a stranger. Errors bars indicate 95% confidence interval. *Lower panel:* Accuracy percentages to verify matching shape-label parings for shapes associated with the self, the best friend, and a stranger. Errors bars indicate 95% confidence interval.

other two interactions with training, and did not interact with any other effect. Including personal distress increased the statistical significance of the triple interaction ($p = .037$), did not affect the other two interactions with training, but revealed a marginal perspective (i.e., with emotional self-salience) by personal distress interaction, $F(1,98) = 3.832$, $p = .053$, $\eta_p^2 = 0.038$. We examined this interaction via a Pearson correlation that showed a small but significant positive interaction between emotional self-salience (i.e., higher emotional intensity for the self-judgements than for other-judgements) and personal distress, $r(102) = 0.219$, $p = .027$. Given that the triple interaction significance was modulated by these two covariates, caution regarding its interpretability is warranted.

3.2.2.2. Planned comparisons. In order to directly test the hypothesized impact of imitation-inhibition training on self-other distinction, we conducted two planned contrasts to compare the congruency effect (i.e., the extent of overall bias and thus self-other distinction) of the imitation-inhibition group to the two other training groups. The congruency effect in the imitation-inhibition group ($M = 0.782$, $SD = 1.218$) was significantly higher than in the imitation group ($M = 0.270$, $SD = 0.752$, $t(99) = 2.042$, $p = .044$, $d = 0.51$, *95% CI* [0.014, 1.001]) but did not significantly differ from the inhibitory-control group ($M = 0.530$, $SD = 1.086$, $t(99) = 0.995$, $p = .322$, $d = 0.22$, *95% CI* [−0.250,0.752]).

In order to directly test the hypothesized impact of imitation-inhibition training on self-salience, we conducted two sets of two planned contrasts to compare the perspective effects (i.e., the extent to which the median ratings of emotional intensity were superior for self-judgements than other-judgements across all trials (i.e., perspective main effect) then only for the congruent trials) of the imitation-inhibition group to the two other training groups. The perspective main effect in the imitation-inhibition group ($M = -0.248$, $SD = 1.129$) was numerically the highest but did not differ significantly from imitation group ($M = -0.640$, $SD = 1.795$, $t(99) = 1.093$, $p = .277$, $d = 0.26$, *95% CI* [−0.320, 1.106]) and the inhibitory-control group ($M = -0.255$, $SD = 1.423$, $t(99) = 0.022$, $p = .983$, $d = 0.01$, *95% CI [*−0.710, 0.726]). The perspective effect on congruent trials in the imitation-inhibition group ($M = 0.053$, $SD = 0.945$) was significantly higher than in the imitation group ($M = -0.635$, $SD = 1.816$, $t(99) = 2.008$, $p = .047$, $d = 0.48$, *95% CI [*0.008, 1.368]) but did not differ significantly from the inhibitory-control group ($M = -0.401$, $SD = 1.311$, $t(99) = 1.317$, $p = .191$, $d = 0.40$, *95% CI [*−0.230, 1.139]).

3.2.3. Shape-matching task

Rates of correct responses ($M = 0.777$, $SD = 0.011$) of 6 participants were at chance level (50% chance getting the right response; cut-off rate of 0.56 for 95% confidence that performance is above chance) and thus excluded from analyses. The final analyzed sample was distributed as follows: imitation-inhibition group: 30; imitation group: 35; inhibitory-control: 32.

3.2.3.1. Omnibus ANOVA. The repeated-measures ANOVA conducted on RT indicated the assumption of sphericity was violated, $\chi^2(2) = 53.473$, $p < .001$, and thus, a Greenhouse-Geisser correction was used (see Fig. 4, middle panel). The ANOVA revealed a significant main effect of shapes, $F(1.39,94) = 33.046$, $p < .001$, $\eta_p^2 = 0.260$, with RT for the self being fastest and RT for stranger being the slowest, and a significant shape by training interaction, $F(2.78,94) = 2.846$, $p = .044$, $\eta_p^2 = 0.057$. There was no significant main effect of training groups, $F(2,94) = 0.351$, $p = .705$, $\eta_p^2 = 0.007$. The ANOVA with the personal distress as covariate slightly reduced the statistical significance of the shape by training interaction ($p = .058$) and all the other effects were non-significant (p's > 0.398). The ANOVA with the negative affect as covariate revealed that the negative affect by shape interaction was not significant ($p = .417$) and the other effects remained qualitatively unchanged.

The repeated-measures ANOVA conducted on accuracy rates indicated the assumption of sphericity was violated, $\chi^2(2) = 32.599$, $p <$

.001, and thus, a Greenhouse-Geisser correction was used (see Fig. 4, lower panel). The ANOVA revealed a significant main effect of shapes, $F(1.54,94) = 45.832$, $p < .001$, $\eta_p^2 = 0.328$, with the highest accuracy for the self and lowest from the stranger, and a marginally significant shape by training interaction, $F(3.09,94) = 2.178$, $p = .091$, $\eta_p^2 = 0.044$. There was no significant main effect of training groups, $F(2,94) = 1.865$, $p = .161$, $\eta_p^2 = 0.038$. The ANOVA with the personal distress as covariate revealed only non-significant effects (p's > 0.295). The ANOVA with the negative affect as covariate revealed a non-significant negative affect by shape interaction ($p = .435$) and the other effects remained qualitatively unchanged.

3.2.3.2. Planned comparisons. In order to directly test the hypothesized impact of imitation-inhibition training on self-salience, for RTs then accuracy rates, we conducted two planned contrasts to compare the self-shape performance advantage (i.e., the extent the performance is better for the shape associated with the self over the average performance of the shapes associated with the best friend and the stranger) of the imitation-inhibition group to the two other training groups.

For RTs, the self-shape performance advantage in the imitation-inhibition group ($M = 66.784$, $SD = 90.259$), was significantly higher than in the inhibitory-control group ($M = 23.412$, $SD = 59.813$; $t(94) = 2.322$, $p = .022$, $d = 0.57$, *95% CI* [6.282, 80.461]) but did not differ significantly from the imitation group ($M = 51.545$, $SD = 68.751$; $t(94) = 0.833$, $p = .407$, $d = 0.19$, *95% CI* [−21.072, 51.552]).

For the accuracy rates, the self-shape performance advantage in the imitation-inhibition group was numerically the highest ($M = 0.134$, $SD = 0.119$) but the difference was not significant against the imitation group ($M = 0.090$, $SD = 0.136$; $t(94) = 1.394$, $p = .167$, $d = 0.34$, *95% CI* [−0.019, 0.106]) and the inhibitory-control ($M = 0.091$, $SD = 0.122$; $t(94) = 1.344$, $p = .182$, $d = 0.36$, *95% CI* [−0.021, 0.107]).

4. Combined results

Because both experiment 1 and 2 were under-powered in terms of sample size and the methods were identical (except for be-imitated group of experiment 1 that was here excluded), we re-examined the planned comparisons with the two data sets combined to obtain well-powered estimates of the effects of interests. The other analyses can be found in supplementary materials. Caution regarding the interpretability these results is however warranted, since analyzing the combined experiments data consists in a post-hoc multiple testing of the same data, which increases the risk that the obtained significant effects are false positives from 5% (i.e., as usual with p < .05) to maximum 8%, as calculated from the formula of Sagarin, Amber, and Lee (2014) for post-hoc re-examination of same data after sample augmentation.

4.1. Sample

178 female participants were allocated to either the imitation ($N = 62$), imitation-inhibition (N = 62), or inhibitory-control ($N = 54$) training condition.

4.2. Empathic performance

After outlier and missing data exclusion (see respective experiments details), 168 participants were distributed between the imitation ($N = 59$), imitation-inhibition ($N = 58$), and inhibitory-control ($N = 51$) training conditions.

Planned comparisons targeting self-other distinction by assessing the congruency effect in the imitation-inhibition group ($M = 0.611$, $SD = 1.053$) versus the other groups did not show significant group differences ($M = 0.442$, $SD = 1.138$, $t(165) = 0.851$, $p = .396$, $d = 0.15$, *95% CI* [−0.223, 0.560]) and inhibitory-control group ($M = 0.484$, $SD = 1.017$, $t(165) = 0.615$, $p = .539$, $d = 0.12$, *95% CI* [−0.280, 0.533]; see Fig. 5).

Planned comparisons on the self-salience revealed that the perspective main effect in the imitation-inhibition group ($M = -0.003$, $SD = 1.163$) did not significantly differ from the one of the imitation group ($M = -0.299$, $SD = 1.936$, $t(165) = 1.047$, $p = .297$, $d = 0.19$, *95% CI* [−0.262, 0.853]) and the inhibitory-control group ($M = -0.356$, $SD = 1.203$, $t(165) = 0.615$, $p = .231$, $d = 0.28$, *95% CI* [−0.226, 0.931]). The perspective effect on congruent trials in the imitation-inhibition group ($M = 0.157$, $SD = 1.014$) was significantly higher than in the imitation group ($M = -0.428$, $SD = 1.164$, $t(165) = 2.350$, $p = .020$, $d = 0.54$, *95% CI* [0.094, 1.078]) and the inhibitory-control group ($M = -0.503$, $SD = 1.299$, $t(165) = 2.552$, $p = .012$, $d = 0.57$, *95% CI* = [0.150, 1.172]; see Fig. 5).

4.3. Shape matching performance

After outliers and missing data exclusion (see respective experiments

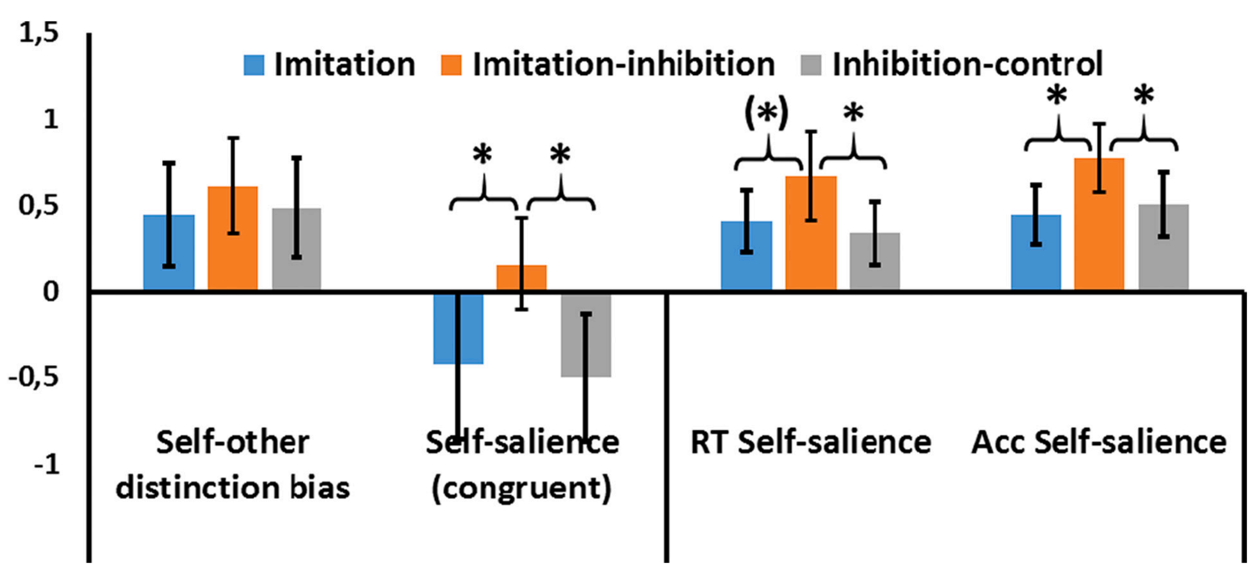

Fig. 5. Impact of socio-cognitive training types on the self-other distinction bias and emotional self-salience measured with the Affective touch paradigm and on the perceptual self-salience in terms of RT (ms divided 100 for illustrative purpose) and accuracy rate (multiplied by 5 for illustrative purpose). Errors bars indicate between-subject 95% confidence intervals. * = $p < .05$, (*) = $p < .10$.

details), 144 participants were distributed between the imitation (N = 52), imitation-inhibition (N = 46), and inhibitory-control (N = 46) training conditions.

Planned comparisons on the self-salience analyzed with RTs revealed that the self-shape performance advantage in the imitation-inhibition group (M = 66.869, SD = 86.956) was marginally significantly higher than in the imitation group (M = 40.879, SD = 63.779, $t(141)$ = 1.801, p = .074, d = 0.34, *95% CI* [−2.534, 54.513]) and significantly higher than in the inhibitory-control group (M = 33.810, SD = 61.235, $t(141)$ = 2.224, p = .028, d = 0.44, *95% CI* [3.675, 62.443]; see Fig. 5).

Planned comparisons on the self-salience analyzed with the accuracy rates revealed that the self-shape performance advantage in the imitation-inhibition group (M = 0.155, SD = 0.133) was significantly higher than in the imitation group (M = 0.089, SD = 0.123, $t(141)$ = 2.552, p = .012, d = 0.52, *95% CI* [0.015, 0.117] and the inhibitory-control group (M = 0.100, SD = 0.125, $t(141)$ = 2.060, p = .041, d = 0.43, *95% CI* [0.002, 0.107]; see Fig. 5).

4.4. Cross-tasks correlations

Aiming to test whether self-salience in the Affective touch task relates to self-salience in the Shape-matching task, we conducted four Persons correlations on 138 participants (after combined exclusions of each task). Self-salience measured as the main effect of perspective in the Affective touch task did not significantly correlates with the self-salience measured as the self-shape performance advantage in terms of RT, $r(138)$ = 0.008, p = .930, nor accuracy rates, $r(138)$ = −0.092, p = .484. Self-salience measured as the effect of perspective on the congruent trials of the Affective touch task did not significantly correlate with the self-salience measured as the self-shape performance advantage in terms of RT, $r(138)$ = 0.077, p = .367, nor accuracy rates, $r(138)$ = 0.061, p = .474.

5. Discussion

The border between what we think and feel for ourselves and what others might think or feel is highly permeable and causes biased cognitions and confusions that undermine the understanding of others and oneself. Self-other distinction enables us to tease apart self-experienced thoughts and feelings from those of others and is therefore a crucial social-cognitive ability. While delineating the neurocognitive underpinnings of self-other distinction and how to best measure them is still work in progress, Santiesteban et al. (2012) have devised a socio-cognitive training protocol intended to enhance self-other distinction. Previous studies show that training to counter-imitate led to reduced self-other interferences (i.e., altercentric and egocentric biases) in automatic imitation and visual perspective taking (Santiesteban et al., 2012), but also increased empathic affect sharing on measures devoid of task demands for self-other distinction (de Guzman et al., 2015). These seemingly contradictory findings raises the interesting question of which processes and cognitive functions were actually affected by the training. The present study thus examined which of two possible functions were trained: self-other distinction, measured via the overall extent of ego- and altercentric bias, or relative self-salience, that is the extent to which perceptual information about the self is prioritized over information pertaining to another person. In two experiments, the participants who completed the imitation-inhibition training were expected to show either better self-other distinction or lower self-salience than the participants who completed the control-training sessions, that is, trained imitation or inhibitory-control (or being imitated in experiment 1). Analyses of the emotional intensity ratings in the Affective touch task revealed that while in both experiments self-other distinction was not higher in the imitation-inhibition training group, self-salience was highest in the imitation-inhibition training group, albeit not always to a statistically significant extent but more so when considering self-salience for congruent trials only. Analyses of speed and accuracy in the Shape-matching task revealed in both experiments that self-salience was highest in the imitation-inhibition training group, albeit not always to a statistically significant extent. Combining both experiments to increase statistical power and to combine the evidence, however, strengthened the statistical validity of these findings. We will now discuss these findings and their implications in some more detail.

The first hypothesis the present study tested was whether self-other distinction performance in empathy would be enhanced following imitation-inhibition training. Our results indicated that it was not the case across two experiments. Moreover, if anything, self-other distinction was numerically worst in the imitation-inhibition group when combining the two datasets. Three potential explanations for this finding are considered respectively. The first potential explanation is that our sample sizes were underpowered to replicate the findings of Santiesteban et al. (2012), which can cause false positive or false negative findings. However, our study consisted of two procedurally identical experiments (essentially an internal replication by repetition of experiment 1 by experiment 2), which resulted in largely consistent findings. Moreover, combining the two datasets resulted in more than 50 participants per training group, which was sufficiently powered to detect the effects of interest. The second potential explanation is that the training effects on self-other distinction in automatic imitation and visual perspective taking do not generalize to self-other distinction in empathy. However, a conceptual analysis of the trained and tested tasks would not lend much support to this interpretation. Rather, one could take the stance that self-other distinction in empathy, measured with the Affective touch task, shares more features with automatic imitation and visual perspective-taking tasks than these two latter tasks share between themselves: Imitation is considered as an ontogenetic precursor of empathy (but not of perspective taking) (Iacoboni, 2009) while the affective touch and perspective-taking paradigms (but not automatic imitation) measure egocentric and altercentric biases through explicit evaluations of self and another person's mental states. Moreover, the socio-cognitive training has already been shown to influence empathy (but not self-other distinction in empathy) (de Guzman et al., 2015). The third explanation is that imitation inhibition did not enhance self-other distinction, but affected performance in our task in a different way, which is discussed below.

The second hypothesis the present study tested was whether the relative self-salience would be altered following imitation-inhibition training. Based on the study of de Guzman et al. (2015) showing higher empathic responding following the socio-cognitive training, we expected the imitation-inhibition training would lead to prioritization of the other person's affect and thus the participants who completed that training would have the smallest relative self-salience. Our results indicated a distinct level of self-salience in the imitation-inhibition group, but this was characterized by the highest (not the smallest) level of self-salience. Although this higher self-salience was found both with the Affective touch task and the Shape-matching task and across both experiments, the group differences were of variable statistical reliability and generally of small effect sizes (M_d = 0.43). This consistent but small effect raises two questions. First, although higher relative self-salience following imitation-inhibition training could explain why automatic imitation interference was reduced in Santiesteban et al. (2012), it is harder to explain how it reduced the egocentric inference in the visual perspective taking task in the same study. However, it could be argued that the Director's task is used without trials requiring to take the self-perspective, which prevents comparisons between self-judgements and other-judgements trials to calculate relative self-salience. Instead, we can only infer that in conflicting visual perspectives (i.e., experimental trials in the Director's task) self-salience was not reduced following the imitation-inhibition training. Indeed, we found that imitation-inhibition training did not impact self-salience calculated as the main effect of perspective, but only self-salience calculated on congruent trials, that is when perspectives are *not* conflicting. Moreover, visual examination of the plot of the increased altercentric bias found in experiment 2 (see Fig. 4, upper panel) shows that this a priori incoherent finding is explained by the increased intensity of ratings for self-congruent trials (i.e., the higher the average rating for self-congruent, the higher the difference from the average rating in self-incongruent). Finally, finding that imitation-inhibition training affected performance in absence of conflicting perspectives also explains why imitation-inhibition training had effects on empathy measures in de Guzman et al. (2015), when no perspective conflict was present. The second question to address is why imitation-inhibition training specifically altered self-salience on congruent trials. One aspect to consider is that, for both self-salience in the Shape-matching task and self-salience on congruent trials of the Affective touch task, the relative self-prioritization occurred most likely on an early processing stage or at least on less high-level processing stages than when perspectives are conflicting (requiring awareness and regulation of the self-other difference). Another aspect to consider is a potential strategy the imitation-inhibition provokes: It is plausible that the participants, by training to not imitate another person's finger movements, adopted a strong top-down self-focus, possibly on early sensory cues, to facilitate performance at resisting imitative tendencies. If so, this self-focus mindset could have gated early processes and could be effective for congruent perspectives trials but would be less effective when attentional demands must be diverted to resolve the self-other differences (i.e., incongruent trials). These explanations are however speculative and remain to be tested and validated by further research.

By conceptually replicating the impact of the socio-cognitive training onto self-other distinction in the affective domain and by examining self-salience with two distinct measures, this study addressed two additional questions related to cross-domain generalization. First, regarding self-other distinction, the findings of Santiesteban et al. (2012) were interpreted as training self-other distinction in automatic imitation carried over to visual perspective taking and thus would support the existence of a domain-general mechanism of self-other distinction. The current evidence, by not replicating a beneficial impact on self-other distinction, does not support the domain-generality hypothesis. However, the reason why the training did not affect self-other distinction in empathy may not be related to a domain difference (cf. two previous paragraphs). Second, regarding self-salience, only one study so far examined the hypothesis of a cross-domain self-salience (also referred to as self-bias; Nijhof et al., 2020) and they found non-significant correlations between self-salience measured with the Shape-matching task and an attentional blink task. In our study, we found a similar pattern of higher self-salience in the imitation-inhibition group across both tasks and both experiments but the cross-tasks correlations are, however, non-significant. Hence, our results do not clearly support nor contradict the cross-domain hypothesis of self-salience.

Although our results seem to contradict the initial finding of Santiesteban et al. (2012) that imitation-inhibition training enhances self-other distinction and rather suggests that it is self-salience that is modulated, we must remind the weak statistical reliability of our findings as the sample sizes were under-powered to replicate the initial findings. Moreover, the group-differences were statistically inconsistent across measures and experiments, which suggests there is substantial inter-individual variability on those measures and/or on the effect of the socio-cognitive training. It is only once a large sample is gathered ($N >$ 50 per training group, against $N > 16$ per training group in Santiesteban et al., 2012), here through combining the two identical experiments, that reliable significant differences could be observed, albeit of small to moderate effect sizes. However, combining two experiments increased the rate of type I errors (from 5% to maximum 8%) as we performed an additional analysis on the same data; hence caution is again warranted.

At last, in Experiment 2, unexpected group differences were found for the self-reported level of personal distress and negative affect. Including these variables as covariates in the analyses of social cognitive performance had no or little qualitative impact on the results with the exception of a marginally significant interaction between personal distress and relative self-salience in the Affective touch paradigm. This interaction allowed to reveal a significant positive correlation between personal distress and relative self-salience, which translates as higher emotional intensity ratings for the self (than for the other person) among the individuals reporting higher personal distress tendencies. Personal distress occurs when witnessing another person's affect but experiencing a self-focused emotion (Eisenberg et al., 1989). Self-other distinction is often mentioned to prevent personal distress but it seems possible that personal distress tendencies might also be related to relative self-salience in empathy, that is, to the extent to which our personal affect is experienced as more emotionally intense than when imaging the emotion experienced by another person. In line with how our findings imply that relative self-salience should be considered along with self-other distinction to understand the egocentric and altercentric biases, the correlation between personal distress and relative self-salience supports the possibility that the relative self-salience is also a key element to consider in the emergence of personal distress.

6. Conclusions

Our actions and thoughts are deeply influenced by other people's actions and thoughts. While self-other distinction is currently in the spotlight in order to explain these influences, it hides the fact that self-salience is an equally likely predictor of self-other interferences, that is, egocentric and altercentric biases, and possibly personal distress. This study demonstrates a case where an effect on self-other distinction should be reconsidered as an effect on self-salience. More importantly, we demonstrated it is feasible and useful to consider both self-salience and self-other distinction as two complementary angles to explain the past, present, and future self-other distinction findings.

Declaration of competing interest

The authors declare they have no competing interests.

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Appendix A. Supplementary data

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