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Nicholas M. Thompson[1], Carien M. van Reekum[1], Bhismadev Chakrabarti*[1,2,3]

1 School of Psychology and Clinical Language Sciences, University of Reading, UK

2 India Autism Center, Kolkata, India

3 Department of Psychology, Ashoka University, India

*Corresponding author

Bhismadev Chakrabarti

b.chakrabarti@reading.ac.uk

School of Psychology and Clinical Language Sciences,

University of Reading,

Reading, RG6 6ES,

United Kingdom

Abstract

Understanding and sharing *others'* emotions (i.e. empathy) requires the ability to manage one's *own* emotions (i.e. emotion regulation). Indeed, empirical evidence suggests that empathy and emotion regulation are related. This evidence is largely based on self-report measures of both constructs. The current study examined how task measures that assess processes related to empathy are associated with self-reported emotion dysregulation in a young adult sample. An eye-tracking based perspective-taking task was used as a proxy measure of cognitive empathy. A spontaneous facial mimicry (SFM) task, wherein the activation of the Zygomaticus Major and the Corrugator Supercilii were measured during the passive viewing of happy and angry faces, was used as a proxy measure of affective empathy. The perspective-taking task metric showed a negative relationship with emotion dysregulation. The overall SFM metric was not significantly associated with emotion dysregulation. Follow-up analyses revealed that SFM for angry faces was inversely proportional to emotion dysregulation; no such relationship was observed for SFM for happy faces. These findings build upon prior work by demonstrating a positive relationship between adaptive emotion regulation and a behavioural measure of cognitive empathy. The findings for affective empathy are suggestive of a valence-specific relationship between SFM and emotion regulation.

Keywords: empathy, emotion regulation, cognitive, affective, social cognition

"Hatred is blind; rage carries you away" (Alexandre Dumas, The Count of Monte Cristo). Rage can be viewed as a failure of appropriate emotion regulation, and the ensuing blindness that Dumas refers to can be one that prevents us from seeing or feeling others' emotions. As this example illustrates, the interpersonal processes of empathy and the intrapersonal processes of emotion regulation are intrinsically linked. Prior work has largely examined emotion regulation from an intrapersonal perspective, paying little attention to relevant interpersonal emotion processes such as empathy (for exceptions, see Horn et al., 2019; Zaki & Williams, 2013). Conversely, empathy has largely been studied from an interpersonal perspective, with relatively little consideration given to the potential influence on intrapersonal processes such as emotion regulation (for exceptions, see Lockwood et al., 2014; Thompson et al., 2022). Understanding the shared variance between empathy and emotion regulation, and what could drive such overlap between these related socio-emotional processes, has the potential to improve future models on emotion regulation and empathy. To this end, the current study examined how task measures that assess processes related to cognitive and affective empathy are associated with self-reported difficulties in emotion regulation (henceforth emotion dysregulation).

Empathy comprises a cognitive and an affective dimension. Cognitive empathy reflects the capacity to *understand* the emotional/mental experiences of others; affective empathy reflects the capacity to *share* others' emotions, for instance, feeling sad in response to the sadness of others (Chakrabarti & Baron-Cohen, 2006; Decety & Jackson 2004; Preston & de Waal 2002; Thompson et al., 2019). While cognitive and affective empathy processes may operate in tandem, they are mediated by largely separable underlying mechanisms and neural substrates (Kanske et al., 2016; Preckel et al., 2018; Shamay-Tsoory et al., 2009). Affective empathy processes can occur with relative spontaneity. The observation of others' emotional behaviours can spontaneously activate the observer's own affective and/or motor representations associated with the first-hand experience of those behaviours. This affective/motor resonance can result in an embodied simulation of an observed emotion, and consequently, emotional congruence between the observer and the other (Bernhardt and Singer, 2012; de Waal and Preston, 2017; Hatfield et al., 1993). In contrast, cognitive empathy is typically more reliant upon effortful cognitive processes (see reviews by Thompson et al., 2019; Yu & Chou, 2018).

Cognitive empathy recruits various cognitive processes, notably those that enable the observer to take the perspective of another individual (Frith & Frith, 2003; Thompson et al., 2019). Humans typically interpret incoming information based on their own egocentric perspective (Coburn et al., 2015; Wimmer & Perner, 1983). To accurately represent another individual's perspective, which may differ from one's own, this 'egocentric bias' must be inhibited. Inadequate inhibition of this bias can result in egocentric interference, whereby one's own knowledge, beliefs, or current emotional state can impact the accuracy and efficiency with which one is able to infer another's experience (Camerer et al., 1989; Epley et al., 2004; Schmid & Schmid-Mast, 2010; Silani et al., 2013; Todd et al., 2015).

The capacity to share others' emotions (i.e. affective empathy) is driven largely by mimicry/embodiment-related processes. The inherent human predisposition to spontaneously mimic the emotional behaviours of others, such as their facial expressions, can induce in the observer an emotional state isomorphic to that of the perceived other (de Waal & Preston, 2017; Hatfield et al., 1993; Preston & de Waal 2002). Spontaneous facial mimicry (SFM) has been studied empirically using facial electromyography (fEMG), which has demonstrated that the perception of emotional faces elicits activity in congruent muscle groups (e.g. the Zygomaticus Major and the Corrugator Supercilii in response to happy and angry faces, respectively) (Dimberg & Thunberg, 1998). SFM can occur rapidly and automatically, even when the observer is not consciously aware of the presence of a face (Bornemann et al., 2012; Dimberg et al, 2000).

The ability to regulate one's emotions effectively is crucial for adaptive socio-emotional functioning (Gross & John, 2003); difficulties in emotion regulation are associated with negative consequences such as depression and anxiety (Crowell, et al. 2014; Folk et al. 2014). Effective emotion regulation is dependent upon various factors, such as the individual's capacity to be aware of their emotions and utilise adaptive regulatory strategies to manage emotions across diverse contexts (Gratz & Roemer, 2004). In the current study we assess emotion regulation using a self-report measure that captures respondents' typical experiences of difficulties with emotion regulation (Kaufman et al., 2016).

Regarding the relationship between cognitive empathy and emotion regulation, prior work has highlighted overlap in the cognitive control processes and neural correlates that underlie these abilities (e.g. Morawetz et al., 2022; Thompson et al., 2019). Cognitive control encompasses a range of distinct but interrelated processes, such as working memory updating, inhibitory control, and set shifting, which govern the adaptive control of action (Miyake et al., 2000). Prior work has linked each of these cognitive control processes to cognitive empathy (Austin et al., 2014; Carlson et al., 2004; Carlson & Moses, 2001; Gökçen et al., 2016; Mutter et al., 2006; Vetter et al., 2013), where they support the ability to simultaneously represent one's own and another's state, inhibit one's default egocentric perspective to take the perspective of another individual, and draw upon relevant knowledge from memory (Bird and Viding, 2014; Chakrabarti and Baron-Cohen, 2006; O'Connell et al., 2015). These same cognitive control processes have also been implicated in emotion regulation, where they support the ability to manage negative affect and exert control over one's affective responses (e.g. Hendricks & Buchanan, 2016; Schmeichel & Demaree, 2010; Schmeichel et al., 2008). Thus, greater cognitive empathy could support adaptive emotion regulation, and vice versa, via improved efficiency/efficacy of these cognitive control processes. Indeed, prior work has demonstrated that a greater capacity for cognitive empathy is associated with more adaptive emotion regulation (e.g. Lockwood et al, 2014; Okun et al., 2000; Powell, 2018; Thompson et al., 2022; Troyer & Greitemeyer, 2018; Tully et al., 2016).

While the evidence for cognitive empathy being positively associated with adaptive emotion regulation is relatively clear, there is less clarity regarding the relationship between affective empathy and emotion regulation. Prior work suggests that greater affective empathy could be associated with increased emotion dysregulation (Thompson et al., 2022; Schipper & Petermann, 2013). In support of this assertion, individuals with borderline personality disorder (BPD), which is characterised by emotion dysregulation, show atypically high levels of affective empathy (Harari et al., 2010; Ripoll et al., 2013). Given that emotional stimuli/experiences can have a deleterious effect on the capacity to maintain effective cognitive control (Tottenham et al., 2011), it is possible that the increased emotional reactivity associated with higher levels of affective empathy (Rueckert et al., 2011) could interfere with the ability to utilise adaptive regulation strategies which are reliant upon cognitive control processes mediated largely by the PFC (McRae et al., 2010; Urry et al., 2009). Consistent with this assertion, some findings suggest that the tendency to resonate more strongly with others' emotions is associated with less adaptive emotion regulation (Contardi et al., 2016; Grynberg & López-Pérez, 2018; MacDonald & Price, 2019; Thompson et al., 2022).

In contrast, other studies have found negative relationships between affective empathy and metrics indicative of emotion dysregulation, such as the frequency of using maladaptive suppression strategies (Lockwood et al., 2014; Powell, 2018; Troyer & Greitemeyer, 2018). A recent study found that trait affective empathy was negatively associated with difficulties with emotional awareness, but positively associated with difficulties maintaining focus on goal-directed behaviours and being able to utilise effective strategies to control emotions (Thompson et al., 2022 study 1). This suggests that affective empathy may support some aspects of emotion regulation but hinder others.

In addition to potential differences in the specific aspects of emotion regulation being assessed, the contrasting findings of prior work could reflect variability in how the measures used conceptualise affective empathy. Some measures, such as the Questionnaire Measure of Emotional Empathy (QMEE; Mehrabian & Epstein, 1972) and the Personal Distress subscale of the Interpersonal Reactivity Index (IRI; Davis, 1983) assess more automatic aspects of affective empathy. Other measures, such as the Affective Empathy subscale of the Questionnaire of Cognitive and Affective Empathy (QCAE; Reniers et al., 2011), also capture aspects of affective empathy that rely more upon controlled processes, such as those that necessitate the observer being able to distinguish between self and other (Decety & Jackson, 2004, 2006; Eisenberg, 2000).

Critically, most prior studies examining the relationship between empathy and emotion regulation have used self-report measures of both constructs. While ‘trait’ measures can provide useful indices of respondents’ self-perceptions of their capacity for empathy, they typically assess empathy in a relatively broad manner, and as noted above, may vary in their conceptualisation of the boundaries between the cognitive and affective dimensions. Additionally, trait measures may be less effective in assessing more ability-based aspects of empathy (Dziobek et al., 2008) of which individuals may not be fully aware, such as the ability to manage co-active self and other representations (Bird & Viding, 2014; Thompson et al., 2019).

A task paradigm commonly used to assess perspective-taking ability (a process related to cognitive empathy) is the ‘director task’ (Keysar et al., 2000). In this task, participants are required to move objects positioned on a shelving unit in response to instructions delivered by the 'director', who is viewing the shelves from the opposite side and for whom some objects are occluded. By tracking participants' eye gaze patterns, one can quantify their egocentric bias and efficiency in suppressing this egocentricity (Keysar et al., 2000; Santiesteban et al., 2012; Symeonidou et al., 2016). In this study we used an eye-tracking metric from the director task as a proxy for perspective-taking ability.

As a proxy measure of affective empathy processes, we measured fEMG metrics of congruent muscle activity in response to angry and happy faces. Prior work has demonstrated that the magnitude of SFM is positively associated with self-report indices of congruent emotional experience (Sato et al., 2013; Wild et al., 2001, though see also Hess & Blairy, 2001) and trait measures of affective empathy (Dimberg et al., 2011; Sonnby-Borgstrom, 2002), which suggests that it can provide a reliable measure of an individual's propensity to resonate with others' emotional states (i.e. affective empathy).

Considering the prior evidence reviewed, we expected emotion dysregulation to show a negative relationship with cognitive empathy. Based on the rationale that the SFM task assesses more automatic processes associated with emotion sharing which could negatively impact one's ability to enact adaptive emotion regulation strategies, we predicted that trait emotion dysregulation would show a positive relationship with affective empathy.

Methods

Participants

Forty-eight right-handed participants (31 females) were recruited from the University of Reading student population via the online research panel and poster advertisements. This sample size was chosen based on studies published prior to data collection which also tested correlations between self-report measures and fEMG (e.g. Sato et al., 2013) or director task eye-tracking metrics (e.g. Nilson et al., 2013), and in light of time and financial constraints, which limited the maximum sample it was feasible to collect for this study. The mean age of the sample was 21.29 yrs (SD = 4.03). Participants self-reported as White (70%), South Asian (11%), East Asian (9%), Black (6%), mixed or otherwise defined (4%). Reimbursement was in the form of either course credit or cash payment of £7 per hour. Questionnaires were completed online and the tasks as part of a lab session, which took place in a well-lit room. All participants had normal or corrected to normal vision; visual acuity was not explicitly measured. This study was completed as part of the first author's PhD thesis and the lab session included two additional tasks and two questionnaires not reported in this manuscript (see supplemental materials for details). Data for this study were collected in 2016/2017. All participants gave informed consent prior to taking part in the study. Ethical approval was obtained from the University of Reading Research Ethics Committee.

Materials & Procedure

Emotion Dysregulation. Trait emotion dysregulation was assessed using the Difficulties in Emotion Regulation Scale short form (DERS-SF) (Kaufman et al., 2016). The DERS-SF (henceforth, DERS) is an 18-item questionnaire assessing difficulties with various aspects of emotion regulation. Respondents report the frequency with which they tend to experience difficulties in these aspects of emotion regulation using a 5-point Likert scale, where 1 = almost never (0-10% of the time) and 5 = almost always (91-100% of the time); higher ratings reflect increased emotion dysregulation. The sum of all items provides a total score reflecting overall levels of emotion dysregulation (DERS-Total). The DERS-Total score demonstrated high internal consistency, Cronbach's $\alpha_{\text{DERS-Total}}$ = .89.

Director Task (DT). Stimuli consisted of computerised images of a 4x4 shelving unit containing various objects. There were six object sets, each comprising six objects. Each set was used on four control trials and four experimental trials, with different instructions across the two conditions. While all objects were visible to the participant, two objects were always located on shelves with covered backs, meaning they were not visible to the director. The director was physically present in the room and sat opposite participants facing a screen that was positioned back-to-back with the screen on which participants completed the task. This approach was adopted to increase the ecological validity over previous versions of the task in which only a ‘virtual’ director is used. A photograph of the director facing the participant was visible though the shelves (see Figure 1).

Participants were informed that the director would verbally instruct them to move a particular object to a particular location, and that they should “take into account which objects are visible to the director”. The target object referred to in the director’s instruction was always one of three similar objects. For example, where the instruction referred to a ball, a tennis ball, football, and basketball were present. Instructions on experimental trials created a conflict between the director and participant perspectives as they referred to a target object visible only to the participant. For instance, the instruction to move the “big ball” could induce participants to incorrectly consider the foil object (i.e. the largest ball visible to them) as the target. However, the correct target would be the largest ball visible to both the participant and director. To respond correctly, participants need to inhibit their egocentric perspective in order to select the object that matches the instruction when considering the director’s perspective. There were two types of conflict on experimental trials: spatial (e.g. “move the top/bottom ball”) and size (e.g. “move the big/small ball”). On control trials there was no conflict as the director’s instruction referred to a mutually visible object.

Each trial started with a central fixation cross which remained on screen as the scripted instruction was delivered verbally by the director. Immediately following the instruction, the director pressed the spacebar and after a delay of 500 ms the stimuli were presented. The cursor was not visible until the participant clicked the left mouse button; once the cursor appeared, participants then clicked on the target object, then on the new location, at which point the display updated to show the object in the new location. Participants were instructed that they should make the first mouse button click only once they have decided upon the target object and the new location. Response time was calculated as the delay between stimulus onset and the first mouse click. The task consisted of 48 trials (24 experimental, 24 control) and lasted approximately 15 minutes. The trial order was pseudorandom, with no more than 3 trials of either condition in succession. The trial order was reversed for half of the sample. This director task differed from some previous versions in that there was no time limit on each trial, and participants completed 6 practice trials, 3 of which involved seeing the shelves from the director's perspective.

Figure 1. Illustrative example of stimuli from the participant perspective in the director task. Instructions on experimental trials referred to an object occluded from the director's perspective, e.g. "the big cup". Control trial instructions for the same stimuli referred to a mutually visible object, e.g. "the small cup". The individual shown in this figure is the first author, who has consented to his image being published.

Eye-Tracking Recording & Processing

Gaze data were recorded using a Tobii X2-60 eye-tracker recording at 60Hz, positioned below the monitor on which the task was completed. Participants' eye-gaze was tracked during the initial 'decision period' from stimulus onset until the first mouse click to provide an indication of the objects being considered as potential targets (mean ± SD duration of decision period = 3182.39 ms ± 809.70 ms). The display was separated into 16 regions corresponding to each shelf area. Analyses focused upon the regions of interest (ROI), which were the shelves on which the target and foil objects were located. Any gaze points within the corresponding ROIs were classified as gaze to the target or foil.

The key metric extracted from this task as a measure of cognitive empathy was the duration of gaze time on the target object relative to the foil object on experimental trials. This was calculated by dividing target gaze time by foil gaze time, with larger values reflecting better perspective-taking ability. Unlike other possible metrics, such as the time it takes for the participant to make their first gaze to the target object, this metric does not assume that the first look at the target object denotes the point at which egocentric bias has been successfully inhibited and can account for instances in which participants look back and forth between the target and foil. To isolate experimental trials that tapped into perspective-taking abilities, we had two inclusion criteria: 1) participants had to look at the foil object (to ensure egocentric bias was induced), and 2) a correct response had to follow (to ensure egocentric bias was successfully inhibited).

Technical issues resulted in missing eye-tracking data for one participant, and the loss of data for ~10 trials for two participants. Alongside the participant with missing eye-tracking data, five participants for whom less than 50% of overall gaze points were captured were excluded from the analyses. Any trials where more than ⅓ of all gaze points were not captured were removed. Based on the aforementioned inclusion criteria, incorrect trials and trials on which there were no gaze points on the foil object (<100ms total gaze to foil) were removed prior to calculation of the DT perspective-taking metric. Following these trial-level exclusions, two participants were left with fewer than 10 experimental trials and were removed. This left a final sample of N=39 with (mean ± SD) 19.62 ± 3.70 experimental trials from which the DT perspective-taking metric was calculated.

Spontaneous Facial Mimicry (SFM) Task. Affective empathy was assessed using a SFM task, in which fEMG was used to record activity of the Corrugator Supercilii and Zygomaticus Major during the passive viewing of emotional facial expressions. Face stimuli were taken from the Mindreading set (Baron-Cohen et al. 2004) and comprised 4000 ms clips of four different targets (2 males, 2 females) making happy and angry facial expressions. Dynamic stimuli were used as they are more ecologically valid and have been shown to elicit greater SFM relative to static stimuli (Weyers et al., 2006; Rymarczyk et al., 2011). Each clip was shown six times in a randomised order resulting in 48 trials in total (24 happy face trials, 24 angry face trials). Trials included the following sequence of events: 1) central fixation cross for 1000ms, 2) angry or happy facial expression clip for 4000ms, 3) blank screen for 1000ms (Figure 2). Participants were instructed simply to pay attention to the faces for the duration of the task, which lasted approximately 5 minutes. To reduce the likelihood that they were focusing upon their facial muscles, in accordance with prior SFM studies (e.g. Sims et al., 2012), participants were informed that the EMG sensors were measuring sweat gland activity.

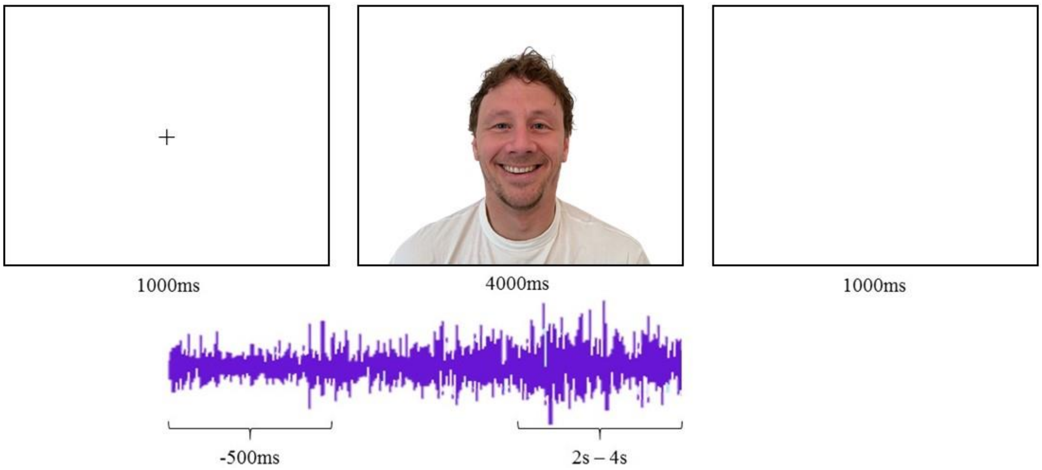

Figure 2. Schematic of trial structure in the SFM task. The key metric of SFM extracted from this task was the mean of the baseline-corrected corrugator (for angry faces) and zygomaticus (for happy faces) activity within the 2-4 second epoch post stimulus onset. The happy expression stimulus shown in this figure is for illustration purposes; the actual stimuli used in the task came from the Mindreading set (Baron-Cohen et al., 2004). The individual shown in this figure consents to their image being published.

Facial EMG Recording & Processing

EMG activity was measured using sensors positioned over the Zygomaticus Major (ZM) and Corrugator Supercilii (CS) in accordance with the guidelines proposed by Fridlund and Cacioppo (1986). The skin was first cleaned using 70% alcohol wipes, after which 4mm Ag/AgCl surface sensors (Discount Disposables, USA) filled with isotonic electrode gel (Mansfield R&D, UK) were attached bipolarly to the left side of the face using 5mm collars (Discount Disposables), at a distance of 10mm apart. A ground electrode was positioned on the left mastoid process.

The EMG signal was recorded using an ML-870 Power Lab amplified 10,000 times by an ML-138 Octal Bioamp and recorded/processed using LabChart 8 (AD Instruments). The raw EMG signal was sampled at a rate of 1kHz, digitised with 16-bit precision. Digital 500Hz low-pass and 50Hz high-pass filters were applied to the signal offline. The EMG data were logarithmically transformed to remove negative values and minimise the impact of any extreme values.

Data from three participants were removed due to poor quality EMG recordings. A further two participants were removed due to lost event markers and a corrupted recording file. Data were visually inspected and any trials with clear movement artefacts/noise were removed (81 trials). Any trials in which the mean CS or ZM activity deviated from the group mean by more than 3*SD were removed (11 trials). Two participants were removed due to having lost 50% of trials in at least one condition. This left a final sample of N=40, with (mean ± SD) 23.38 ± 1.14 trials per condition from which the SFM metric was calculated.

To test for the emergence of SFM, the magnitude of EMG activity during the four second presentation of the facial expression clips relative to a 500 ms baseline during the fixation screen period, was examined. The key metric extracted from this task as a measure of SFM was the mean of the baseline-corrected ZM activity for happy faces and CS activity for angry faces during the 2-4 second epoch following stimulus onset. This epoch was selected because the dynamic facial expressions typically reached maximal intensity at approximately the 2000 ms mark (Sims et al., 2012).

Data Analysis

A fault with the online questionnaire system led to one participant having incomplete data; this participant was removed prior to data processing/analysis. To test for the presence of egocentric bias in the DT, paired samples t-tests were used to compare the following metrics across the experimental and control conditions: 1) the mean response time (RT) for correct trials; 2) the proportion of trials in which the foil object was looked at; 3) the target/foil object gaze ratio. For the RT analysis, trials with RT less than 1000ms or which deviated from the group mean by more than 3*SD were removed. To test for the emergence of SFM, paired samples t-tests were used to compare ZM and CS activity across the baseline and stimulus epochs.

The key metrics extracted from each task for the correlation analysis were: (1) the relative proportion of gaze time on target versus foil objects on experimental trials in the DT, and (2) mean baseline-corrected congruent muscle activity during the 2-4 second period in the SFM task. Normality of each correlation variable was assessed using Shapiro-Wilk tests; as some of the variable distributions showed significant deviation from normality, Spearman's rho is reported for all correlations to enable their direct comparability. All *p*-values are reported as two-tailed with a significance threshold of $p < .05$. To enable a clearer understanding of the extent to which each correlation result supports the alternative over the null hypothesis, Bayes factors (BF) are reported. In line with standard criteria, we interpret BF_{10} of 1-3 as anecdotal support, 3-10 as moderate support, and 10-30 as strong support for the alternative hypothesis (Jeffreys, 1961; van Doorn et al., 2021). Descriptive statistics for all correlation variables are reported in supplemental materials.

Transparency and openness

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. Data pre-processing was conducted using Microsoft Excel. Analyses were conducted using IBM SPSS Statistics for Macintosh, Version 27.0.1.0. Bayes factors were computed using JASP Version 0.12.2 (JASP Team, 2020) with prior width set to default (Love et al., 2019). The data analysed in this study can be accessed at https://doi.org/10.17605/OSF.IO/D8MXK. This study and the analysis plan were not preregistered.

Results

Director Task. Overall accuracy was high (mean ± SD = 95.52% ± 4.21%). Mean RT for experimental trials (mean ± SD = 3069.47 ms ± 739.87 ms) was significantly larger than for control trials (mean ± SD = 2987.80 ms ± 738.23 ms), $t(45) = -2.26$, $p = .03$. Eye-tracking analyses showed that the foil object was looked at on a significantly greater proportion of experimental (mean ± *SD* = 88.67% ± 14.17%) relative to control trials (mean ± SD = 57.54% ± 16.30%), $t(38) = -14.67$, $p < .001$ (Figure 3, left panel). The ratio of target/foil gaze was significantly lower for experimental (mean ± *SD* = 2.12 ± 0.58) relative to control trials (mean ± *SD* = 2.77 ± 1.56), $t(38) = -2.99$, $p = .005$ (Figure 3, right panel).

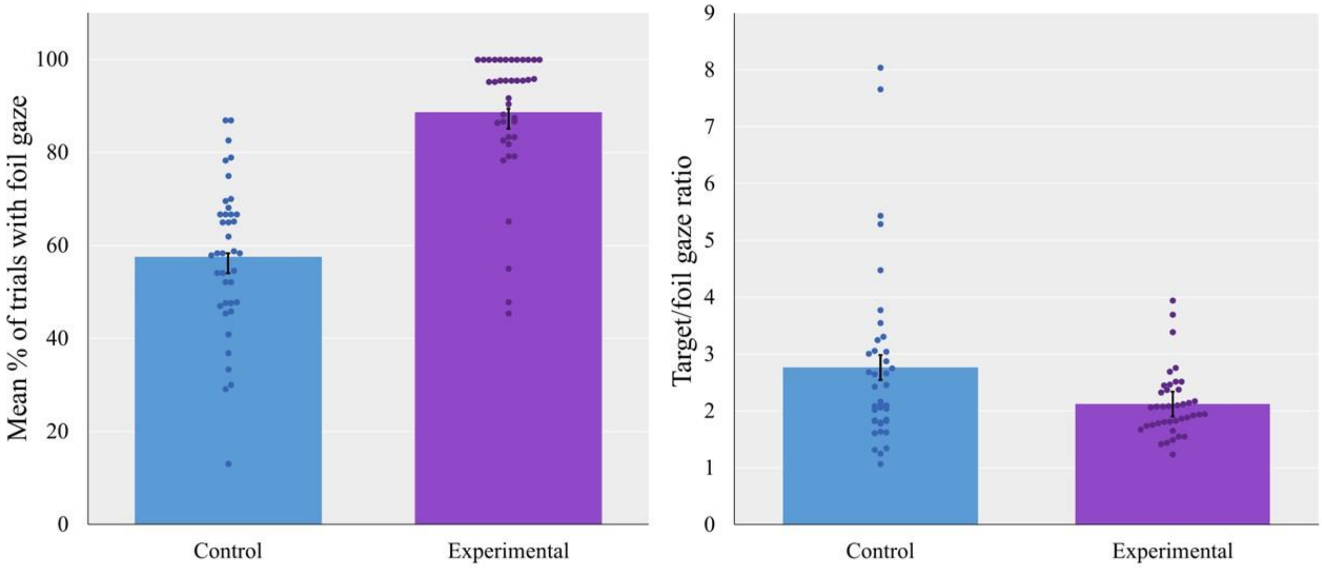

Figure 3. Mean proportion of trials with foil gaze (on the left) and target/foil gaze ratio (on the right) for experimental and control trials. Error bars show within-subjects 95% confidence intervals.

Director Task Correlation with Emotion Dysregulation

To examine the relationship between the DT perspective-taking metric and emotion dysregulation we focused on the experimental condition, as these were the trials in which participants were required to suppress their egocentric bias in order to correctly identify the target object. As predicted, a strong negative correlation between the DT perspective-taking metric and the DERS-total score was observed, *rho*(37) = -.47 ($CI_{95\%}$ [-.69, -.18]), $p = .002$ (Figure 4), which suggests that greater perspective-taking ability was associated with lower self-reported emotion dysregulation. The BF_{10} for this correlation was 12.44, which indicates strong support for the alternative hypothesis. To ensure that this correlation was not overly influenced by any outlier cases, the results following the removal of univariate and bivariate outliers are reported in supplemental materials; the same effect was observed. Exploratory analyses testing the relationship between the DT perspective-taking metric and each DERS subscale are reported in supplemental materials.

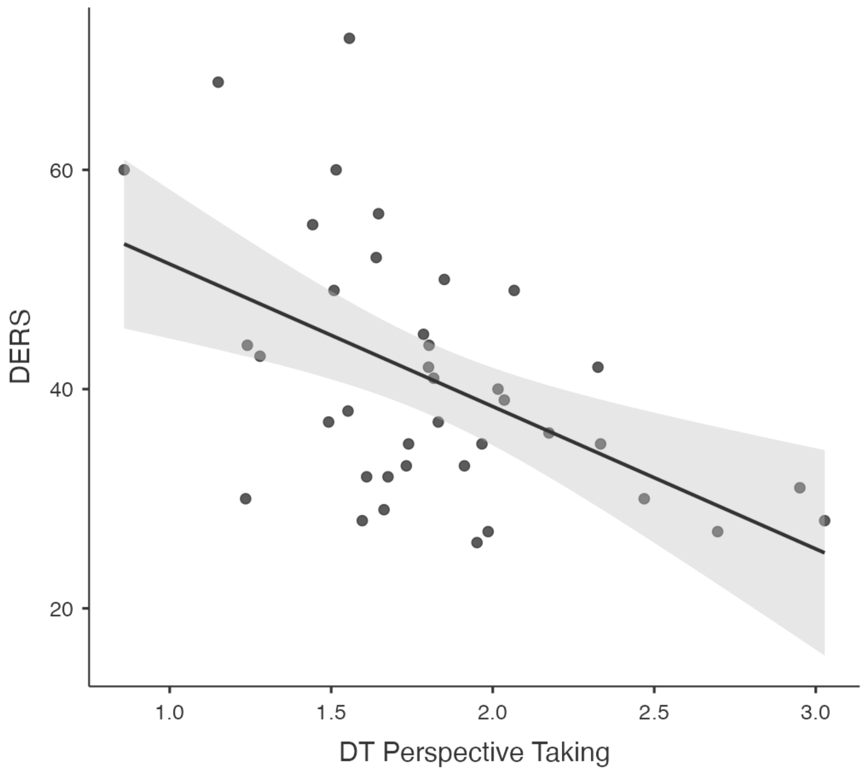

Figure 4. *Scatterplot showing the relationship between DERS-Total score and the DT perspective-taking metric. The shaded grey area depicts the standard error.*

Spontaneous Facial Mimicry Task. Significantly greater ZM activity during the four second stimulus epoch relative to the baseline epoch was observed for happy faces $t(39) = -2.29$, $p = .03$, but not for angry faces $t(39) = .61$, $p = .54$. Significantly greater CS activity during the stimulus presentation epoch relative to the baseline epoch was observed for angry faces $t(39) = -3.75$, $p < .001$. For happy faces, CS activity was significantly lower in the stimulus presentation epoch relative to the baseline epoch $t(39) = 2.29$, $p = .03$. The mean baseline-corrected ZM and CS activity for each one-second epoch of stimulus presentation are presented in Figures 5 and 6, respectively.

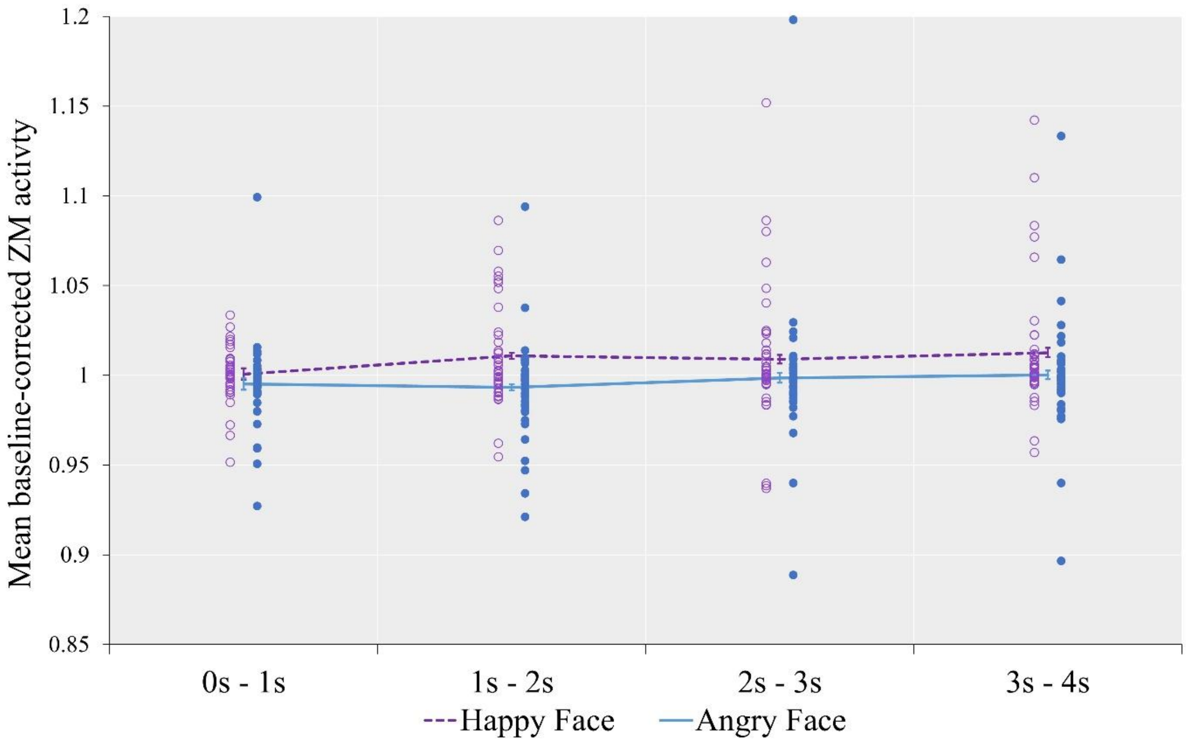

Figure 5. *Mean baseline-corrected Zygomaticus activity for happy and angry faces during each 1-second epoch of stimulus presentation. Error bars show within-subjects 95% confidence intervals.*

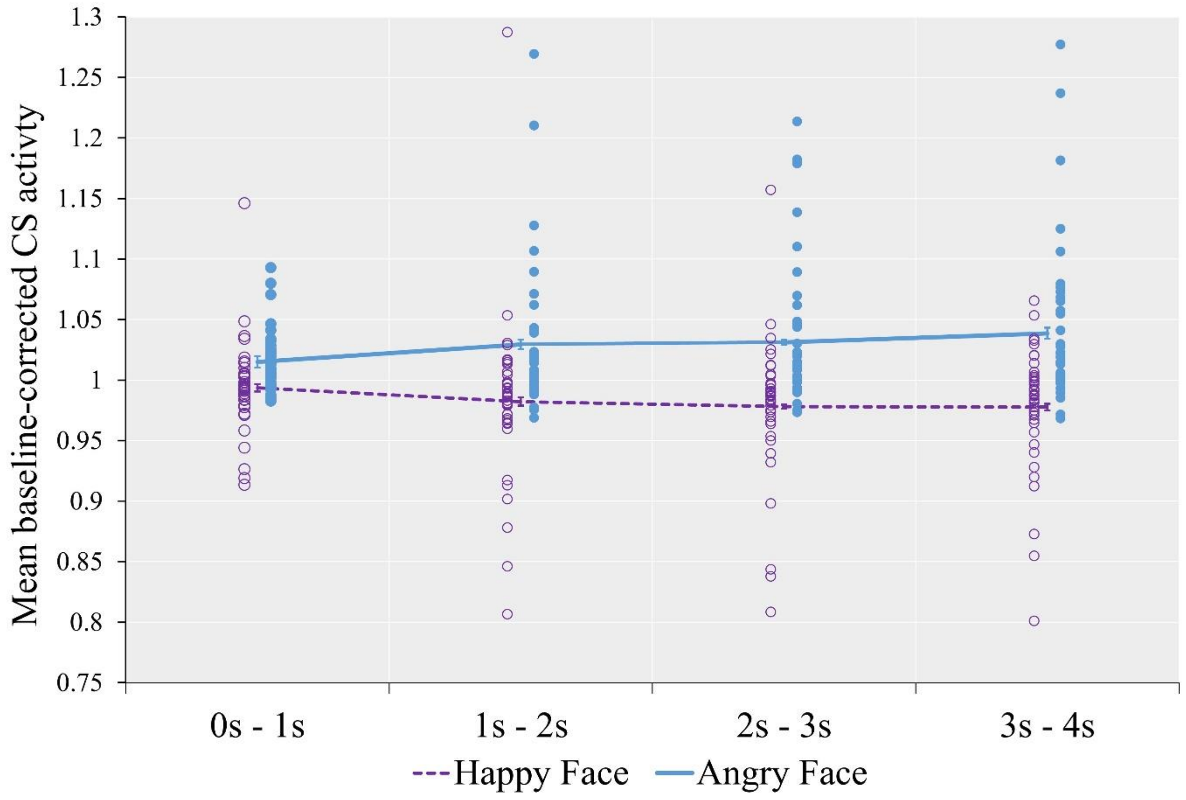

Figure 6. Mean baseline-corrected Corrugator activity for happy and angry faces during each 1-second epoch of stimulus presentation. Error bars show within-subjects 95% confidence intervals.

SFM correlations with Emotion Dysregulation

Contrary to predictions, the mean SFM metric was not significantly correlated with DERS-Total, *rho*(38) = -.26 ($CI_{95\%}$ [-.53, .06]), *p* = .11 (Figure 7). The BF_{10} for this correlation was .73, suggesting anecdotal support for the null hypothesis. To better understand this unexpected result, we conducted exploratory analyses examining the correlations between DERS-Total and ZM activation for happy faces (Happy SFM) and CS activation for angry faces (Angry SFM). The Happy SFM metric showed no relationship with DERS-Total, *rho*(38) = -.03 ($CI_{95\%}$ [-.34, .28]), *p* = .84 (Figure 8, on the left), however, the Angry SFM metric was significantly negatively correlated with DERS-Total, *rho*(38) = -.47 ($CI_{95\%}$ [-.68, -.17]), *p* = .002 (Figure 8, on the right). These two correlations were significantly different (Steiger's Z = 2.25, *p* = .02). The BF_{10} for the Angry SFM-DERS correlation was 17.56, indicating strong support for the alternative hypothesis. The BF_{10} for the Happy SFM-DERS correlation was .21, indicating moderate support for the null hypothesis. To ensure that these correlations were not overly influenced by any outlier cases, the results following the removal of univariate and bivariate outliers are reported in supplemental materials; the same effects were observed. Exploratory analyses testing the relationship between the SFM metrics and each DERS subscale are reported in supplemental materials. Steiger's tests examining the difference between the DT and SFM task correlations with DERS-Total are reported in supplemental materials.

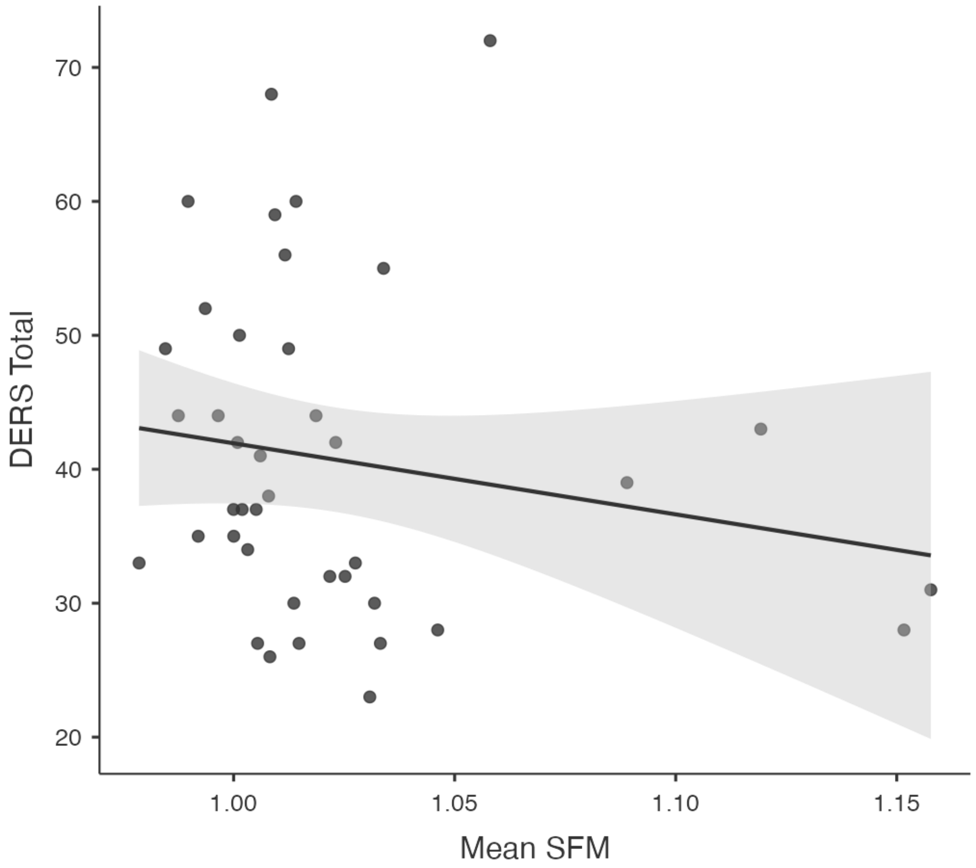

Figure 7. *Scatterplot showing the relationship between the mean SFM task metric and DERS-Total. The shaded grey area depicts the standard error.*

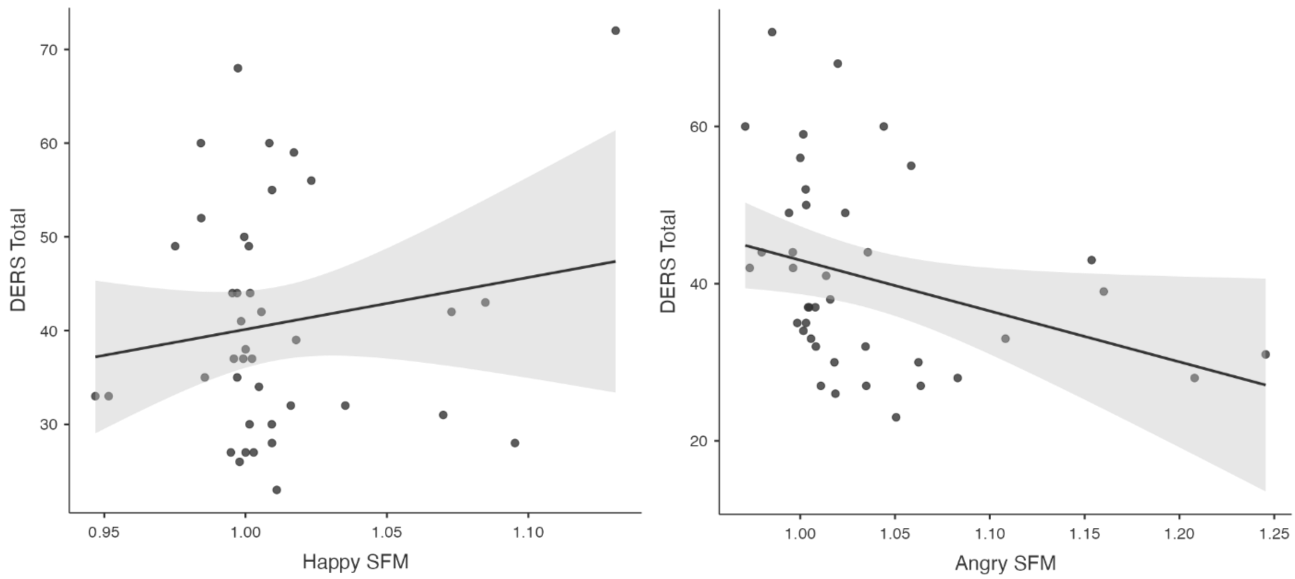

Figure 8. *Scatterplots showing the relationship between DERS-Total and SFM for happy faces (on the left) and SFM for angry faces (on the right). Happy SFM showed no relationship with DERS-Total; angry SFM was negatively correlated with DERS-Total.*

Discussion

This study examined how task measures of cognitive and affective empathy are associated with trait emotion dysregulation. Consistent with our hypothesis, an eye-tracking based measure of perspective-taking ability showed a strong negative relationship with emotion dysregulation. No significant relationship was observed between mean SFM and emotion dysregulation. However, follow-up analyses revealed that spontaneous mimicry of angry faces (indexed by increased CS activation for angry faces) was negatively correlated with emotion dysregulation.

The negative relationship between perspective-taking ability and emotion dysregulation suggests that individuals with a greater capacity for cognitive empathy experience fewer difficulties with emotion regulation in daily life. This finding is consistent with prior work which suggests that cognitive empathy abilities may support adaptive emotion regulation (e.g. Lockwood et al, 2014; Okun et al., 2000; Powell, 2018; Thompson et al., 2022; Troyer & Greitemeyer, 2018; Tully et al., 2016). We propose three possible explanations of this result (Figure 9).

The first possibility is that cognitive empathy processes facilitate emotion regulation. In addition to supporting the ability to take another individual’s perspective, cognitive empathy processes may mediate the ability to shift from one’s immediate experience to different temporal/mental locations, such as the perspective of a future or past self (Buckner and Carroll, 2007; Spreng et al., 2009; Suddendorf and Corballis, 2007; see also O’Connell et al., 2015). Thus, cognitive empathy abilities could support the capacity to reflect upon one’s emotional experience from a more distanced perspective, which might facilitate the selection of contextually appropriate regulatory strategies and the ability to generate alternative appraisals of an emotion-inducing situation (Katzir and Eyal, 2013; Kross and Ayduk, 2011; Wallace-Hadrill and Kamboj, 2016; Wisco and Nolen-Hoeksema, 2011). The second possibility is that emotion regulation processes facilitate cognitive empathy. Individuals with a greater ability to regulate their own emotions may be able to manage negative affect more effectively and efficiently. Reduced experienced negative affect could lead to them having a greater motivation and/or available resources to devote to inferring the internal states of others, which manifests as greater cognitive empathy abilities. The third, and arguably most likely, possibility is that both cognitive empathy and emotion regulation are facilitated by the latent variable cognitive control.

Cognitive empathy is reliant upon various aspects of cognitive control, which mediate the process of taking another individual's perspective and making accurate inferences about their mental/emotional state (e.g. Carlson et al., 2004; Carlson & Moses, 2001; Austin et al., 2014; Gökçen et al., 2016; Marcovitch et al., 2015; Mutter et al., 2006). Given that many forms of adaptive emotion regulation are reliant upon these same processes (e.g. Hendricks & Buchanan, 2016; Schmeichel & Demaree, 2010; Schmeichel et al., 2008), it could be that enhanced efficiency of these cognitive control mechanisms facilitates both cognitive empathy and emotion regulation. It is not possible to objectively characterise here the relative extent to which the director task recruits different sub-processes of cognitive control, such as working memory, inhibition, and set shifting. It would be beneficial for future work to directly examine the unique and combined variance that these different sub-processes of cognitive control account for in the relationship between cognitive empathy and emotion regulation.

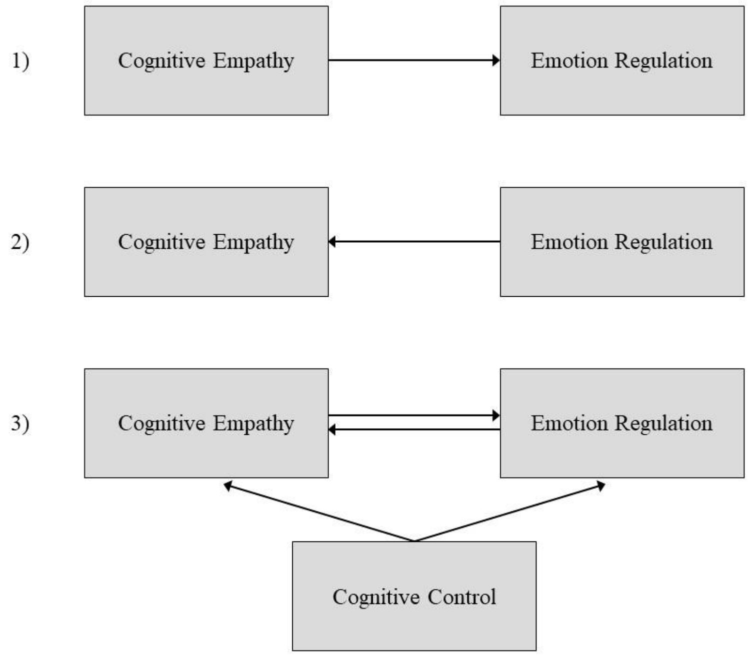

Figure 9. *Depiction of three potential explanations for the relationship between cognitive empathy and emotion regulation: 1) cognitive empathy processes facilitate emotion regulation; 2) emotion regulation processes facilitate cognitive empathy; 3) both cognitive empathy and emotion regulation are facilitated by the latent variable cognitive control.*

Our affective empathy measure was based on SFM, which has been shown to measure one's propensity to resonate with others' emotions (Dimberg et al., 2011; Sato et al., 2013; Sonnby-Borgstrom, 2002). Consistent with prior work, we found that the passive viewing of emotional faces elicits spontaneous activation in congruent muscles (Bornemann et al., 2012; Dimberg & Thunberg, 1998; Dimberg et al., 2000). Our prediction of a positive relationship between SFM and emotion dysregulation was based on previous findings which suggest that affective empathy is associated with less adaptive emotion regulation (Contardi et al., 2016; Grynberg & López-Pérez, 2018; MacDonald & Price, 2019; Thompson et al., 2022), as well as complementary evidence that disorders characterised by emotion dysregulation are associated with atypically high levels of affective empathy (Harari et al., 2010; Ripoll et al., 2013). Given that emotional arousal can negatively impact cognitive control processes (Tottenham et al., 2011) crucial for adaptive emotion regulation (McRae et al., 2010), our rationale was that a heightened propensity to resonate with others' emotions would be associated with increased emotion dysregulation. Contrary to expectation, the DERS was not significantly related to the overall SFM metric. Exploratory follow-up analyses revealed that the DERS was significantly negatively correlated with mimicry of angry faces but showed no relationship with mimicry of happy faces. These findings suggest that a greater propensity to mimic others' angry facial expressions was associated with lower levels of emotion dysregulation, in line with prior studies that found self-reported affective empathy to be negatively associated with emotion dysregulation (Lockwood et al., 2014; Powell, 2018; Troyer & Greitemeyer, 2018).

The decision to explore the relationship between the DERS and the Happy SFM and Angry SFM metrics was taken in response to the unexpected finding of no relationship between the DERS and the Mean SFM metric. As such, the finding of a valence-specific relationship between the DERS and the angry SFM metric warrants replication. Additionally, while SFM magnitude has been shown to correlate with trait measures of affective empathy and the degree of resonance with perceived emotions (e.g. Dimberg et al., 2011; Sato et al., 2013), the corrugator response to angry faces may not necessarily provide an entirely 'pure' measure of one's propensity to resonate with others' emotions. While SFM reflects a relatively automatic and implicit response, it is sensitive to modulation by attentional processes (Murata et al., 2016). Further, the corrugator response may reflect cognitive effort (Hess et al., 1998). Consequently, it is important to consider the possibility that the observed effects were not driven solely by differences in mimicry processes per se, but also by variability in the way in which individuals with higher/lower levels of emotion dysregulation attended to the angry faces.

Finally, some limitations of the current study should be noted. Given the focus upon individual differences, the sample sizes for the correlational analyses were relatively small and would benefit from replication in larger samples. While cognitive and affective empathy were assessed using task measures, emotion dysregulation was measured by self-report, which could be susceptible to response biases (Moskowitz, 1986; Paulhus, 1991; Gerdes et al., 2010). Additionally, given that some emotion regulation processes can be implicit (Gyurak et al., 2011; Thompson et al., 2022), individuals may not necessarily be aware of them. In this context, it is worth noting that the DERS items assess the consequences of emotion (dys)regulation, rather than the processes thereof, which should be accessible via introspection and self-report.

It would be useful for future research to examine the relationship between empathy and emotion regulation using a broader range of measures that assess different aspects of emotion regulation/dysregulation, and to also include measures of cognitive control. For example, it would be useful to use task approaches that enable more objective measures of emotional reactivity/regulation, such as psychophysiology, electroencephalography and functional MRI. Further, it would be beneficial to examine these relationships in populations beyond the neurotypical, predominantly white, student population studied here. It would be particularly relevant to study this relationship in certain psychopathologies, such as autism and BPD, where there is evidence of atypicalities in both empathy and emotion regulation.

Declarations

Funding: This research was supported by a Medical Research Council (MRC) doctoral studentship (MR/J003980/1) awarded to NMT. BC was supported by the MRC (MR/P023894/1) and the Leverhulme Trust (PLP-2015-329).

Contributions: NMT contributed to study design, data collection/analysis, and manuscript preparation. BC and CvR contributed to study design and manuscript preparation.

Competing interests: The authors have no conflicts of interest to declare.

Acknowledgments: We thank Dr Garret O'Connell for sharing Director Task materials from which the version of the task used in the current study was adapted, and Dr Anthony Haffey for his support in integrating the eye-tracking component within the Director Task.

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