

---

AI translation · View original & related papers at  
[chinaxiv.org/items/chinaxiv-202308.00751](https://chinaxiv.org/items/chinaxiv-202308.00751)

---

## The Neurocognitive Basis of Interpersonal Emotion Regulation

**Authors:** Zhang Dandan, Zhang Dandan

**Date:** 2023-08-26T00:00:00+00:00

### Abstract

Interpersonal emotion regulation is a process wherein one party in a social interaction intentionally modifies the emotional state of another party. It facilitates individual mental health and social relationship development, and exhibits unique advantages distinct from self-emotion regulation. In recent years, a substantial body of neuroimaging research has investigated interpersonal emotion regulation, elucidating to some extent the neural substrates of this process: interpersonal emotion regulation engages the mentalizing system (including the precuneus, temporoparietal junction, medial prefrontal cortex, etc.), the emotional response system (including the amygdala, insula, etc.), and the emotion regulation system (including the lateral prefrontal cortex, ventromedial prefrontal cortex, cingulate cortex, etc.), with the mentalizing system constituting a brain region specific to interpersonal emotion regulation that is distinct from self-emotion regulation. Future research could incorporate diverse populations as study subjects, integrate neuroimaging techniques with neuromodulation techniques, and investigate the cognitive neural mechanisms of interpersonal emotion regulation at both single-brain and dual-brain levels, thereby providing a scientific foundation for the implementation and promotion of interpersonal emotion regulation in applied contexts.

### Full Text

## The Neurocognitive Basis of Interpersonal Emotion Regulation

**DONG Wanxin, YU Wenwen, XIE Hui, ZHANG Dandan**

Institute of Brain and Psychological Sciences, Sichuan Normal University, Chengdu 610066, China

## Abstract

Interpersonal emotion regulation refers to the process whereby one party in a social interaction intentionally modifies the emotional state of the other party. This process benefits individual mental health and social relationship development, and offers unique advantages distinct from self-emotion regulation. In recent years, numerous neuroimaging studies have investigated interpersonal emotion regulation, revealing to some extent its neural underpinnings: interpersonal emotion regulation engages the mentalizing system (including the precuneus, temporo-parietal junction, and medial prefrontal cortex), the emotional response system (including the amygdala and insula), and the emotion regulation system (including the lateral prefrontal cortex, ventromedial prefrontal cortex, and cingulate cortex), with the mentalizing system representing a brain region specific to interpersonal emotion regulation. Future research should incorporate diverse populations, integrate brain observation and modulation techniques, and thoroughly investigate the cognitive and neural mechanisms of interpersonal emotion regulation from both single-brain and dual-brain perspectives, thereby providing a scientific foundation for the implementation and promotion of interpersonal emotion regulation in applied contexts.

**Keywords:** emotion regulation, interpersonal emotion regulation, mentalizing system, hyperscanning

---

Emotion regulation serves as a crucial adaptive function that plays an indispensable role in maintaining mental health (McRae & Gross, 2020). Over the past several decades, the cognitive and neural mechanisms of emotion regulation have been extensively investigated, yet the vast majority of studies have focused exclusively on individuals' regulation of their own emotional states—that is, intrapersonal emotion regulation (e.g., Li et al., 2022; Zhao et al., 2021; Gao et al., 2023). Only a handful of researchers have recognized that another form of emotion regulation—interpersonal emotion regulation—also holds significant theoretical and practical value (Niven et al., 2009; Rimé, 2007). It was not until around 2013 that researchers began to directly examine the cognitive and neural mechanisms underlying interpersonal emotion regulation (Hallam et al., 2014; Reeck et al., 2016).

Interpersonal emotion regulation, also termed social emotion regulation, refers to the social processing whereby one party in an interaction (the regulator) intentionally modifies the emotional state of the other party (the regulatee) (Reeck et al., 2016). Based on different regulatory targets, interpersonal emotion regulation can be divided into two types: extrinsic and intrinsic (Gross, 2015; Zaki & Williams, 2013). The process by which an individual actively regulates another person's emotions is called extrinsic emotion regulation, whereas the process by which an individual regulates their own emotions through interaction with others is termed intrinsic emotion regulation. Interpersonal emotion regulation possesses two key characteristics: First, it must be realized through

social interaction, including socially meaningful physical actions such as touching, hand-holding, and hugging, as well as conveying regulation strategies to the regulatee through verbal or written communication (Niven, 2017). Second, the regulator has explicit emotion regulation goals and employs intentional, actively controlled methods to enhance or diminish the regulatee's positive or negative emotional responses (Nozaki & Mikolajczak, 2020). Clarifying these two characteristics helps distinguish interpersonal emotion regulation from social support (e.g., hand-holding, companionship), which, although also featuring social interaction and emotional soothing effects, lacks explicit and active emotion regulation goals and processes.

The capacity for effective interpersonal emotion regulation is vital for improving and maintaining mental health (Zaki, 2020). On one hand, our own mental health relies on interpersonal emotion regulation for maintenance and enhancement: as infants, children, and adolescents, we frequently depend on family and friends for emotion regulation (Niven et al., 2009), and as adults, we seek help from psychotherapists when our mental state and social relationships are severely disrupted, with most psychotherapeutic approaches (e.g., cognitive-behavioral therapy) centering on interpersonal emotion regulation (Xie et al., 2016). On the other hand, as social beings, interpersonal emotion regulation represents an important means by which we maintain and develop social relationships (Zaki, 2020). Research has found that the frequency of daily interpersonal regulation strategies can positively predict relationship quality (Chan & Rawana, 2021) and marital satisfaction (Tepeli Temiz & Elsharnouby, 2022); furthermore, college freshmen's interpersonal emotion regulation abilities can predict the establishment and development of their social relationships during university (Williams et al., 2018). More importantly, interpersonal emotion regulation offers three unique advantages distinct from self-emotion regulation: First, regulators can make objective judgments about the current situation, avoiding the misattributions that regulatees might make due to being "too close to the forest to see the trees" (Reeck et al., 2016), thus interpersonal emotion regulation often proves more effective than self-regulation (Morawetz et al., 2021; Levy-Gigi & Shamay-Tsoory, 2017). Second, interpersonal emotion regulation benefits both parties: while helping others improve their emotions, regulators can also reduce their own negative emotions, thereby decreasing depression and increasing well-being (Doré et al., 2017; Guendelman et al., 2022a). Third, for patients with depression, anxiety, and other conditions featuring severely impaired self-emotion regulation, interpersonal emotion regulation serves as an effective method for alleviating or eliminating negative emotions and social distress (Reeck et al., 2016). These advantages render research on interpersonal emotion regulation necessary and irreplaceable for deepening emotion regulation theory and guiding clinical practice. Building upon existing literature that has reviewed the concepts, behavioral measurement methods, and main theories of interpersonal emotion regulation (Hu et al., 2020; Sheng & Zhang, 2021), the present paper focuses on basic cognitive and neural research, summarizing the current state of interpersonal emotion regulation studies primarily from the

perspective of brain observation.

## 2 Analysis of Current Research on Brain Mechanisms

Based on Reeck et al.'s (2016) synthesis of findings from multiple domains including emotion regulation, empathy, social support, prosocial behavior, attachment, and intimate relationships, scholars currently posit that interpersonal emotion regulation primarily involves three major brain networks: the mentalizing system, the emotion regulation system, and the emotional response system. This section focuses on these three brain networks to respectively review the current state of research on the neural mechanisms of extrinsic and intrinsic interpersonal emotion regulation.

### 2.1 Extrinsic Interpersonal Emotion Regulation

To date, three neuroimaging studies have examined brain activity when individuals regulate others' emotions. First, in an early study, Hallam et al. (2014) had participants orally articulate cognitive reappraisal or expressive suppression strategies while viewing short negative emotional videos, either to improve their own emotions or those of another person viewing the videos simultaneously. The results revealed that both self- and interpersonal emotion regulation commonly activated the regulator's lateral prefrontal cortex and pre-supplementary motor area. Interpersonal emotion regulation, compared to self-regulation, produced greater activation in mentalizing-related regions such as the medial prefrontal cortex and inferior parietal cortex/precuneus, as well as in the posterior insula and caudate nucleus.

Subsequently, Powers et al. (2022) had participants employ cognitive reappraisal strategies to alleviate their own negative emotions while viewing negative emotional images, or imagine viewing negative images with a friend and reappraise the images from the friend's perspective to reduce the friend's negative emotions. The findings showed that interpersonal emotion regulation elicited stronger activation in the precuneus and inferior parietal cortex compared to self-regulation.

In another nearly contemporaneous study, Guendelman et al. (2022a; 2022b) asked participants to orally articulate cognitive reappraisal or mindfulness-acceptance strategies while viewing negative emotional images, either to reduce their own negative emotions or those of another person viewing the images simultaneously. This study found that interpersonal emotion regulation produced greater activation in the precuneus, temporo-parietal junction, and supramarginal gyrus compared to self-regulation. Moreover, activation in these brain regions correlated with emotion regulation effectiveness (lower subjective negative emotion and skin conductance). The precuneus emerged as a core brain region in interpersonal emotion regulation, showing enhanced functional connectivity with parietal emotion regulation regions under interpersonal regulation conditions.

These findings demonstrate that, compared to regulating one's own emotions,

regulating others' emotions produces stronger activation in the regulator's mentalizing system—including the precuneus, temporo-parietal junction, and medial prefrontal cortex (Guendelman et al., 2022a; 2022b; Hallam et al., 2014; Powers et al., 2022)—highlighting the importance of the mentalizing system in regulating others' emotions. The regulator's mentalizing/empathy system is responsible for sensing and identifying others' emotions, inferring the discrepancy between others' current and target emotional states, and simulating others' responses to selected strategies (Reeck et al., 2016). Consistent with these neuroimaging findings, behavioral studies on interpersonal emotion regulation have also revealed that the regulator's mentalizing ability or capacity predicts the effectiveness of interpersonal emotion regulation: regulators who better understand their partners select more effective emotion regulation strategies for them (Levy-Gigi & Shamay-Tsoory, 2017), and regulators exhibit stronger regulation intentions and execution efficacy toward highly intimate versus less intimate others (Tanna & MacCann, 2022).

These three neuroimaging studies also demonstrate that interpersonal emotion regulation significantly activates emotion regulation brain regions such as the dorsolateral prefrontal cortex, supplementary motor area, and cingulate cortex (Guendelman et al., 2022a; Hallam et al., 2014; Powers et al., 2022), underscoring the importance of the emotion regulation system in regulating others' emotions. The regulator's emotion regulation system is responsible for assessing others' emotion regulation needs, generating regulation strategies and implementation methods, maintaining goal-directed behavior, and monitoring regulation outcomes (Reeck et al., 2016). Notably, however, these emotion regulation brain regions are also activated during self-emotion regulation. It therefore remains unclear whether this shared activation results from both forms of emotion regulation drawing upon common emotion regulation brain regions, or from regulators simultaneously regulating their own emotions (emotion co-regulation) while regulating others' emotions. Beyond these similarities with self-regulation, interpersonal emotion regulation also exhibits particularities in its recruitment of the emotion regulation system. For instance, when down-regulating high-intensity negative emotions, regulators perceive cognitive reappraisal strategies as less effortful and more effective when used by others versus themselves (Matthews et al., 2021).

Regarding the emotional response system, although it is known that emotional response regions such as the anterior insula show highly correlated activation patterns when the regulator themselves and their friends are under threat (Beckes et al., 2013), and Guendelman et al. (2022a) also found that regulators' own negative emotions decrease while regulating others' emotions, no interpersonal emotion regulation study to date has directly examined the regulator's emotional response system (amygdala, insula, etc.).

Furthermore, we believe the regulator's reward system is also highly important in interpersonal emotion regulation, though no study has specifically investigated this. Only Hallam et al. (2014) incidentally found that the caudate

nucleus—a key node of the reward system—showed stronger activation during interpersonal versus self-emotion regulation. We contend that extrinsic interpersonal emotion regulation, as a helping and altruistic behavior, very likely elicits activation of the regulator’s reward system (Wu & Hong, 2022). Supporting evidence comes from pain relief studies analogous to emotion regulation: physicians helping patients relieve pain through devices (Jensen et al., 2014) and participants reducing their partners’ pain by stroking their arms (Inagaki & Eisenberger, 2012) both observed more significant activation in reward system regions such as the ventral striatum in the “support provider” compared to non-support conditions.

In summary, the three existing neuroimaging studies on extrinsic interpersonal emotion regulation highlight the importance of the mentalizing system (precuneus, temporo-parietal junction, medial prefrontal cortex) and the emotion regulation system (dorsolateral prefrontal cortex, supplementary motor area, cingulate cortex) in the process of regulators regulating others’ emotions. Questions that remain to be investigated regarding extrinsic interpersonal emotion regulation include: Is the involvement of the regulator’s emotion regulation system caused by emotion co-regulation? How do the regulator’s emotional response and reward systems participate in interpersonal emotion regulation?

## 2.2 Intrinsic Interpersonal Emotion Regulation

To date, two fMRI studies have investigated brain activity when individuals regulate their own emotions using strategies provided by others. First, Xie et al. (2016) had participants either employ cognitive reappraisal strategies themselves while viewing negative emotional images, or receive guidance from a psychotherapist via video to use reappraisal strategies. The results showed that both self- and interpersonal emotion regulation activated the dorsolateral prefrontal cortex, medial prefrontal cortex, and inferior parietal cortex. Interpersonal emotion regulation produced greater activation than self-regulation in the dorsomedial prefrontal cortex, precuneus, and temporo-parietal junction. Additionally, participants’ attachment security positively predicted the effectiveness of interpersonal emotion regulation, consistent with findings from hand-holding studies: participants’ desire for intimacy positively correlated with the emotional soothing effects of hand-holding (Flores & Berenbaum, 2012). In a more recent study, Morawetz et al. (2021) further examined the influence of intimacy level on interpersonal emotion regulation. The experiment used negative images to induce emotions and had participants regulate their emotions using cognitive reappraisal strategies provided by either friends or strangers, or regulate independently. The results indicated that friend-provided regulation was more effective than stranger-provided and self-regulation, with participants showing higher amygdala activation under stranger regulation conditions compared to friend and self-regulation conditions. Both self- and interpersonal emotion regulation commonly activated the lateral prefrontal cortex. Activation levels in the temporo-parietal junction increased sequentially across the three conditions

of “self-regulation,” “stranger regulation,” and “friend regulation.”

These studies demonstrate that, like regulators, regulatees heavily rely on the mentalizing system during interpersonal emotion regulation to comprehend others’ regulatory intentions and behaviors (Dixon-Gordon et al., 2015). This process primarily activates the medial prefrontal cortex, precuneus, and temporoparietal junction (Morawetz et al., 2021; Xie et al., 2016). Similarly, pain relief studies have also highlighted the importance of the mentalizing system: hand-holding with a partner (compared to no hand-holding) not only significantly reduces one’s own pain perception but also enhances functional connectivity between the mentalizing brain network and the pain network (López-Solà et al., 2019).

Regarding the emotion regulation system, the two existing studies did not find differences in neural activity levels between self- and interpersonal regulation, though these may represent false negative results. We propose that although interpersonal emotion regulation ultimately requires regulatees to execute the regulation process themselves, the provision of regulation strategies by others may reduce regulatees’ reliance on prefrontal control systems. Supporting evidence comes from social support studies involving hand-holding (Coan et al., 2017; López-Solà et al., 2019) and companionship (Mulej Bratec et al., 2020): compared to no hand-holding or no companionship, hand-holding or companionship significantly reduced activation in emotion regulation brain regions such as the lateral prefrontal cortex, ventromedial prefrontal cortex, and cingulate cortex.

Furthermore, findings regarding the emotional response system require further validation. Although Morawetz et al. (2021) found that friend-provided and self-regulation produced equivalent reductions in amygdala activation, subjective emotion reports indicated that friend-provided regulation was more effective than self-regulation, yielding inconsistent neural and behavioral indices in that study. By contrast, a companionship study (Mulej Bratec et al., 2020) found consistent results between the emotional response system and subjective emotion reports: compared to no companionship, participants reported weaker fear emotions and showed lower activation in the amygdala and thalamus when accompanied by a therapist. Additionally, a hand-holding study (Coan et al., 2006) found that participants under electric shock threat showed sequentially decreasing activation in emotional response regions such as the anterior insula and hypothalamus across “no hand-holding,” “hand-holding with a stranger,” and “hand-holding with a spouse” conditions.

Beyond these two fMRI studies, a recent functional near-infrared spectroscopy (fNIRS) study (Zhang et al., 2023) employed dual-brain synchronous recording hyperscanning technology to examine inter-brain neural synchronization during interpersonal emotion regulation between romantic partners. Focusing primarily on the “regulatee,” this study found that men in heterosexual couples were more effective at regulating women’s sadness, with female regulatees reporting lower sadness intensity than male regulatees. Additionally, when comparing cognitive

strategies (cognitive reappraisal) and emotional strategies (emotional empathy), cognitive strategies more effectively regulated women's sadness: using cognitive strategies under male-regulating-female conditions significantly enhanced inter-brain synchronization in the right frontopolar cortex (BA10) between partners. This represents the first dual-brain hyperscanning study to directly investigate interpersonal emotion regulation. Moreover, an fNIRS hyperscanning study on parent-child cooperative tasks (Reindl et al., 2018) found that neural synchronization in the right frontopolar cortex (BA10) during cooperation between parents and children mediated the influence of parents' cognitive reappraisal usage habits (whether they frequently used cognitive reappraisal) on children's emotion regulation ability development, suggesting that parent-child inter-brain synchronization in the frontal cortex may constitute the neural basis for emotional connection and particularly the emotion regulation bond between interaction partners. A limitation of these two hyperscanning studies is that researchers placed fNIRS optodes only on the foreheads of both interaction partners (where hair is sparse, facilitating optode placement), meaning they only observed inter-brain synchronization in the anterior prefrontal cortex (primarily the frontopolar cortex), without examining mentalizing system regions such as the precuneus and temporo-parietal junction, and provided incomplete observation of emotion regulation regions such as the dorsolateral prefrontal cortex.

In summary, the two existing fMRI studies on intrinsic interpersonal emotion regulation highlight the importance of the mentalizing system (medial prefrontal cortex, precuneus, temporo-parietal junction) and the emotion regulation system (dorsolateral prefrontal cortex, etc.) in regulatees receiving emotion regulation from others. Questions that remain to be addressed regarding intrinsic interpersonal emotion regulation include: Do regulatees exhibit reduced reliance on the emotion regulation system due to assistance from others? Can regulatees' emotional response system consistently reflect their subjective emotional experiences? Additionally, although a small number of hyperscanning studies have begun to examine the dual-brain interaction characteristics of interpersonal emotion regulation (Wang et al., 2022), current brain coverage remains limited to the frontopolar cortex (Zhang et al., 2023), thus providing very limited information.

### 3 Future Research Directions

Through the above analysis, we find that interpersonal emotion regulation, as a social interaction process, first requires reliance on the mentalizing system (including the precuneus, temporo-parietal junction, and medial prefrontal cortex) to infer the other's emotional state and select appropriate emotion regulation strategies for them. Simultaneously, it must recruit the emotion regulation system (including the lateral prefrontal cortex, ventromedial prefrontal cortex, and cingulate cortex) to actively seek and execute (either self-executed or prompting others to execute) emotion regulation strategies, thereby altering neural activity levels in the regulatee's emotional response system (including the amygdala

and insula). During this prosocial helping process, the regulator's reward system (including the ventral striatum) is also highly likely to participate in and facilitate emotion regulation. However, interpersonal emotion regulation remains an emerging research field, and our understanding of it, particularly its cognitive and neural mechanisms, remains quite limited. Based on existing findings, we identify four key issues that require resolution in the current field.

First, research on the brain mechanisms of extrinsic and intrinsic interpersonal emotion regulation remains incomplete, with insufficient neural evidence. Regarding extrinsic regulation: (1) It is known that regulating both self and others commonly activates the regulator's dorsolateral prefrontal cortex, supplementary motor area, and cingulate cortex (Guendelman et al., 2022a; Hallam et al., 2014; Powers et al., 2022), which seems to indicate that both self-regulation and extrinsic interpersonal regulation require involvement of the emotion regulation system. However, an alternative explanation involving emotion co-regulation must be ruled out—that is, that regulators regulate their own emotions while regulating others' emotions, with only the latter recruiting emotion regulation brain regions. (2) Does activation in the regulator's emotional response brain regions (amygdala, insula, etc.) change due to emotional empathy for the regulatee? Is it influenced by emotion regulation behaviors? (3) Is the regulator's reward system (ventral striatum, etc.) significantly activated during interpersonal regulation due to its prosocial nature (compared to self-regulation)? Regarding intrinsic regulation: (1) Does the regulatee's reliance on the emotion regulation system decrease due to others providing emotion regulation strategies? An affirmative answer to this question is a prerequisite for applying interpersonal emotion regulation to treat patients with impaired self-emotion regulation, such as those with depression and anxiety (Reeck et al., 2016). (2) Does activity in the regulatee's emotional response brain regions change consistently with subjective emotional experience indices? We recommend that future research employ functional magnetic resonance imaging (fMRI) and other techniques alongside innovative interpersonal emotion regulation paradigms to explore these questions. For example, to address the first issue regarding extrinsic regulation (ruling out emotion co-regulation), we could prevent regulators from being directly exposed to negative situations (whereas nearly all previous studies had both parties undergo negative emotion induction simultaneously). If significant activation of the regulator's emotion regulation system can still be observed, this would demonstrate that emotion regulation brain regions also play an important role in strategizing for others' emotion regulation.

Second, existing research has primarily focused on single-brain neural activity, lacking dual-brain studies; yet dual-brain evidence constitutes an indispensable cornerstone for constructing cognitive and neural models of interpersonal emotion regulation. Interactivity represents the key characteristic distinguishing interpersonal emotion regulation from self-emotion regulation. Examining brain activity patterns of regulators and regulatees separately at the single-brain level cannot fully reveal the cognitive and neural processes of both interaction partners (Redcay & Schilbach, 2019). Moreover, single-brain experimen-

tal paradigms lack ecological validity: previous studies have had participants lying in fMRI scanners regulate the emotions of others located outside the scanning room (Guendelman et al., 2022a; 2022b; Hallam et al., 2014), or required participants to imagine a regulatee and complete interpersonal emotion regulation (Powers et al., 2022). Such experimental setups cannot observe natural interactions between emotion regulation partners. Hyperscanning is an effective technique for examining inter-brain neural synchronization and information flow, yet only one dual-brain study directly investigating interpersonal emotion regulation has been identified (Zhang et al., 2023), and its brain observation scope is extremely limited. We recommend that future research utilize whole-brain EEG and fNIRS hyperscanning technologies with high-ecological-validity two-person paradigms to reveal inter-brain interaction processes between regulators and regulatees. For example, Wang et al. (2022) used hyperscanning technology to discover that active listening, as a form of social support, reduces speakers' negative emotional experiences by enhancing information exchange between interaction partners' mentalizing systems (temporo-parietal junction, orbital frontal cortex) and emotion regulation systems (dorsolateral prefrontal cortex).

Third, cognitive and neural models of interpersonal emotion regulation remain incomplete, and the specific brain regions distinguishing interpersonal from self-regulation require further elucidation. Regarding cognitive mechanisms, current cognitive models of interpersonal emotion regulation include the communication model (Dixon-Gordon et al., 2015), the social regulation loop model (Reeck et al., 2016), and the extrinsic emotion regulation model (Nozaki & Mikolajczak, 2020). However, due to the lack of complete empirical evidence, these models cannot yet be discriminated, revised, or integrated. We recommend that future research fully consider the interactive and complex nature of interpersonal emotion regulation, examining how various factors—including relationship contexts, gender, personality traits, and intimacy levels—influence interpersonal emotion regulation. By integrating neurophysiological observation, behavioral measurement, and path analysis techniques, future studies should reveal the cognitive mechanisms underlying regulator-regulatee interactions. For example, research has found that humorous interaction between spouses, as a form of interpersonal emotion regulation, is partially mediated by changes in psychological intimacy between partners (Horn et al., 2019). Regarding neural mechanisms, although the mentalizing system has been basically established as the specific neural basis distinguishing interpersonal from self-emotion regulation, several questions remain: (1) How does the mentalizing system interconnect and coordinate with the emotion regulation and emotional response systems? (2) Do mentalizing brain regions play different roles in extrinsic versus intrinsic regulation processes? We recommend that future research integrate brain observation techniques such as fMRI with brain modulation methods such as transcranial magnetic stimulation, combined with data analysis approaches like dynamic causal modeling, to reveal inter-brain interaction processes between regulators and regulatees. Based on the respective strengths of existing cognitive models,

this would enable construction of a unified, empirically supported cognitive and neural model of interpersonal emotion regulation.

Fourth, applied translational research is insufficient, with no brain modulation studies targeting interpersonal emotion regulation and a lack of training intervention studies. On one hand, brain observation studies can only provide correlational neural evidence. To identify core brain regions for interpersonal emotion regulation and thereby select brain targets for clinical intervention, causal evidence from brain modulation techniques is required, yet no relevant reports have been published to date. We recommend that future research target the important brain regions involved in interpersonal emotion regulation identified in the first and second points above, using transcranial magnetic stimulation and direct current stimulation, and innovatively employing dual-brain-based alternating current stimulation techniques to examine whether activation in core brain regions such as the temporo-parietal junction and dorsolateral prefrontal cortex, as well as changes in inter-brain synchronization, causally influence interpersonal emotion regulation effectiveness. On the other hand, training intervention research on interpersonal emotion regulation remains extremely scarce. In the applied domain, only two studies from the same research group have been identified to date (Doré et al., 2017; Morris et al., 2015): training was conducted through an online interactive platform where participants engaged in both intrinsic and extrinsic interpersonal emotion regulation with real others. The results showed that participants who helped others regulate emotions more frequently during the three-week training reported more significant increases in subjective well-being; participants with more severe depressive symptoms benefited more from the training, experiencing reduced depressive symptoms and increased continuous thinking post-training. We recommend that future applied research proceed along two lines: training to enhance interpersonal emotion regulation abilities in healthy populations, and clinical interventions for special populations such as those with depression. For healthy population studies, well-controlled laboratory training should be employed to examine the effectiveness of interpersonal emotion regulation training and its short- and long-term effects on mental health while maximizing control of confounding factors (e.g., training duration). For clinical population studies, we recommend targeting patients with social anxiety, depression, autism, and other conditions characterized by impaired social functioning, combining brain modulation with interpersonal emotion regulation training to investigate the clinical value of behavioral-brain interventions in alleviating symptoms, reducing negative mood, and restoring social function.

## References

高可翔, 张岳瑶, 李思瑾, 袁加锦, 李红, 张丹丹. (2023). 腹内侧前额叶在内隐认知重评中的因果作用. *心理学报*, 55(2), 210–223.

胡娜, 桑标, 刘俊升, 潘婷婷, 黄元元. (2020). 社会互动视角下的人际情绪调节: 概念、测量和理论取向. *心理科学*, 43(5), 1227–1234.

生雪梅, & 张嘉琪. (2021). 人际情绪调节策略的概念及研究现状. *心理学进展*, 11(2), 604–609.

Beckes, L., Coan, J. A., & Hasselmo, K. (2013). Familiarity promotes the blurring of self and other in the neural representation of threat. *Social Cognitive and Affective Neuroscience*, 8(6), 670–677.

Chan, S., & Rawana, J. S. (2021). Examining the associations between interpersonal emotion regulation and psychosocial adjustment in emerging adulthood. *Cognitive Therapy and Research*, 45(4), 652–662.

Coan, J. A., Beckes, L., Gonzalez, M. Z., Maresh, E. L., Brown, C. L., & Hasselmo, K. (2017). Relationship status and perceived support in the social regulation of neural responses to threat. *Social Cognitive and Affective Neuroscience*, 12(10), 1574–1583.

Coan, J. A., Schaefer, H. S., & Davidson, R. J. (2006). Lending a hand: Social regulation of the neural response to threat. *Psychological Science*, 17(12), 1032–1039.

Dixon-Gordon, K. L., Bernecker, S. L., & Christensen, K. (2015). Recent innovations in the field of interpersonal emotion regulation. *Current Opinion in Psychology*, 3, 36–42.

Doré, B. P., Morris, R. R., Burr, D. A., Picard, R. W., & Ochsner, K. N. (2017). Helping others regulate emotion predicts increased regulation of one's own emotions and decreased symptoms of depression. *Personality and Social Psychology Bulletin*, 43(5), 729–739.

Flores Jr, L. E., & Berenbaum, H. (2012). Desire for emotional closeness moderates the effectiveness of the social regulation of emotion. *Personality and Individual Differences*, 53(8), 952–957.

Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry*, 26(1), 1–26.

Guendelman, S., Bayer, M., Prehn, K., & Dziobek, I. (2022a). Regulating negative emotions of others reduces own stress: Neurobiological correlates and the role of individual differences in empathy. *NeuroImage*, 254, Guendelman, S., Bayer, M., Prehn, K., & Dziobek, I. (2022b). Towards a mechanistic understanding of mindfulness-based stress reduction (MBSR) using an RCT neuroimaging approach: Effects on regulating own stress in social and non-social situations. *NeuroImage*, 254, 119059.

Hallam, G. P., Webb, T. L., Sheeran, P., Miles, E., Niven, K., Wilkinson, I. D., ... & Farrow, T. F. (2014). The neural correlates of regulating another person's emotions: an exploratory fMRI study. *Frontiers in Human Neuroscience*, 8, 376.

Horn, A. B., Samson, A. C., Debrot, A., & Perrez, M. (2019). Positive humor in couples as interpersonal emotion regulation: A dyadic study in everyday life

on the mediating role of psychological intimacy. *Journal of Social and Personal Relationships*, 36(8), 2376–2396.

Inagaki, T. K., & Eisenberger, N. I. (2012). Neural correlates of giving support to a loved one. *Psychosomatic Medicine*, 74(1), 3–7.

Jensen, K. B., Petrovic, P., Kerr, C. E., Kirsch, I., Raicek, J., Cheetham, A., ... & Kaptchuk, T. J. (2014). Sharing pain and relief: neural correlates of physicians during treatment of patients. *Molecular Psychiatry*, 19(3),

Levy-Gigi, E., & Shamay-Tsoory, S. G. (2017). Help me if you can: Evaluating the effectiveness of interpersonal compared to intrapersonal emotion regulation in reducing distress. *Journal of Behavior Therapy and Experimental Psychiatry*, 55, 33–40.

Li, S., Xie, H., Zheng, Z., Chen, W., Xu, F., Hu, X., & Zhang, D. (2022). The causal role of the bilateral ventrolateral prefrontal cortices on emotion regulation of social feedback. *Human Brain Mapping*, 43(9),

López-Solà, M., Geuter, S., Koban, L., Coan, J. A., & Wager, T. D. (2019). Brain mechanisms of social touch-induced analgesia in females. *Pain*, 160(9), 2072–2085.

Matthews, M., Webb, T. L., & Sheppes, G. (2021). Do people choose the same strategies to regulate other people's emotions as they choose to regulate their own? *Emotion*, 22(8), 1723–1738.

McRae, K., & Gross, J. J. (2020). Emotion regulation. *Emotion*, 20(1), 1–9.

Morawetz, C., Berboth, S., & Bode, S. (2021). With a little help from my friends: The effect of social proximity on emotion regulation-related brain activity. *NeuroImage*, 230, 117817.

Morris, R. R., Schueller, S. M., & Picard, R. W. (2015). Efficacy of a web-based, crowdsourced peer-to-peer cognitive reappraisal platform for depression: randomized controlled trial. *Journal of Medical Internet Research*, 17(3), e4167.

Mulej Bratec, S., Bertram, T., Starke, G., Brandl, F., Xie, X., & Sorg, C. (2020). Your presence soothes me: a neural process model of aversive emotion regulation via social buffering. *Social Cognitive and Affective Neuroscience*, 15(5), 561–570.

Niven, K. (2017). The four key characteristics of interpersonal emotion regulation. *Current opinion in psychology*, 17, 89–93.

Niven, K., Totterdell, P., & Holman, D. (2009). A classification of controlled interpersonal affect regulation strategies. *Emotion*, 9(4), 498–509.

Nozaki, Y., & Mikolajczak, M. (2020). Extrinsic emotion regulation. *Emotion*, 20(1), 10–15.

Powers, J. P., Capistrano, C. G., McIntosh, D. N., Bedacarratz, A. M., & McRae, K. (2022). Reappraisal and mentalizing: Perceived difficulty and effects

on negative emotion. *Emotion*, 23(2), 345–356.

Redcay, E., & Schilbach, L. (2019). Using second-person neuroscience to elucidate the mechanisms of social interaction. *Nature Reviews Neuroscience*, 20(8), 495–505.

Reeck, C., Ames, D. R., & Ochsner, K. N. (2016). The social regulation of emotion: An integrative, cross-disciplinary model. *Trends in Cognitive Sciences*, 20(1), 47–63.

Reindl, V., Gerloff, C., Scharke, W., & Konrad, K. (2018). Brain-to-brain synchrony in parent-child dyads and the relationship with emotion regulation revealed by fNIRS-based hyperscanning. *Neuroimage*, 178, 493–

Rimé, B. (2007). Interpersonal emotion regulation. In Gross, J. J. (Ed.), *Handbook of Emotion Regulation* (pp. 466–485). New York: Guilford Press.

Tanna, V. J., & MacCann, C. (2022). I know you so I will regulate you: Closeness but not target's emotion type affects all stages of extrinsic emotion regulation. *Emotion*, 23(5), 1501–1505.

Tepeli Temiz, Z., & Elsharnouby, E. (2022). Relationship Satisfaction and Well-being During the COVID-19 Pandemic: Examining the Associations with Interpersonal Emotion Regulation Strategies. *Cognitive Therapy and Research*, 46(5), 902–915.

Wang, S., Lu, J., Yu, M., Wang, X., & Shangguan, C. (2022). “I’m listening, did it make any difference to your negative emotions?” Evidence from hyperscanning. *Neuroscience Letters*, 788, 136865.

Williams, W. C., Morelli, S. A., Ong, D. C., & Zaki, J. (2018). Interpersonal emotion regulation: Implications for affiliation, perceived support, relationships, and well-being. *Journal of Personality and Social Psychology*, 115(2), 224–254.

Wu, Y. E., & Hong, W. (2022). Neural basis of prosocial behavior. *Trends in Neurosciences*, 45(10), 749–762.

Xie, X., Bratec, S. M., Schmid, G., Meng, C., Doll, A., Wohlschläger, A., ... & Sorg, C. (2016). How do you make me feel better? Social cognitive emotion regulation and the default mode network. *NeuroImage*, 134,

Zaki, J. (2020). Integrating empathy and interpersonal emotion regulation. *Annual Review of Psychology*, 71, 517–

Zaki, J., & Williams, W. C. (2013). Interpersonal emotion regulation. *Emotion*, 13(5), 803–810.

Zhang, W., Qiu, L., Tang, F., & Li, H. (2023). Affective or cognitive interpersonal emotion regulation in couples: an fNIRS hyperscanning study. *Cerebral Cortex*, 33(12), 7960–7970.

Zhao, J., Mo, L., Bi, R., He, Z., Chen, Y., Xu, F., ... & Zhang, D. (2021). The VLPFC versus the DLPFC in downregulating social pain using reappraisal and

distraction strategies. *The Journal of Neuroscience*, 41(6), 1331–1339.

*Note: Figure translations are in progress. See original paper for figures.*

*Source: ChinaXiv — Machine translation. Verify with original.*