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How do you make me feel better? Social cognitive emotion regulation and the default mode network

Xiyao Xie [a,c,d,1], Satja Mulej Bratec [b,c,d,1], Gabriele Schmid [e], Chun Meng [c,d], Anselm Doll [b,c,d], Afra Wohlschläger [c,d], Kathrin Finke [a], Hans Förstl [f], Claus Zimmer [c], Reinhard Pekrun [a], Leonhard Schilbach [h,i], Valentin Riedl [c,d,g], Christian Sorg [c,d,f,*]

[a] Department of Psychology, Ludwig-Maximilians-Universität München, Munich, Germany
[b] Graduate School of Systemic Neurosciences, Ludwig-Maximilians-Universität München, Munich, Germany
[c] Department of Neuroradiology, Klinikum rechts der Isar, Technische Universität München, Munich, Germany
[d] TUM-NIC Neuroimaging Center, Klinikum rechts der Isar, Technische Universität München, Munich, Germany
[e] Department of Psychosomatics and Psychotherapy, Klinikum rechts der Isar, Technische Universität München, Munich, Germany
[f] Department of Psychiatry, Klinikum rechts der Isar, Technische Universität München, Munich, Germany
[g] Department of Nuclear Medicine, Klinikum rechts der Isar, Technische Universität München, Munich, Germany
[h] Department of Psychiatry, University Hospital Cologne, Cologne, Germany
[i] Max Planck Institute of Psychiatry, Munich, Germany

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ABSTRACT

Socially-induced cognitive emotion regulation (Social-Reg) is crucial for emotional well-being and social functioning; however, its brain mechanisms remain poorly understood. Given that both social cognition and cognitive emotion regulation engage key regions of the default-mode network (DMN), we hypothesized that Social-Reg would rely on the DMN, and that its effectiveness would be associated with social functioning. During functional MRI, negative emotions were elicited by pictures, and – via short instructions – a psychotherapist either down-regulated participants' emotions by employing reappraisal (Reg), or asked them to simply look at the pictures (Look). Adult Attachment Scale was used to measure social functioning. Contrasting Reg versus Look, aversive emotions were successfully reduced during Social-Reg, with increased activations in the prefrontal and parietal cortices, precuneus and the left temporo-parietal junction. These activations covered key nodes of the DMN and were associated with Social-Reg success. Furthermore, participants' attachment security was positively correlated with both Social-Reg success and orbitofrontal cortex involvement during Social-Reg. In addition, specificity of the neural correlates of Social-Reg was confirmed by comparisons with participants' DMN activity at rest and their brain activations during a typical emotional self-regulation task based on the same experimental paradigm without a psychotherapist. Our results provide first evidence for the specific involvement of the DMN in Social-Reg, and the association of Social-Reg with individual differences in attachment security. The findings suggest that DMN dysfunction, found in many neuropsychiatric disorders, may impair the ability to benefit from Social-Reg.

1. Introduction

From the very beginning of our lives, our emotions are influenced by others. Particularly, socially-induced emotion regulation from caregivers is the cornerstone for developing self-regulatory abilities (Calkins and Hill, 2007; Fox and Calkins, 2003), and interacts with the development of social functioning (Láng, 2010; Roque et al., 2013). In adulthood, emotions are often regulated by family members, friends, and – when emotions become a burden to our health – by professional therapists. Socially-induced cognitive emotion regulation (Social-Reg) is of particular interest. Cognitive emotion regulation (such as reappraisal, where one reinterprets the meaning of a stimulus in order to alter its emotional impact; Ochsner et al., 2012) is known to be one of the most effective ways of regulating emotions (Gross, 2014; Ochsner and Gross, 2005), and is widely applied both in everyday life (Niven et al., 2009) and in clinical practice (Cuijpers et al., 2013; DeRubeis et al., 2008). The current study focused on Social-Reg and its underlying brain mechanisms.

Abbreviations: Social-Reg, socially-induced cognitive emotion regulation; CBT, cognitive behavioral therapy; PFC, prefrontal cortex; ACC, anterior cingulate cortex; PCC, posterior cingulate cortex; TPJ, temporo-parietal junction; DMN, default mode network; Self-Reg, self-induced cognitive emotion regulation; OFC, orbitofrontal cortex; AAS, Adult Attachment Scale.

* Corresponding author at: Department of Neuroradiology and Psychiatry, Klinikum rechts der Isar, Technische Universität München, Ismaninger Str. 22, 81675 Munich, Germany.
E-mail address: christian.sorg@tum.de (C. Sorg).
[1] These authors contributed equally to this work.

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To accurately place the current study, we first clarify the relevant concepts linked with Social-Reg. In general, emotion regulation refers to a set of processes that can alter emotional experiences (Gross, 2014). Adding the social realm, emotions can either be regulated by the person experiencing them, termed *intrapersonal* emotion regulation (here referred to as self-induced emotion regulation), or by another person, termed *interpersonal* (Zaki and Williams, 2013) or social emotion regulation (Reeck et al., 2015) (here also referred to as socially-induced emotion regulation; the term 'induced' is used to explicitly stress the origin of regulation). Social emotion regulation and related phenomena have recently received increased attention across multiple research domains, particularly in social and cognitive neuroscience. For instance, verbal support from others, like emotional supportive messages and empathic paraphrasing, has been shown to attenuate negative feelings induced by socially unpleasant events (Onoda et al., 2009; Seehausen et al., 2012); likewise, holding hands or viewing photos of one's partner was also reported to reduce fear and fear-related neural activations induced by electric shocks (Coan et al., 2006; Eisenberger et al., 2011; Younger et al., 2010). Referring to these examples, we can further differentiate social emotion regulation from social emotion modulation. Social emotion regulation refers to a goal-driven process, in which one person (the regulator) regulates another person's (the target's) emotions (Reeck et al., 2015; Zaki and Williams, 2013), while social emotion modulation is a more passive process, which often occurs outside of any explicit goal (Zaki and Williams, 2013). In more detail, if people wish to influence their own emotions by engaging an external regulator, the process is referred to as *intrinsic* social emotion regulation (Gross, 2013, 2014, 2015; Zaki and Williams, 2013). For example, people draw on others' support as a resource to attenuate negative affect and intensify positive affect (Gable and Reis, 2010; Rimé, 2009). On the other hand, if the regulatory process is initiated by the regulator in order to target the emotions of another person, this is called *extrinsic* social emotion regulation (Gross, 2013, 2014, 2015; Zaki and Williams, 2013). It has been shown that people attempt to regulate others' emotions through empathic and supportive behaviors (Batson, 2011; Niven et al., 2009). Furthermore, a recent neuroimaging study found that the attempt to regulate another's emotions activated brain regions linked with both affective and cognitive empathy (Hallam et al., 2014).

Social-Reg is particularly important, both for general well-being and in psychotherapy. Social-Reg refers to the process during which the regulator provides the target with alternative interpretations for emotion-triggering stimuli in order to alter the target's emotions (Reeck et al., 2015). Besides their effectiveness, cognitive strategies for emotion regulation are highly adaptive, and are especially valuable when the stimulus has to be approached or is unavoidable (Gross, 1998; Ochsner et al., 2012). In daily life, when people are troubled with emotional difficulties, positively reframing the situation or talking about their opportunities can foster a positive outlook on the situation so as to help them overcome negative affect (Burleson, 2003; Clark et al., 1998). Importantly, Social-Reg is also a main treatment strategy for neuropsychiatric disorders featured with impaired emotion regulation (e.g., major depression and anxiety) (Borkovec and Ruscio, 2001; Cuijpers et al., 2013; DeRubeis et al., 2008; Frewen et al., 2008). In cognitive–behavioral therapy (CBT), for example, a therapist instructs and guides the patient to identify and change negative thoughts through a series of treatment sessions (Beck, 1997; Butler et al., 2006). Social-Reg in psychotherapy is an essential approach to equip patients with skills of identifying and regulating emotions — to ultimately train them to become their own therapists (Berking et al., 2013; Biesheuvel-Leliefeld et al., 2015; Neacsiu et al., 2014).

Despite its relevance in both daily life and the clinical context, the neural basis of Social-Reg remains poorly understood. The neural processes underlying Social-Reg in the target likely overlap with those of social cognition and cognitive emotion regulation (Reeck et al., 2015). Social cognition encompasses all processes dealing with social information, such as perceiving, thinking about, and making sense of ourselves and others in the social world. It relies on a distributed set of brain areas, such as the medial prefrontal cortex (PFC), anterior and posterior cingulate cortex (ACC and PCC, respectively), precuneus, and the temporo-parietal junction (TPJ) (for reviews, see Adolphs, 2009; Frith, 2007; Lieberman, 2007). Cognitive emotion regulation, on the other hand, refers to cognitive processes for managing emotional events and responses (e.g., reappraisal; Ochsner and Gross, 2005). Existing findings suggest that cognitive emotion regulation relies on the dorsolateral and dorsomedial PFC as well as parietal cortices (Buhle et al., 2014; Ochsner et al., 2012).

Interestingly, brain structures involved in social cognition and cognitive emotion regulation overlap in prefrontal and parietal lobes, more specifically, in areas of the so-called default mode network (DMN). The DMN is an intrinsic brain network of coherent ongoing low-frequency activity, initially identified during resting-state (i.e., a state of passive viewing or with eyes closed without performing a task) as a task-negative network (Amft et al., 2015; Andrews-Hanna, 2012; Buckner et al., 2008; Raichle et al., 2001). However, recent evidence revealed that the DMN is in fact consistently activated during tasks involving social, affective and introspective processes (Mason et al., 2007; Northoff et al., 2006; Schilbach et al., 2008). Even more, an explicit overlap has been reported between the resting-state DMN and areas related to social cognition in the dorsomedial PFC, precuneus and TPJ (Amft et al., 2015; Mars et al., 2012; Schilbach et al., 2012). Critically, aberrant functioning of the DMN is a prominent neurophysiological vulnerability for psychiatric disorders hallmarked by emotion dysregulation, such as major depression (Broyd et al., 2009; Hamani et al., 2011; Orosz et al., 2012).

Besides its neural basis, it also remains unexplored whether the effectiveness of Social-Reg or the DMN involvement during Social-Reg might interact with certain individual characteristics of social functioning, such as attachment security. Adult attachment security refers to the extent to which one is willing to trust and rely on others, which is an important modulator of social–emotional information processing (Mikulincer and Shaver, 2008; Vrtička and Vuilleumier, 2012). Existing studies found that the attachment security level shaped the effects of social support on pain ratings and associated neural processing (Hurter et al., 2014; Krahé et al., 2015; Sambo et al., 2010).

Considering the above-presented background, we inferred the following hypotheses. First of all, we expected that Social-Reg would recruit regions of the DMN due to their involvement in both social cognitive processes and cognitive emotion regulation. In addition, we expected that people would vary in the extent to which they benefit from Social-Reg based on their social functioning, as measured with the individual attachment security. Moreover, we also expected a positive association between attachment security and DMN involvement during Social-Reg.

To test these hypotheses, we conducted a functional MRI (fMRI) experiment, in which pictures were used to elicit aversive emotions in healthy individuals. A psychotherapist either down-regulated participants' emotions by employing the reappraisal strategy, or asked them to simply look at the pictures without changing their emotions. Contrasting these two conditions allowed us to identify the neural correlates of Social-Reg. To investigate the relationship of Social-Reg with social functioning, participants' attachment security was measured by the Adult Attachment Scale, and linked to both Social-Reg effectiveness and Social-Reg-related brain activations. To further specify the neural correlates of Social-Reg, two additional control experiments were included. 1) To formally assess the link between neural correlates of Social-Reg and the DMN, resting-state fMRI was carried out to identify the participants-specific DMN; we then compared Social-Reg-related activations with this DMN. 2) To examine whether Social-Reg was distinct from self-induced cognitive emotion regulation (Self-Reg), the same experimental procedure was repeated without a psychotherapist, wherein participants either actively down-regulated their emotions