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Review article

The effect of strategies, goals and stimulus material on the neural mechanisms of emotion regulation: A meta-analysis of fMRI studies

Carmen Morawetz[a,b,*], Stefan Bode[c], Birgit Derntl[d], Hauke R. Heekeren[a,b]

[a] Department of Education and Psychology, Freie Universität Berlin, Germany
[b] Center for Cognitive Neuroscience Berlin, Freie Universität Berlin, Germany
[c] Melbourne School of Psychological Sciences, The University of Melbourne, Australia
[d] Department of Psychiatry and Psychotherapy, University of Tübingen, Germany

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ABSTRACT

Emotion regulation comprises all extrinsic and intrinsic control processes whereby people monitor, evaluate and modify the occurrence, intensity and duration of emotional reactions. Here we sought to quantitatively summarize the existing neuroimaging literature to investigate a) whether different emotion regulation strategies are based on different or the same neural networks; b) which brain regions in particular support the up- and down-regulation of emotions, respectively; and c) to which degree the neural networks realising emotion regulation depend on the stimulus material used to elicit emotions. The left ventrolateral prefrontal cortex (VLPFC), the anterior insula and the supplementary motor area were consistently activated independent of the regulation strategy. VLPFC and posterior cingulate cortex were the main regions consistently found to be recruited during the up-regulation as well as the down-regulation of emotion. The down-regulation compared to the up-regulation of emotions was associated with more right-lateralized activity while up-regulating emotions more strongly modulated activity in the ventral striatum. Finally, the process of emotion regulation appeared to be unaffected by stimulus material.

Contents

* Corresponding author at: Department of Education and Psychology, Freie Universität Berlin, Habelschwerdter Allee 45, 14195 Berlin, Germany.
E-mail address: Carmen.morawetz@fu-berlin.de (C. Morawetz).

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1. Introduction

Cognitive control of emotions by means of flexibly responding to affective events is of great importance in our daily social life and instrumental for our mental and physical well-being (Berking and Wupperman, 2012; Eftekhari et al., 2009; Gross et al., 2006; Gross and Muñoz, 1995). Emotion regulation comprises all extrinsic and intrinsic control processes whereby people monitor, evaluate and modify the occurrence, intensity and duration of emotional reactions (Thompson, 1994). In the last 10 years, more than 500 neuroimaging studies have investigated the neural basis of emotion regulation, and substantial progress has been made toward building neurally plausible models of emotion regulation that consider multiple cognitive control processes (e.g., Etkin et al., 2015; Gross, 2002; Kalisch, 2009; Koole, 2009; Ochsner et al., 2012; Phillips et al., 2008; Smith and Lane, 2015). However, single studies usually provide limited insight into the function of specific brain regions (Sarter et al., 1996; Yarkoni et al., 2010). Several reviews and meta-analyses have permitted some synthesis of imaging results on emotion regulation, specifically focusing on reappraisal as a regulation strategy (Buhle et al., 2014; Diekhof et al., 2011; Frank et al., 2014; Kohn et al., 2014; Messina et al., 2015). However, any comprehensive meta-analysis on emotion regulation requires consideration not only of the neural basis underlying reappraisal of negative emotions, but also of other emotion regulation strategies as well as the direction of the regulation strategy and the conditions that influence emotion regulation such as the nature of emotion induction method. Previously, several moderators of strategy effectiveness including factors related to strategy type, purpose of the regulation strategy and study design have been identified (Webb et al., 2012). Thus, different regulation strategies might engage different neural networks, and these networks might be recruited to a different extent depending on the regulation goal and the emotion induction. Here we provide a comprehensive and systematic meta-analysis of functional magnetic resonance imaging (fMRI) studies, which investigated a variety of emotion regulation strategies in combination with different emotion induction methods and regulation goals. The current meta-analysis examined whether 1) different emotion regulation strategies are based on different or the same neural networks; 2) which brain regions in particular support the up-regulation and the down-regulation of emotions, respectively; and 3) to which degree the neural networks realising emotion regulation depend on the stimulus material used to elicit emotions. In the following section we will briefly review some of the key findings of previous neuroimaging studies on emotion regulation and explain the sorting of studies for the current meta-analysis.

1.1. Emotion regulation processes and strategies

Different frameworks for conceptualising emotion regulation have been proposed that distinguish between different emotion regulation processes and strategies (Gross, 1998a, 1998b; Koole, 2009; Larsen, 2000; Parkinson and Totterdell, 1999; Thayer et al., 1994; Webb et al., 2012). The most widely used model to date is the process model of emotion regulation that proposes five distinct emotion regulation processes and corresponding emotion regulation strategies (Gross, 1998a, 1998b): situation selection, situation modification, attentional deployment (distraction, concentration), cognitive change (reappraisal), and response modulation (suppression). An alternative, more recent classification of emotion regulation strategies considers the target and function of regulation (Koole, 2009). In this view, emotion regulation targets three emotion-generating systems (attention, knowledge, and the body), and emotion regulation strategies can be classified along their psychological function as need-oriented (e.g., when targeting the attention system in terms of thinking pleasurable or relaxing thoughts), goal-oriented (e.g., when targeting the knowledge system by cognitive reappraisal), or person-oriented (e.g., when targeting the body by controlling breathing). Importantly, both frameworks are in agreement that emotion regulation is based on three main processes (Gross, 1998a, 1998b) or emotion generating systems (attentional deployment/attention, cognitive change/knowledge and response modulation/body; Koole, 2009) and use highly similar categories for goal-oriented emotion regulation strategies targeting these processes/systems (distraction, cognitive reappraisal, suppression). Within this framework, distraction is defined as a process in which selective attention is used to limit the extent to which the emotionally evocative aspects of an event or stimulus are attended and appraised (Kalisch et al., 2006; Kanske et al., 2011; McRae et al., 2010). Emotion regulation via reappraisal is more diverse and comprises various tactics such as reinterpretation (changing the meaning of a stimulus), detachment or distancing (creating a sense of physical or psychological distance from the emotional event; e.g., through perspective taking), reality challenge (changing the authenticity of what is being depicted), or acceptance (invoking the justification that sometimes bad things happen) (McRae et al., 2012). Finally, suppression is used to modify the behavioural or physiological response to an emotional stimulus, e.g., facial expressions (Vrticka et al., 2011).