Oxford Handbooks Online

Emotion Regulation: Neural Bases and Beyond

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The Oxford Handbook of Social Neuroscience
Edited by Jean Decety and John T. Cacioppo

Print Publication Date: Sep 2011
Subject: Psychology, Cognitive Neuroscience, Personality and Social Psychology
Online Publication Date: Sep 2012
DOI: 10.1093/oxfordhb/9780195342161.013.0018

Abstract and Keywords

This chapter provides a brief background on emotion regulation and describes in detail two classes of emotion regulation strategies. Towards that end, the remainder of the chapter is organized into three parts. In the first, it defines what we mean by emotion and emotion regulation, and introduces our approach to understanding them at multiple levels of analysis. In the second, it reviews current research on two kinds of cognitive strategies for regulating emotion: attention deployment and cognitive change. Finally, it considers the implications of this review for future research on emotion regulation.

Keywords: emotion regulation, emotion, cognitive strategies, attention deployment, cognitive change

Life is full of both profound tragedies and routine setbacks, and the emotions elicited by these events can interfere with our everyday lives. However, we humans possess an astonishing faculty for regulating these emotions and adapting to the situations from which they arise. Whether it's positively reframing an undesirable situation to make it more manageable or steering oneself away from a potential threat, the ability to successfully regulate one's emotions is a key aspect of mental health. Indeed, individual differences in emotion regulation have implications for well being, and chronic regulatory failure is associated with disorders ranging from depression to addiction (Davidson, Putnam, & Larson, 2000; Ochsner & Gross, 2005). In this chapter, we will provide a brief background on emotion regulation and describe in detail two classes of emotion regulation strategies. Towards that end, the remainder of this chapter is organized into three parts. In the first, we define what we mean by emotion and emotion regulation, and introduce our approach to understanding them at multiple levels of analysis. In the second, we review current research on two kinds of cognitive strategies for regulating emotion. Finally, we consider the implications of this review for future research on emotion regulation.

The Playing Field

In sports, it's always important to know the rules of the game before one begins to play. In reviewing the literature on emotion regulation, it is much the same: Before diving into the literature, it's important to clearly define the terms and limits of what is to be considered.

What is Emotion?

To understand the process of emotion regulation, one must first understand what regulatory processes are targeting. Emotions can be thought of as responses to adaptive challenges that involve changes (p. 278) in physiology, behavior, and experience (Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000; Ochsner & Barrett, 2001; Scherer, Schorr, & Johnstone, 2001). This response is triggered by an appraisal of the significance of the challenge to one's current goals, wants, or needs. This emotion-generative cycle, where appraisals generate responses, may repeat as the output of one cycle contributes to the input for the next.

Neuroimaging studies of emotion have identified several subcortical structures that play key roles in triggering emotional responses, with the amygdala and striatum foremost among them (Kober et al., 2008; Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008). The amygdala is commonly associated with the detection of arousing stimuli in general and potential threats in particular (Phelps, 2006; Whalen, 1998), while the striatum is thought to be important for learning about the rewarding or reinforcing properties of a stimulus (Kelley, 2004).

The Process Model of Emotion Regulation

With roots in prior work on ego defense, stress and coping, and delay of gratification (Ochsner & Gross, 2005), current research has progressed from the study of general constructs to investigating questions about particular behavioral and experiential consequences of successful regulation, different strategies that may be employed, and which brain systems are involved with which strategies.

A process model of emotion regulation put forth by James Gross guides much of this work. According to this model, the emotion regulatory impact of different forms of emotion regulation can be understood in terms of how they impact specific stages of the emotion generation process. Some kinds of strategies, such as *situation selection* or *situation modification*, entail avoiding or changing the emotion-eliciting event itself. Other kinds of strategies, such as *attention deployment* and *cognitive change*, involve changing how one attends to and appraises the meaning of the emotion-eliciting event. The final kind of strategy, known as *response modulation*, involves controlling how one responds behaviorally to an emotion, such as suppressing the expression of an emotion (Gross, 1998).

To make this concrete, consider the example of a painful breakup. An individual struggling with undesirable negative emotions may choose to cut themselves off entirely from their former partner (*situation selection*), or they might only associate with that former partner in contexts that are deemed emotionally “safe,” for instance, in a group setting (*situation modification*). Alternatively, this individual may select more internal means of easing the pain associated with their breakup. They may choose to distract themselves from their emotional turmoil by throwing themselves into their work or hobbies (*attention deployment*), or they might attempt to rethink their perspective on the breakup, ultimately deciding that it was the best outcome for both parties involved (*cognitive change*). Finally, the individual could simply choose to “keep a stiff upper lip”—suppressing the expression of their emotion so that no one else can tell what they are feeling (*response modulation*).

Current behavioral research has sought to compare and contrast the consequences of deploying different kinds of emotion regulatory strategies. For example, it has been found that response modulation strategies such as expressive suppression may diminish facial and bodily movements associated with emotion, despite little change in subjective report of that emotional experience and potentially dangerous increases in physiological markers of arousal (Gross, 1998; Roberts, Levenson, & Gross, 2008). By contrast, cognitive change strategies such as reappraisal have been shown to decrease subjective report of emotional experience, absent of unwanted physical or social disadvantages, and may be associated with decreased stress reactivity, compared to a more suppressive style of regulation (Moore, Zoellner, & Mollenholt, 2008). Further, the tendency to reappraise rather than to suppress is associated with better interpersonal functioning, more positive emotion, less negative emotion, and greater well-being (Gross & John, 2003).

Levels of Analysis

Our approach to describing the mechanisms underlying emotion and emotion regulation draws on the theories and methods of social psychology on the one hand, and cognitive and affective neuroscience on the other. This *social cognitive and affective neuroscience* approach (Ochsner, 2007; Ochsner & Barrett, 2001) seeks to describe the mechanisms underlying emotion and emotion regulation at three levels of analysis. The first is the social level, at which we describe specific kinds of behaviors and experiences that are of interest. The second is the cognitive, or information processing level, at which we describe the mental representations and psychological processes that give rise to the phenomenon in question. The third is the neural level, at which we describe the neural systems whose computations embody processes at the cognitive level.

(p. 279) One benefit of this multi-level approach is that it helps clarify which levels of analysis are addressed by our terminology. In the case of emotion regulation this is especially important, because some terms can ambiguously refer to multiple levels of analysis. For example, the term *suppression* has been used in at least three ways. First, *suppression* is often used to describe behavioral attempts to keep an emotion or thought out of awareness or to keep a given action from being executed (Gross & Levenson, 1993; Wegner, Schneider, Carter, & White, 1987). In this case, the term *suppression* refers to the social-level task given to participants. In the second, *suppression* refers not to the specific behaviors in which participants engage, but rather to the goal of reducing the occurrence of a thought or emotion, which can be achieved by various means, including cognitive change (Phan et al., 2005; Urry et al., 2006). When used in this way, the meaning of the term *suppression* shades between references to explicit social-level goals consciously held by participants and cognitive-level processes used to achieve those goals. Finally, in the third, *suppression* is used specifically to refer only to hypothetical cognitive processes that achieve the goal of keeping emotions or thoughts out of awareness (Freud, 1900/1980).

So which is it? Is suppression a social level goal, a social level behavior, or a cognitive process? For present purposes, we treat *suppression* as a social-level strategy that involves goals and specific behaviors designed to attain them. In like fashion, the strategies described under Gross’s process model of emotion regulation also are described at the social level in terms of the goals and behaviors used to attain them.

In the following review, our goal is to carefully distinguish between and describe the relations among the three levels, while neither conflating nor confusing them. The data from functional neuroimaging studies allow us to do this in two ways. By measuring brain activity elicited while subjects are participating in behavioral tasks, we have two dependent measures—one at a neural level and one at the social level—that we can use to gain leverage on theories of the psychological processes that connect them. This is, of course, a difficult task because no task is process-pure and no brain structure uniquely participates in one psychological process (Kosslyn, 1994). Nevertheless, we argue that attempting to triangulate on core processes using two kinds of data (as when conducting functional imaging studies) can provide novel insights not obtainable using just one type of data (e.g., behavior-only studies; Ochsner, 2007).

Current Work: From Attention Deployment to Cognitive Change

With the above considerations in mind, this chapter focuses on reviewing neuroimaging studies of two kinds of cognitive strategies: attention deployment and cognitive change. We focus on these two strategies because they are associated with clearly defined social-level behavioral strategies that can be studied in an imaging environment, and because—perhaps not coincidentally—they have been the focus of the largest amount of work.

Attention Deployment

Attention deployment refers to the use of control processes to modify emotional responses by devoting less conscious attention to the emotional content of a given stimulus. This diversion of attention has been shown, in turn, to promote decreases in reported emotion, as well as decreases in activity in areas associated with the processing of affective responses, such as the amygdala and the anterior insula (Ochsner & Gross, 2005).

In general usage, attention deployment strategies may not be associated with an explicit regulatory goal. Although they promote a reduction in behavioral and neural markers of an emotional response, the need to split attention across multiple tasks may end up having a beneficial, albeit not necessarily intended, emotion regulatory effect. In this sense, the regulatory effects of attention deployment are “implicit,” because they occur in the absence of explicit awareness of a goal and subsequent attempts to regulate emotion.

We have divided the various types of attention deployment strategies into three classes—those that alter the emotional response through a distracting task or secondary stimulus (*distraction*), those that direct attention away from the emotional content of a stimulus towards some other perceptual feature (*selective attention*), and those that involve an explicit semantic judgment of the stimulus that focuses attention on a single dimension of meaning (*selective construal*).

Distraction

Distraction is an emotion regulation strategy that recruits various cognitive processes—such as those involved in shifting attention and mediating conflict—towards the goal of modulating affect. Studies of distraction typically involve diminishing participants' attention to emotional stimuli by using an unrelated distractor task that participants must complete simultaneously with exposure to an emotionally (p. 280) evocative event. Though these studies typically use pain as an elicitor of negative emotion, some recent studies have attempted to test the regulatory effects of distraction on the experience of emotion associated with other stimuli—for instance, the anticipation of subsequent negative stimuli, such as aversive photos.

Distraction consistently has been shown to produce decreases in both subjective report of pain and activity in areas associated with pain processing—the so-called "pain matrix," encompassing the secondary somatosensory cortex, the insula, portions of the anterior cingulate cortex, and the thalamus (Jones, 1998). Studies that report these modulations have asked participants to complete a verbal attention task distraction during cold pressor pain (e.g., pain caused by immersing a participant's arm in ice cold water) (Frankenstein, Richter, McIntyre, & Remy, 2001), a self-distraction task during thermal pain (Tracey et al., 2002), the Stroop task during thermal pain (Bantick et al., 2002; Valet et al., 2004), a rapid serial visual-processing task distraction during capsaicin-induced hyperalgesia (Wiech et al., 2005), a multisource interference task distraction during transcutaneous electrical nerve stimulation (Seminowicz & Davis, 2007), and an auditory distractor task during visceral pain (Dunckley et al., 2007). In addition, two studies have reported activations in the periaqueductal gray—an area associated with pain analgesia (Wager et al., 2004)—associated with distraction during the experience of pain (Tracey et al., 2002; Valet et al., 2004).

Several of these studies have also observed activations in the dorsal anterior cingulate cortex (ACC) and the lateral prefrontal cortex (PFC) during distraction (Bantick et al., 2002; Frankenstein et al., 2001; Seminowicz & Davis, 2007; Valet et al., 2004), areas typically associated with cognitive control. However, as these regions have also been associated with working memory and other executive functions (Wager & Smith, 2003), it should be noted that these activations could be attributable to either the conscious regulation of pain, participation in the distractor tasks themselves, or some combination of the two.

Similar results were reported in the few studies that examined distraction's impact on the experience of non-pain-related negative emotion. For example, distraction from anxious anticipation of subsequent negative emotion by means of an N-back task resulted in decreases in amygdala activity compared to the attended condition and increases in activity in the ventrolateral PFC (Erk, Abler, & Walter, 2006). Similar recruitment of the left lateral PFC was observed in association with self-distraction during pain-related anxiety (Kalisch, Wiech, Herrmann, & Dolan, 2006). Interestingly, although the authors of the latter study suggest a left-distraction/right-reappraisal lateralization of function in the brain, to date, no studies have directly compared distraction-based emotion regulation and cognitive reappraisal-based emotion regulation.

Selective Attention

Selective attention strategies draw on cognitive processes used to shift and engage attention to effect modulations in affective responding. Neuroimaging studies of this strategy typically involve paradigms where participants are instructed to focus on the non-emotional portions of an affective stimulus or combination of stimuli. Though this manipulation can be associated with an increase in attentional load, it does not constitute a distractor task, per se. Studies of distraction, as discussed above, typically shift participants' attention by means of some cognitive task or other-modal cue.

Selectively directing attentional resources away from the emotional content of a stimulus has been shown to modulate affective responding, as well as affective processing at the neural level. For instance, amygdala activity in response to fear faces was decreased when participants judged the orientation of a set of bars on either side of the image, compared to simply attending to the faces (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002). This task is distinguished from a distraction paradigm in that the faces and bars are not presented in competing sensory modalities. They are two visual stimuli presented side-by-side and for such a brief amount of time that they could be said to constitute a single composite stimulus.

Another study produced similar results in response to the presentation of pairs of fear faces and houses—amygdala activity was significantly lower when low trait-anxiety subjects attended to houses, as opposed to fear faces (Bishop, Duncan, & Lawrence, 2004). In a later study, participants were presented letter strings superimposed over fear faces and asked to make easy or difficult judgments of the strings. Amygdala activity in response to fear faces was significantly lower while under high perceptual load compared to low perceptual load (Bishop, Jenkins, & Lawrence, 2007). Finally, recent work using EEG suggests that the late positive potential (LPP), a measure of attention to emotional stimuli, is affected by similar manipulations. (p. 281) When attention is selectively directed to nonarousing portions of aversive images, the LPP is reduced (Dunning & Hajcak, 2009; Hajcak, Dunning, & Foti, 2009).

However, several other studies examining the effects of selective attention on emotional experience have produced discrepant results. For instance, in studies using similar face versus house matching tasks, the amygdala was activated irrespective of attention to fear faces (Anderson, Christoff, Panitz, De Rosa, & Gabrieli, 2003; Vuilleumier, Armony, Driver, & Dolan, 2001). Additionally, a similar pattern of amygdala activity was observed in a comparison of attended versus ignored anger prosody (Sander et al., 2005). However, though attention failed to modulate amygdala activity in this study, the orbitofrontal cortex (OFC) showed greater activity during the attended than the ignored condition. Further, this activity was strongly correlated with an individual difference measure of proneness to anxiety, suggesting that individual differences may contribute to the degree that such manipulations modulate affective processing.

One potential source of inconsistency in these studies of selective attention is the varying degree of attentional demand between tasks. For instance, the participants in the studies by Vuilleumier et al. (2001) and Anderson et al. (2003) performed at a higher rate of success than the subjects in the study described by Pessoa and colleagues (Pessoa et al., 2002). In a later study, Pessoa et al. included task difficulty as a variable, and found that amygdala activity was greater for fear faces as opposed to neutral faces only when the bar-orientation task was least difficult (Pessoa, Padmala, & Morland, 2005). Although this indicates a relationship between attentional demand and modulation of the emotional experience, in the absence of a way to quantify attentional load on the same metric across different studies and tasks, these results still do not resolve why no attention-related amygdala modulation was observed in Vuilleumier et al. (2001) and Anderson et al. (2003), the putatively “easier” tasks.

That being said, the correlation reported between proneness to anxiety and OFC activity during the attended condition is of note (Sander et al., 2005), especially in light of findings in several studies by Bishop and colleagues (2004). In their 2004 study, the face versus house matching task produced no attentional modulation of amygdala activity in the high trait-anxiety subjects (Bishop et al., 2004). Later, it was observed that high state anxiety was associated with increased amygdala activity to fear faces under low perceptual load, and further, that high trait anxiety was associated with less dorsal ACC, dorsolateral PFC, and ventrolateral PFC activity during low perceptual load. Further research should be conducted to clarify the relationship between attentional focus and individual differences in level of anxiety, which might modulate sensitivity to unattended affective stimuli.

Selective Construal

Selective construal strategies can be thought of as a specific type of selective attention in which attention is directed to an alternative dimension of semantic meaning, rather than an alternative perceptual aspect of a stimulus. Such studies typically ask participants to make judgments about some aspect of the meaning or content of emotional stimuli that is orthogonal to its emotional content.

Somewhat confusingly, depending on the study, construal along either emotional or non-emotional dimensions both have been shown to modulate affect and activation in areas related to affective processing (e.g., the amygdala). On one hand, consider that several of these studies have shown a relative decrease in amygdala activation as a result of directly judging the emotional, rather than the perceptual features of a stimulus. Such judgments include matching of aversive scenes or emotional faces in terms of their affective as opposed to perceptual qualities, (Hariri, Bookheimer, & Mazziotta, 2000; Hariri, Mattay, Tessitore, Fera, & Weinberger, 2003; Lieberman et al., 2007; Lieberman, Hariri, Jarcho, Eisenberger, & Bookheimer, 2005) and active rating of emotional responses versus passive viewing of emotionally charged photos (Taylor, Phan, Decker, & Liberzon, 2003). Furthermore, a recent behavioral study yielded evidence that these effects can even be conserved over time. Pairing aversive images with affective labels—which presumably directs participants to construe them in terms of their affective meaning—was associated with greater decreases in physiological responses to those images after an eight-day period, than those images that had been unpaired (Tabibnia, Lieberman, & Craske, 2008). These effects have been accompanied by activity in the ACC (Hariri et al., 2000; Hariri et al., 2003; Taylor et al., 2003), as well as prefrontal activations, including right ventrolateral PFC (Hariri et al., 2000; Hariri et al., 2003; Lieberman et al., 2007) and right dorsomedial PFC (Taylor et al., 2003). However, a later study comparing active rating versus passive viewing of sad and happy films (a paradigm similar to Taylor et al., 2002) did not (p. 282) observe a decrease in self-report of emotion or neural indicators of emotional processing, though active rating once again produced activity in the ACC (Hutcherson et al., 2005).

On the other hand, many studies of selective construal have failed to observe any modulation in affective processing areas. In paradigms similar to those described above, no significant differences were observed in amygdala activity when participants make gender as opposed to affect judgments of happy, disgusted, fearful, and sad faces, (Gorno-Tempini et al., 2001; Winston, O'Doherty, & Dolan, 2003), emotion versus age judgments of famous individuals with negative associations (Cunningham, Johnson, Gatenby, Gore, & Banaji, 2003), and trustworthiness versus age judgments of differentially trustworthy faces (Winston, Strange, O'Doherty, & Dolan, 2002).

One potential explanation for these discrepant results is a difference in the stimuli used across studies. Whereas studies that do not observe amygdala modulation typically use lower-intensity, lower-arousal stimuli, such as expressive Ekman faces (Gorno-Tempini et al., 2001; Winston et al., 2003), several studies that *do* observe amygdala modulation use highly aversive, high-arousal images from the International Affective Picture System (Hariri et al., 2003; Taylor et al., 2003). Among the differences between these two kinds of stimuli that could be responsible for the discrepant results, one possibility is that faces have significance that systems like the amygdala have evolved to detect, regardless of attentional engagement. Alternatively, high arousal stimuli may elicit more amygdala activity overall and thus may have more "room to fall" when attentional resources drop.

Another factor is that studies of selective construal have used two similar, but functionally different paradigms. The first group of studies compares two different *tasks* (matching vs. labeling, (Hariri et al., 2000; Hariri et al., 2003)), while the second group compares two different *judgments* (e.g., gender vs. valence assessments; Cunningham et al., 2003; Gorno-Tempini et al., 2001; Winston et al., 2003; Winston et al., 2002). This raises the possibility that the attentional demands of the match task may simply be greater than those of the label task, while emotional and gender judgments impose similar attentional load, at least in some cases. Therefore, this increased load may account for the amygdala deactivations observed in the former studies as opposed to the latter. Indeed, Lieberman et al. (2007) controlled for these differences, and observed the greatest amygdala deactivations in the "affect label" condition, as compared to "affect match," "gender label," or "gender match." All in all, the variability in these results speaks to a need for further clarity in future studies of selective construal strategies.

Summary

In general, studies of attention deployment strategies have been rather limited in terms of their scope. Most of these studies have been focused on the regulation of affective perception, rather than affective responding. This has resulted in paradigms that produce interesting results, but sometimes fail to achieve a certain level of construct or ecological validity. On the one hand, while pain-related stimuli are certainly arousing and affective, they don't represent the kind of multidimensional emotional experiences of every day life. On the other hand, fear faces, such as those used in studies of selective attention and selective construal, lack inherent affective significance in the experimental environment. While they may have significance for survival in everyday life (e.g., in our evolutionary context, a fear face may have indicated a need to run away from a predator in the African savannah, and still communicates the presence of potential dangers), they may be too abstracted from the survival goals of a subject in a neuroimaging study to elicit a meaningful level of emotional response. Clearly, we need to find a middle ground. Future work in this area should employ more self-relevant stimuli in an effort to make this so.

Furthermore, the relatively stark delineation of stimuli used to study these three types of strategies makes a comparison between forms of attention deployment rather problematic. To reiterate, studies of distraction focus predominantly on pain-related stimuli, while, for the most part, studies of selective attention and selective construal use emotional face stimuli. To truly parcellate which attention-deployment strategies are most efficient at regulating which emotions—and furthermore, which neural mechanisms facilitate this regulation—a direct comparison of these strategies must be performed within subjects, using the same emotionally evocative stimuli.

Cognitive Change

Research addressing the use of cognitive change to regulate emotional responses usually focuses on changes in emotional experience brought about by either the cognitive manipulation of current emotional states or the cognitive generation of new (p. 283) emotional states. In general, while the strategies used to achieve these ends have similar functional goals as attention-deployment strategies (e.g., modulation of affect), they are more dependent upon higher cognitive faculties like mental imagery, memory, and response selection (Ochsner & Gross, 2005).

Reappraisal

Reappraisal is an umbrella term that encompasses various sub-strategies used to mentally transform the meaning of a stimulus, thereby changing one's affective response to it. In this way, reappraisal can be used to increase, decrease, or maintain an emotional response, in some cases by fundamentally altering one's personal relationship to it. To achieve these varied ends, reappraisal draws upon a wide array of cognitive processes including those involved in working memory, language, response inhibition, and control of response conflicts. Studies of reappraisal examine the behavioral and neural consequences of modifying responses to emotionally arousing stimuli. These studies often, but not always, involve an explicit goal to regulate emotion, whereby participants are instructed to actively construe emotional stimuli in a different way in order to change their emotional state. The majority of these studies have focused on decreasing feelings of negative affect, although current research has begun to examine the use of similar strategies with positive or discrete types of emotion as well (Kim & Hamann, 2007; Kober, Kross, Hart, Mischel, & Ochsner, in press).

In a typical study, participants are presented with an emotionally charged stimulus and instructed to think about it through a particular cognitive frame that changes the meaning or affective value of the stimulus. The different means of reappraising can be thought of as sub-strategies that exert different kinds of change on the lens through which a stimulus is viewed. Two sub-strategies in particular have received the most attention. The first is *reinterpretation*, which involves re-thinking the event, actors, and context of an image. The second is *distancing,* which involves viewing an image from the perspective of a detached (objective) third-person observer. In addition, various other reappraisal-like sub-strategies have been studied that combine elements of reappraisal with other strategies. For example, "cognitive substitution," described below, involves aspects of both reappraisal and distraction as participants generate and focus on emotions related to a cue, but that are different than those typically associated with it.

Reinterpretation

Cognitive strategies focused on reinterpretation typically involve a rethinking or reimagining of the outcomes, dispositions, or intentions associated with an affective stimulus in such a way that changes the initial emotional response to that stimulus. For example, a participant may be presented with an image of a crying child that initially evokes feelings of sadness or fear for the distressed child, but when given the cue to reinterpret, the participant may imagine that the child will soon be found and comforted by her mother and the situation will resolve itself positively (Ochsner, Bunge, Gross, & Gabrieli, 2002).

Reinterpretation-based reappraisal has been shown to modulate amygdala activity associated with emotions elicited by normatively aversive images (Johnstone, van Reekum, Urry, Kalin, & Davidson, 2007; Kim & Hamann, 2007; Ochsner et al., 2002; Ochsner et al., 2004; Phan et al., 2005; Urry et al., 2006; van Reekum et al., 2007), images of moral violations (Harenski & Hamann, 2006), and positive images (Kim & Hamann, 2007). Reinterpretation typically is associated with increased activity in a network of regions associated with cognitive control, including dorsolateral PFC, dorsomedial PFC, and dorsal ACC. Some recent work has examined the connectivity between areas of the PFC and amygdala, observing an inverse relationship between ventrolateral PFC activity and amygdala activity (Urry et al., 2006), a relationship between the ventrolateral PFC and the amygdala mediated by the ventromedial PFC (Johnstone et al., 2007), and both positive and negative mediations of ventrolateral PFC activity and reappraisal success by striatum and amygdala activity, respectively (Wager et al., 2008).

Until recently, no study had directly compared either the behavioral or neural effects of an attentional control-based strategy with those of a cognitive change-based strategy. McRae and colleagues sought to make this comparison, examining both the emotional consequences and neural underpinnings of distraction versus reappraisal within the same subjects (McRae et al., 2010). Consistent with prior work, reappraisal and distraction both down-regulated behavioral ratings of negative emotion, as well as activation in the amygdala. In addition, both conditions produced increased activity in PFC and ACC. In the critical comparison between reappraisal and distraction, reappraisal led to greater drops in subjective report of negative affect, as well as greater increases in medial PFC and anterior temporal (p. 284) regions—areas typically associated with processing the semantic content of affective stimuli. By contrast, distraction was observed to induce significantly greater drops in amygdala activity and significantly greater increases in PFC and attention-related parietal areas.

Distancing

The reappraisal sub-strategy known as distancing draws on cognitive processes similar to those involved in reinterpretation, although in this case in an effort to assume a personally, and hence emotionally, removed perspective. In studies of distancing, participants are instructed to act as third-person observers while perceiving emotionally arousing stimuli. For instance, if presented with a gory photo of an accident, one might take the viewpoint of detached, clinical observer not personally connected to the events or individuals depicted in the photo (Ochsner et al., 2004).

Distancing-based strategies have been shown to modulate amygdala activity associated with emotions elicited by sad films (Levesque et al., 2003), erotic photos (Beauregard, Levesque, & Bourgouin, 2001), aversive images (Ochsner et al., 2004), pain anticipation (Kalisch et al., 2005), threatening images (Eippert et al., 2007), and negative images with social content, specifically (Koenigsberg et al., in press). Though distancing strategies differ qualitatively from reinterpretation strategies, they activate a similar set of areas: dorsomedial PFC, dorsolateral PFC, and dorsal ACC, suggesting that they rely on a largely similar set of underlying processes. In direct comparisons of reinterpretation and distancing (Kim & Hamann, 2007; Ochsner et al., 2004), it was reported that generally, reinterpretation recruits lateral PFC regions more strongly than distancing and conversely, distancing recruits medial PFC regions more strongly than reinterpretation. This differentiation falls in line with previous research linking the lateral and medial aspects of the PFC to processes involved in working memory/selective attention (Knight, Staines, Swick, & Chao, 1999; Miller & Cohen, 2001; Ochsner et al., 2004; Smith & Jonides, 1999) and self-reflection on affective states (Gusnard, Akbudak, Shulman, & Raichle, 2001; Lane, Fink, Chau, & Dolan, 1997; Lieberman, 2007; Simpson, Drevets, Snyder, Gusnard, & Raichle, 2001), respectively.

Several studies have also examined the effect of *reducing* psychological distance—i.e., feeling closer to—an emotional stimulus. In such studies, participants are asked to fully immerse themselves in an aversive image and imagine that the emotional events depicted are happening to them (Eippert et al., 2007; Ochsner et al., 2004). Neurally speaking, immersion yields similar results to other forms of cognitive change, activating such areas as dorsomedial PFC, dorsolateral PFC, and ventrolateral PFC. Critically, immersion strategies typically increase amygdala activity. When immersion was directly compared with distancing, immersion was associated with greater medial PFC and posterior cingulate activity, while distancing produces more lateral PFC and OFC activity (Ochsner et al., 2004).

Summary

Consistently, cognitive change strategies have been observed to modulate both self-report of emotion and affective processing. In turn, these modulations have been typically linked to activity in the PFC and dorsal ACC. The relative regularity of these results over the course of many studies is encouraging, and speaks to the use of strongly evocative stimuli and discrete regulatory strategies. As we begin to know more and more about what areas of the brain are involved in such regulatory processes, we can expand our scope to examine the differences between specific strategies, as well as investigate how and why regulation fails in certain populations.

As work progresses, however, there comes a crucial need for regularity and specificity of terminology—if our goal as a field is to develop an understanding of the unique brain systems that implement different strategies. Studies that offer their participants a variety of qualitatively different strategies and suggest that they simply use the strategy that works best (Johnstone et al., 2007; Kim & Hamann, 2007; Urry et al., 2006) pose a potential problem, because though the implicit goal of emotion regulation is constant, at any given moment, we cannot be sure what subjects are actually doing to dampen or heighten their emotional responses.

Conclusions and Future Directions

With all the progress that has been made on understanding the cognitive and neural mechanisms of emotion regulation, there is still much that remains unclear. Indeed, for every question answered, two more seem to crop up in its place. In this section we consider work on strategies related to, but that do not fit perfectly in the preceding review, critically sum up what the review has told us, and consider issues that future work might fruitfully explore.

(p. 285) Hybrid Strategies

There are many cognitive regulatory strategies that combine key elements of attention deployment or cognitive change strategies. Cognitive substitution is one such combination, drawing upon aspects of distraction, selective attention, and reappraisal to effect a change in the emotional experience of an affective stimulus by replacing the initial appraisal of that stimulus with an unrelated, but preferential emotional experience.

Several studies have examined the effects of supplanting the initial emotional response with an entirely new emotional experience, like thinking of a positive memory during a sad film (Cooney, Joormann, Atlas, Eugene, & Gotlib, 2007) or thinking of something calming during reward expectation or shock expectation (Delgado, Gillis, & Phelps, 2008; Delgado, Nearing, LeDoux, & Phelps, 2008). In these studies, the cognitive substitution strategy has modulated activity in key processing areas—the amygdala (Delgado, Nearing, et al., 2008) and the ventral striatum (Delgado, Gillis, et al., 2008)—and has been associated with dorsolateral, ventrolateral, and ventromedial PFC activity.

It should be noted that some studies of attention deployment can be thought of as potentially falling under this hybrid category; for instance, the Kalisch et al. (2005) study of self-distraction's effect on the experience of pain-related anxiety. As previously mentioned, in this study participants were instructed to distract themselves by thinking of anything that would get their minds off the pain they were about to experience. The neuroimaging results from this study—activity in the left lateral PFC—further suggest a similarity.

Critical Summary

To different degrees, attention deployment and cognitive change strategies have been shown to modulate both subjective reports and neural signatures of various emotional responses. Whereas reappraisal-based cognitive change strategies such as reinterpretation and distancing consistently have been shown to modulate affective processing and experience, results have been more mixed for attention deployment strategies, such as selective attention and selective construal. Ultimately, though similar brain regions are associated with supporting these strategies, including the PFC and the ACC, many questions remain about differential recruitment of these areas across various strategies of emotion regulation.

Future Directions

With the preceding review in mind, there are numerous directions for future work. Here we consider four of the most salient.

Defining Boundaries

Moving forward, researchers must be careful to differentiate between qualitatively different forms of regulation. Consider, for example, that in the cognitive change literature, multiple studies couch reinterpretation or distancing strategies in terms of "suppression" (Levesque et al., 2003; Phan et al., 2005, respectively) or cue their subjects to implement a reinterpretation strategy with the word "suppress" (Koenigsberg et al., in press; Urry et al., 2006; van Reekum et al., 2007). As suppression comprises a very different, response-focused form of emotion regulation, characterized by a modulation of the behavioral response to an emotional stimulus (Gross, 1998), rather than an internal reframing of affective meaning of that stimulus, we must maintain consistency in the usage and definition of these key terms.

Researchers also should guard against spillover between strategies when instructing participants to regulate. For instance, in a direct comparison between reappraisal and suppression strategies—an important contrast, to be sure—what was billed as a reappraisal strategy ultimately took the form of a combination of perspective-taking frames and changes in selective attention (Goldin, McRae, Ramel, & Gross, 2008). Indeed, every strategy involves combinations of processes of multiple kinds. Our point here is simply to say that instructional sets should be kept clearly oriented towards one *strategy* or another, so as to know to what we can attribute observed effects—the multiple processes engaged by one strategy or the combination of two different strategies.

Similar issues exist in studies of attention deployment. As previously discussed, discrepant results have been observed in studies of both selective attention and selective construal, due to inconsistencies between paradigms. For instance, a lack of clarity in operationalizing attentional load has produced a set of studies that observe modulation of affective processing due to attentional shifts (Pessoa et al., 2002; Bishop et al. 2004), and a competing set of studies that observe no such modulation (Vuillumier et al., 2001; Anderson et al., 2003). In addition, because the lines between distraction and selective attention are sometimes blurred in the descriptions researchers give of their own work, (p. 286) we must be sure to test differences in psychological processes, not simply semantics.

Critical Comparisons

As our understanding of various emotion regulatory strategies grows, comparisons between different strategies along the regulatory continuum become crucial. This will afford us more clarity regarding the component processes that comprise different regulation strategies. It is critical that we build on general statements regarding “the modulation of affective processing” by pursuing specific information about how different types of strategies utilize different psychological processes to modulate emotional experiences. Studies like those that compare reappraisal and distraction (McRae et al., in press) and reappraisal and suppression (Goldin et al., 2008) are beginning to address these important issues.

Broadening the Scope

As our understanding of attention deployment and cognitive change grows, it’s important to consider new avenues of emotion regulation. It’s critical that we use stimuli that a) truly evoke emotion and b) cover a diversity of emotions. Real-life emotional experiences cannot be totally understood by simply accounting for valence—there’s more to life than negative and positive events. Fear, sadness, anger, and consummatory desire are all emotions that, from time to time, call for regulation. Studies that have begun to examine the behavioral and neural circumstances of such regulation (Delgado et al., 2008; Kober et al., 2010) are adding depth to our field and deepening our knowledge of emotion regulation.

We can also explore new avenues of regulation. For instance, two recent studies have examined a cognitive change strategy modeled on mindfulness-based meditation practices. When employing this “acceptance” strategy, subjects viewed their negative emotions as transient mental events that would soon pass. In one study, while subjects “accepted” their negative autobiographical memories, this strategy evoked left lateral PFC activity and modulated both subjective report of negative emotion, as well as subgenual cingulated and medial PFC activity (Kross, Davidson, Weber, & Ochsner, 2009). The acceptance strategy has also been observed to down-regulate activity in the right amygdala and right anterior insula, in response to both highly aversive images and thermal pain, respectively (Kober et al., in prep). Additionally, a correlational analysis between “accept” activity and acceptance success scores revealed bilateral activations in lateral PFC, suggesting a neural similarity to reappraisal strategies like reinterpretation.

Individual Differences

The model discussed in this chapter provides a framework for testing hypotheses about the ranges of both normal and abnormal emotion regulatory abilities. For instance, recent research has investigated the impact of gender on reappraisal (McRae et al., 2008), ruminative tendencies on reappraisal (Ray et al., 2005), dispositional mindfulness on selective construal abilities (Creswell et al., 2007), and anxious tendencies on selective attention abilities (Bishop et al., 2004, Bishop et al., 2007). Learning how these individual differences affect our capability for effective emotion regulation will fill in the gaps in our knowledge, and ultimately shed light on why we so frequently fail in our attempts to regulate. Studies like these serve to better crystallize our understanding of emotion regulation as a dynamic process, dependent on myriad person-specific and situation-specific factors.

From there, it becomes imperative that we also study emotion regulation in the context of dysfunction, as well. Investigations of the influence of certain disorders on regulative capabilities, such as depression (Beauregard et al., 2001; Johnstone et al., 2007), social anxiety (Goldin et al., 2009), and borderline personality disorder (Koenigsberg et al., in press), have revealed abnormal patterns of PFC activity and amygdala modulation in abnormal populations. Future research should continue to interrogate the relationship between such disorders and regulatory failures.

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