Emotion Regulation and Cognition

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Imagine two job candidates waiting for an important interview. They are both terribly nervous, and can't stop their hands from trembling. Each feels sick to his stomach, and each worries that his fear will interfere with his interview performance. If only they could calm down and regain their confidence! The first candidate decides to direct his attention away from his fearful thoughts, and think instead about calming things. The second candidate decides to attend to the interview but to reinterpret it as an opportunity to find whether the company is good enough for *him*, to see whether *he* would enjoy working there. Both of these options lessen the anxiety of the candidates and they feel more confident as the receptionist buzzes them in.

This vignette begins with an emotion—fear, yet its alleviation consists of two types of regulating cognitive processes. In this chapter, our goal is to provide an introduction to how people regulate their emotions, with a particular emphasis on how cognitive processes enable important types of emotion regulation. In the first section, we provide an overview of emotion and emotion regulation, and present a framework that has proved useful for organizing the many different types of emotion regulation strategies. We then discuss the role cognition plays in this framework. In the second section, we analyze the neural systems that give rise to our abilities to cognitively regulate emotion. We specifically examine two different types of cognitive control—attention based and meaning based—that are useful in regulating emotional responses. In the third section, we outline individual differences in emotion regulation. In particular, we describe adaptive and maladaptive variations in attention-based and meaning-based strategies. We conclude by outlining future directions in the field of emotion regulation, emphasizing the areas where a consideration of cognitive approaches is likely to continue to yield exciting new results.

Emotion and Emotion Regulation

Emotions have been said to represent the "wisdom of the ages" (Lazarus, 1991, p. 820),

providing time-tested responses to recurrent adaptive problems. This idea has been developed by functionalist perspectives that highlight the crucial benefits of emotion: emotions prepare time-tested behavioral responses (Cosmides & Tooby, 2004), improve decision making for events that are personally relevant (Damasio, 1999), enhance memory for events that are important to remember (Phelps, 2006), and facilitate interpersonal interactions (Keltner & Kring, 1998). That said, emotions are not always helpful—sometimes they can work against us (Parrott, 1993). This can happen when an emotion is of the wrong type, or if it occurs at the wrong time, or with an intensity that may be out of place. In such situations, we may be motivated to regulate our emotions. But to understand the mechanisms of emotion regulation, we must first consider its target—namely emotion itself.

What is Emotion?

The word "emotion" came to psychology from everyday usage, and it does not have a well-defined boundary. This means that many different phenomena fall under this heading. Emotions vary in their intensity, ranging from mild to overwhelming panic-like responses; they also vary in their duration and in the speed of their onset and decline. Some emotions like sadness rise and fall slowly, whereas other emotions like disgust quickly rise to their peak and return to baseline just as quickly (Davidson, 1998). Therefore, to provide a single, tidy definition of emotion that spans all its instances has proven to be a challenging task. Nevertheless, progress is possible if we consider prototypical features that tend to be common across most instances of emotion. Here we will consider three such features.

First, emotions arise when an individual attends to a situation that she deems meaningful to her goals (Lazarus, 1991). The goals may be enduring (writing a novel) or ephemeral (having another slice of pizza), biologically based (hunting for food) or culturally derived (respecting

one's elders), peripheral (finding the shortest grocery check-out lane) or central to one's self concept (being a good father), widely shared and accepted (wanting to be good at one's profession), or personal and idiosyncratic (staging beetle fights). But whatever the end goal, it is the meaning attached to the goal-relevant situation that generates emotion. It is of note that the meaning may be generated by a cognitive or an emotional process, or some combination of both. In our opening example, the interview (the situation) was cognitively meaningful to the candidate's goal of gainful employment, and it therefore generated emotion—fear.

Second, emotions may be conceptualized as multifaceted, embodied phenomena that involve loosely coupled changes in subjective experience, behavior, and peripheral physiology (Mauss, Levenson, Wilhem, & Gross, 2006). The subjective experience part of emotion—typically called feeling—is an internal representation of the changes invoked by the unfolding emotion (Damasio, 1999). The behavioral part of emotion can include changes in activity of the muscles of the face (e.g. being happy can make us smile) and body (e.g. fear can make us freeze), and in what one says, as well as more general changes in basic motivational states such as the likelihood of approach or withdrawal from a relevant stimulus in the environment (Frijda, 1986). The peripheral physiological part of emotion includes the autonomic and neuroendocrine responses that provide metabolic support for anticipated and actual behavioral responses (Levenson, 1999).

Third, emotions are often malleable. Yes, they can interrupt what we're doing and force themselves upon and force themselves on our awareness (Frijda, 1986). However, in doing so, they must compete with other cognitions and other emotions that may well take precedence. In our opening example the interview situation produced anxiety, but it was partially over-ruled by a new construal. This essential malleability of emotions was first emphasized by William James

(1884), who viewed emotions as response tendencies that could be modulated in a large number of ways. Cognitive control is surely an important path to modulating emotion; in other words, cognition is central to emotion regulation.

The Modal Model of Emotion

These three core features of emotion—its generation from meaningful situations, its experiential, behavioral, and physiological aspects, and its core malleability—constitute what we refer to as the "modal model" of emotion. This model underlies lay intuitions about emotion (Barrett, Ochsner & Gross, 2007; Gross 1998a) and represents several points of agreement among emotion researchers and theorists. According to this model, emotion arises in the context of a person-situation transaction that compels attention, has a particular meaning to an individual, and gives rise to a coordinated yet malleable multisystem response to the ongoing person-situation transaction. Importantly, situations may be attended to and appraised with conscious awareness, or the attention-appraisal process steps may occur unconsciously. The attention-appraisal process steps, occurring within the brain, connect the emotion generating situation to the emotional response.

To illustrate the modal model, let's say one is cut off in traffic (or, alternatively, recalls a time when one was cut off in traffic). Regardless of whether the situation is external or internal, directed attention and appraisal constitute one's assessment of—among other things—the situation's familiarity and value relevance (Ellsworth & Scherer, 2003). In our example, an emotional response is the result of first attending to this incident and then appraising that the traffic injustice was particularly flagrant. It is the combined effect of attention to emotional features and a particular appraisal that lead to an emotional response.

As noted previously, the emotional responses generated by attention and appraisals are

thought to involve changes in experiential, behavioral, and physiological response systems. In this example one may respond with a feeling of rage, a rude hand gesture, and amygdala activation, respectively. However, if a response does occur, it could change the situation that generated the response. Thus, an angry gesture could lead to an apologetic gesture from the driver of the offending car which could in turn lead to one being forgiving rather than angry.

What is Emotion Regulation?

Like "emotion", the concept of "emotion regulation" has many possible meanings. In part this is because the concept inherits all of the complexities that are inherent in the term "emotion." However, we can again make progress by postulating a general definition and by outlining dimensions along which prototypical instances of emotion regulation occur. These dimensions, and their end points, sketch the boundary conditions within which episodes of emotion regulation are most likely to reside.

We begin with a high level definition. In general, emotion regulation refers to processes that influence which emotions we have, when we have them, and how we experience or express these emotions (Gross, 1998a). Emotion regulation is defined by the activation of a goal to modify the emotion-generative process, and involves the motivated recruitment of one or more processes to influence emotion generation (Gross, Sheppes, & Urry, in press).

The first dimension of variation across emotion regulation episodes is whether the emotion-regulatory goal is activated in the individual who is having (or is likely to have) an emotion episode, or in someone else. The former—which we refer to as intrinsic regulation—involves the activation of a regulation goal in the person who is having the emotion. As we have already seen by way of example, intrinsic emotion regulation can be rooted in cognition. The latter—which we refer to as extrinsic regulation—involves the activation of a regulation goal in a

person other than the one who is having the emotion in question. In extrinsic regulation, social communication is involved and is thus partly cognitive.

A second dimension of variation across emotion regulation episodes is whether the motivation to engage in emotion regulation is short-term hedonic (to feel less negative or more positive in the near-term) or instrumental (to achieve one's long-term goals) (Tamir, 2009). Both types of emotion regulation often arise from cognitive processes.

A third dimension of variation across emotion regulation episodes is whether the emotion-regulatory goal is explicit or implicit (Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trotschel, 2001). Implicit goals are activated outside of an individual's awareness, such as when an individual unconsciously stands next to the exit sign and feels calm while standing there. Explicit goals are activated with some measure of awareness, such as when an individual realizes he is feeling grumpy, and makes a conscious effort to look cheerful. Both implicit and explicit goals may be governed by cognitive processes.

The Process Model of Emotion Regulation

One of the challenges in thinking about emotion regulation is finding a conceptual framework that can help to organize the numerous forms of emotion regulation. The modal model suggests one approach, in that it specifies a sequence of processes involved in emotion generation, each of which is a potential target for emotion regulation. In Figure 1, we present the process model of emotion regulation, which highlights the five points in the modal model where individuals can regulate their emotions. These points correspond to five families of emotion regulation processes: situation selection, situation modification, attentional deployment, cognitive change, and response modulation. Below we elaborate on each of these families, particularly focusing on two regulation families that are most unambiguously cognitive in nature:

attentional deployment and cognitive change.

Situation selection refers to efforts an individual makes to influence the situation he will encounter, with a view to increasing (or decreasing) the likelihood that certain emotions will arise. Situation selection may best be captured in the classic conceptualization of choosing between approaching and avoiding a situation. Our job candidates from the opening paragraph of this chapter may for example choose to reduce their anxiety by deciding to go back home and eschewing the interview entirely. Avoidance functions as a very strong regulatory option that intersects the emotion generative process at the earliest point. Nevertheless, it can be clearly maladaptive if overused (Campbell-Sills & Barlow, 2007).

Situation modification consists of efforts to modify the situation directly so as to alter its emotional impact. For example, when a conservative family member visits, situation modification may consist of removing controversial politically themed artwork.

Attentional deployment refers to directing attention in a way that alters the emotion-response trajectory. This takes place after an emotional situation has been encountered. An important feature of attentional deployment is that, unlike situation selection and situation modification, the emotion regulation is primarily cognitive. There are several attention regulation options:

A) *Distraction* involves a shift in attention either away from the emotional aspects of the situation or away from the situation altogether. If one of our job candidates decided to think about the exploits of the 2010 San Francisco Giants instead of dwelling on the upcoming interview, he would be using distraction to lessen his fear. Distraction as a regulatory strategy involves loading working memory with independent neutral contents (Van Dillen & Koole, 2007). The strategy involves replacing current emotional information with independent neutral information. Distraction also filters incoming emotional information, which competes with emotion-regulatory processes at

an early processing stage before stimuli are represented in working memory for further semantic evaluative processing. That is, distraction prevents the affective meaning of a stimulus from being processed by blocking it via an early attentional filter. Studies have indicated that distraction is equally effective in attenuating negative affect under low and high levels of emotional intensity (Sheppes & Meiran, 2007).

B) *Rumination* is an emotion regulation strategy that involves directing attention inward, focusing on negative aspects of the self in an abstract, passive, and repetitive way (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008; Watkins, 2008). Rumination could be viewed as asking big 'why'; questions (e.g., Why am I sad? Why do these bad things happen to me?) about the causes of negative events, without a translation into a concrete way to deal with things.

C) In recent years, influential accounts from eastern philosophy and Buddhism have introduced *mindfulness* as an additional form of attentional regulation. Mindfulness involves attending to emotional experiences by focusing on immediate here and now aspects with an orientation of curiosity, openness, and acceptance (Bishop et al., 2004). Mindfulness has proven to be an adaptive way to regulate negative emotions and has been incorporated into cognitive treatments of anxiety and depression (Goldin, McRae, Ramel, & Gross, 2008).

Cognitive change refers to changing one's appraisal(s) in a way that alters the situation's emotional significance, by changing how one thinks about the situation itself or about one's capacity to manage its demands. One form of cognitive change that has been extensively studied is *reappraisal*. Reappraisal involves changing the situation's meaning in such a way that there is a change in the person's emotional response to that situation. For example, one of the job candidates from the opening paragraph reappraised the interview's meaning from a situation in which he was being judged to one where he was doing the judging! Studies of reappraisal have

provided evidence that reappraisal leads to decreased negative emotion experience and expressive behavior (Dandoy & Goldstein, 1990; Gross, 1998a), decreased startle responses (Dillon & LaBar, 2005; Jackson, Malmstadt, Larson & Davidson, 2000), decreased neuro-endocrine responses (Abelson, Liberzon, Young, & Khan, 2005), and decreased autonomic responses (Stemmler, 1997; but see Gross, 1998a). Comparable effects have been observed when research participants use reappraisal in the lab (Egloff, Schmukle, Burns, & Schwerdtfeger, 2006, or in everyday life (Gross & John, 2003). Consistent with these behavioral and physiological findings, reappraisal is associated with decreased activation in subcortical emotion-generative regions such as the insula and the amygdala. We discuss the neural architecture of emotion regulation in detail in the next section.

Response modulation refers to attempting to change one or more of the experiential, behavioral, or physiological components of an activated emotion response. In this final stage of the emotion-generative process (shown on the right side of Figure 1), experiential, behavioral, and physiological emotional response tendencies have been launched. Regulation targets one of these response systems that have been sufficiently evolved. For example, exercise may be used to decrease physiological and experiential effects of certain emotions. Another modulation strategy that targets the behavioral response tendency is *expressive suppression,* which involves inhibiting emotion-expressive facial behavior (Richards & Gross, 1999, 2000).

Cognitive Consequences of Emotion Regulation

Each of the above regulation strategies may result in different cognitive consequences. For example, Richards & Gross (2000) contrasted the impact of reappraisal and suppression on memory. Participants watched a series of slides that either elicited high or low levels of negative emotion. Some participants were randomly assigned to view the slides while inhibiting their

ongoing emotion-expressive behavior (expressive suppression), while others were assigned to view the slides with the detached interest of a medical professional (cognitive reappraisal). A third group was asked to simply view the slides (control). As slides were presented, participants were informed that the study was designed to understand how people use visual and biographical information when "forming impressions of people who have been injured." Specifically, participants were told that they would see several slides of people who had all been severely injured, either recently (high negative emotion) or in the distant past (low negative emotion), and that they would hear each person's name, occupation, and type of accident. The suppression participants fared worse than the control participants in a test where subjects were asked to write down details associated with each slide as it was presented a second time. The drop in performance occurred for both low and high intensity slides. By contrast, reappraisal did not impact performance on the memory test.

More recently, Hayes et al. (2010) used functional imaging to investigate the neural processes of memory formation during emotion regulation. Participants viewed negative pictures while alternately engaging in cognitive reappraisal, expressive suppression, or passive viewing. They were asked to return two weeks later for a surprise memory test. Behavioral results showed a reduction in negative affect and a retention advantage for reappraised stimuli relative to expressive suppression. Imaging results showed that successful encoding during reappraisal was uniquely linked with increased co-activation of the left inferior frontal gyrus, amygdala, and hippocampus.

The Neural Bases of Emotion and Emotion Regulation

To better understand attention-based strategies (e.g. distraction) and meaning-based strategies (e.g. reappraisal), it is useful to consider underlying neural mechanisms. Historically, there have been two approaches to understanding neural bases of emotional processes. One is a bottom up approach. This approach emphasizes the affective properties of stimuli. The second is

a top down approach. This approach analyzes the higher level cognitive processes that interpret the meaning of the stimuli in the context of an individual's current goals, wants, and needs (Scherer, Schorr, & Johnstone, 2001). Distraction and reappraisal are primarily top-down processes that act upon generative processes that could themselves be top down or bottom up. To understand interactions between various types of processes, we must rely upon methods that are integrative across both approaches.

The Bottom-Up Approach

The bottom-up approach characterizes emotions as a response to stimuli with intrinsic or learned reinforcing properties (e.g., Rolls, 1999). As such, emotions are seen as inevitable consequences of perceiving certain kinds of stimuli. Early animal research supported this approach. Experiments suggested that direct electrical stimulation could trigger either aggressive or pro-social behavior, depending on the specific site of the stimulation. This research focused on subcortical structures such as the hypothalamus and the amygdala as well as on the cortical systems with which these regions were connected (Cannon, 1915; Panksepp, 1998).

Modern recording and lesion studies have built on these findings by elaborating complementary roles for subcortical and cortical systems in emotional learning. For example, it has been shown that the amygdala is implicated in aversive learning, and the medial and orbital frontal cortex supports extinctions and alteration of the stimulus-reinforcer associations (LeDoux, 2000). The main thrust of the bottom-up approach was that emotion is a response to stimulus properties that could be perceived and encoded directly. Participants were simply asked to passively perceive purportedly affective stimuli as their responses were recorded in a scanner.

While the emotion-as-stimulus property yielded stable results among non-human animals, imaging studies on humans have led to more variable results. For example, amygdala activation

in response to emotional stimuli was only found inconsistently (Phan, Wager, Taylor, & Liberzon, 2002; Wager et al., 2008). Other studies (for a review see Ochsner & Gross, 2005) showed that pre-frontal systems—not important in animal work—are reliably activated in studies of human emotion generation. It seemed that studying emotion generation in humans involves something more than mapping the neural signals resulting from the bottom-up processing of affective stimuli.

The Top-Down Approach

Top down approaches have helped to fill in our understanding of the neural bases of emotion generation and emotion regulation. They describe emotion as the product of cognitive appraisal processes that evaluated the meaning of stimuli in relation to an individual's current context—her goals, wants, and needs (Scherer, Schorr, & Johnstone, 2001). While some of these appraisals arise in subcortical structures, others seem to require engagement of prefrontal cortical systems. For example, a delayed order in a restaurant could be appraised as incompetence and lead to anger, or it could be seen as the result of an overburdened staff and lead to patient understanding. As such, cognitive re-appraisals could be involved in emotion regulation. Similarly, top down attentional distraction could direct regulatory processes.

A key foundational principle underlying top down approaches is that unlike other mammals, humans possess a large capacity to make conscious and deliberative choices about the way they construe, respond to, and regulate emotionally evocative situations. Regulatory processes in particular rely on cognitive systems such as selective attention, working memory, language, inhibitory control and long term memory.

These higher cognitive processes have been associated with regions of the lateral and medial pre-frontal cortex (PFC) thought to implement processes important for regulatory control,

and regions of dorsal anterior cingulate cortex (ACC) thought to monitor the extent to which control processes are achieving their goals (e.g. Botvinick, Braver, Barch, Carter, & Cohen, 2001). The use of top down approaches may help explain some of the apparent inconsistency of the early (bottom-up) emotion imaging literature. It is possible that individuals in these studies spontaneously used cognitive regulatory strategies—a phenomenon quite common in behavioral research (Drabant, McRae, Manuck, Hariri, & Gross, 2009; Erber, 1996). Additionally, the participants may have controlled their attention to and appraisal of emotionally evocative stimuli. This could help to explain some instances of PFC activity, and also explain failures to observe amygdala activity.

Despite its promise, the top-down approach does not directly address the fact that humans are not immune from brain electrical and chemical manipulations to subcortical regions (Panksepp, 2003). It seems likely that there is some conservation of subcortical emotional processes in humans. Everyday experience suggests that top down generative and regulatory processes often interact with bottom up processes. In the next section, we consider how bottom-up and top-down approaches might be integrated.

Integrating Bottom-Up and Top-Down Approaches

It is likely that the distinction between bottom-up and top-down processing is relative rather than absolute, and that there is a continuum along which processes can be arrayed with the two approaches at each end point. Nonetheless, the distinction is a useful heuristic for guiding thinking about the way in which the two types of processes interact with each other, and how they may be usefully integrated.

Ochsner and Gross (2007) suggested an initial integrative working framework of the cognitive control of emotions. According to this framework, emotion generation and regulation

involve the interaction of fast appraisal systems such as the amygdala that encode the affective properties of stimuli in a bottom up fashion, with control systems implemented in the prefrontal and cingulate cortex that support controlled top-down stimulus appraisals (Ochsner, Bunge, Gross & Gabrieli, 2002; Ochsner & Gross, 2005; McRae, Ochsner, & Gross, 2011).

The framework posits that emotions can be generated and modulated either by bottom up or top-down processes. For instance, top-down processes can focus attention on particular stimuli, and in so doing have the capacity to regulate emotions by selectively determining the information that have access to generative bottom-up processes. Once the bottom-up generation begins, top-down processes can regulate or alter the in which triggering stimuli are appraised. To illustrate how this model might be applied to specific types of emotion regulation processes, we next detail two cognitive forms of emotion regulation that have, to date, received a great deal of empirical attention: attentional distraction and cognitive reappraisal.

Attentional Distraction

Attention is a basic cognitive process that acts as a gatekeeper by allowing passage of goal relevant information for further processing. Processes that are not affected by attentional manipulation may be defined as automatic; other processes generate altered responses—behavioral and neural—when attention is directed towards them.

According to the integrative framework, attentional deployment in the context of emotion should work much the same way as it does in other non-emotional cognitive contexts. For example, looking at photographs of faces activates the fusiform face area, whereas directing attention to other stimuli decreases its activation (Kanwisher, Stanley, & Harris, 1999). We could therefore expect that in the case of emotion, if attention is directed, automatically or willfully, towards emotionally evocative stimuli, there should be increased activity in regions—

such as the amygdala—that participate in appraising these stimuli. Conversely, directing attention away from such stimuli should decrease, for example, amygdala activity. In attentional distraction, a secondary task is engaged to divert attention from processing a primary target stimulus. As such, incoming emotional information competes with the secondary task at an early processing stage before stimuli are represented in working memory for further semantic evaluative processing (Sheppes & Gross, in press).

Most studies on distraction have focused on examining the impact of performing a cognitive task on responses to (often aversive) affective stimuli. For example, one study used fear faces as stimuli and found that amygdala responses diminished when participants performed a line orientation judgment task (Pessoa, McKenna, Gutierrez & Ungerleider, 2002; see Pessoa, this volume). Other studies have shown that performing a verbal fluency task (Frankenstein, Richter, McIntyre & Remy, 2001), the Stroop task (Bantick et al., 2002; Valet et al., 2004), or simply being asked to think about "something else" (Tracey et al., 2002) diminishes the aversiveness of pain and may reduce activity in cortical and sub-cortical pain related regions, including the mid-cingulate cortex, insula, thalamus, and periaqueductal grey. Tracey et al. (2002) applied heat stimulation to the hands of subjects who were asked to either focus on or distract themselves from the painful stimuli, which were cued using colored lights. Functional imaging revealed that activation in the periaqueductal gray was significantly increased during the distraction condition.

Additionally, as predicted by the model above, regions such as the orbitofrontal cortex (OFC), medial PFC, ACC, and dorsolateral PFC may be more active during distraction (Frankenstein et al., 2001; Tracey et al., 2002; Valet et al., 2004). More recently, it has become possible to specifically distinguish the neural bases of distraction from those of cognitive

reappraisal. We will detail these differences below after first surveying the neural correlates of cognitive reappraisal.

Cognitive Reappraisal

Appraisal theorists have described the cognitive steps needed to transform a percept into something that elicits emotion. Cognitive change refers to changing how we appraise the situation we are in to alter its emotional significance, either by changing how we think about the situation or about our capacity to manage the demands it poses. As discussed above, cognitive reappraisal entails attending to an emotional stimulus and reinterpreting its meaning in a way that alters its emotional impact (e.g., Gross, 1998a).

As would be predicted by the integrative working model above, several studies (for a review, see Ochsner & Gross, 2008) published to date indicate that reappraisal depends on interactions between prefrontal and cingulate regions implicated in cognitive control and (frequently subcortical) regions such as the amygdala and insula that have been implicated in emotional responding. Neuroimaging studies also show that reappraisal is cognitively complex and requires processes for generating, implementing, and maintaining an alternative cognitive construal of a situation (Ochsner & Gross, 2008). During reappraisal, activated regions include dorsal portions of the prefrontal cortex (PFC) implicated in working memory and selective attention, ventral portions of the PFC that have been implicated in language or response inhibition, dorsal portions of the ACC implicated in monitoring control processes, and portions of the medial PFC implicated in reflecting upon one's own or someone else's affective states. It further appears that reappraisal may modulate systems involved in bottom-up appraisal—including the amygdala which has been implicated in the detection and encoding of affectively arousing stimuli, and the insula which receives viscera-sensory inputs and may play a general

role in affective experience.

While top-down systems such as the PFC/ACC are consistently activated during reappraisal, the specific regions of activity vary across studies. This may well occur because cognitive reappraisal may include a variety of different operationalizations that include (a) re-interpreting the situational aspects of the stimuli (e.g. the sick child in the picture will soon get better) or (b) by distancing oneself by adopting a detached third person perspective (e.g., viewing the sick child in the picture as unfamiliar person that the participant does not know). Oschsner et al. (2004) showed that the latter type of regulation recruited medial prefrontal regions implicated in internally focused processing whereas situation-focused regulation recruited lateral prefrontal regions implicated in externally focused processing. This suggests that both common and distinct neural systems support different forms of reappraisal and that which particular prefrontal systems modulate the amygdala in different ways depends on the regulatory goal and strategy employed.

Comparing Neural Correlates of Distraction and Reappraisal

As we have seen, attentional distraction and cognitive reappraisal recruit partially overlapping brain regions: each one depends upon interactions between PFC, interpreted as implementing cognitive control, and sub-cortical regions, interpreted as mediating emotional responses. However, the process model would suggest that the two strategies have fundamental differences: they may draw upon different neural mechanisms and drive different emotional consequences. For example, we would expect that distraction and reappraisal vary in (1) when they act upon the emotion generative process and (2) the neural bases that support both strategies. Specifically, we would predict that attentional distraction should reduce emotional salience early on, before emotional information is represented in working memory. By contrast, reappraisal should allow for elaborated emotional processing prior to its modulation. In terms of

neural bases, this would lead to the prediction that distraction should engage an attentional control network and reappraisal would be supported by an affective meaning neural network.

In a recent event related potential (ERP) study we have shown that distraction modulated an electro-cortical component that denotes enhanced emotional processing (the late positive potential) at its earliest point and reappraisal modulated this component only at a late point (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011). The early modulation in distraction represents a time point when emotional processing is being represented in working memory. By contrast, the late modulation in reappraisal denotes a time point when meaning has already been elaborated about received emotional information.

Two additional recent studies provide support for partially dissociable neural bases of distraction and reappraisal (McRae et al., 2010). Relative to distraction, reappraisal led to greater decreases in self-reported negative affect and to greater increases in a network of regions associated with processing affective meaning (medial prefrontal and anterior temporal cortices). Relative to reappraisal, distraction led to greater decreases in amygdala activation and to greater increases in activation in prefrontal and parietal regions. Taken together, these data suggest that distraction and reappraisal differentially engage neural systems involved in attentional deployment and cognitive reframing and have different emotional consequences.

As we have seen in this section, recently developed methods in neuroscience have enabled a better understanding of the mechanisms underlying two types of emotion regulation. This is an instance of a broader trend: as emotion regulation further captures the attention of neuroscientists and cognitive psychologists, a more extensive and sophisticated array of tools, techniques and empirical methods has become available to the field. Cognitive-experimental methods allow emotion regulation researchers to assess the role of cognitive processes, such as

selective attention, without relying upon self-reported measures (Joormann & Gotlib, 2010). Similarly, in addition to the results discussed in this section, neuroscience has proven extremely helpful in studying the brain bases of emotion regulation (Berkman & Lieberman, 2009).

Individual Differences in Emotion Regulation

We have now examined the neural process involved in attentional distraction and cognitive reappraisal. Next, we examine how people vary in implementing these cognitive regulation strategies. We will consider both adaptive and maladaptive variations in attentional deployment and cognitive change.

Individual Differences in Attentional Deployment

When attentional strategies are used adaptively, pleasant or neutral distractions could be used to alter an emotional response. Then, if necessary, one can commence problem solving (Nolen-Hoeksema, 1991). As we have noted above, distracting responses are thoughts and behaviors that help divert one's attention away from one's undesirable emotional state and its consequences and turn it to pleasant or benign thoughts and activities that are absorbing, engaging, and capable of providing positive reinforcement (Csikszentmihalyi, 1990; Nolen-Hoeksema, 1991). For example, concentrating on a project at work may help take one's mind off a disturbing argument until more resources are available to tackle the underlying issue. However, just as some individuals are instrumental in their attentional deployment strategies, others are burdened by them. We will specifically examine one such response style—rumination.

Rumination is a mode of responding to distress that involves repetitively and passively focusing one's attention on symptoms of distress and on the possible causes and consequences of these symptoms. Contrary to distraction, habitual rumination has been shown to maintain and exacerbate depression by enhancing negative thinking, impairing problem solving, interfering

with instrumental behavior, and eroding social support (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Specifically, longitudinal studies have shown that people who engage in rumination when distressed have more prolonged periods of depression and are more likely to develop depressive disorders (Just & Alloy, 1997; Kuehner & Weber, 1999; Nolan, Roberts, & Gotlib, 1998); similar results were found in samples of adolescents or children (Abela, Brozina, & Haigh, 2002). Other measures of rumination—in particular, those assessing a perseverative focus on the self and one's problems—have demonstrated similar links to depression (Luminet, 2004).

In addition, chronic ruminators appear to behave in ways that are counterproductive to their support relationships. In a study of bereaved adults, ruminators were more likely to reach out for social support after their loss, but they reported more social friction and less emotional support from others (Nolen-Hoeksema & Davis, 1999).

Lastly, it is important to mention that chronic use of distraction without subsequently engaging in reappraisal or problem solving may morph into avoidance of negative emotions through maladaptive avoidance behaviors. Wenzlaff and Luxton (2003) suggest that avoidance can in-turn fuel rumination. Similarly, engaging in behavioral avoidance can also contribute to rumination when these behaviors create more problems in individuals' lives. This is supported by the findings that adolescent girls who engage in binge eating (a common avoidance behavior) display increases in rumination over time (Nolen-Hoeksema, Stice, Wade, & Bohon, 2007).

Individual Differences in Cognitive Change

As we have noted above cognitive reappraisal is a form of cognitive change that involves construing a potentially emotion-eliciting situation in a way that changes its emotional impact. In this literature the adaptive profile of reappraisal is contrasted with the maladaptive profile of

expressive suppression, which is a form of response modulation that involves inhibiting ongoing emotion-expressive behavior. According to the process model of emotion regulation discussed above (Gross, 1998b), reappraisal—which occurs relatively early in the emotion-generative process—changes the entire emotional sequence, with minor physiological, cognitive or interpersonal costs. By contrast, suppression—which occurs later in the emotion-generative process— comes with substantial emotional, cognitive, and social costs (see Gross, 2002 for a review).

Individual differences in the habitual use of reappraisal and suppression revealed several differential associations with emotion experience, cognition, relationship, and well-being. For example, habitual use of reappraisal correlated negatively with depression, and use of suppression correlated positively with depression (Gross & John, 2003; John & Gross, 2004). In addition, habitual use of reappraisal correlated positively with positive emotion, and negatively with negative emotion.

Thus, adaptive, habitual use of cognitive reappraisals can provide several benefits. But habitual use of certain regulatory strategies may not reflect fixed or immutable traits—rather this habitualization may be socially acquired and be sensitive to individual development. Specifically, Dweck (e.g. 1999) and her colleagues have suggested that the beliefs people hold about the malleability of personal attributes impact the amount of control they have on their emotions: Individuals who hold entity beliefs view attribution as relatively fixed (e.g. “The truth is, people have very little control over their emotions”) and therefore difficult to control, whereas individuals who hold incremental beliefs view emotions as malleable (e.g. “If they want to, people can change the emotions they have”) and controllable.

These general beliefs should influence the individual’s emotion-regulation efforts. For

example, people who believe that emotions are fixed and cannot be changed will likely apply those beliefs to their own emotions as well. If they have no reason to think regulatory strategies would be successful, they are unlikely to expend energy implementing them. In contrast, individuals who believe emotions are not fixed but can be controlled should have high levels of emotion regulation efficacy. This prediction should certainly apply to cognitive reappraisal.

The effect of an individual's beliefs about emotions and emotion regulation on their emotion regulation strategies has been examined. Researchers have used the Emotion Regulation Questionnaire Cognitive Reappraisal Scale to show that implicit theories of emotion are indeed related to individuals' sense of efficacy in emotion regulation (Tamir, John, Srivastava, & Gross, 2007). Individuals who viewed emotion as more malleable were indeed more likely to report actively modifying their emotions by using reappraisals.

Directions for Future Research

Using our process model of emotion regulation, we have considered the neural correlates of two cognitive regulation strategies and individual differences in the operationalization of these two strategies. In this last section, we consider three growth points that we consider particularly exciting: (1) Developing more detailed process models of emotion regulation, (2) Finding neural correlates to support such models, and (3) Exploring the sources of individual differences in emotion regulation choice and efficacy.

As a conceptual model, the process model (Figure 1) has proved to be remarkably enduring. However as the field of emotion regulation has expanded there is a need for more detailed understanding of the processes postulated by the process model. One important contribution has been work establishing the importance of the emotional intensity that one faces when regulating emotions, strategies' underlying cognitive operation, and whether the goal of a

particular strategy is to provide short-term relief or long-term adaptation (Sheppes & Gross, in press). As the field continues to mature, our understanding will become increasingly nuanced as we develop better descriptions of underlying regulatory operations due to a better understanding of their temporal dynamics and neural bases, as well as other factors like individual differences, nature of the stimuli one is facing and availability of cognitive resources to name a few areas of improvement.

As our understanding of the neural bases of emotion and emotion regulation has expanded, it has become clear how important it will be to employ new and more sophisticated methods. For example, EEG studies are now being used to evaluate more clearly the temporal dynamics and unfolding of different emotion regulation strategies (e.g., Hajcak, MacNamara, & Olvet., 2010) and neuroimaging studies are being designed that can better probe the neural bases of different strategies (see Ochsner & Gross, 2005, 2008; Wager et al., 2008, for reviews). A new generation of studies may be possible that involve co-registration of ERPs and fMRI which may help the field to make better inferences regarding the tight links between rapid temporal dynamics captured best by ERPs, and fine spatial dynamics enabled by fMRIs. Further, sophisticated connectivity analysis may reveal antecedent and projecting networks involved in emotion regulation.

We have noted that people differ in their regulation choice and efficacy. One intriguing puzzle is how these differences come about. There are diverse possibilities, and it is likely that all of them play a role. However, disassociating the circumstances that could isolate the influence of each has not been yet been comprehensively attempted. Genetics, for example, may play a part in shaping individual differences in regulation strategies as well as explanatory styles. It is known, for example, that the explanatory styles of monozygotic twins are more highly correlated

than the explanatory style of dizygotic twins (Schulman, Keith, & Seligman, 1993). This finding does not necessarily imply that there is a gene related to explanatory style. Genes may influence other factors, such as intelligence, which could then in turn lead to certain types of beliefs. How genes might influence habitual regulation choice and efficacy is unknown.

Another possibility is that teachers could also help to create individual differences. Teachers' comments about children's performance may affect children's attribution about their successes and failures in the class-room. But positive comments do not always drive helpful attributions. Mueller and Dweck (1998) found that teachers praising children for their intelligence led to greater helplessness characteristics in the face of difficulty compared to situations in which children were praised for their effort.

Researchers have also analyzed the relationships between how a particular explanatory style of a parent might impact their offspring (e.g., Seligman et al., 1984). The broad conclusion appears to be that explanatory style is transmitted to children by parents, but not universally so. Future studies must explore moderators of this potential link; plausible candidates include the time spent by the parents and children and the type of their interaction. It is known that children from happy and supportive homes are more likely as adults to have an optimistic explanatory style for bad events (Franz, McClelland, Weinberger & Peterson, 1994). Trauma, media and social networks may also play a part in shaping regulatory differences. However a comprehensive view across all these influences has yet to emerge.

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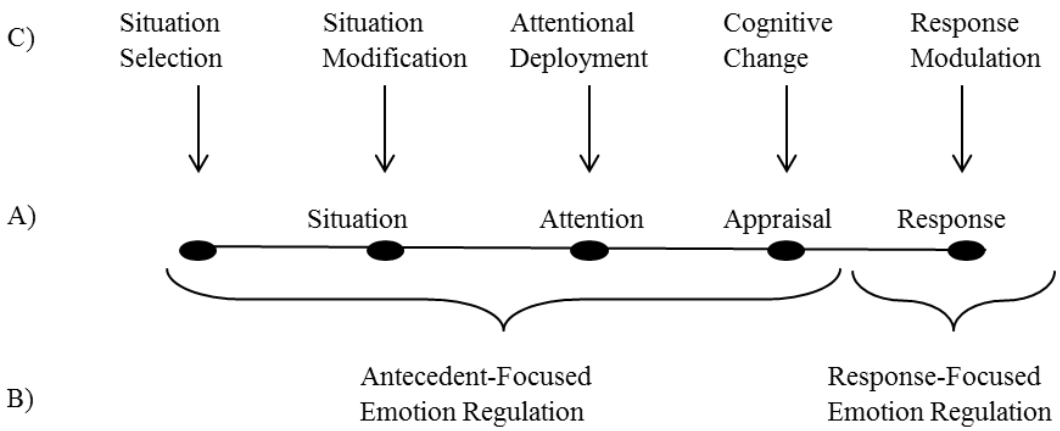
Figure Captions

Figure 1. The process model of emotion regulation (adapted from Sheppes & Gross, in press) A) Components of emotion generation. B) Antecedent-focused versus response-focused emotion regulation strategies. C) Five emotion regulation families.

Figure 1


C)
Situation Selection
Situation Modification
Attentional Deployment
Cognitive Change
Response Modulation
A)
Situation
Attention
Appraisal
Response
B)
Antecedent-Focused Emotion Regulation
Response-Focused Emotion Regulation