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# Gender Differences in Emotion Regulation: An fMRI Study of Cognitive Reappraisal

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Despite strong popular conceptions of gender differences in emotionality and striking gender differences in the prevalence of disorders thought to involve emotion dysregulation, the literature on the neural bases of emotion regulation is nearly silent regarding gender differences (Gross, 2007; Ochsner & Gross, in press). The purpose of the present study was to address this gap in the literature. Using functional magnetic resonance imaging, we asked male and female participants to use a cognitive emotion regulation strategy (reappraisal) to down-regulate their emotional responses to negatively valenced pictures. Behaviorally, men and women evidenced comparable decreases in negative emotion experience. Neurally, however, gender differences emerged. Compared with women, men showed (a) lesser increases in prefrontal regions that are associated with reappraisal, (b) greater decreases in the amygdala, which is associated with emotional responding, and (c) lesser engagement of ventral striatal regions, which are associated with reward processing. We consider two non-competing explanations for these differences. First, men may expend less effort when using cognitive regulation, perhaps due to greater use of automatic emotion regulation. Second, women may use positive emotions in the service of reappraising negative emotions to a greater degree. We then consider the implications of gender differences in emotion regulation for understanding gender differences in emotional processing in general, and gender differences in affective disorders.

KEYWORDS amygdala, cognitive reappraisal, emotion regulation, fMRI, gender differences

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THE IDEA that men and women differ in their emotional responses is nearly irresistible. Book after book, and magazine after magazine states and restates this thesis (Gray, 1992). Such a view seems well justified by striking gender differences in the prevalence of affective disorders (Bourdon et al., 1988; Gater et al., 1998; Kessler, McGonagle, Swartz, Blazer, & Nelson, 1993). However, despite lay convictions and psychiatric considerations, the empirical evidence on gender differences in emotional responding is mixed (Bradley, Codispoti, Sabatinelli, & Lang, 2001; Fujita, Diener, & Sandvik, 1991; Grossman & Wood, 1993; Labouvie-Vief, Lumley, Jain, & Heinze, 2003; Seidlitz & Diener, 1998), and negative findings are surprisingly common (Wager, Phan, Liberzon, & Taylor, 2003). How can this puzzling state of affairs be explained?

One possibility is that the apparently obvious gender differences in emotional responding that we read about (and think we see) on a regular basis are the result not of differences in immediate emotional reactivity—as we typically imagine—but instead of differences in emotion regulation. After all, there is a growing appreciation of the fact that emotional responses are a joint function of initial emotional reactivity and ongoing emotion regulation (Gross, 2007). This means that it is impossible to tell from behavior alone whether differences between men and women in emotional responding are the result of differences in reactivity, regulation, or both.

In order to understand gender differences in emotional responding, we argue that it is necessary to (a) study the unique contributions of emotion and emotion regulation and (b) include measures that go beyond self-reports of emotional experience. To prepare the ground for a study that examines neural bases for gender differences in emotional reactivity and regulation, we first consider common beliefs about gender differences in emotion. Next, we review empirical findings on gender differences in emotional responding. Noting the gap between popular expectations and empirical findings, we propose an account that revolves around gender differences in emotion regulation.

## Common beliefs regarding gender differences in emotion

Perceptions of gender differences in emotional responding constitute one of the most robust gender stereotypes there is (Fabes & Martin, 1991; Fischer, 1993; Grossman & Wood, 1993; Hess et al., 2000; Plant, Hyde, Keltner, & Devine, 2000; Timmers, Fischer, & Manstead, 2003). In fact, the belief that women are more emotional than men has been labeled a 'master stereotype' (Shields, 2003). Men and women, older and younger individuals, as well as individuals from a range of cultural backgrounds hold the belief that women are more emotional than men (Belk & Snell, 1986; Birnbaum, Nosanchuk, & Croll, 1980; Heesacker et al., 1999; Hess et al., 2000).

While this belief is particularly pronounced for the behavioral expression of emotion (Fabes & Martin, 1991; LaFrance & Banaji, 1992), it is applied across different emotion components, including the intensity of emotional experience (Fischer, 2000; Johnson & Shulman, 1988; Plant et al., 2000; Robinson, Johnson, & Shields, 1998). With the exception of anger and possibly pride, this belief generalizes across a range of discrete positive and negative emotions such as happiness, fear, disgust, and sadness (Birnbaum et al., 1980; Briton & Hall, 1995; Fabes & Martin, 1991; Grossman & Wood, 1993; Kelly & Hutson-Comeaux, 1999; Shields, 2003). Thus, the belief that women are more emotional than men is strongly held and pervasive across individuals, across emotional response domains, and across different emotions.

## Empirical findings regarding gender differences in emotion

Empirical studies of gender differences in emotion have produced far less consistent results than might be expected based on popular convictions. In accordance with popular beliefs, there is some evidence that in the domain of emotional expression, women display more emotion than men (Brody, 1997). However, reports of emotion measured in other domains are less straightforward. Some studies of self-reported emotional



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experience indicate that women may indeed be more emotionally responsive than men (Bradley et al., 2001; Fujita et al., 1991; Lucas & Gohm, 2000; Seidlitz & Diener, 1998).

One limitation of these studies is that most have relied upon self-report methods, which leave them vulnerable to the effects of gender stereotypes because they ask individuals to report their experiences retrospectively (Grossman & Wood, 1993; Hess et al., 2000). When retrospective and stereotypical biases are removed from these reports, gender differences in emotional responding tend to disappear (Barrett, Robin, Pietromonaco, & Eyssell, 1998; Robinson et al., 1998) or emerge only relatively late in the emotional response, after offset of emotional stimuli (Gard & Kring, 2007).

Studies using physiological responses to emotional stimuli—which are thought to be less subject to the biases associated with self report—hold out the possibility of clarifying the mixed findings from the self-report literature. Studies of this nature only sometimes support the notion that also women are emotionally more reactive than men in terms of psychophysiological reactivity (Bradley et al., 2001; Kring & Gordon, 1998; Labouvie-Vief et al., 2003), and there seem to be as many reports that do not indicate that there are sex differences in responding (Katkin & Hoffman, 1976; Kelly, Tyrka, Anderson, Price, & Carpenter, 2008; Vrana & Rollock, 2002).

Another response domain that has attracted interest is brain responses, and in particular, activity in neural regions that are related to emotional responding, such as the amygdala. Although there appear to be gender differences in laterality of amygdala responding as it relates to subsequent memory (Cahill et al., 2001; Cahill, Uncapher, Kilpatrick, Alkire, & Turner, 2004) the literature is unclear as to gender differences in overall responding. There have been reports of greater amygdala activity in men than women (Hamann, Herman, Nolan, & Wallen, 2004; Schienle, Schafer, Stark, Walter, & Vaitl, 2005) but some meta-analytic data show no gender differences in emotional reactivity in the amygdala (Wager et al., 2003).

## Bridging the gap between common conceptions and empirical findings

If gender differences (typically) fail to emerge in studies of emotional reactivity, how are we to explain the widespread consensus that there *are* gender differences in emotional responding? And how are we to explain the marked gender differences in affective disorders? At least two possible explanations exist.

The first possibility is that men and women do not actually differ in their emotional responding. On this view, apparent gender differences in emotional responding are an illusion created by stereotypes that are so pervasive that they bias participants' reports of their own and others' emotional responses. If this were so, studies employing subjective measures of experience should observe gender differences, but studies that use implicit measures of emotion, or objective measures of physiological and neural changes due to emotion, should not show gender differences. This, however, is not what we see.

A second possibility is that emotional responding, as measured in the majority of these studies, is a function of two dissociable processes: emotional reactivity and emotion regulation. If this were the case, gender differences in emotional responding could arise either from differences in emotional reactivity per se, or from differences in how those emotions are regulated, or some interaction between emotional reactivity and emotion regulation. On this account, the inconsistency in the literature is due to variation in the degree to which different experimental paradigms allow for the relative contributions of emotional reactivity and emotion regulation.

## Gender differences in emotion regulation

If emotional reactivity refers to the processes that determine the nature and strength of an individual's unaltered emotional response, emotion regulation refers to processes that individuals use to influence the nature of those emotions and how emotions are experienced



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and expressed. Emotion regulation can be deliberate or habitual, conscious or unconscious, and can involve changes in the magnitude, duration, or quality of one or several components of an emotional response. Emotion regulation strategies can target one's own emotions or those of another individual, at a variety of time points in the emotion generation process (Gross, 2007). Because emotion regulation is an ongoing process, the overall trajectory of an emotional response can be characterized by the effects of regulation as much as the effects of 'pure' reactivity.

One particularly interesting candidate for examining gender differences in emotion regulation is cognitive reappraisal. Cognitive reappraisal, when used to down-regulate one's negative emotional response, refers to the reframing or recontextualization of a negative stimulus in less emotional terms (Giuliani & Gross, in press). Cognitive reappraisal is an appropriate point of focus because this type of emotion regulation has been systematically studied in experimental contexts that allow for the separation of emotional reactivity and regulation.

Converging evidence from several studies has shown that reappraisal effectively diminishes negative affect as measured by self-reported emotional experience (Gross, 1998), the affectively-modulated startle response (Jackson, Malmstadt, Larson, & Davidson, 2000), and other peripheral physiological measures (Eippert, Viet, Weiskopf, Birbaumer, & Anders, 2007). In addition, individuals who report using reappraisal more frequently in everyday life experience lesser negative affect and fewer depressive symptoms (Gross & John, 2003).

An emerging literature on the neural bases of emotion regulation has confirmed and extended the role of reappraisal as an effective strategy for the down-regulation of negative affect (Ochsner & Gross, 2005). Activity in emotion-responsive brain regions such as the amygdala and insula are effectively down-regulated by reappraisal. Simultaneously, regions of prefrontal cortex that have been implicated in cognitive control and working memory become more active during reappraisal (Eippert et al., 2007; Goldin, McRae, Ramel, & Gross, 2008; Kim & Hamann, 2007; Levesque et al., 2003; Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner et al., 2004; Phan et al., 2005). These studies have led to the increasingly common conceptualization of emotional responding as the result of an interplay between emotion-responsive regions such as the amygdala and insula, and prefrontal cognitive control regions (Urry et al., 2006).

Despite the potential value of distinguishing between emotional reactivity and emotion regulation, most studies of gender differences in emotional responses using experimental stimuli do not address whether individuals are permitted to effortfully influence their emotional responses during the course of the experiment. Consequently, most reports of gender differences in emotional tasks may be the downstream result of the natural interplay between emotional reactivity and the manipulation of that reactivity using emotion regulation. This conflation of reactivity and regulation makes it difficult to discern the true nature of gender differences in emotional responding.

Because few studies in the literature experimentally separate reactivity from regulation, it is unknown how much previously reported gender differences in emotional responding reflect gender differences in reactivity, regulation, or both. Unfortunately, most studies that are designed to separate reactivity from regulation have used only women (Eippert et al., 2007; Goldin et al., 2008; Harenski & Hamann, 2006; Kim & Hamann, 2007; Ochsner et al., 2002, 2004) or did not compare men and women (Phan et al., 2005; Urry et al., 2006; van Reekum et al., 2007).

To our knowledge, no experimental study has allowed men and women to demonstrate their respective naturalistic reactivity to negative emotional stimuli along with their abilities to use cognitive regulation in order to down-regulate those negative emotional responses. Individual difference studies indicate that men and women report using reappraisal with comparable frequency in everyday life (Gross & John, 2003; Gross, Richards, & John, 2006). However, these individual difference studies have at least two crucial limitations. First, these studies employ self-report measures which are



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subject to stereotypic biases. Second, they only measure the frequency with which individuals use these strategies in everyday life, which may not speak to an individual's ability to use a particular strategy when confronted with the instructions to do so.

## The present study

The present study addresses critical gaps in the literature by investigating gender differences in emotional reactivity and regulation. We used an established within-subjects functional magnetic resonance imaging (fMRI) paradigm to create conditions of unregulated responding and cognitive regulation using validated negative stimuli. Comparing unregulated responses to negative versus neutral stimuli allowed us to test for gender differences in reactivity, and comparing responses to negative stimuli under the instruction to reappraise versus the instruction to respond naturally allowed us to test for gender differences in emotion regulation ability.

We hypothesized that men and women would show comparable reactivity, as indexed by increases in self-reported emotional experience and activity in emotion-related regions such as the amygdala. We hypothesized that gender differences would emerge when considering the comparison between unregulated responding and cognitive regulation. More specifically, we predicted that women would show lesser decreases in negative affect due to regulation (as indexed by decreases in self-reported negative affect and amygdala activity). We also predicted that these smaller decreases in emotional responding in women would be accompanied by lesser increases in prefrontal regions known to be involved in cognitive control.

## Method

### *Participants*

Twenty-five participants between the ages of 18 and 22 were recruited and compensated for their time. Of these, 13 were women (mean age = 20.60 years; 7 white, 1 African American, 3 Asian American, 2 Hispanic, 1 Native American) and 12 were men (mean age = 20.36 years; 7 white, 1 African American, 2 Asian American, 2 Hispanic). Potential participants were excluded if they were (a) left-handed, (b) below age 18 or above age 22, (c) not native English speakers, (d) had current or past diagnosis of neurological or psychiatric disorder, (e) had a history of head trauma, (f) were pregnant, (g) currently used psychoactive medication, or (h) had any non-MRI compatible conditions (e.g. metal in body, tattoo on face or neck, pregnancy, medicine delivery patch). Participants provided written consent in compliance with the Institutional Review Board guidelines at Stanford University.

### *Task*

The trial structure was identical to previous investigations of cognitive reappraisal (e.g. Ochsner et al., 2004). As shown in Figure 1, at the start of each trial, an instruction word was presented in the middle of the screen ('decrease' or 'look'; 4 seconds), a picture was presented (negative if instruction was decrease (regulation instruction), negative or neutral if instruction was look (non-regulation instruction; 8 seconds) followed by a rating period (scale from 1–4; 4 seconds) and then the word 'relax' (4 seconds). The comparisons from the 8-second picture presentation period are the only trial periods reported here. Following presentation of each picture, participants were prompted to answer the question 'How negative do you feel?' on a scale from 1 to 4 (where 1 was labeled 'weak' and 4 was labeled 'strong'). Responses were made on a 4-button button box using the participant's dominant (right) hand.

A total of 90 trials (30 of each trial type) were administered in 4 runs of 22 or 23 trials each. Stimuli were presented and button responses collected using Psyscope software (Cohen, MacWhinney, Flatt, & Provost, 1993) running on a Macintosh G3 computer. An LCD projector displayed stimuli on a screen mounted on a custom head coil fitted with a bite-bar to limit head motion.

Picture stimuli were taken from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2001).Pictures were randomized into four different picture presentation orders



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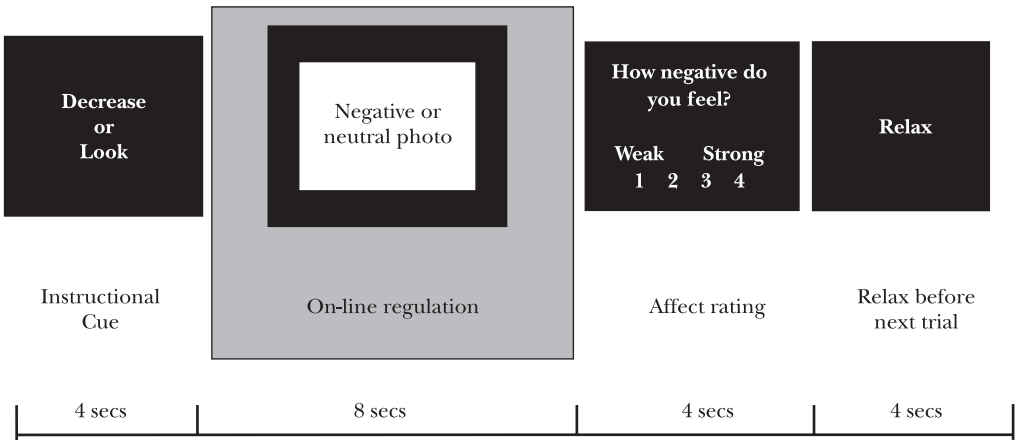


*Figure 1.* Event-related emotion regulation task

to reduce the effect of idiosyncratic assignment of picture to instruction and picture order. Within each order, pictures were counterbalanced into the look negative and the decrease negative conditions such that normative valence and arousal ratings did not differ between the two conditions. Instruction and picture types were pseudo-randomized with the constraint that no more than three of any instruction type or picture type followed each other sequentially.

### *Procedure*

After reading an overview of the task, participants completed a practice session during which the experimenter showed sample negative and neutral images not used in the experiment. For the regulation (decrease) trials, the experimenter prompted the participant to narrate aloud his or her self-generated reinterpretation of the image. Reinterpretations were limited to three categories: (1) It's not real (e.g. it's just a scene from a movie, they're just pretending), (2) Things will improve with time (e.g. whatever is going wrong will resolve over time), (3) Things aren't as bad as they appear to me (e.g. the situation looks worse than it is, it could be a lot worse, at least it's not me in that situation). Any reports which suggested that participants were using a non-cognitive strategy (such as expressive suppression, or averting attention from the emotional aspects of the picture) led to the participants being corrected and redirected to use one of the three strategies mentioned above.

### *Imaging parameters*

Twenty-five axial slices (4 mm thick, 1mm skip) were collected at a 3T (GE Signa LX Horizon Echospeed) scanner with a T2* sensitive gradient echo spiral-in-out pulse sequence (TR = 2.00, TE = 30 ms, 60° flip angle, 24-cm field of view, 64 × 64 data acquisition matrix) which has been shown to effectively reduce signal dropout at high field strengths. Evaluation of signal dropout in medial temporal and orbitofrontal regions revealed that the signal retained was equal to or better than previous reports using this sequence (Preston, Thomason, Ochsner, Cooper, & Glover, 2004). A total of 230 whole-brain images were taken in each of four 7-minute, 40-second runs.

T2-weighted flow-compensated spin echo scans were acquired for anatomical localization using identical slice prescription as the functional scans.

### *Data analysis*

For the behavioral data, mean negative affect ratings were calculated for the look negative, look neutral, and decrease negative conditions. We used a repeated measures general linear



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model (GLM) with experimental condition (look negative, decrease negative, or look neutral) as a within-subjects factor and gender as a between-subjects factor. Follow-up *t* tests were done to test for main effects of reactivity (look negative versus look neutral trials) and regulation (decrease negative versus look negative trials) and interactions with gender. These were performed using the Statistical Package for the Social Sciences version 15 (SPSS; Chicago, IL).

For the fMRI data, each participant's sequential functional volumes were realigned to the first scan and co-registered to his or her anatomical MRI using an automated rigid-body transformation algorithm using statistical parametric mapping software (SPM2; Wellcome Department of Imaging Neuroscience, University College London, UK). Default SPM2 settings were used to warp volumetric MRIs to fit a standardized template (16 nonlinear iterations), and normalization parameters were applied to subjects' co-registered functional images. Normalized images were resampled into 2 × 2 × 2 mm voxels. Finally, images were smoothed with a 6 mm full width at half maximum kernel.[1]

Preprocessed images were entered into a GLM in SPM that modeled the canonical hemodynamic response function convolved with an 8-second boxcar representing the picture-viewing period. These models were used to create subtraction contrasts between conditions of interest (look negative > look neutral, decrease negative > look negative and its inverse) for each subject. These individual contrasts were then entered into a one-sample *t* test to perform a random-effects group analysis. Unless otherwise noted, group-level results result from a display threshold of $p < .001$, uncorrected, with an extent threshold of 5 voxels. We performed region of interest (ROI) analyses upon an *a priori* region of interest, the amygdala. These analyses tested for the effects of reactivity (look negative > look neutral contrast) and regulation (look negative > decrease negative). For these analyses, we restricted our comparison to voxels within an anatomical amygdala ROI and lowered our display threshold to $p < .05$, with an extent threshold of 5 voxels.[2] Our whole brain analysis investigated gender differences in emotion regulation regions for the decrease negative > look negative contrast.

## Results

### *Behavioral data*

To examine behavioral effects, we conducted a 2 (Gender) × 3 (Condition: look neutral, look negative, decrease negative) analysis of variance on mean ratings of negative affect, with condition as a within-subjects factor. This analysis revealed an effect of condition ($F(2,20) = 203.612$, $p < .001$). Neither the main effect of gender nor the condition × gender interaction reached statistical significance ($p$s > .22).

**Emotional reactivity** Follow-up contrasts with look negative and look neutral conditions showed that negative affect was significantly greater when individuals were responding naturally to negative pictures than to neutral pictures ($F(1,22) = 54.57$, $p < .001$). Follow-up *t* tests revealed no differences in any condition as a function of participant gender ($p$s > .24). These effects can be seen in Figure 2.

**Emotion regulation** Follow-up contrasts with decrease negative and look negative conditions showed that negative affect was significantly greater when individuals were responding naturally to negative pictures than when they were cognitively regulating their responses ($F(1,22) = 374.59$, $p < .001$). Follow-up *t* tests revealed no differences in any condition as a function of participant gender ($p$s > .24). These effects can be seen in Figure 2.

### *fMRI data*

To examine BOLD responses, we examined gender differences with respect to two contrasts, one focused on emotional reactivity, the second focused on emotion regulation.

**Emotional reactivity** To examine emotional reactivity, we used an ROI approach to investigate our *a priori* region of interest, the amygdala. We examined reactivity by contrasting responses



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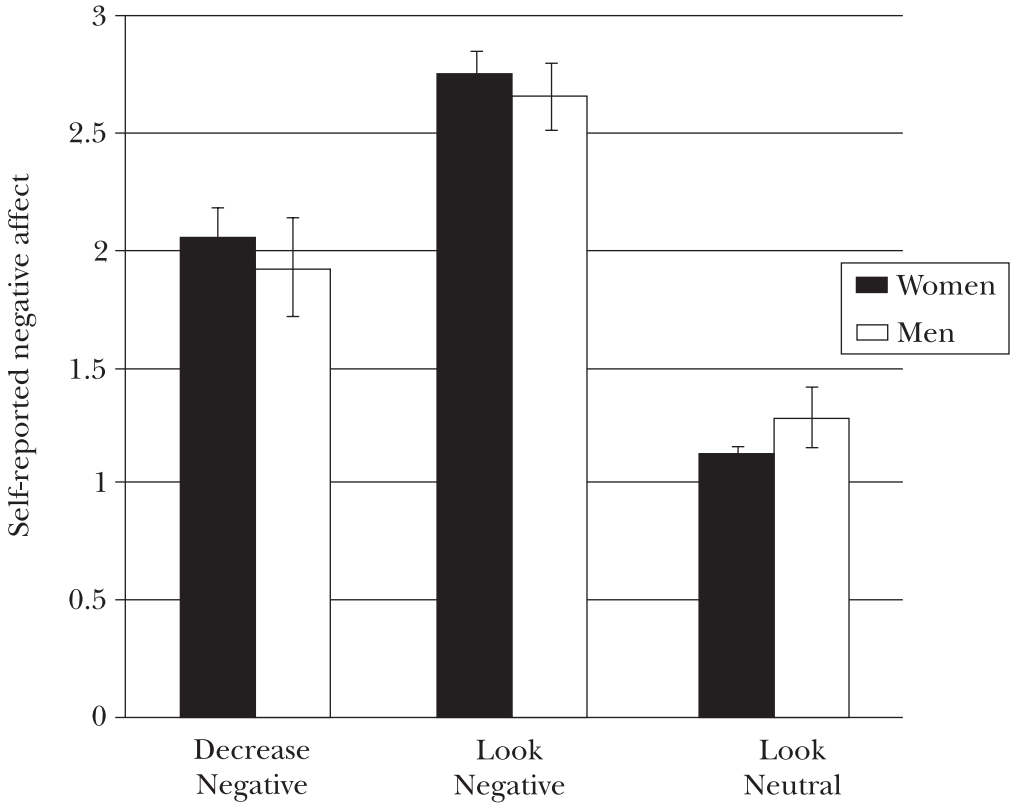


*Figure 2.* Ratings of self-reported negative affect taken after each trial for conditions in which individuals were asked to look and respond naturally to neutral pictures (Look Neutral), look and respond naturally to negative pictures (Look Negative) and use cognitive reappraisal to decrease their negative affect while looking at negative pictures (Decrease Negative). Error bars represent standard error of the mean (SEM).

during the look negative condition with responses during the look neutral condition. We observed greater amygdala activity during the look negative than the look neutral condition (106 voxels in right amygdala, peak at [18, 2, –18] $t = 3.54$, $p < .002$; 38 voxels in left amygdala, peak at [–12 0 –16] $t = 3.56$, $p < .002$). When performing a two-sample $t$ test between men and women using the anatomical ROI, we did not observe any gender differences in amygdala activation for the reactivity contrast (look negative > look neutral).

**Emotion regulation** To examine emotion regulation, we considered first the *a priori* region of interest associated with emotional reactivity, the amygdala. Next, we used a whole-brain approach to identify regions associated with top-down control.

To identify the neural correlates of decreased emotion reactivity due to regulation, we performed an ROI analysis on the amygdala. We looked for voxels within the amygdala that were more active when participants were responding naturally to negative pictures than when they were actively regulating (look negative > decrease negative). We observed greater amygdala activity for the look negative condition than the decrease negative condition (11 voxels in right amygdala, peak at [24 0 –20] $t = 1.94$, $p < .03$). Group differences were investigated using a two-sample $t$ test. We observed a significantly greater regulation effect (look



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negative—decrease negative) in men compared to women (15 voxels in left amygdala, peak at [–26, 4, –18] $t = 3.11$, $p < .003$; Figure 3). The same two-sample t-test investigating greater activity in females than males did not return any significant clusters.

To identify regions involved in active regulation, we used a whole-brain approach and identified regions that were significantly more active during active regulation than the naturalistic viewing of negative pictures (decrease negative—look negative trials). This contrast revealed greater activity in several regions previously associated with cognitive reappraisal, such as the anterior cingulate, superior, middle, and inferior frontal gyri, inferior parietal lobule, and superior and inferior temporal gyri (see Table 1, Figure 4).

In order to examine gender differences in these regions, we wanted to directly test voxels that showed greater activation during reappraisal in women than men. To this end, we used a two-sample $t$ test at the whole brain level. This analysis revealed several clusters that were more active in women than men during reappraisal of negative pictures. These areas included the ventral striatum, anterior cingulate, and superior frontal and inferior frontal gyri (see Table 2, Figure 5). Men showed no areas that they used to a greater extent than women, even with a more liberal threshold of $p < .01$.

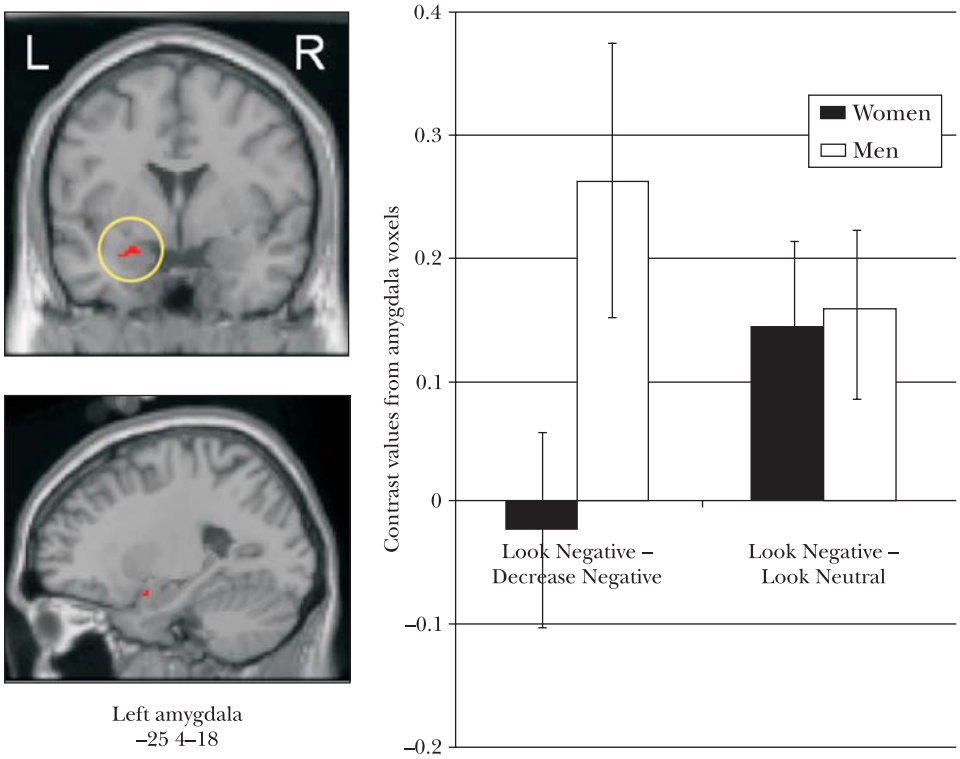


*Figure 3.* Greater left amygdala activity in men than women for the down-regulation contrast (Look Negative > Decrease Negative). Men show greater down-regulation of left amygdala, as evidenced by greater decreases when using cognitive regulation. Contrast values from this region for the regulation contrast (Look Negative > Decrease Negative) and reactivity contrast (Look Negative > Look Neutral) are shown on the right. Error bars represent SEM.



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*Table 1.* Men and women ($N = 23$) whole brain activations for regulation contrast (Decrease Negative > Look Negative). Threshold is $p < .001$.

| Region | MNI X | MNI Y | MNI Z | Extent | *Z* value | Hemisphere |
|---|---|---|---|---|---|---|
| Inferior frontal gyrus | –56 | 20 | 14 | 525 | 5.23 | Left |
| Superior frontal gyrus | –10 | 10 | 70 | 2694 | 4.93 | Left |
| Inferior frontal gyrus | 50 | 30 | –10 | 437 | 4.2 | Right |
| Middle frontal gyrus | –42 | 4 | 46 | 241 | 4.11 | Left |
| Superior frontal gyrus | –18 | 22 | 56 | 16 | 3.31 | Left |
| Middle frontal gyrus | 46 | 6 | 48 | 8 | 3.26 | Right |
| Cingulate gyrus | –2 | –52 | 28 | 356 | 4.24 | Left |
| Anterior cingulate | 2 | 18 | –10 | 38 | 3.85 | Right |
| Cingulate gyrus | –2 | –22 | 34 | 8 | 3.21 | Left |
| Inferior parietal lobule | –48 | –66 | 36 | 763 | 4.86 | Left |
| Caudate | –16 | 16 | 8 | 191 | 4.27 | Left |
| Caudate | 20 | 14 | 20 | 124 | 4.15 | Right |
| Inferior temporal gyrus | –58 | –8 | –18 | 62 | 4.02 | Left |
| Superior temporal gyrus | 58 | –58 | 28 | 121 | 3.97 | Right |
| Middle temporal gyrus | –62 | –40 | –6 | 86 | 3.84 | Left |
| Superior temporal gyrus | 50 | –36 | 4 | 38 | 3.52 | Right |

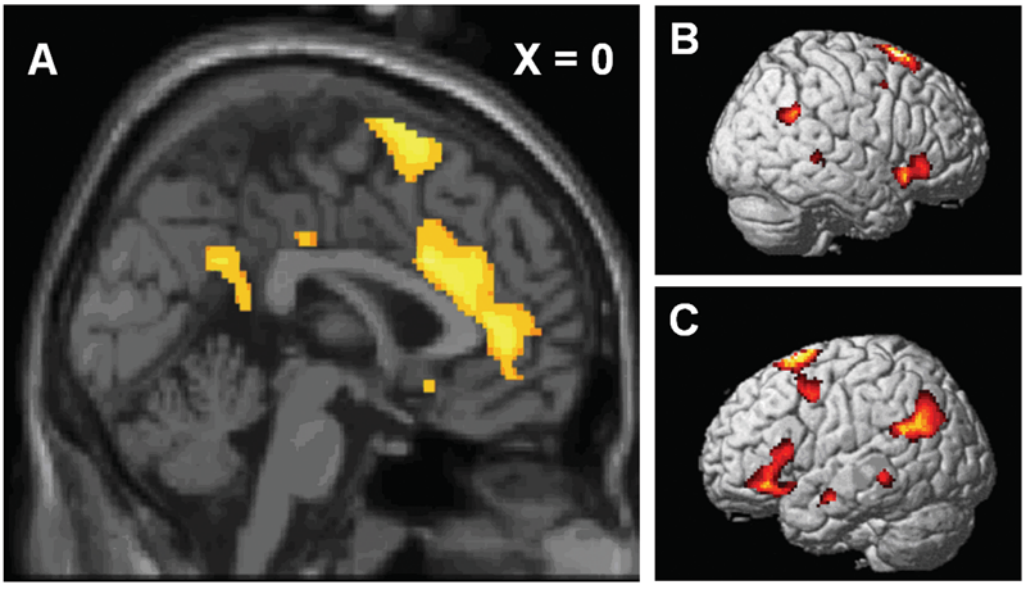


*Figure 4.* Whole brain activations in men and women for the regulation contrast (Decrease Negative > Look Negative). Midline anterior cingulate activity is shown in panel A. Panels B and C are lateral renderings of the right and left sides of the brain respectively.



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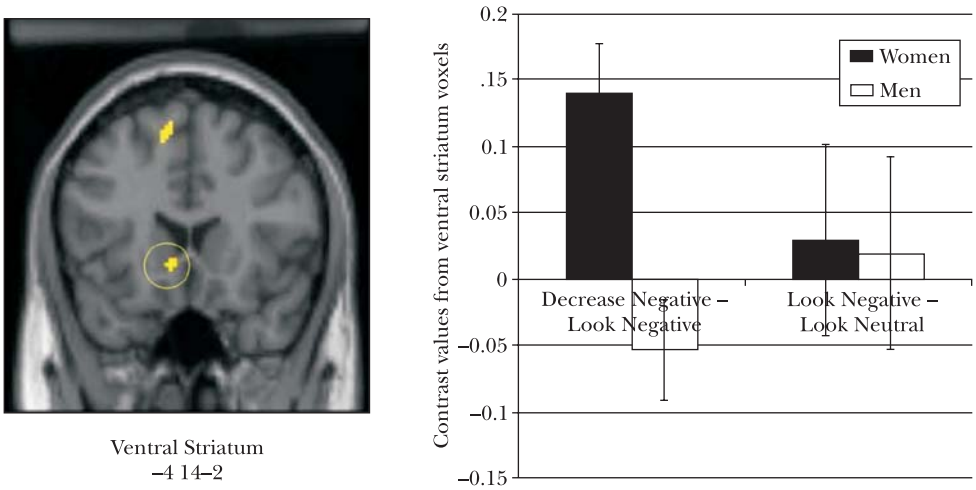


*Figure 5.* Greater ventral striatum activity in women than men for the regulation contrast (Decrease Negative > Look Negative). Contrast values from this region for the regulation contrast (Look Negative > Decrease Negative) and reactivity contrast (Look Negative > Look Neutral) are shown on the right. Error bars represent SEM.

*Table 2.* Gender differences (women – men) for whole brain regulation contrast (Decrease Negative > Look Negative). Threshold is $p<.001$

| Region | MNI X | MNI Y | MNI Z | Extent | Z value | Hemisphere |
|---|---|---|---|---|---|---|
| Ventral striatum | –4 | 14 | –2 | 77 | 4.19 | Left |
| Extra-nuclear | –2 | 26 | 2 | 10 | 4.08 | Left |
| Anterior cingulate | 16 | 28 | –6 | 99 | 3.95 | Right |
| Inferior frontal gyrus | –20 | 36 | –8 | 16 | 3.84 | Left |
| Sub-gyral | 36 | 38 | 18 | 45 | 3.76 | Right |
| Superior frontal gyrus | –12 | 22 | 52 | 20 | 3.6 | Left |
| Cingulate gyrus | 18 | –36 | 38 | 6 | 3.43 | Right |
| Sub-gyral | –30 | –72 | –6 | 5 | 3.35 | Left |
| Sub-gyral | –26 | 44 | 8 | 7 | 3.2 | Left |

## Discussion

Although there are widespread perceptions of gender differences in emotion, empirical studies have failed to provide clear evidence for such differences. The present study tested the hypothesis that gender differences in emotional responding might be due not to gender differences in emotional reactivity, but instead to gender differences in emotion regulation. To test this hypothesis, we used subjective reports of negative affect and fMRI signal from the amygdala to measure gender differences in emotional reactivity by comparing natural responses to negative and neutral pictures. We used these same measures of emotional responding to quantify gender differences in the success of cognitive regulation by comparing natural responses and cognitive regulation of negative pictures. Finally, we used fMRI signal from prefrontal regions to identify gender differences in control-related regions that are more active during cognitive regulation than naturalistic responding to negative pictures.



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In terms of self-reported negative affect, we found that the negative picture stimuli elicited comparable levels of negativity in men and women. In addition, both genders were equally effective at using cognitive reappraisal to down-regulate their negative affective responses to the negative pictures. Neurally, we found that men and women show comparable amygdala response to the negative images, but men showed greater down-regulation than women (as indexed by decreases in amygdala activity during reappraisal). Furthermore, men showed significantly less activity than women in prefrontal regions that have been previously observed as more active during the cognitive regulation of emotion. Lastly, women showed greater ventral striatal activity during the down-regulation of negative emotion than men.

The discrepancy between behavioral and BOLD responses offers potentially important insights regarding gender differences in emotion regulation. Because men and women do not differ on either self-reported negative affect or amygdala reactivity to the unregulated negative pictures, it is unlikely that these differences arise because women initially found the negative images more unpleasant than men. What, then, might account for this discrepancy? In the following sections, we consider two non-competing possibilities. The first is that men are able to use regulation with greater efficiency, or less effort, than women. The second is that women up-regulate positive emotion to a greater extent than men when attempting to down-regulate negative emotion. We discuss the evidence needed to confirm one or both of these hypotheses, and discuss the ramifications of both possibilities on the conceptualization of gender differences in emotional responding and the application of this knowledge to the treatment of clinical disorders in men and women.

### *Are men more efficient than women at reappraisal?*

Because men showed greater down-regulation of amygdala activity and less prefrontal activity during regulation, one might conclude that men are able to regulate their negative emotion with greater efficiency than women. Despite their comparable decrements in negative experience, it is possible that reappraisal may be less effortful for men than women, requiring less engagement of the prefrontal structures usually implicated in the strategic implementation of cognitive and emotional control. Several areas of prefrontal cortex have been implicated in the use of cognition to regulate emotion (Ochsner & Gross, 2005). The degree to which these prefrontal regions are active is commonly thought to reflect the amount of effortful, conscious control that is being implemented to override more automatic behaviors (Miller & Cohen, 2001). Therefore, one possible explanation for the relatively lesser prefrontal activity in men than women is that men are able to generate and implement cognitive emotion regulation strategies with less effort or difficulty than women.

This interpretation of the data at first may seem to conflict with the finding that men and women do not report differences in the frequency with which they utilize cognitive emotion regulation in everyday life (Gross & John, 2003; Gross et al., 2006) . However, the interpretation we offer is that men are not merely more practiced in using reappraisal (which would be reflected greater frequency of use) but rather that when they are instructed to regulate, they do so in a quicker, more automatic way. If this is true, explicit self-reports of regulation frequency may not reflect important gender differences. To detect such differences, measures of automatic emotion regulation would need to be employed. The results of the present study may predict that men would show greater levels of automatic emotion regulation than women.

One particular challenge in testing this prediction is that most measures of emotion regulation involve explicit measures of conscious or deliberate emotion regulation attempts (e.g. Gross & John, 2003). In fact, there are few established measures of automatic emotion regulation. However, we have recently adapted a version of the implicit attitudes task (IAT) to evaluate the degree to which individuals implicitly evaluate emotion regulation in a positive way, dubbed the Emotion Regulation IAT (ER-IAT; Mauss, Evers, Wilhelm, & Gross, 2006). Using this measure, positive implicit evaluation



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of emotion regulation has been shown to be associated with less negative affect and more adaptive cardiovascular responding to an anger provocation, without greater effortful or deliberate engagement of emotion regulation strategies. These results suggest that ER-IAT scores translate into greater use of automatic emotion regulation when individuals are faced with affective stimuli.

A reanalysis of ER-IAT data from prior studies—motivated by the present hypothesis regarding gender differences in automatic emotion regulation—reveals an intriguing gender difference in this measure of implicit attitudes about emotion regulation. Men showed a stronger bias score on the ER-IAT, indicating that men have more positive implicit attitudes toward emotion regulation than women (ER-IAT bias scores: men = –0.4013, women = –0.2216, $t(189) = 3.050, p < .01$). It bears noting that ER-IAT scores are uncorrelated with explicit reports of reappraisal use in everyday life in both men and women (all $p$s > .1). These findings are consistent with the notion that men and women may differ in automatic but not deliberate emotion regulation. That is, when regulating their emotions, men might indeed engage more automatic, less deliberate processes than women.

That being said, there are several limitations to this interpretation of the present results. First of all, it is important to note that this interpretation considers amygdala activity to be a more sensitive or informative measure of negative responding than self-reported emotional experience. Because amygdala activity, and not self-reported negative affect differs between men and women, this interpretation takes the amygdala activity to reflect greater detection or processing of negative information that is not apparent in self-reports. Although the relationship between self-reported experience and the amygdala is a topic of debate, some have suggested the amygdala may play an indirect role in experience via a modulatory influence on other systems (Anderson & Phelps, 2002).

Second, it must be emphasized that our evidence for the lesser effort hypothesis is indirect. In future work, several behavioral or neural measures might provide support for this hypothesis. Trial-by-trial online effort or success ratings may reveal differences that support this notion. In addition, one could imagine that men are able to regulate more efficiently because they are able to select and implement a regulation strategy more quickly than women. Asking individuals to indicate when they have finished regulating on each trial may provide a measure of speed. In like fashion, using neuroimaging parameters or methods with greater temporal resolution may provide insight as to whether the gender differences observed here are due to differences in temporal dynamics in men and women (Williams et al., 2005). For example, the effects we observe could be due to faster down-regulation of amygdala activation or disengagement of prefrontal control regions in men than women.

### *Do women use positive emotion more than men?*

In addition to the prefrontal differences mentioned above, women engaged the ventral striatum to a greater extent than men during reappraisal. The ventral striatum has been implicated in reward-related processing in humans (Knutson, Adams , Fong, & Hommer, 2001; McClure, York, & Montague, 2004) and animals (Elliott, Friston, & Dolan, 2000). The ventral striatum is also more active when individuals are processing positive or humorous stimuli (pictures, films, etc; (Mobbs, Greicius, Abdel-Azim, Menon, & Reiss, 2003) and its activity may predict self-reports of positive affect (Knutson, Taylor, Kaufman, Peterson, & Glover, 2005). Therefore, it is possible that women are generating positive affect to a greater extent than men in order to down-regulate their negative responses. It is well-documented that positive emotion, or humor, can be used strategically to regulate negative emotion (Tugade & Fredrickson, 2004). In accordance with these studies, we suggest that men may be quantitatively reducing the amount of negative affect they are experiencing, whereas women may be qualitatively transforming their negative affect into positive affect.

This account might help explain why there is less down-regulation of the BOLD response in the



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amygdala in men than in women. This is because the amygdala is thought to reflect the encoding and generation of responses to negatively *and* positively arousing cues (Anderson et al., 2003; Garavan, Pendergrass, Ross, Stein, & Risinger, 2001; Hamann & Mao, 2002). On this account, women may be offsetting their negative affect with an increase in positive affect, and hence show no change in amygdala responses, but an overall decrease in negative affect as indexed by self-report. While speculative, this account of gender differences is consistent with the finding that women score higher than men on both the behavioral inhibition scale and the reward sensitivity subscale of the behavioral activation scale (Carver & White, 1994; Gard & Kring, 2007). Lastly, this idea fits with the fact that women tend to represent their emotional experiences more complexly than men, which includes simultaneously appraising situations in both negative and positive ways (Feldman Barrett, Lane, Sechrest, & Schwartz, 2000).

Like the efficiency hypothesis, this account is not without limitations. This interpretation of the results assumes that self-reported negative experience represents the critical endpoint of the emotion-regulation process. The previous interpretation held amygdala activity as the most appropriate measure of regulation success, which differs between men and women. By contrast, this one emphasizes self-reported experience as a measure of regulation success and considers amygdala—and striatal—activity as an indicator of mechanisms, which differ, but result in similar affect reports in men and women. In addition, it must be emphasized that we do not have direct evidence regarding differences in the content of men and women's reappraisals. In future work, detailed descriptions of the reappraisal strategies that are used by men and women may support this hypothesis. In addition, due to time constraints in the fMRI environment, we only asked participants to rate their emotional experience as to how negative they felt. Asking participants to rate their positive *and* negative feelings may provide more direct evidence about the hypothesis that women are introducing or up-regulating positive feelings in order to decrease negative affect.

### *Implications for psychopathology*

Women are diagnosed with affective disorders up to twice as frequently as men (Gater et al., 1998; Kessler et al., 1993). Women are up to three times more likely than men to develop major depressive disorder in response to a stressful event (Maciejewski, Prigerson, & Mazure, 2001) and show a greater number of severe depressive symptoms than men (Young, Fogg, Scheftner, Keller, & Fawcett, 1990). In addition, women have greater lifetime prevalence of social and specific phobias, other anxiety disorders (Wilhelm, Parker, & Hadzi-Pavlovic, 1997), and comorbid depression and anxiety (Gorman, 2006).

Previous researchers interested in gender differences in psychiatric conditions such as depression have focused primarily on the fact that women ruminate more often than men, which results in prolonged negative affect (Nolen-Hoeksema & Jackson, 2001; Thayer, Newman, & McClain, 1994). For example, women use rumination to a greater extent than men in an attempt to curtail negative mood (Nolen-Hoeksema, Morrow, & Fredrickson, 1993). What is not yet clear, however, is how rumination relates to emotional reactivity, on the one hand, and other forms of regulation, on the other.

The relationship between rumination and reappraisal has begun to be investigated (Ray, Wilhelm, & Gross, 2008), and individual differences in rumination have been shown to affect the degree to which women can use cognitive regulation to increase negative emotion using a variation on the same task used in the present study (Ray et al., 2005). Clearly, if we are to understand gender differences in emotional responding, one crucial priority is characterizing the nature of the interaction between gender, rumination, and reappraisal.

In particular, many affective disorders are characterized by failures of emotion regulation and many of the empirically validated treatments for these disorders involve training in emotion regulation in general, and the type of cognitive change that is used during reappraisal more specifically (Beck, Rush, Shaw, & Emery, 1979). The present results imply that gender differences may be important when using



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cognitive-based therapies to decrease negative affect in the context of affective disorders.

If the first hypothesis is taken seriously, the lesser prefrontal activity in males might lead to the conclusion that women devote more executive resources toward cognitive reappraisal than men. Therefore, interventions that instruct patients in the use of reappraisal may benefit from the proposal that women may not have as many resources available for concurrent executive tasks. Conversely, when women are faced with distraction or fatigue, their ability to successfully down-regulate negative emotions may be compromised to a greater extent than is seen in men. Alternatively, these results might lead one to conclude that men may be able to be trained in reappraisal with more ease and efficiency than women.

Taking into account the second hypothesis, the observation that women have greater ventral striatal activation than men may also be important to guide development of treatment in the future. Women may use positive emotion in the service of down-regulation of negative emotion to a greater extent than men. This is consistent with reports that women use positive re-focusing as a coping strategy to a greater extent than men (Garnefski, Teerds, Kraaij, Legerstee, & van den Kommer, 2004). If this is the case, therapies that guide patients toward reducing their overall arousal state, or use neutral as a target state, may work less successfully in women. At present, there is limited support for this notion. In one study of depressed men and women, supportive and interpretive therapies were evaluated for their effect on depressive symptom levels. In this study, supportive therapy was designed to involve more praise, empathy, affiliation, and emphasis on strengths and talents, whereas interpretive therapy was focused more on the patient's insight into his or her emotional conflicts. Women achieved better outcomes after completing supportive therapy than interpretive therapy. Conversely, men showed better outcomes after completing interpretive than supportive therapy (Ogrodniczuk, Piper, Joyce, & McCallum, 2001).

### *Limitations and directions for future research*

The present study has several limitations. First, adherence to gender norms was not measured in this study. Therefore, a separate investigation of biological sex and gender differences was not possible (Unger, 1979). One important direction for future research is a separate consideration of gender and sex on emotional reactivity and regulation.

Second, we examined general negative responses in a very simple emotional context (picture viewing) and one explicit form of regulation (instructed cognitive reappraisal). In future work, it will be important to systematically vary the complexity of the eliciting circumstances and to examine a wider array of specific emotional responses (such as fear, anger, sadness). It also will be important to consider a range of implicit and explicit regulation processes.

Third, phase in menstrual cycle has been shown to have important effects on emotional responding (Amin, Epperson, Constable, & Canli, 2006; Goldstein et al., 2005; Pearson & Lewis, 2005; Protopopescu et al., 2005). In fact, some have proposed that the sex differences in emotional responsively can be largely explained by hormonal effects that vary drastically over the course of the menstrual cycle (Altemus, 2006). We did not have menstrual cycle data on the female participants in this study, and one important direction for future research is the inclusion of such data.

### *Concluding comment*

It is widely believed that men and women differ in their emotional responding. As we have seen, however, empirical studies on this topic have been mixed. This presents something of a puzzle, and in this article, we have explored one possible explanation for this puzzle, namely that gender differences in emotional responding may arise—at least in part – from differences in emotion regulation.

To test this idea, we used fMRI to examine gender differences in emotional reactivity and emotion regulation using cognitive reappraisal.



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We found that men and women did not differ on measures of emotional reactivity. In addition, both genders reported comparable decreases in negative experience when using cognitive reappraisal. However, men showed greater decreases in amygdala activity during regulation, along with lesser control-related prefrontal activity during cognitive regulation. Women showed greater ventral striatal activity during cognitive regulation than men.

These results led us to examine two explanations of these findings, namely (1) that men are able to use cognitive regulation with less effort than women and (2) that women use positive affect in the service of down-regulating negative affect to a greater extent than men. It is too early to tell whether one or both of these explanations is correct, but however this turns out, we believe that any analysis of gender differences in emotional responding would do well to consider both emotional reactivity and regulation.

## Notes

1. One participant (female) was removed from all analyses due to motion greater than 3 mm over the course of the four scans. Behavioral data reported here also exclude this participant.
2. One participant (female) was removed due to extreme activation levels in the amygdala during the look negative condition (> 3 SDs away from the female mean). Behavioral data reported here also exclude this participant.

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IRIS B. MAUSS, PhD, received her PhD from Stanford University, and is now an assistant professor of psychology at the University of Denver. In her research, she utilizes a multi-method approach including experience sampling, behavioral coding, implicit measures, and measures of autonomic physiological responses. Her work addresses questions concerning the implications of emotions and emotion regulation for psychological and physical health, automatic processes in emotion regulation, and the sociocultural context of emotion regulation.

JOHN J.D. GABRIELI, PhD, is the Grover Herman Professor in Health Sciences and Technology and Cognitive Neuroscience in the Department of Brain and Cognitive Sciences at MIT. His work investigates the organization of memory, thought and emotion in the human brain. To this end, he studies the healthy brain, as well as those with developmental and psychiatric disorders using functional and structural brain imaging.

JAMES J. GROSS, PhD, is an associate professor in the Department of Psychology at Stanford University, and Director of the Stanford Psychophysiology Laboratory. He is a leading researcher in the areas of emotion and emotion regulation, and is well known for his innovative theoretical and experimental analyses of emotion regulation processes. He is also an award-winning teacher, a Bass University Fellow in Undergraduate Education, and the Director of the Stanford Psychology One Teaching Program. Dr. Gross earned his BA in philosophy from Yale University and his PhD in clinical psychology from the University of California, Berkeley. He has received early career awards from the American Psychological Association, the Western Psychological Association, and the Society for Psychophysiological Research. His current research examines emotion regulation processes in healthy and clinical populations using behavioral, autonomic, and fMRI measures.



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