

Seeing, Thinking, and Feeling: Emotion-Regulating Effects of Gaze-Directed Cognitive Reappraisal

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Cognitive reappraisal (CR) is an emotion-regulatory (ER) process that is theorized to operate via changes in appraisals. CR is distinct from attentional deployment (AD), an ER process that is theorized to operate via changes in attention. However, a recent neuroimaging study has suggested that the ER effects of CR might largely be explained by AD. In this study, I manipulated CR while holding visual AD constant across CR conditions. In a randomized within-subjects design, 54 participants used CR to increase and decrease emotion in response to unpleasant pictures. This was compared with simply viewing the pictures. On all trials, gaze was directed to a circumscribed area of the pictures. Even with gaze held constant across conditions, increase reappraisals led to higher ratings of emotional intensity, greater corrugator activity, and greater autonomic arousal. In addition, decrease reappraisals led to lower ratings of emotional intensity and lower corrugator activity, the latter of which held only when gaze was directed to arousing information. Overall, the results suggest that changes in appraisal are the likely mechanism for the ER effects of CR.

Keywords: cognitive reappraisal, attentional deployment, process model, emotion regulation

Emotions promote adaptive responses to challenge (Levenson, 2003). However, situations in which it is important for people to regulate their emotions are ubiquitous in daily life (Gross & Thompson, 2007). As spelled out in the process model of emotion regulation (Gross, 1998; Gross & Thompson, 2007), people have many means of accomplishing their emotion-regulatory goals. According to appraisal theories of emotion, thinking is the precursor to feeling (Roseman & Smith, 2009), thus altering one's thinking should be an effective means of altering one's feelings, an approach to emotion regulation called *cognitive reappraisal* (CR).

CR refers to the process of modifying the appraised meaning of an emotion-triggering event. Experiments have shown that

participant-generated reappraisals are effective in modifying subjective emotional experience, neural activation (Kalisch et al., 2005; McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008; Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner et al., 2004; Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008), and expressive behavior (Deveney & Pizzagalli, 2008; Gross, 1998; Jackson, Malmstadt, Larson, & Davidson, 2000) in accordance with one's regulatory goal, but findings are mixed with respect to autonomic physiology (Eippert et al., 2007; Gross, 1998; Kalisch et al., 2005; Sheppes, Catran, & Meiran, 2009; Urry, van Reekum, Johnstone, & Davidson, 2009).

Attentional deployment (AD) is another family of processes by which people can alter their emotions. AD refers to deploying one's attention toward or away from certain aspects of emotion-triggering events. Experiments have shown that directing gaze toward emotional relative to neutral areas of unpleasant pictures, a way of manipulating AD, augments the late positive potential, a brain event-related potential that is sensitive to affective arousal (Dunning & Hajcak, 2009; Hajcak, Dunning, & Foti, 2009). Moreover, MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) found that training attention toward threat-related stimuli led to increased emotional reactivity in a subsequent task without changing self-reported emotional state.

Importantly, AD is theorized to be distinct from CR with respect to mechanisms for emotion-regulatory effects. Changes in emotion that occur as a function of AD processes should be mediated by changes in attention. Changes in emotion that occur as a function of CR processes should be mediated by changes in appraisal. However, this latter notion was recently called into question. Van Reekum et al. (2007) examined the neural correlates of reappraisals that increase and decrease unpleasant emotion evoked using pictures. Participants spent less time looking at emotional information in the pictures when applying reappraisals to decrease their negative emotion. Moreover, the variance in brain activation ex-

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I am indebted to Lindsay C. Rauch, recipient of an undergraduate Summer Scholar Award from Tufts University in 2007, for helping me design the gaze-directed cognitive reappraisal task for another study and to Jennifer A. DiCorcia for her many hours of assistance with set-up and maintenance of the eye-tracking system. I would like to thank (in alphabetical order) Jeffrey L. Birk, Sarah R. Cavanagh, Jennifer A. DiCorcia, and Philipp C. Opitz for their very helpful comments on an earlier version of this article. I would also like to thank (again in alphabetical order) Kristin Brethel, Deirdre Byrne, Matthew Chan, Caitlin Dockweiler, Michael Egan, Howard Hsu, Nicholas Lamm, Julie McKay, Emma Murphy, Alan Poey, Laura Sherman, Khalilah Ummah, and Joanna Witkin for their assistance with data collection and processing. Finally, I am grateful to Mikhail Evstafiev for permitting me to use his photograph in Figure 1 and to Frank Wilhelm and Peter Peyk for making ANSLAB, a suite of open-source Matlab routines used to process physiological data, available as freeware in the Society for Psychophysiological Research Software Repository (<http://www.sprweb.org/repository>).

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plained by reappraising was substantially reduced when taking gaze behavior into account. These findings suggest that changes in neural activation may actually have been caused by changes in attentional deployment instead of (or in addition to) changes in appraisals.

The purpose of this study was to determine whether emotion-regulating effects of CR are observed when AD is held constant across reappraisal conditions. In a randomized within-subjects design, participants used CR to actively increase and decrease emotion in response to unpleasant pictures. This was compared with simply viewing the pictures. On all trials, gaze was directed to a circumscribed area of the pictures, as confirmed with eye tracking. I examined the effects of CR on subjective emotional experience (ratings of intensity), expressive behavior (corrugator muscle activity), and autonomic physiology (heart rate and electrodermal activity).

In recognition of the theoretical distinction between attentional deployment and cognitive change families of emotion regulation (Gross & Thompson, 2007), I hypothesized that even when gaze was held constant across conditions (thus preventing an AD strategy for emotion regulation), increase reappraisals would lead to higher ratings of subjective emotional intensity, greater corrugator activity, and greater autonomic arousal compared with viewing unpleasant pictures. I also hypothesized that decrease reappraisals would lead to lower ratings of subjective emotional intensity and lower corrugator activity compared with viewing unpleasant pictures. I did not expect that decrease reappraisals would necessarily affect autonomic physiology given previous mixed findings.

Method

Participants

Fifty-four undergraduates participated in exchange for course credit. Of the 50 participants for whom demographic data were available, 26 were women (52%) and 38 were White (76%). Ages ranged from 17 to 22 years ($M = 18.8$, $SD = 1.04$). All procedures were approved by the Institutional Review Board at Tufts University. Participants provided written informed consent before participating.

Materials and Procedures

Stimuli. Participants viewed a set of digital color pictures (800 pixels \times 600 pixels) selected from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008). I selected 27 unpleasant pictures on the basis of normative data across men and women so as to be highly arousing ($M = 5.93$, $SD = 0.28$, on a scale ranging from 1 to 9 where 9 = *completely aroused*) and unpleasant ($M = 2.10$, $SD = 0.31$, on a scale ranging from 1 to 9 where 9 = *completely happy*).¹ I selected 12 neutral pictures so as to be low in arousal ($M = 3.06$, $SD = 1.09$) and neither pleasant nor unpleasant ($M = 4.99$, $SD = 0.05$).

Cognitive reappraisal. Participants were trained to follow one of three prerecorded auditory CR instructions during each of 78 picture trials. The instruction to increase served as a cue to actively try to feel more emotion. For example, in response to a picture of a girl curled up on the floor with eyes closed, participants were told they could imagine that the girl's mother had just

died. Conversely, the instruction to decrease signified the cue to actively try to feel less emotion. For example, participants were told they could imagine that the girl in the picture was tired and had fallen asleep. Alternatively, on view trials, participants were instructed to view the picture without trying to change the way they felt.

Immediately before completing the reappraisal task, participants were trained to reappraise using a standardized set of instructions in which example reappraisals were provided for the increase and decrease instructions in response to sample pictures. Participants then practiced generating their own reappraisals of new sample pictures. Afterward, I asked about the strategies participants had used with the new sample pictures and coached participants as needed. Participants uniformly demonstrated the ability to generate reappraisals that conformed to the instructions they received.

The reappraisal task was presented using E-Prime (Psychology Software Tools, Pittsburgh, PA) in three blocks of 26 trials of unpleasant and neutral pictures. The unpleasant pictures were paired with increase, decrease, and view instructions (one instruction per trial), whereas neutral pictures were only paired with the view instruction (because there was no emotion to be regulated). Each picture was presented in two trials, once with gaze directed to an arousing area and once with gaze directed to a nonarousing area as described in the next paragraph. The trial structure is presented in Figure 1.

Gaze direction. During the reappraisal task, gaze was directed to a specific area of interest in each picture half way through the trial. This was accomplished by fading out all but one square (250 pixels \times 250 pixels) of the image (see Figure 1). For unpleasant pictures, the saturated square illuminated one area of the picture judged to be emotionally arousing (arousing focus) or one area judged to be neutral (nonarousing focus). For neutral pictures, the saturated square illuminated one area of the picture judged to include a central feature (arousing focus) or one area judged to be peripheral (nonarousing focus). Participants were instructed to keep their gaze focused within the area of interest as they implemented the reappraisal instruction. Looking time data (reported later) validated the selection of these areas of interest as well as task compliance.

There were nine unpleasant pictures for each of six cells in this fully within-subjects design, described by the cross between reappraisal goal (increase, view, or decrease) and gaze direction (arousing focus or nonarousing focus). There were 12 neutral pictures for an additional two cells (arousing focus or nonarousing focus; both paired with the view instruction). More neutral than unpleasant pictures were presented to somewhat offset the preponderance of unpleasant images in each block of trials. Conditions were presented in random order for each participant. Pictures were randomly assigned to each trial.

¹ The following pictures from the International Affective Picture System 2006 set, listed by catalog number, were used: unpleasant—2683, 2703, 2717, 3016, 3051, 3063, 3100, 3225, 3261, 6021, 6312, 6570, 6821, 7380, 9040, 9253, 9254, 9405, 9420, 9423, 9433, 9560, 9571, 9800, 9901, 9910, and 9911; neutral—2038, 2214, 2749, 6150, 7009, 7010, 7020, 7035, 7185, 7235, 7640, and 7950.

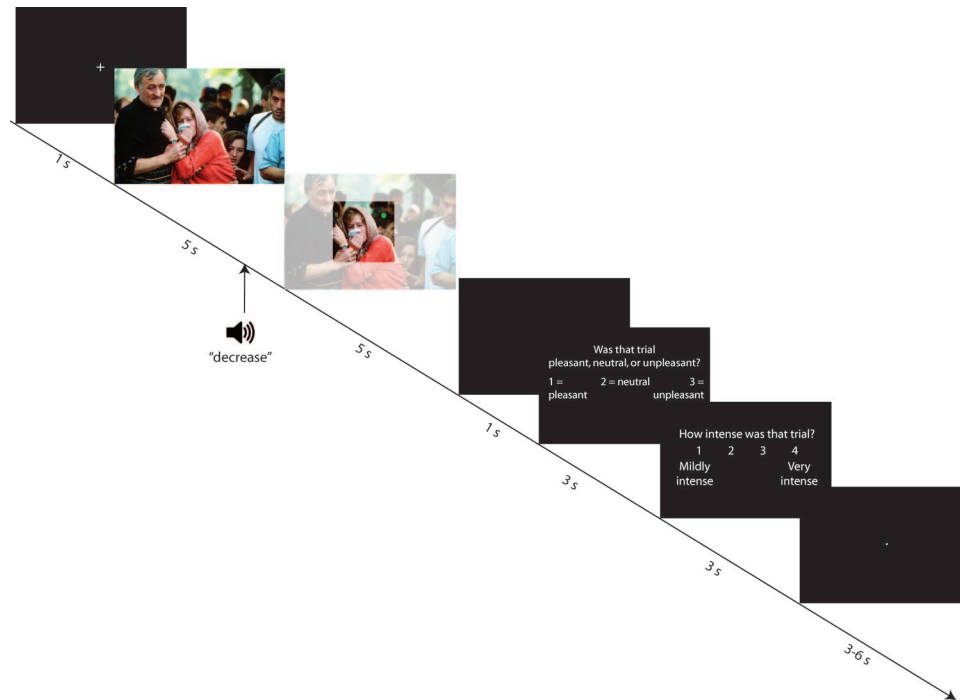


Figure 1. Trials began with a white fixation cross presented in the center of a black screen for 1 s, followed by the presentation of a picture for a total of 10 s. For the first 5 s, the entire picture was visible. For the last 5 s, most of the picture was faded out except for one square area to which gaze was directed. The cognitive reappraisal instruction was delivered 4 s after picture onset. As a way of ensuring that gaze would remain focused in the square, participants were asked to press a button as soon as they saw a 33-ms green dot presented in the square area (data not reported; dot response accuracy mirrors the eye-tracking findings). At the end of each trial, participants were prompted to judge picture valence (data not reported) and intensity. Intensity ratings were provided on a scale ranging from 1 (*mildly intense*) to 4 (*very intense*). Each rating screen remained present for 3 s. Participants then saw a black screen with a central white fixation dot that lasted from 3 to 6 s. Photo of mourning family from Evstafiev (1992). Used with permission of the photographer.

Ratings of Emotional Intensity

Subjective ratings of emotional intensity were provided on a scale ranging from 1 (*mildly intense*) to 4 (*very intense*) at the end of each trial.

Peripheral Physiology

Peripheral data were collected using an MP150 system (Biopac, Goleta, CA) and processed using ANSLAB (Wilhelm & Peyk, 2005).

Corrugator electromyography. Corrugator electromyography was selected as an index of facial expressive behavior, even that which is not overtly observable. It is sensitive to stimulus valence, exhibiting greater activity in response to unpleasant stimuli and lower activity in response to pleasant stimuli (Bradley & Lang, 2007). Two 4-mm Ag/AgCl electrodes were placed in bipolar configuration over the left eye per Fridlund and Cacioppo (1986). One ground electrode for all physiological channels was placed on the forehead. Corrugator electromyography was sampled at 2000 Hz and bandpass-filtered online (5 Hz to 3 kHz; 60-Hz notch filter on). Offline, data were resampled to 400 Hz, rectified and smoothed with a 16-Hz low-pass filter, decimated to 4 Hz, and smoothed with a 1-s prior moving average filter.

Electrocardiography. Electrocardiography was used to measure heart rate (HR), which is dually innervated by the sympathetic and parasympathetic branches of the autonomic nervous system. In event-related paradigms involving passive viewing of unpleasant pictures, HR exhibits an initial, parasympathetically mediated deceleration (Bradley & Lang, 2007). Two disposable Ag/AgCl electrodes pregelled with 7% chloride gel (1 cm circular contact area) were placed under the left and right collarbones on the chest after swabbing with an alcohol prep pad and then gently debriding using an electrode prep pad. ECG was acquired continuously at 1,000 Hz.

Offline, the ECG signal was downsampled to 400 Hz and bandpass-filtered from 0.5 to 40 Hz. Interbeat interval series were created by identifying R-spikes using automated ANSLAB algorithms. R-spikes that were not detected automatically, thus leading to an erroneously long period between successive R-spikes, were marked for inclusion by hand. Similarly, R-spikes that were identified incorrectly, thus leading to an erroneously short period between successive R-spikes, were removed by hand. Following such artifact correction, the interbeat interval series was converted to HR in beats per minute. HR data were decimated to 10 Hz and then smoothed with a 1-s prior moving average filter.

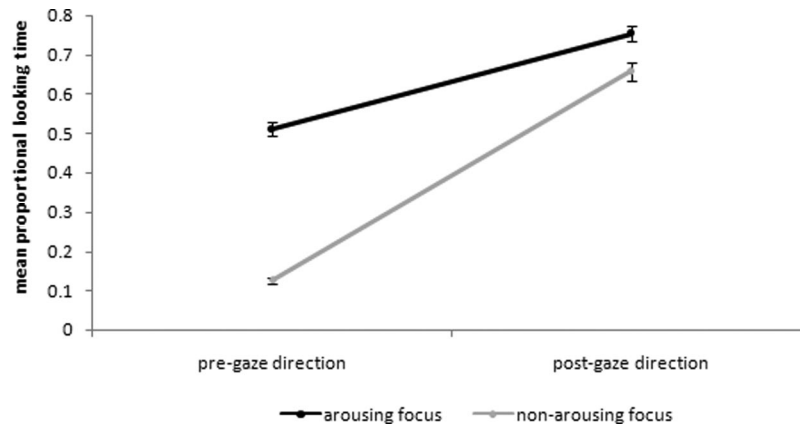


Figure 2. Mean time spent looking at the unpleasant pictures expressed as a proportion of 5 s, the total possible viewing time. Means are reported separately for looking time before (pregaze direction; left side of the figure) and after (postgaze direction; right side of the figure) gaze was directed to subjectively defined areas of interest. Documenting the validity of the areas of interest, participants spent more time looking in the arousing area (black line) than in the nonarousing area (gray line) before gaze was directed (i.e., when gaze was free to vary naturally). Documenting compliance with the gaze direction manipulation, looking time increased from before to after gaze direction for both area-of-interest types, an increase that was bigger for the nonarousing area because so little time was spent in that area to begin with.

Electrodermal activity. Electrodermal activity (EDA) was selected as a pure measure of sympathetic activation of the autonomic nervous system. Two disposable Ag/AgCl electrodes pre-gelled with 0.5% chloride isotonic gel (1 cm circular contact area) were attached to the distal phalanges of the index and middle fingers on the left hand. EDA level was recorded with DC coupling and constant voltage electrode excitation at 31.25 Hz (sensitivity = .7 nS). Offline, EDA was smoothed with a 1 Hz low-pass filter, decimated to 10 Hz, and linearly detrended on a trial-by-trial basis.²

Eye Tracking

Bilateral eye-tracking data were unobtrusively collected using a Tobii T120 Eye Tracker (Danderyd, Sweden; sampled at 60 Hz). Fixations were identified when gaze fell within a radius of 30 pixels for at least 100 ms, averaged across both eyes. Looking time within the prescribed square area was expressed as a proportion of the 5-s viewing time occurring both before and after gaze direction.

Data Reduction and Analysis

Emotion elicitation manipulation check. A premise of this work was that the unpleasant pictures would elicit unpleasant emotional responses that could be regulated by cognitive reappraisal. Finding increased corrugator, increased EDA, or deceleration in HR during the 4-s time period after picture onset (but before delivery of the reappraisal instruction) would be taken as evidence of this premise. For this question, trials were baseline corrected for the 100-ms (EDA or HR) or 250-ms (electromyography) time bin immediately preceding picture onset. After baseline correction, the data for this 4-s window of interest were averaged across time bins, trials, and conditions separately for unpleasant and neutral pictures for each participant. The mean was

then submitted to paired *t* tests comparing responses to unpleasant versus neutral pictures.

Effects of reappraisal goal and gaze direction. Reappraisal-related change was captured by subtracting baseline signal recorded during the 100-ms (EDA or HR) or 250-ms (electromyography) time bin just before instruction delivery from all subsequent time bins within a 6-s window immediately following this baseline period. To account for delay in EDA response, only time bins occurring 2 s after instruction delivery were included. Following baseline correction, the data were then averaged across time bins and trials within each cell (described by reappraisal goal and gaze direction) for each participant. The mean estimate was then tested with a multivariate general linear model (GLM) to assess the effects of reappraisal goal (increase, maintain, or decrease) and gaze direction (arousing or nonarousing).

Data retention. To prevent leveraging of condition estimates by outlying values, only trials falling less than 4 standard deviations from the within-subjects mean were retained on a measure-by-measure basis for each participant. This criterion led to very little data loss. Across conditions, 100% of trials were retained for ratings of emotional intensity, corrugator activity, HR, and EDA; 99% of trials were retained for looking time.

To prevent leveraging of groupwise differences between conditions, analyses were completed with and without multivariate outliers (i.e., participants for whom the estimate of Mahalanobis distance across variables within each measure was too large [$p < .001$]; see Fidell & Tabachnick, 2003). Two participants' EDA data were excluded on this basis; thus, the subsample size was 52.

² Repeating all EDA analyses with no linear detrending reveals the same results.

Emotional intensity ratings were unavailable for 3 participants (key presses were not recorded); thus, the subsample size was 51. Corrugator data were available for all participants, and so the subsample size was 54. HR data for 1 participant were excluded because of poor signal quality, thus making the subsample size 53. Eye-tracking data were unavailable for 2 participants (equipment failure) and were unusable for 3 participants (problems with the data files), thus the subsample size for looking time was 49.

Results

I used responses to unpleasant and neutral pictures to document the success of emotion elicitation. I used responses to unpleasant pictures alone to validate the subjectively defined areas of interest and the gaze direction manipulation and to test the a priori predictions about the emotion-regulating effects of cognitive reappraisal. Across all analyses, results were considered statistically significant at an alpha of .05 (two-tailed). Multivariate *F* statistics are reported for the repeated measures GLMs. Estimates of within-subjects effect size (Cohen’s *d_z*, which is calculated as the mean difference divided by the standard deviation of the mean difference) are reported for paired effects.

Preliminary Analyses

Have we effectively elicited negative emotion? Averaged across conditions within the 4-s period after picture onset, a paired *t* test indicated that participants experienced the unpleasant pictures ($M = 2.71, SD = 0.35$) as more intense than the neutral pictures ($M = 1.18, SD = 0.16$), $t(50) = 31.26, p < .001, d_z = 4.38$. Unpleasant pictures also led to greater corrugator activity ($M = 0.49, SD = 1.06$) than neutral pictures ($M = -0.11, SD = 0.96$), $t(53) = 4.09, p < .001, d_z = 0.56$. Finally, unpleasant pictures produced a significant deceleration in HR ($M = -1.06, SD = 1.09$) compared with neutral pictures ($M = -0.45, SD = 1.22$), $t(52) = -3.02, p = .004, d_z = 0.41$. There was no difference in EDA between unpleasant ($M = .037, SD = .063$) and neutral ($M = .035, SD = .073$) pictures, $t(51) = 0.17, p = .866, d_z = 0.02$. Overall, these results confirm that the intended unpleasant emotional state was elicited.

Validating the areas of interest and the gaze direction manipulation. A repeated measures GLM with two factors, gaze direction (arousing or nonarousing) and time (pregaze direction or postgaze direction), revealed a significant interaction for unpleasant picture trials across reappraisal conditions, $F(1, 48) = 235.00, p < .001$. As shown in Figure 2, participants looked more in the arousing than in the nonarousing areas of interest. Follow-up analyses (Fisher’s Least Significant Difference) indicated that this difference was larger during the pregaze direction period ($p < .001, d_z = 3.32$) than during the postgaze direction period ($p < .001, d_z = 1.22$) because so little time was spent looking at the nonarousing area during this period when gaze was free to vary naturally. This validates the subjectively defined arousing and nonarousing areas of interest. Moreover, looking time significantly increased from before to after gaze direction, a difference that was larger for the nonarousing area ($p < .001, d_z = 3.37$) than for the

Table 1
Means (and Standard Deviations) for the Dependent Measures as a Function of Reappraisal Goal and Gaze Direction

Dependent measure	<i>F</i> statistics for main effect of reappraisal goal	Across gaze directions			Arousing		Nonarousing		
		Increase	View	Decrease	Increase	View	Decrease	View	Decrease
Proportional looking time	$F(2, 47) = 0.29, p = .752$	0.71 (0.15)	0.7 (0.16)	0.7 (0.15)	0.76 (0.16)	0.75 (0.17)	0.74 (0.15)	0.66 (0.17)	0.66 (0.16)
Ratings of emotional intensity	$F(2, 49) = 31.06, p < .001$	2.92 _a (0.33)	2.67 _{a,b} (0.42)	2.55 _b (0.42)	2.99 (0.35)	2.71 (0.5)	2.6 (0.49)	2.84 (0.38)	2.51 (0.44)
Corrugator activity	$F(2, 52) = 6.34, p = .003$	0.28 _a (1.33)	-0.24 _{a,b} (0.48)	-0.48 _b (0.93)	0.48 _a (1.99)	-0.1 _{a,b} (0.48)	-0.46 _b (0.99)	0.08 _a (0.84)	-0.37 _a (0.68)
Heart rate	$F(2, 51) = 21.94, p < .001$	0.83 _a (1.73)	-0.4 _a (1.6)	-0.35 (1.42)	0.76 (2.1)	-0.29 (1.8)	-0.32 (1.82)	0.91 (1.91)	-0.51 (1.78)
Electrodermal activity	$F(2, 50) = 4.96, p = .011$	0.03 _a (0.05)	0.01 _a (0.04)	0.01 (0.05)	0.029 (0.051)	0.002 (0.054)	0.011 (0.071)	0.03 (0.068)	0.002 (0.059)

Note. Arousing = gaze directed to an emotionally relevant area of the picture; nonarousing = gaze directed away from the emotionally relevant areas of the picture. For the two planned comparisons of interest (increase vs. view, decrease vs. view), means sharing the same subscript within a row differ at $p < .05$ according to Fisher’s Least Significant Difference across gaze directions. Given the marginally significant interaction between reappraisal goal and gaze direction for corrugator activity, significant differences for that measure are also shown within each gaze direction.

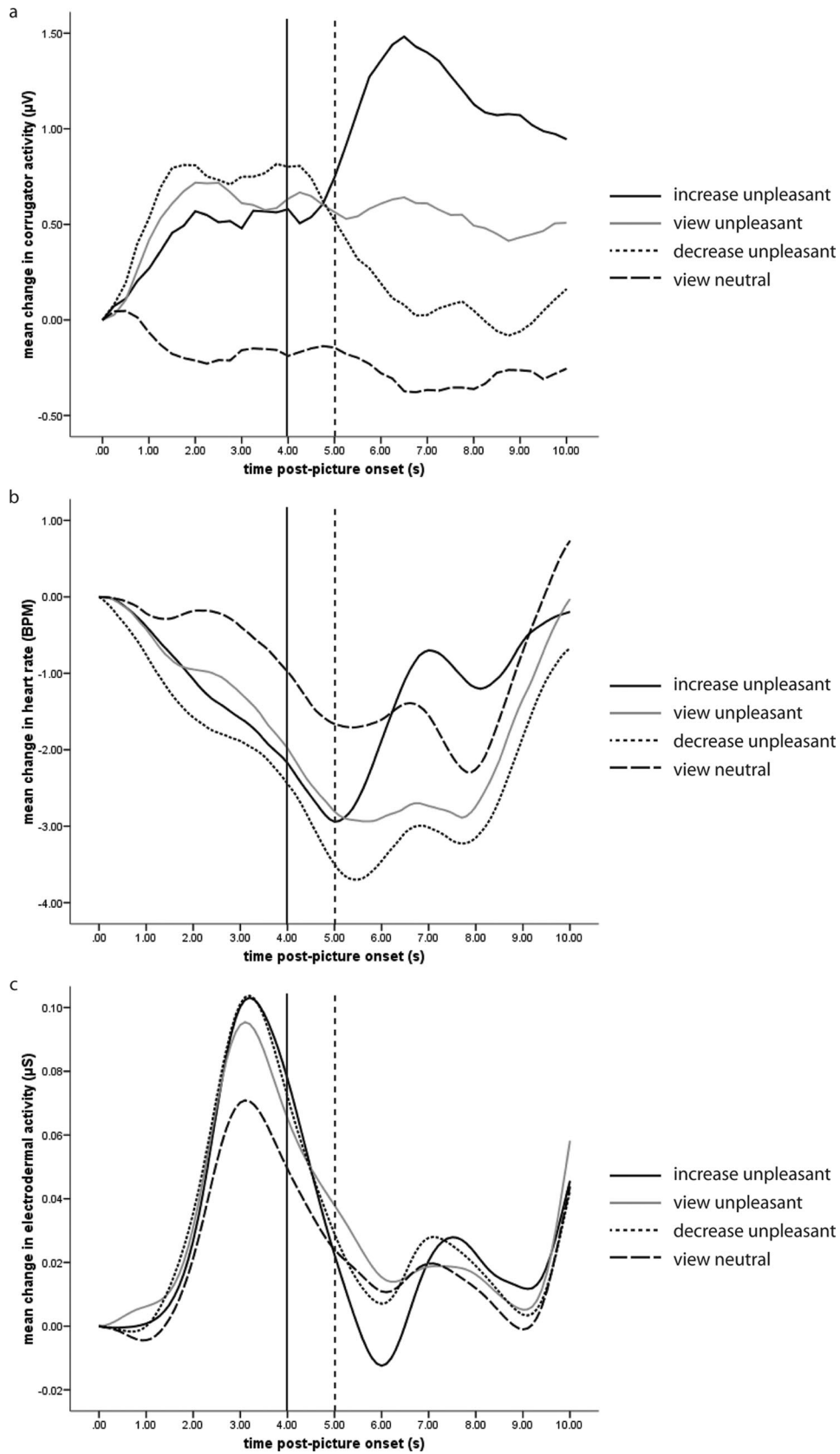


Figure 3 (opposite).

arousing area ($p < .001$, $d_z = 2.38$). This suggests that participants were compliant with the gaze direction manipulation.

Did participants look in the prescribed area equally across CR conditions? As suggested by mean looking time during the postgaze direction period of unpleasant picture trials in Table 1, a repeated measures GLM with two factors, reappraisal goal (increase, view, or decrease) and gaze direction (arousing or nonarousing), indicated that there was no main effect of reappraisal goal, $F(2, 47) = 0.29$, $p = .752$, nor an interaction between reappraisal goal and gaze direction, $F(2, 47) = 0.89$, $p = .418$.³ This suggests that gaze direction was not confounded with CR in explaining emotion-regulating effects on other measures. As earlier, participants looked longer in the arousing than in the nonarousing areas, as indicated by the main effect of gaze direction, $F(1, 48) = 70.96$, $p < .001$.

Hypothesis Testing

Means and standard deviations for all measures and F statistics for the CR main effect are presented in Table 1. Figures 3 and 4 present the time course for change in the physiological measures over the entire picture-viewing period when gaze was directed to arousing (see Figure 3) and nonarousing (see Figure 4) information. The data in these two figures were baseline-corrected using the time bin immediately before picture onset.

Data analysis strategy. For each of four dependent measures (ratings of emotional intensity, corrugator muscle activity, HR, and EDA), hypothesis testing was accomplished using a repeated measures GLM testing the independent and interactive effects of two factors, reappraisal goal (increase, view, or decrease) and gaze direction (arousing or nonarousing). Significant main effects of reappraisal goal were followed up with two planned comparisons (Fisher's Least Significant Difference for increase vs. view and decrease vs. view). Significant interaction effects were followed up with the same two planned comparisons within each of the two gaze direction conditions. Estimates of effect size (Cohen's d_z) for each of the two planned comparisons (increase vs. view and decrease vs. view) across and within gaze directions are reported in Table 2.

Does CR have emotion-regulating effects across gaze direction conditions? As shown in Table 1, there were main effects of CR on subjective emotional intensity, corrugator activity, HR, and EDA. Increase reappraisals of unpleasant pictures led to higher ratings of subjective emotional intensity, greater corrugator activity, and greater EDA and HR compared to the view condition. In addition, decrease reappraisals of unpleasant pictures led to lower ratings of subjective emotional intensity and lower corrugator activity compared to the view condition. This pattern confirms that CR has the predicted emotion-regulating effects even though gaze was held constant across reappraisal conditions.⁴

Does the effect of reappraisal depend on gaze direction? It was conceivable that CR might interact with gaze direction in influencing emotion. The interactive effect of CR and gaze direction was only (marginally) significant for corrugator muscle activity, $F(2, 52) = 2.89$, $p = .064$ (see descriptives in Table 1 and effect sizes in Table 2). Follow-up analyses (Fisher's Least Significant Difference) indicated that gaze direction had little effect on increase reappraisals, for which higher corrugator activity was evident for increasing compared with viewing when gaze was directed to both the arousing ($p = .043$) and nonarousing ($p = .001$) areas. Gaze direction had more of an impact on decrease reappraisals, for which lower corrugator activity for decreasing compared with viewing was observed only when gaze was directed to the arousing area ($p = .015$), not when directed to the nonarousing area ($p = .299$). As is evident in Figure 4a, directing gaze to the nonarousing area in the view condition was sufficient on its own to reduce corrugator activity, leaving little room for further declines as a function of reappraisal.

Does directing gaze by itself influence emotion across CR conditions? In keeping with recent electrophysiological findings (Dunning & Hajcak, 2009; Hajcak et al., 2009), it was conceivable that directing gaze toward and away from emotionally arousing information might, in and of itself, have emotion-regulating effects. Indeed, a main effect of gaze direction showed that ratings of emotional intensity were higher when gaze was directed to an arousing area ($M = 2.78$, $SE = .05$) than to a nonarousing area ($M = 2.66$, $SE = .05$), $F(1, 50) = 11.78$, $p = .001$, $d_z = 0.48$. Similarly, corrugator activity was higher when gaze was directed to an arousing area ($M = -0.03$, $SE = .11$) than to a nonarousing area ($M = -0.26$, $SE = .08$), $F(1, 53) = 6.65$, $p = .013$, $d_z = 0.35$.

Discussion

Previous studies of CR using visual stimuli have allowed gaze to vary naturally. This makes it possible that the apparent emotion-regulating effects of CR, an emotion regulatory process falling within the cognitive change family of emotion regulatory processes, might actually be explained by AD, a different family of emotion regulatory processes (Gross & Thompson, 2007). This possibility was supported by van Reekum et al. (2007), who took

³ Green dot detection accuracy (see the Figure 1 legend) confirms a similar lack of a reappraisal goal main effect or an interaction between reappraisal goal and gaze direction.

⁴ In a separate set of GLMs, looking times in the prescribed area for each of six conditions (3 reappraisal goals \times 2 gaze directions) were entered as covariates. Table 2 provides Cohen's d_z effect size for the increase versus view and decrease versus view comparisons for the original data and then again with these looking time covariates. Note that the effect sizes changed very little when looking time covariates were included.

Figure 3 (opposite). Effects of cognitive reappraisal (CR) while gaze was directed to an arousing area. Panels a (corrugator activity), b (heart rate in beats per minute [BPM]), and c (electrodermal activity) depict change in activity over the entire 10-s picture presentation period. The CR instruction was presented 4 s after picture onset (marked with the vertical solid black line). Gaze was directed 5 s after picture onset (marked with the vertical dotted black line). Solid black lines represent unpleasant trials in which participants received the CR instruction to increase. Solid gray lines represent unpleasant trials in which participants received the CR instruction to view. Black lines with short hash marks represent unpleasant trials in which participants received the CR instruction to decrease. Black lines with long hash marks represent neutral trials for which participants received the CR instruction to view.

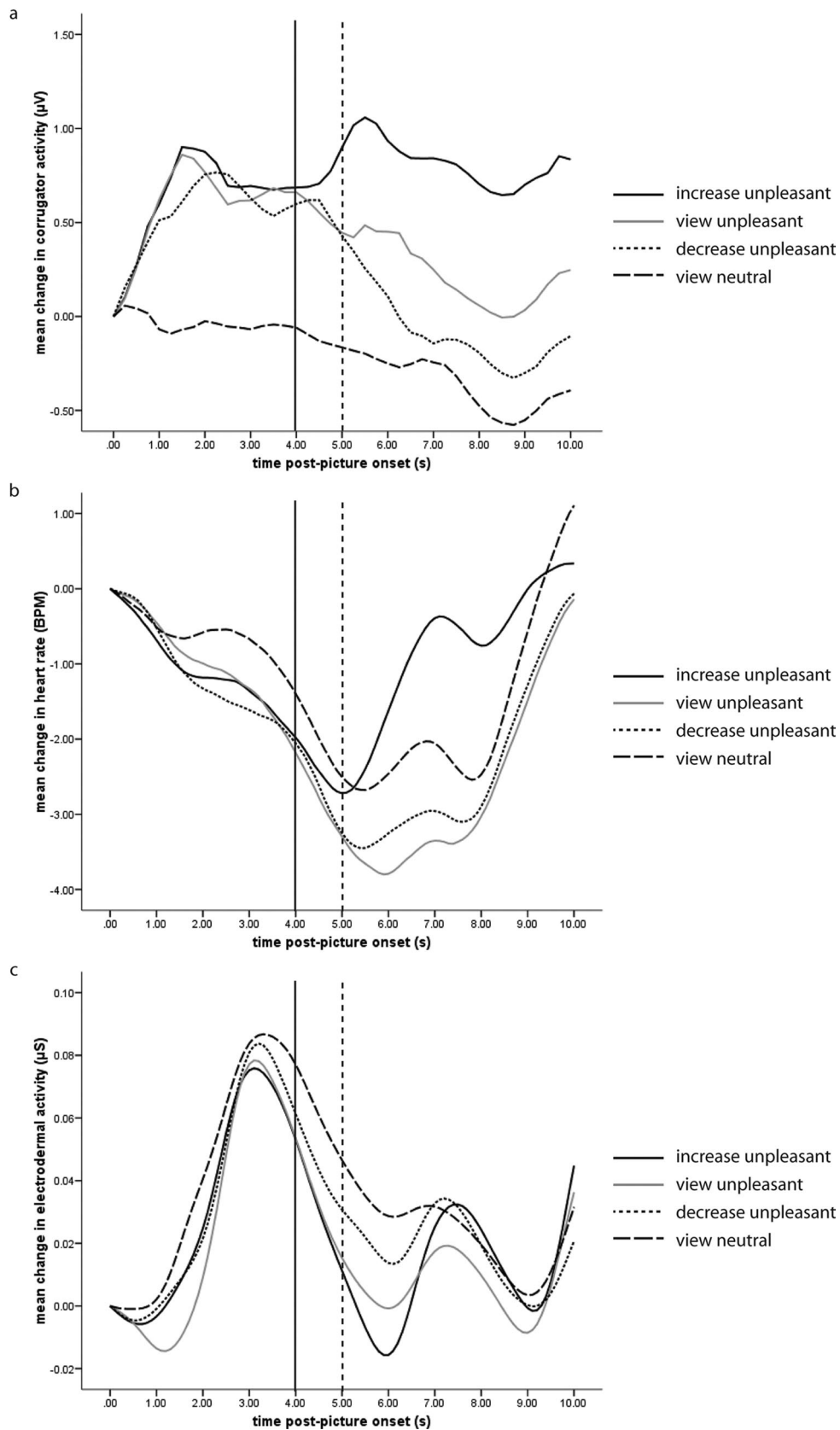


Figure 4 (opposite).

Table 2
Cohen's *Dz* Effect Sizes for the Two Reappraisal Comparisons of Interest, Increase-View and Decrease-View

Variable	Across gaze directions		Arousing		Nonarousing		<i>n</i>
	Increase-view	Decrease-view	Increase-view	Decrease-view	Increase-view	Decrease-view	
Proportional looking time							
Original	0.07	0.04	0.12	0.06	0.01	0.00	49
With covariates	—	—	—	—	—	—	—
Ratings of emotional intensity							
Original	0.82	0.38	0.63	0.27	0.54	0.29	51
With covariates	0.83	0.37	0.63	0.24	0.56	0.33	46
Corrugator activity							
Original	0.38	0.29	0.28	0.34	0.47	0.14	54
With covariates	0.39	0.29	0.31	0.34	0.44	0.15	49
Heart rate							
Original	0.90	0.04	0.50	0.01	0.83	0.07	53
With covariates	0.93	0.01	0.52	0.01	0.86	0.03	48
Electrodermal activity							
Original	0.43	0.03	0.48	0.12	0.27	0.10	52
With covariates	0.41	0.14	0.54	0.25	0.22	0.08	47

Note. Arousing = gaze directed to an emotionally relevant area of the picture; nonarousing = gaze directed away from the emotionally relevant areas of the picture. The phrase “with covariates” indicates that looking times in the prescribed area for each of six conditions (3 reappraisal goals \times 2 gaze directions) were included as covariates in estimating the marginal means (and standard deviations) that were used to compute Cohen's *dz*. The word *original* indicates that no covariates were included. The with-covariates *n* is 5 less than the original *n* because of missing observations for looking time data. See Data Retention section for details.

an individual-difference approach to show that the effects of reappraising unpleasant pictures on neural activation were substantially reduced when accounting for variation in eye gaze behavior, an index of visual attentional deployment.

In this study, I determined that cognitive reappraisal affects subjective experience of emotional intensity and autonomic physiology even when attentional deployment was equivalent across reappraisal conditions. If visual attentional deployment was the causal agent for the impact of reappraisal on these indices of emotion, then constraining gaze would have prevented reappraisal from having any effect. Yet, as predicted and despite equivalent looking times in the prescribed areas, increase reappraisals prompted higher ratings of emotional intensity, greater corrugator activity, and greater autonomic arousal than viewing unpleasant pictures. In addition, decrease reappraisals prompted lower ratings of emotional intensity. These results suggest that changes in appraisal are the mechanism by which CR affects these aspects of the multisystem emotion response. However, although this study rules out changes in visual attention, other mechanisms (e.g., motivation or empathy) aside from changes in appraisal might still be operating in addition to (or instead of) changes in appraisals (Parkinson, 1997). Future studies that either manipulate or hold these factors constant in the context of reappraisal are needed.

By contrast to the measures of subjective emotional intensity and autonomic physiology, the effects of CR on expressive behavior, as measured via activity over the corrugator muscle region, varied as a function of gaze direction. Whereas increase reappraisals led to greater corrugator muscle activity compared with the view condition in both gaze direction conditions, decrease reappraisals led to lower corrugator muscle activity than the view condition only when gaze was directed to the arousing area. When gaze was directed to the nonarousing area, there was no effect of decrease reappraisals relative to the view condition on corrugator activity. This appears to be at least in part because of a floor effect: When otherwise responding naturally (i.e., during the view condition), diverting gaze away from unpleasant visual information was sufficient on its own to down-regulate expressive behavior to its baseline level.

In future studies, it would be important to ensure that the initial response (i.e., the response engendered during the first 4 s of picture presentation in this particular paradigm) is sufficiently high to allow for further declines in expressive behavior beyond those that occur by directing gaze to nonarousing information. It is unclear why expressive behavior was more sensitive to this apparent floor effect than subjective emotional intensity (for which the decrease reappraisal effect was present in both gaze direction conditions). Nevertheless, my specula-

Figure 4 (opposite). Effects of cognitive reappraisal (CR) while gaze was directed to a nonarousing area. Panels a (corrugator activity), b (heart rate in beats per minute [BPM]), and c (electrodermal activity) depict change in activity over the entire 10-s picture presentation period. The CR instruction was presented 4 s after picture onset (marked with the vertical solid black line). Gaze was directed 5 s after picture onset (marked with the vertical dotted black line). Solid black lines represent unpleasant trials in which participants received the CR instruction to increase. Solid gray lines represent unpleasant trials in which participants received the CR instruction to view. Black lines with short hash marks represent unpleasant trials in which participants received the CR instruction to decrease. Black lines with long hash marks represent neutral trials for which participants received the CR instruction to view.

tion is that, in a floor effect–free context, decrease reappraisals should exert emotion-regulating effects on expressive behavior over and above AD just as they did for subjective experience and just as increase reappraisals did for all three measures of the multisystem emotion response (subjective experience, expressive behavior, and autonomic physiology).

Attending to arousing areas of unpleasant pictures led to higher ratings of emotional intensity and corrugator muscle activity than did attending to nonarousing areas. Attending to emotional versus neutral information has been shown in previous work to influence electrophysiological indices of emotional arousal (Dunning & Hajcak, 2009; Hajcak et al., 2009) and subjective mood states (MacLeod et al., 2002; See, MacLeod, & Bridle, 2009). The results of this study thus converge with those of previous studies in suggesting that AD is effective in regulating some aspects of the multisystem emotion response. Future studies that test the gaze directions studied here and that also allow gaze to vary freely on some trials are warranted. This would allow one to determine whether directing gaze to arousing and nonarousing information has emotion-regulatory effects compared with free viewing or whether the differences in subjective ratings of intensity and expressive behavior observed here are carried by one or the other.

Conclusion

In sum, CR (thinking) affected subjective emotion experience and autonomic physiology (feeling) despite equivalence of visual AD (seeing). These findings dovetail nicely with the process model of emotion regulation (Gross, 1998; Gross & Thompson, 2007), which suggests that there are five theoretically distinct families of processes by which people can alter their emotions, two of which are (a) deploying one's attention toward or away from certain aspects of situations and (b) modifying one's appraisals of the situations one faces. This study provides empirical evidence for the distinctiveness of the attentional deployment and cognitive change families, thus moving forward understanding of the processes underlying regulation of emotion, an important pursuit because emotion regulation processes are tightly linked to well-being (John & Gross, 2004).

References

- Bradley, M. M., & Lang, P. J. (2007). Emotion and motivation. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed., pp. 581–607). Cambridge, UK: Cambridge University Press.
- Deveney, C. M., & Pizzagalli, D. A. (2008). The cognitive consequences of emotion regulation: An ERP investigation. *Psychophysiology*, *45*, 435–444.
- Dunning, J. P., & Hajcak, G. (2009). See no evil: Directing visual attention within unpleasant images modulates the electrocortical response. *Psychophysiology*, *46*, 28–33.
- Eippert, F., Veit, R., Weiskopf, N., Erb, M., Birbaumer, N., & Anders, S. (2007). Regulation of emotional responses elicited by threat-related stimuli. *Human Brain Mapping*, *28*, 409–423.
- Evstafiev, M. (1992). A family mourns during a funeral at the Lion's cemetery in Sarajevo, 1992 [Photo]. Retrieved from <http://commons.wikimedia.org/wiki/File:Evstafiev-bosnia-sarajevo-funeral-reaction.jpg>
- Fidell, L. S., & Tabachnick, B. G. (2003). Preparatory data analysis. In J. A. Schinka & W. F. Velicer (Vol. Eds.), and I. B. Weiner (Editor-in-Chief), *Handbook of psychology: Vol. 2. Research methods in psychology* (pp. 115–142). Hoboken, NJ: Wiley.
- Fridlund, A. J., & Cacioppo, J. T. (1986). Guidelines for human electro-myography research. *Psychophysiology*, *23*, 567–589.
- Gross, J. J. (1998). Antecedent- and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality and Social Psychology*, *74*, 224–237.
- Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 3–24). New York: Guilford Press.
- Hajcak, G., Dunning, J. P., & Foti, D. (2009). Motivated and controlled attention to emotion: Time-course of the late positive potential. *Clinical Neurophysiology*, *120*, 505–510.
- Jackson, D. C., Malmstadt, J. R., Larson, C. L., & Davidson, R. J. (2000). Suppression and enhancement of emotional responses to unpleasant pictures. *Psychophysiology*, *37*, 515–522.
- John, O. P., & Gross, J. J. (2004). Healthy and unhealthy emotion regulation: Personality processes, individual differences, and life span development. *Journal of Personality*, *72*, 1301–1333.
- Kalisch, R., Wiech, K., Critchley, H. D., Seymour, B., O'Doherty, J. P., Oakley, D. A., et al. (2005). Anxiety reduction through detachment: Subjective, physiological, and neural effects. *Journal of Cognitive Neuroscience*, *17*, 874–883.
- Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International Affective Picture System (IAPS): Affective ratings of pictures and instruction manual* (Rep. No. A-8). Gainesville: University of Florida.
- Levenson, R. W. (2003). Blood, sweat, and fears—The autonomic architecture of emotion. *Annals of the New York Academy of Sciences*, *1000*, 348–366.
- MacLeod, C., Rutherford, E., Campbell, L., Ebsworthy, G., & Holker, L. (2002). Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology*, *111*, 107–123.
- McRae, K., Ochsner, K. N., Mauss, I. B., Gabrieli, J. J. D., & Gross, J. J. (2008). Gender differences in emotion regulation: An fMRI study of cognitive reappraisal. *Group Processes and Intergroup Relations*, *11*, 143–162.
- Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. E. (2002). Rethinking feelings: An fMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience*, *14*, 1215–1229.
- Ochsner, K. N., Ray, R. D., Cooper, J. C., Robertson, E. R., Chopra, S., Gabrieli, J. D., et al. (2004). For better or for worse: Neural systems supporting the cognitive down- and up-regulation of negative emotion. *NeuroImage*, *23*, 483–499.
- Parkinson, B. (1997). Untangling the appraisal-emotion connection. *Personality and Social Psychology Review*, *1*, 62–79.
- Roseman, I. J., & Smith, C. A. (2009). Appraisal theory: Overview, assumptions, varieties, controversies. In K. R. Scherer, A. Schorr, & T. Johnstone (Eds.), *Appraisal processes in emotion: Theory, methods, research* (pp. 3–19). Oxford, UK: Oxford University Press.
- See, J., MacLeod, C., & Bridle, R. (2009). The reduction of anxiety vulnerability through the modification of attentional bias: A real-world study using a home-based cognitive bias modification procedure. *Journal of Abnormal Psychology*, *118*, 65–75.
- Sheppes, G., Catran, E., & Meiran, N. (2009). Reappraisal (but not distraction) is going to make you sweat: Physiological evidence for self-control effort. *International Journal of Psychophysiology*, *71*, 91–96.
- Urry, H. L., van Reekum, C. M., Johnstone, T., & Davidson, R. J. (2009). Individual differences in some (but not all) medial prefrontal regions reflect cognitive demand while regulating unpleasant emotion. *NeuroImage*, *47*, 852–863. doi:10.1016/j.neuroimage.2009.05.069

- van Reekum, C. M., Johnstone, T., Urry, H. L., Thurow, M. E., Schaefer, H. S., Alexander, A. L., et al. (2007). Gaze fixations predict brain activation during the voluntary regulation of picture-induced negative affect. *NeuroImage*, *36*, 1041–1055.
- Wager, T. D., Davidson, M. L., Hughes, B. L., Lindquist, M. A., & Ochsner, K. N. (2008). Prefrontal-subcortical pathways mediating successful emotion regulation. *Neuron*, *59*, 1037–1050.
- Wilhelm, F. H., & Peyk, P. (2005). ANSLAB: Autonomic Nervous System

Laboratory (Version 4.0) [Computer software]. Retrieved from <http://www.sprweb.org>

Received March 12, 2009
Revision received August 12, 2009
Accepted August 20, 2009 ■