PHYSIOLOGICAL MEASURES OF AFFECTIVE CHRONOMETRY DURING HABITUAL AND VOLUNTARY USE OF EMOTION REGULATION STRATEGIES

by

MARISA MENCHOLA

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

2007

THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

As members of the Dissertation Committee, we certify that we have read the dissertation

prepared by Marisa Menchola

entitled Physiological Measures of Affective Chronometry during Habitual and Voluntary Use of Emotion Regulation Strategies

and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy

____ Date: September 27th, 2007
Alfred W. Kaszniak

____ Date: September 27th, 2007
John J.B. Allen

____ Date: September 27th, 2007
Hal Arkowitz

____ Date: September 27th, 2007
David A. Sbarra

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copies of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

____ Date: September 27th, 2007
Dissertation Director: Alfred W. Kaszniak

STATEMENT BY AUTHOR

SIGNED: Marisa Menchola

ACKNOWLEDGEMENTS

I would not have been able to complete my graduate studies without the guidance and support I received from many people along the way. I wish to thank Al Kaszniak for his generous and kind mentorship, and for giving me the tools, the encouragement and the confidence to make it this far. I am also especially grateful to Anne Herring and Catherine Shisslak, superb clinical supervisors, caring mentors, and dear friends. I wish to thank Hal Arkowitz, John Allen and Dave Sbarra, as well as Dick Bootzin and Varda Shoham, for their valuable input at different stages in this project. Finally, this would not have been possible without the unconditional support from my family and friends. I am very lucky to have you.

TABLE OF CONTENTS

TABLE OF CONTENTS, Continued

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Emotions are currently conceptualized as ongoing temporal processes. Consistent with this view, an important target of attempts at emotion regulation are the temporal characteristics of an emotional response. The process model of emotion regulation (Gross, 1998a) distinguishes between antecedent- and response-focused emotion regulation strategies, depending on when during the unfolding emotional response they act. Two strategies that exemplify this distinction are cognitive reappraisal and expressive suppression. The present study explored the effects of the interaction between habitual engagement in reappraisal and suppression and their voluntary manipulation. Using a between-subjects design, 122 participants selected based on their self-reported habitual emotion regulation strategy (reappraisal, suppression, or both strategies without clear preference for one over the other) received instructions to engage in reappraisal, suppression, or merely watch emotion-eliciting images. Chronometric analyses of emotion-related psychophysiological measures (startle reflex modulation, corrugator electromyography, and skin conductance) were performed in order to further characterize the differences in the time course of these two strategies during the down-regulation of negative emotion. As expected, instructions to reappraise resulted in lower unpleasantness and arousal ratings, as well as less overall corrugator electromyographic activity, compared to instructions to suppress. No differences between instruction conditions were observed on startle reflex or skin conductance. Moreover, no differences were observed in the chronometry of any of the physiological measures. Habitual emotion regulation style had no direct effect on any of the dependent variables, and it did not interact with instruction condition. The implications for the study of the chronometry of emotion regulation are discussed.

INTRODUCTION

Emotion regulation has been defined as "the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features, to accomplish one's goals" (Thompson, 1994, pp. 27-28). Emotion regulation strategies include: a) attempts to increase, maintain, and decrease both negative and positive emotions; b) automatic and controlled processes; and c) strategies that manipulate the emotion-eliciting stimulus or one or more of the physiological, subjective or behavioral components of the emotional response (Gross, 1998a; Gross & Levenson, 1993).

Currently, emotions are conceptualized as unfolding processes with temporal characteristics. Frijda (1993) has emphasized that emotions are not so much discrete states as they are processes that develop over time. Emotions develop as a function of transactions between a subject and affective "moving targets" in the environment, frequently resulting in distinct periods of emotional "peaks." It is the unfolding of these transactions and their fluctuation over time that Frijda calls *emotion episodes*. Davidson (1998) has used the term *affective chronometry* to refer to the temporal processes involved in emotional responses. These temporal processes include features like rise time to peak (i.e., the amount of time an individual requires to attain maximal emotional response) and recovery time (i.e., the time necessary for components of an emotional response to return to a baseline level), parts of a broader set of emotional characteristics that comprise affective style.

Consistent with these views, Gross (1998a) has developed a process model of emotion regulation. According to this model, one of the main targets of attempts at emotion regulation is the temporal dimension of the emotion response. Emotion regulation may involve changes in the latency, rise time, magnitude, duration, and offset of responses in behavioral, experiential, or physiological domains (Gross, 2002). Specific emotion regulation strategies can be implemented at different points along the timeline of the unfolding emotional response. *Antecedent-focused* emotion regulation strategies are employed before the response tendencies have become fully activated and have generated behavioral and peripheral physiological responding. Examples of antecedent-focused emotion regulation strategies are situation selection (i.e., approaching or avoiding certain situations on the basis of their likely emotional impact); situation modification (tailoring the situation to alter its emotional impact); attentional deployment (selecting what aspect of the situation to focus on); and cognitive change (selecting the meaning to be attached to the particular aspect of the situation selected). *Response-focused* emotion regulation strategies are employed once an emotion is already underway, after the response tendencies have been generated. These strategies intensify, diminish, prolong, or curtail ongoing emotional experience, expression, or physiological responding.

Two commonly used strategies that exemplify the difference between antecedent- and response-focused emotion regulation are cognitive reappraisal and expressive suppression (Gross, 1998a; 1998b). Reappraisal is a type of cognitive change that consists in cognitively transforming the situation so as to alter its emotional impact. It influences the appraisal process itself by changing the way an event is interpreted. In contrast, suppression is a type of response modulation that consists in inhibiting ongoing emotion-expressive behavior. The model predicts that during the down regulation of negative emotion, because reappraisal is implemented early in the emotion-generative process it should decrease the emotional experience as well as emotional expression. In contrast, since suppression acts later in the emotion-generative process, it should decrease behavioral expression but be less effective in modifying the ongoing emotional experience. Experimental manipulations of reappraisal and suppression have provided support for the distinctions between these two strategies. Using emotion-eliciting films and slides, Gross and colleagues have found that while suppression does decrease expressive behavior for negative emotions like disgust and sadness, it does not lessen the unpleasant emotional experience (Gross, 1998b; Gross & Levenson, 1993, 1997; Richards & Gross, 1999). Moreover, suppression seems to increase autonomical arousal. While results are mixed across studies and physiological measures, suppression often results in increased sympathetic activation of cardiovascular and electrodermal systems (Gross, 1998b; Gross & Levenson, 1993, 1997). In contrast, reappraisal can effectively decrease expressive behavior and the reported experience of negative emotion, with no increases in sympathetic arousal (Gross, 1998b; Richard & Gross, 2000).

The experimental literature contrasting cognitive reappraisal and expressive suppression has not taken into consideration individual differences in habitual emotion regulation when examining the effects of the manipulation of these strategies. Importantly, individual differences in habitual use of reappraisal and suppression may have significant personal and interpersonal consequences. In a series of studies, Gross and John (2003) found that self-reported habitual suppression was associated with lower self-reported levels of positive emotional experience, life satisfaction and well-being, as well as with avoidance of attachment, poorer social support, and higher levels of reported depressive symptoms. In contrast, habitual use of reappraisal was associated with greater positive emotional experience, life satisfaction, and well-being, and lesser negative emotional experience and depressive symptoms. However, the interaction between habitual style and voluntary engagement in an emotion regulation strategy has not been explored. Thus, it is not possible to conclude, for example, whether suppression would be as "autonomically costly" in habitual suppressors, or whether instructions to reappraise would be equally effective in reducing negative emotional experience in people who do not habitually engage in such a strategy.

The main goal of the present study was to explore how individual differences in habitual emotion regulation style interact with specific instructions to down-regulate negative emotion using a picture perception paradigm for the elicitation of emotion (see Lang, 1995, for a review). Previous studies comparing reappraisal and suppression have used self-report measures of emotional experience and behavioral measures of expression, together with physiological measures of autonomic arousal. The present study employed physiological measures of affective chronometry related to emotional experience and expression to better characterize temporal differences between emotion regulation strategies. In recent years, the question of how the physiological component of emotional responses resolves over time has received increased attention, and research has explored the temporal characteristics of measures such as startle reflex potentiation, electromyographic (EMG) activity of facial muscles related to emotional expression, and skin conductance (SC) activity. However, only a handful of studies have performed chronometric analyses of these measures during emotion regulation tasks.

Physiological measures of affective chronometry in emotion regulation

When studying the temporal aspects of emotion regulation, physiological measures that can capture brief changes in emotional states over short periods of time in a relatively unobtrusive manner are particularly useful tools (Davidson, 1998; Jackson, Malmstadt, Larson, & Davidson, 2000). Startle reflex and facial muscle EMG are measures that have been used extensively in picture perception studies of emotional response and as indexes of affective chronometry in emotion regulation. The affective modulation of the startle reflex has been widely used as a measure of emotion-related action tendency (e.g., Bradley, Lang, & Cuthbert, 1993; Lang, Greenwald, Bradley, & Hamm, 1993; Cuthbert, Bradley, & Lang, 1996; Manber, Allen, Burton, & Kaszniak, 2000). The reflex can be elicited in experimental situations with a “startle probe” (a 50ms burst of 95db white noise) and the magnitude of the eyeblink can be measured through EMG recordings of the orbicularis oculi muscle. Extensive research by Lang and his colleagues (e.g., Vrana, Spence, & Lang, 1988; Cuthbert et al., 1996; Lang, Bradley, & Cuthbert, 1990; Lang et al., 1993) has shown that probes administered during presentation of highly arousing unpleasant images elicit eyeblink EMGs that are larger in magnitude than those elicited during the presentation of neutral or positive images, while presentation of highly arousing pleasant images inhibits the reflex relative to neutral images. These findings have been interpreted in motivational terms (Lang, 1995; Lang et al., 1992): an unpleasant foreground stimulus activates the aversive motivational system, thus potentiating the startle response, while a pleasant foreground stimulus activates the appetitive motivational system, which in turn inhibits the startle response. EMG of facial muscles involved in emotional expression provides another useful measure, as it can be reliably observed even in the absence of overt facial expressions. Activity in the corrugator supercilii muscle (involved in frowning) typically increases during processing of unpleasant stimuli, and decreases during processing of pleasant stimuli (e.g., Bradley et al., 1990; Brown & Schwartz, 1980; Lang et al., 1993; Schwartz, Ahern, & Brown, 1979; Sutton, Davidson, Donzella, Irwin, & Dottl, 1997). In addition to these measures, SC has been widely used as an index of physiological arousal in the picture perception paradigm. Self-report of arousal correlates positively with SC magnitude: SC is typically larger during exposure to both positive and negative images than during exposure to neutral images (Greenwald, Cook, & Lang, 1989; Lang et al., 1993; Cuthbert et al., 1996).

Chronometric analyses of these measures can be used to characterize the timing and intensity of an emotional response, for example, by presenting startle probes at various points in different experimental trials (Jackson et al., 2000). Davidson and colleagues have interpreted startle magnitude during picture exposure as providing an index related to the peak of emotional response, whereas startle magnitude following the *offset* of the pictures is taken to reflect the recovery from emotional challenge (Davidson, 1998). Most of the relevant previous studies have focused on the temporal resolution of these physiological measures themselves, and of startle in particular, during anticipation of a visual emotional stimulus, during its presentation, or after stimulus offset. During the anticipation phase (following a cue predicting the valence of the upcoming stimulus), startle reflex seems to be modulated by arousal: cues for upcoming positive and negative images elicit larger blinks than cues for neutral images (Dichter, Tomarken, & Baucom, 2002; Sabatinelli, Bradley, & Lang, 2001), although startle may be less potentiated during anticipation of pleasant than unpleasant images (Nitchske, Larson, Smoller, Navin, Pederson, et al., 2002). There is also evidence that SC increases during anticipation of emotional stimuli following arousal, with greater SC in anticipation of positive and negative images compared to neutral (Erickson, 1996). In contrast, corrugator activity seems to be greater in anticipation of negative than neutral or positive images (Sutton et al., 1997; but see Erickson, 1996). During the presentation of emotional visual stimuli, there is an initial 300-800ms "prepulse" period post-stimulus onset during which there is overall inhibition of startle magnitude but with greater inhibition during emotionally arousing images (Bradley, Cuthbert, & Lang, 1993). After the first second of image presentation, the expected effects of valence on startle and corrugator activity and of arousal on SCR are typically observed. Results are more mixed for startle modulation after stimulus offset, with several studies finding no significant valence effects on startle (Bradley et al., 1993; Dichter et al., 2002; Jackson, Mueller, Dolski, Dalton, Nitschke, et al., 2003), some finding a weakened valence effect (Burton, Kaszniak, McRae, & Stevens, 2003; Larson, Sutton, and Davidson, 1998), and at least one study finding an inverted, "rebound" effect, with positive images eliciting greatest blinks 3 seconds postoffset (Burton, 2003).

Few studies have used these physiological indexes to examine the temporal features of emotion regulation strategies. Gross and colleagues explored the time course of the physiological effects of expressive suppression, and found that some of its autonomic effects can be seen after the individual is given the instruction to suppress but before the onset of the emotional stimulus, i.e., while the individual is "preparing" to suppress (Gross & Levenson, 1993, 1997). Moreover, these autonomic effects seem to persist after the stimulus to be suppressed is removed (Gross, 1998b; Gross & Levenson, 1993). Jackson et al. (2000) measured eyeblink startle magnitude and corrugator activity during and after exposure to unpleasant and neutral visual stimuli. Four seconds after the onset of positive and negative images, participants were asked to suppress, enhance, or simply maintain their emotional response to the stimulus (neutral images were always accompanied by instructions to "maintain"). It is important to emphasize that unlike expressive suppression, in this paradigm instructions to "suppress" were aimed at the suppression of the emotional *experience*, not emotional expression. Startle probes were presented and corrugator EMG was analyzed at the post-picture onset, post-instruction, and post-picture offset periods. Instructions to enhance negative emotion led to larger startle eyeblinks and greater corrugator activity compared to the "maintain" and "suppress" instructions, while instructions to suppress negative emotion resulted in smaller eyeblinks and lower corrugator activity than during the "maintain" and "enhance" instructions. Moreover, startle eyeblinks during the post-instruction period were smaller than during the post-picture offset period, which the authors hypothesized might reflect an attenuation of startle due to an attentional demand caused by concurrent processing of the emotion regulation instruction and picture viewing. The opposite was true for corrugator activity: it was greater during the post-instruction period than after picture offset, which the authors attributed to the natural decay of the emotional response following stimulus offset. Using a similar enhance/maintain/suppress paradigm, Dillon and LaBar (2005) attempted to disentangle the contributions of arousal and valence to startle modulation by including both positive and negative images. They also provided participants with "enhance" and "suppress" instructions during neutral pictures in order to assess general, emotion-independent attentional/effort factors. The pattern of emotion regulation effects on startle magnitude, enhance > maintain > suppress, was the same for positive and negative trials, suggesting that startle modulation during attempts to increase or decrease emotional responses is dependent on arousal rather than valence. The authors attributed this finding to the possibility that startle may be more sensitive to arousal than valence when the individual is actively engaged in emotional responses (Lang, Bradley & Cuthbert, 1997). A compatible explanation is provided by Witvliet & Vrana (1995, 2000), who similarly found that during emotional imagery there was an effect of both valence and arousal on startle. These authors suggest that when using slides as the emotion eliciting stimuli, highly arousing positive slides are more interesting, engage more visual attention, and thus attenuate the response to the acoustic probes. In contrast, imagery does not engage sensory modality-specific attention, allowing for observation of arousal-induced potentiation of startle (Witliev & Vrana, 1995). Consistent with this explanation, Dillon and LaBar (2005) point out that in response to the "enhance" cue many participants reported imagining themselves in the scenes depicted, whereas in response to the "suppress" cue many participants reported cognitively distancing themselves from the scenes. The authors raise the possibility that differences in the use of imagery in response to the cues may explain their finding.

This latter issue highlights one characteristic of studies using the enhance/maintain/suppress paradigm that limits their ability to make inferences regarding emotion regulation effects: there is likely to be wide variability in the strategies each participant uses in order to enhance or suppress their emotional experience. In Jackson et al.'s (2000) study, common strategies reported by participants were attempts to focus on positive/negative aspects or possible outcomes, attempts to rationalize the situation, or imagining themselves or a loved one in the situation, strategies which could involve imagery, cognitive change, or attentional selection. Without knowing for sure what strategies participants used, it is difficult to attempt to explain the emotion regulation effects observed.

The present study

The present study compared two specific emotion regulation strategies believed to act at different points in the unfolding emotional response, cognitive reappraisal and expressive suppression, in a sample selected based on their self-reported habitual emotion regulation strategy (reappraisal, suppression, or both strategies without clear preference for one over the other), in order to examine the interaction between habitual emotion regulation strategies and their voluntary manipulation. In addition, as suggested in the existing literature (Jackson et al, 2000; Nitschke et al, 2002), fine-grained chronometric analyses were conducted on measures related to emotional experience, expression, and arousal (i.e., startle reflex modulation, corrugator EMG, and SCR) during stimulus presentation. The main goal of the study was to compare reappraisal and suppression during the down-regulation of negative emotions. Positively valenced stimuli were included in order to account for arousal effects, however analyses of group differences and of the chronometry of physiological measures during the regulation of positive emotion will not be reported here.

Based on the process model of emotion regulation and empirical findings reviewed above, we expected habitual and voluntary use of reappraisal to be related to overall lower levels of negative emotional experience and expression, both self-reported and as indexed by physiological measures, as well as to earlier decreases in physiological indexes of negative affect, compared to suppression. While we expected habitual and voluntary use of suppression to have comparable effects on physiological indexes of expression of negative emotion, we predicted suppression would result in higher levels of reported and physiological emotional arousal and no decreases on the experience of negative emotion, compared to reappraisal. We further predicted that when habitual style and instruction conflicted (i.e., when reappraisers were instructed to suppress or suppressors were instructed to reappraise), the manipulation would fail to override the individual's habitual style, and the response pattern predicted for the habitual style would be observed.

METHODS

Sample

Undergraduate students taking introductory psychology classes were administered the Emotion Regulation Questionnaire (Gross & John, 2003; see below for inclusion criteria) in order to identify habitual reappraisers, suppressors, and a “non-preference” group which consisted of individuals who reported engaging in both strategies habitually, without relying on either one primarily. Individuals meeting criteria for either group were invited to participate for class credit or $20 in compensation. Efforts to recruit equal numbers of participants belonging to each group were unsuccessful due to difficulty recruiting individuals meeting criteria for the reappraisers and suppressors groups. Our final sample consisted of 38 reappraisers, 27 suppressors, and 57 individuals in the non-preference group, for a total of 122 participants. In addition, while gender was balanced within the non-preference group, it was unbalanced among reappraisers and suppressors. There were roughly twice as many female than male reappraisers, and twice as many male than female suppressors. Table 1 summarizes the characteristics of the sample.

Measures and Stimuli

Emotion Regulation Questionnaire (ERQ). The ERQ (Gross & John, 2003) is a self-report measure designed to assess individual differences in the habitual use of cognitive reappraisal and expressive suppression. It consists of 10 items, 6 targeting reappraisal (e.g., “I control my emotions by changing the way I think about the situation

Table 1
Sample characteristics

	Reappraisers	Group Suppressors	Non-Preference
N	38	27	57
Instruction condition			
Reappraise	10	9	20
Suppress	15	10	22
Watch	13	8	15
Males/Females	26/74 %	63/37 %	46/54 %
Age	21.26	19.80	19.28
Education	13.40	13.12	12.98
ERQ subscale scores			
Reappraisal	36.38	19.10	27.57
Suppression	7.63	21.15	14.65

I'm in") and 4 targeting suppression (e.g., "I control my emotions by not expressing them"). Participants rate their agreement with each item on a 7-point scale. Based on 4 different samples, Gross and John (2003) reported average Chronbach's alpha reliabilities of .79 for the Reappraisal scale and .73 for the Suppression scale. Scale intercorrelations ranged from –.04 to .06, suggesting two independent factors. The ERQ was used to identify individuals for each of the three habitual regulation groups. The reappraisers group was defined as those scoring in the 75th percentile or higher (for the total sample) on the Reappraisal scale, and in the 25th percentile or lower on the Suppression scale. The inverse guidelines were used to select suppressors. Individuals in the non-preference group scored between the 25th and 75th percentiles on both scales.

International Affective Picture System (IAPS). The IAPS (Center for the Study of Emotion and Attention, 1999) is a widely used instrument for the elicitation of emotion in picture perception paradigms. It contains images that vary in normatively-rated experience of emotional valence and arousal. IAPS images normatively rated as positive, neutral, or negative, are indeed typically rated as inducing similarly valenced emotional experiences, while positively and negatively normed images are consistently rated as inducing greater levels of emotional arousal than neutral images (e.g., Vrana, Spence & Lang, 1988; Bradley et al., 1993). For this study, 144 IAPS pictures (48 of each valence) were used to elicit emotion. Table 2 shows the average valence and arousal ratings for the images used, based on normative data. Ratings are based on 9-point scales, with higher numbers reflecting more positive and more arousing ratings. Appendix A lists all the IAPS pictures used, as well as their individual normative ratings for valence and arousal.

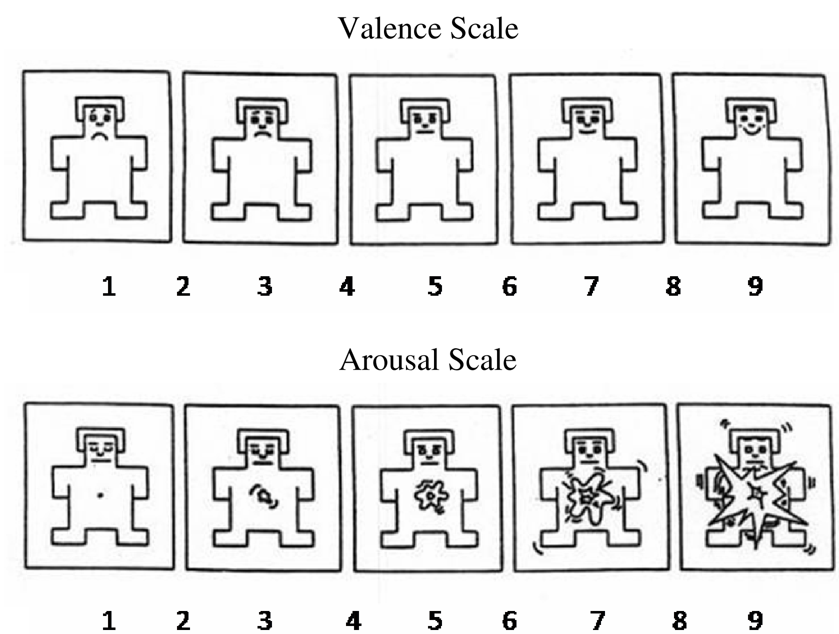
Table 2
Normative valence and arousal ratings for IAPS images used

Image type	Valence	Arousal
Positive	7.41	5.88
Neutral	5.00	3.89
Negative	2.24	6.35

Images were block randomized to approximate an even distribution of image types throughout the experiment, and no more than three images of the same valence were presented consecutively. Two stimulus sets differing in presentation order were constructed using the same images.

Self-Assessment Manikin (SAM). The SAM (Lang, 1980; see Figure 1) was designed to allow subjects to report their subjective emotional experience in response to emotion-eliciting images while minimizing the effects of language and culture. The SAM consists of two ordinal scales for self-report ratings of emotional valence and arousal, each allowing for 9-point responses. SAM ratings have been found to correlate with physiological responses to the images, with ratings of valence (higher scores indicating greater positive valence of emotional experience) correlating negatively with corrugator EMG activity and positively with zygomaticus EMG activity, while ratings of arousal correlate positively with electrodermal activity (Bradley et al., 1990; Lang, 1995; Lang et al., 1993).

Figure 1
Self-Assessment Manikin (Lang, 1980)



Physiological measures of emotional experience and expression. Corrugator and orbicularis EMG were recorded. Given that left hemiface EMG has been found to be greater than right hemiface EMG during presentation of emotional stimuli (e.g., Reminger, Kaszniak, & Dalby, 2000), recordings were made from the left side of the participant's face only. Two electrodes of 4mm inner diameter were filled with SignaGel conductive electrolyte and attached to each site, 1cm apart, with a common ground attached to the center of the forehead. Impedances of all electrode sites were below 10kohms. Two 8mm Ag-AgCl electrodes filled with Gel 101 electrode paste were attached to the palm of the left hand for the recording of skin conductance response. Electrodes were connected to BioPac bioamplifiers and a BioPac MP150 system (BIOPAC Systems, Inc.; Goleta, CA). Skin conductance recordings were sampled at 500Hz, corrugator recordings were sampled at 1000Hz, and orbicularis recordings were sampled at 2000Hz to allow for clearer resolution of startle reflex modulation.

Procedures

After informed consent was obtained and electrodes were attached, the experimenter –blind to the participant's habitual regulation strategy group– read standardized instructions for the assigned condition. Instructions were similar to those used in previous studies using emotion-eliciting pictures or films (e.g., Gross, 1998b). "Reappraise" subjects were instructed to adopt a detached attitude and to think about the images they were seeing objectively, in such a way that they did not feel anything at all. "Suppress" subjects were instructed to not let their feelings show, in such a way that a person watching them would not know they are feeling anything. “Watch” subjects were instructed to simply attend to the slides for the entire presentation period (the complete instruction scripts are provided in Appendix B). Three slides were presented for practice of the instructions, and participants in the Reappraise and Suppress conditions were asked to describe what they did while viewing these pictures in order to ensure that they were engaging in the appropriate manipulation. Instructions for the use of the SAM were provided on a computer screen, and four more images were presented on-screen as practice trials for the SAM. Startle probes were administered during the practice trials to allow for and accelerate any startle habituation effects. Clarification regarding the instructions or the rating scales were provided as needed.

During the experiment, participants sat in a comfortable, upright reclining chair in a temperature-controlled (72 degrees Fahrenheit), dimly lit room, while the experimenter remained in a separate control room. IAPS images of 800x600 resolution were displayed on a 17’’ computer monitor approximately 2 feet from the subject. Each trial consisted of 7 seconds of blank screen, 6 seconds of image presentation, followed by another 7 seconds of blank screen and presentation of the SAM scales accompanied by spoken, digitized instructions prompting the participant to provide the ratings. Stimulus presentation and sequencing scripts were controlled by the DMDX version of the DMASTR software (developed at Monash University and at the University of Arizona by K.I. Forster and J.C. Forster) and executed on a Gateway PC with Intel® Pentium processor. Physiological measures were recorded for the 3 seconds before, 6 seconds during, and 3 seconds after image presentation, for a total of 12s per trial. Startle probes were administered 2, 3.5, and 5 seconds after image onset. For each of the 48 pictures of each valence, 12 pictures had probes at each probe time, and 12 pictures were not accompanied by probes. Acquisition and reduction of psychophysiological data were performed using AcqKnowledge 3.9 software (BIOPAC Systems Inc.; Goleta, CA) on a Gateway PC with Intel® Pentium processor. Startle data for 8 participants, corrugator data for 5 participants, and skin conductance data for 3 participants were lost due to experimenter or equipment error. This data loss was comparably distributed across habitual groups and instruction conditions.

Physiological data reduction

Orbicularis and corrugator EMG data were amplified 1000 times and processed off-line. Conditioning included band-pass filtering in the range of 10 to 500 Hz with a Hamming window (1001 coefficients; Hamming, 1977), signal rectification, and for the orbicularis signal waveform smoothing over a moving window of 10 points. The SCR signal was low-pass filtered online (10Hz) and amplified 20 times.

Startle reflexes were defined as positive peak-to-peak orbicularis activity within a 150ms time window after startle probe onset. Valid startle responses were defined as those changes in orbicularis activity that exceeded mean resting baseline levels, and trials in which orbicularis data did not meet this criterion were dropped from the analysis. This resulted in the loss of 4.1% of the total number of startle responses. In addition, 3 participants were excluded from the startle analyses because more than 20% of their trials failed to reach threshold. For the chronometric analysis of startle resolution, separate averages were calculated for the 2, 3.5, and 5s probe times. For corrugator data, change scores were calculated by subtracting the mean muscle activity for the 3-second baseline period from the mean muscle activity from seconds 2, 3, and 4 during image presentation. For the chronometry analysis, we computed means for each second of image presentation. Two separate skin conductance measures were obtained, only for trials without probes. Skin conductance level (SCL) was defined as the average magnitude of the skin conductance signal over the 6 seconds of image presentation. A change score was used, obtained by subtracting baseline SCL for the 3 seconds prior to image presentation from the SCL during image presentation. For the chronometric analysis of SCL, means were obtained for each 0.5 seconds of image presentation. Change scores for each half-second were also obtained by subtracting baseline SCL. In addition, skin conductance responses (SCR) were defined as positive trough-to-peak changes in skin conductance. We included responses with onset between 1 and 3 seconds after picture onset and with peak 1 to 4 seconds after response onset. For the analysis of SCR chronometry, time-to-peak scores (i.e., time from image onset to peak skin conductance signal) were calculated. An unexpectedly low number of SCR's was obtained. The average participant displayed scorable SCR's in response to only 25% of non-probe trials, and 14 participants had no scorable SCR's during non-probe trials. The proportion of scorable responses and the percentage of participants with no scorable responses did not differ by habitual group or instruction condition.

Raw data for all physiological measures were converted into z-scores on a within-subject basis to reduce the influence of high between-subjects variability in overall response magnitudes. Z-scores were computed based on the means and standard deviations across image valences. Outlier responses identified as scores 3 or more standard deviations above or below the mean for an individual were excluded. This criterion resulted in the exclusion of 1.1% of startle responses, 0.6% of corrugator responses, and 0.2% of skin conductance responses (note that while skin conductance data was standardized to detect outlier responses, the unstandardized results are presented below). For each physiological measure, data from participants falling 3 or more standard deviations above or below the sample mean for that variable were excluded. This resulted in the loss of startle data from 5 participants, corrugator data from 4 participants, and skin conductance data from 2 participants.

RESULTS

For each dependent variable a repeated measures analysis of variance (ANOVA) was performed for positive, neutral and negative images, with image type as the within-subject variable and group and instruction as between-subjects factors. Table 3 lists the means and standard deviations for each dependent variable by image type.

Table 3
Means and standard deviations for all variables by image type [M (SD)]

	Image type		
Measure	Positive	Neutral	Negative
SAM Valence[a]	6.18 (0.73)	4.93 (0.32)	2.93 (0.89)
SAM Arousal[a]	4.33 (1.45)	3.06 (1.19)	5.10 (1.62)
Startle reflex[a]	–0.09 (0.14)	–0.07 (0.16)	0.04 (0.18)
Corrugator EMG[a,b]	–0.19 (0.23)	–0.02 (0.14)	0.19 (0.23)
Skin conductance level[b,c]	–0.10 (0.40)	–0.13 (0.34)	–0.11 (0.33)
Skin conductance response[c]	0.98 (.083)	0.70 (0.64)	0.74 (0.62)

[a] Within-subject *z*-score. [b] Change score from baseline [c] In μSiemens.

As mentioned before, while positive pictures were included in order to account for arousal effects, group differences were examined during exposure to negative images only. For this purpose, significant effects were explored further with univariate ANOVAs. Table 4 lists the means and standard deviations for each dependent variable by instruction condition. A similar strategy was followed for the chronometric analyses of physiological measures during viewing of negative images. Repeated measures ANOVAs were performed initially with time as the within-subject variable and group and instruction as between-subject factors. Significant effects were explored further through univariate ANOVAs performed separately for each time point. Given the unequal distribution of gender across groups, gender was initially entered in the analyses together with group and instruction. If no significant main effect or interaction was found for gender, it was removed from the analysis to capitalize on degrees of freedom.

Table 4
Means and standard deviations for all variables by instruction condition [M (SD)]

	Instruction		
Measure	Reappraise	Suppress	Watch
SAM Valence[a]	3.24 (0.98)	2.55 (0.69)	3.11 (0.86)
SAM Arousal[a]	4.63 (1.73)	5.65 (1.41)	4.93 (1.59)
Startle reflex[a]	0.05 (0.19)	0.07 (0.20)	0.00 (0.16)
Corrugator EMG[a,b]	0.08 (0.16)	0.21 (0.20)	0.27 (0.29)
Skin conductance level[b,c]	–0.06 (0.25)	–0.11 (0.24)	–0.16 (0.48)
Skin conductance response[c]	0.85 (0.53)	0.58 (0.53)	0.84 (0.77)

[a] Within-subject *z*-score. [b] Change score from baseline [c] In μSiemens.

Given the small cell sizes for the reappraiser and suppressor groups, we calculated effect sizes for each dependent variable, in order to explore whether there might be effects that were undetected due to lack of power. Table 5 lists the effect sizes for each comparison by instruction condition. Finally, no effect was found for stimulus set on any of the variables, and all results presented are collapsed across stimulus set.

Table 5
Effect sizes and 95% confidence intervals for all comparisons by instruction condition [ES (95% CI)]

	Instruction		
Measure	Reappraise vs. Watch	Suppress vs. Watch	Reappraise vs. Suppress
SAM Valence	0.14	–0.72	0.82
	(–0.33; 0.61)	(–1.20; –0.25)	(0.37; 1.26)
SAM Arousal	–0.18	0.48	–0.64
	(–0.65; 0.29)	(0.01; 0.95)	(–1.09; –0.20)
Startle reflex	0.29	0.38	–0.10
	(–0.21; 0.78)	(–0.09; 0.85)	(–0.56; 0.35)
Corrugator EMG	–0.80	–0.24	–0.70
	(–1.30; –0.31)	(–0.69; 0.20)	(–1.16; –0.24)
Skin conductance level	0.27	0.14	0.20
	(–0.20; 0.74)	(–0.32; 0.59)	(–0.23; 0.63)
Skin conductance response	0.01	–0.40	0.50
	(–0.51; 0.54)	(–0.90; 0.11)	(0.00; 1.01)

Self-reports of valence

As expected, a significant effect of image type was found, $F(2, 120) = 305.00$, $p < .000$. Both the linear, $F(1) = 571.65$, $p < .000$, and quadratic, $F(1) = 188.54$, $p < .000$, effects were significant. Negative images were rated as more unpleasant than neutral, $t(121) = 24.77$; $p < .000$, and positive, $t(121) = 23.91$; $p < .000$, images. Positive images were rated as more pleasant than neutral, $t(121) = 19.27$, $p < .000$ images.

For valence ratings of negative images there were also main effects of gender, $F(1) = 4.58$, $p = .035$, and instruction, $F(2) = 4.74$, $p = .011$. Females rated negative images as more negative than males, $t(120) = 3.22$, $p = .002$, and instructions to suppress resulted in more negative ratings than instructions to reappraise, $t(84) = 3.76$, $p < .000$, and watch $t(81) = –3.15$, $p = .002$, which did not differ from each other, $t(73) = .58$, $p =$

.566. Given the lack of difference between the reappraise and watch conditions, we compared the obtained valence ratings to the normative valence ratings for our stimulus sets, in order to clarify whether our instructions to reappraise had failed to reduce unpleasantness ratings or whether instructions to watch unexpectedly reduced unpleasantness ratings. For this purpose, normative valence scores were first transformed to match the direction of the SAM valence scale used in this study, with lower scores indicating more unpleasant ratings. All instruction conditions resulted in less negative ratings (i.e., higher valence scores) than those from the normative sample. Instructions to reappraise and watch resulted in ratings 1.71 and 1.48 standard deviations above the normative mean, respectively, while instructions to suppress resulted in ratings 0.52 standard deviations above the normative mean.

Self-reports of arousal

As expected, a significant effect of image type was found, $F(2, 120) = 169.37$, $p < .000$. Both the linear, $F(1) = 34.44$, $p < .000$, and quadratic, $F(1) = 207.08$, $p <.000$, effects were significant. Neutral images were rated as less arousing than both positive, $t(121) = 15.34$, $p < .000$, and negative, $t(121) = -14.25$, $p < .000$, images. Negative images were rated as more arousing than positive images, $t(121)= -5.42$, p < .000.

For arousal ratings of negative images there was a main effect of instruction, $F(2) = 4.11$, $p = .019$. Instructions to suppress resulted in higher arousal ratings than instructions to reappraise, $t(84)= -2.97$, $p = .004$, and watch, $t(81) = 2.06$, $p = .043$, which did not differ from each other, $t(73) = -.76$, $p = .451$. Again, we compared the arousal ratings to the normative ratings for the stimulus sets. Instructions to reappraise and watch resulted in arousal ratings 2.56 and 2.12 standard deviations below the normative mean, while instructions to suppress resulted in arousal ratings 1.05 standard deviations below the normative mean.

Startle reflex modulation and chronometry

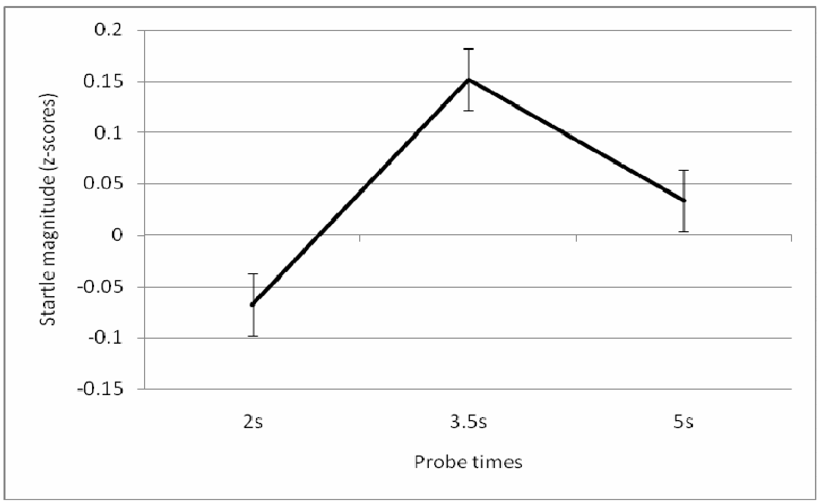
As expected, a significant effect of image type on startle magnitude was found, $F(2, 104) = 14.15$, $p < .000$. Both the linear $F(1) = 27.95$, $p <.000$, and quadratic, $p =.029$ effects were significant. Probes during negative images resulted in significantly larger orbicularis responses than during neutral, $t(105) = -4.11$, $p < .000$, and positive, $t(105) = -5.29$, $p < .000$, images. However, startle response magnitude did not differ for positive and neutral images, $t(105) = -.88$, $p = .379$. During viewing of negative images, there were no effects of instruction, $F(2) = 1.16$, $p = .317$, or group $F(2) = .36$, $p = .697$, on startle response magnitude.

The chronometric analysis of startle responses elicited during viewing of negative images revealed a significant effect of time, $F(2, 95) = 14.03$, $p < .000$. Probes at 2s resulted in smaller blinks than probes at 3.5s, $t(105) = -5.84$, $p = .000$, and 5s, $t(104) = -2.93$, $p = .004$; probes at 5s resulted in smaller blinks than probes at 3.5s, $t(104) = 2.78$, $p = .006$. Figure 2 illustrates the time course of the startle response for negative images across groups. In addition, a significant group by instruction by time interaction was found, $F(8) = 1.99$, $p = .050$. At the 5s probe time and for instructions to reappraise only, the non-preference group showed larger startle responses than suppressors, $t(21) = -2.74$,

p = .012, and marginally larger startle responses than reappraisers, $t(24) = -1.86$, p =.076, while reappraisers and suppressors did not differ from each other, $t(15) = 1.08$, p = .296. There were no significant group differences at the earlier probe times.

Figure 2

Startle reflex magnitude for negative images by probe time



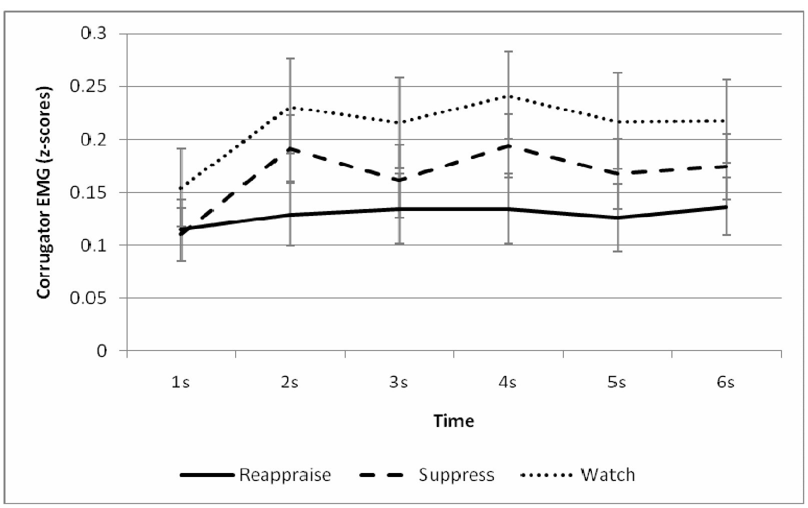
Corrugator EMG magnitude and chronometry

As expected, a significant effect of image type was found, $F(2, 111) = 41.22$, $p <$ .000. For this measure, only the linear effect was significant, $F(1) = 83.16$, $p < .000$. Negative images resulted in greater corrugator EMG activity than neutral, $t(112) = -7.23$, $p < .000$, and positive, $t(112) = -9.12$, $p < .000$, images, and positive images resulted in less corrugator activity than neutral images, $t(117) = -6.90$, $p < .000$. For negative images, a main effect of instruction was found, $F(2) = 7.74$, $p = .001$, with instructions to reappraise resulting in less corrugator activity than instructions to suppress, $t(77) = -3.24$,

p = .002, and watch, $t(66) = -3.33$, p =.001, which did not differ from each other, $t(77)$ = –1.04, p = .303.

Analyses of corrugator chronometry during viewing of negative images revealed a significant effect of time, $F(5, 104) = 6.17$, $p < .000$, with lower mean corrugator levels during the first second of image presentation than during all other seconds (all comparisons at $p < .01$). There were no interactions between time and group, $F(10, 210)$ = 1.53, p = .129, or instruction, $F(10, 210) = 0.89$, p = .548. However, examination of the difference scores between seconds 2 and 1 revealed a significant effect of instruction, $F(2) = 3.22$, p = .044, with instructions to watch resulting in larger increases in corrugator activity from second 1 to second 2 than instructions to reappraise, $t(70) = -2.84$, p = .006. Figure 3 illustrates the time course for corrugator activity by instruction condition.

Figure 3
Mean corrugator EMG activity by second of negative image presentation

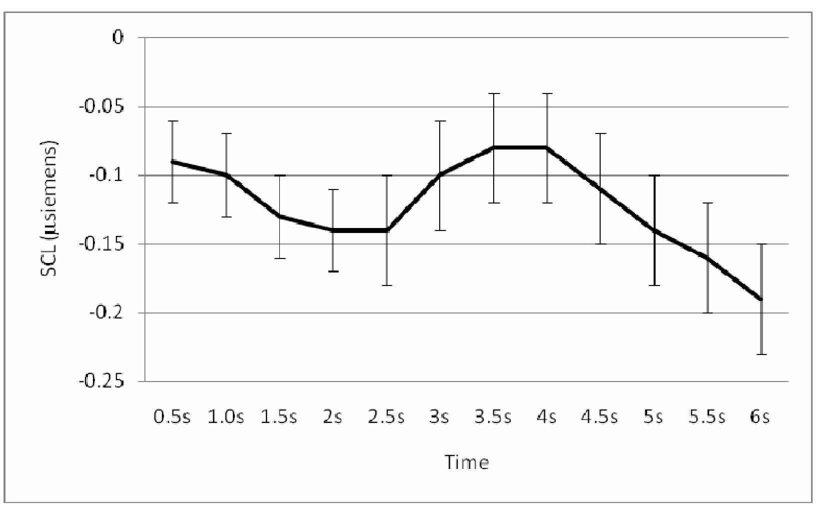


Skin conductance levels, responses and chronometry

Analysis of SCL failed to identify the expected effect of image type, $F(2, 105) = .48$, $p = .622$, as mean SCL scores did not differ among positive, negative, and neutral images. Moreover, for all image types skin conductance changes from baseline were negative, indicating that skin conductance levels were overall *lower* during image viewing than during the baseline period.

For negative images, there were no significant effects of group, $F(2) = .08$, $p = .486$, or instruction, $F(2) = .099$, $p = .398$, on SCL. Chronometric analyses did reveal a significant time effect, $F(11, 96) = 6.12$, $p < .000$, but no significant interactions between time and group, $F(22, 194) = .85$, $p = .667$, or instruction, $F(22, 194) = .85$, $p = .259$. Figure 4 illustrates the time course of skin conductance levels during exposure to negative images.

Figure 4
Mean skin conductance levels for each half-second of negative image presentation



Analysis of skin conductance responses revealed a significant effect of image type, *F*(2, 69) = 11.11, $p < .000$. There was a significant linear effect, *F*(1) = 19.05, p < .000, while the quadratic effect failed to reach significance, *F*(1) = 2.66, *p* = .108. Contrary to expectations, positive images resulted in larger SCR's than neutral, *t*(84) = 3.55, *p* = .001 and negative, *t*(84) = 3.29, *p* = .001, images, while negative and neutral images did not differ, *t*(80) = .61; *p* = .546. Moreover, during viewing of negative images, neither group, *F*(2) = .32, *p* = .730, nor instruction, *F*(2) = 1.94, *p* = .151, had an effect on SCR. Mean time-to-peak for negative images was 3.62s (*SD* = .97). There were no effects of group, *F*(2) = 1.68, *p* =.193, or instruction, *F*(2) = .78, *p* =.455, on time-to-peak.

DISCUSSION

The main purpose of the present study was to explore the interaction between habitual emotion regulation style and instructions to engage in reappraisal and suppression. Overall, self-reported preferred emotion regulation strategy did not have an effect on self-report or physiological measures, nor did it interact with instruction. This lack of effect suggests that the effects of these regulation instructions can be observed independent of an individual's habitual style. On the other hand, differences between instructions to reappraise and suppress were seen primarily, though not exclusively, on self-report variables. Expressive suppression showed the predicted effects, resulting in higher unpleasantness and arousal ratings. Instructions to reappraise resulted in lower unpleasantness and arousal ratings than instructions to suppress, but they did not differ from instructions to just watch.

Instructions to suppress had no effect on physiological measures, i.e., they did not result in enhanced potentiation of the startle reflex, increased corrugator EMG activity, higher mean skin conductance levels, or greater skin conductance responses than instructions to just watch. The lack of effect on corrugator EMG is particularly interesting given the nature of expressive suppression, and given that previous studies (Gross, 1998b; Gross & Levenson, 1993, 1997; Richards & Gross, 1999) have shown that it can effectively reduce outward emotional expression. Consistent with Gross' model, by failing to change the appraisal of the unpleasant stimulus (as reflected in the self-report ratings), suppression seems to be unable to interrupt the elicitation of the facial EMG expressive component, even if it can successfully inhibit visible outward expression through voluntary muscle control. In contrast, reappraisal did decrease corrugator activity. Again consistent with the model, this suggests that corrugator activity may be reduced when there is a change in the appraisal of the stimulus, which in turn reduces the expressive component of the emotional response, in comparison to when attempts are made at modifying a response already underway.

Like suppression, reappraisal did not have an effect on startle or skin conductance. The lack of effect of these instructions on the startle reflex may indicate that, as consciously regulated strategies, they impact the conscious emotional experience but not the relative activation of more automatic approach and withdrawal systems and this defensive reflex. Studies using the enhance/maintain/suppress paradigm have found that startle magnitude can indeed be altered, increasing when subjects enhance their negative experience in comparison to maintain and suppress instructions. It is difficult to reconcile the two sets of findings given the differences between the two paradigms. In particular, participants in enhance/maintain/suppress studies report often engaging in cognitive distancing when instructed to suppress negative emotion, a strategy which seems similar to our instructions to reappraise. It should also be noted that the non-significant but moderate effect size of instructions to suppress on startle enhancement in the present study suggests that an effect may be detected on a larger sample.

The lack of effect of reappraisal and suppression on skin conductance measures is difficult to interpret given our failure to replicate the expected effect of image type, which raises questions regarding the validity of the measures in this experiment. With that in mind, it should be noted that previous findings regarding the effects of suppression on autonomic activation are mixed, and at least one study failed to find an effect on electrodermal activity (coincidentally, the only study that also used slides instead of films to elicit negative emotion).

Perhaps the most intriguing result was the lack of difference in self-report measures between instructions to reappraise and just watch. The small effect sizes on these measures when comparing the two conditions suggest that this finding is not likely due to lack of power to detect an effect. Moreover, comparison to the normative ratings of the images suggests that instructions to watch indeed resulted in relatively large decreases on unpleasantness and arousal ratings (between 1.5 and 2 standard deviations below normative ratings). One interesting possibility is that directing and maintaining the attentional focus on the stimulus decreases experiential (and potentially physiological) components of negative emotion. Turning and maintaining attention outward towards the stimulus may interrupt the "iterative reappraisal" that can take place when confronted with an emotional situation. In other words, instead of a linear stimulus – appraisal – reappraisal process, an iterative process is more likely: Attention is directed at the stimulus, the stimulus is appraised, it elicits an emotional reaction, this reaction is appraised in turn, and a series of reappraisals of the stimulus and the response follow. Maintaining attention on the stimulus may short-circuit this process. This explanation is consistent with principles of mindfulness-based approaches, which emphasize non-judgmental, non-reactive, present-moment awareness (Kabat-Zinn, 1990). It is also consistent with David Barlow's conceptualization of anxious apprehension, in which it is the turning inward of attention towards physiological reactions which triggers a chain of appraisals that potentially results in panic. According to Barlow, it is this "shift in attention to a self-evaluative focus" that further increases arousal and negative affect (Barlow, 2002, p.65).

There were no effects of group or instruction on the chronometry of physiological measures. One possibility is that the between-subjects design, in which subjects received the instructions beforehand, blurred the differences between antecedent- vs. response-focused strategies. This may have resulted in somewhat of an "anticipatory appraisal" instead of true reappraisal, similar to getting ready before a stressful situation (like a feedback session with one's supervisors) by appraising the situation in non-emotional terms in advance (e.g., by telling oneself, "It's going to be difficult, but this will be helpful and they mean well."). Another possibility is that differences in chronometry would be observable on a larger scale. For example, the effects of suppression may be observable several seconds, minutes, or even hours after an emotional episode during which the individual engaged in suppression. Consistent with this possibility, a recent study using functional magnetic resonance imaging to examine the neural bases of reappraisal and suppression (Goldin, McRae, Ramel, & Gross, in press) found that while reappraisal resulted in increases in prefrontal cortex (PFC) within 5 seconds of the onset of an emotion eliciting film, PFC responses during suppression were observed 10.5 to 15 seconds into the film. It is possible that chronometry differences in startle reflex, corrugator EMG, and skin conductance measures would be observable during time periods longer than the 6-second image presentation we examined. Alternatively, reappraisal may not be a truly antecedent-focused strategy. Perhaps a stimulus needs to be appraised and a response needs to be elicited, before self-monitoring determines the need to engage in reappraisal.

Limitations and future directions

One limitation of the study was the small sample sizes for some cells due to the difficulty recruiting reappraisers and suppressors. However, the modest to small effect sizes on most variables where effects were not found suggest that it is unlikely that we failed to detect large effects that would have been detected with a larger sample. A related limitation is the stringent criteria used to select reappraisers and suppressors, which were imposed in consideration of internal validity but may decrease our power to generalize conclusions. Moreover, the large number of individuals meeting the reappraiser and suppressor criteria who declined to participate raises questions regarding how those individuals might differ from those who agreed to participate. In addition, while participants were given thorough instructions and given the opportunity to practice, receive feedback, and ask questions regarding their instructions, we did not formally assess how well they remained engaged in the instructions throughout the experiment with a debriefing at the end.

Regarding the study of affective chronometry during emotion regulation, it will be helpful to conduct fine-grained analyses of the anticipation and recovery periods to be able to capture group differences that may not be evident during the brief slide presentation period. Previous studies exploring individual differences (i.e., frontal asymmetry and anxiety symptoms) in the temporal processes of emotional responses (indexed by the resolution of the startle reflex, e.g., Jackson et al., 2003; Larson, Nitschke & Davidson, 2007; Larson, Sutton, & Davidson, 1998) have found individual differences to affect the recovery from aversive stimuli, even in the absence of group differences during stimulus presentation. These authors have suggested that individual differences during stimulus presentation might be less pronounced than following picture presentation because an acute emotional stimulus is likely to elicit a normative response across subjects, yet individuals are likely to differ widely in time to recover. Similarly, the use of other emotion-eliciting methods (e.g., interpersonal tasks, imagery, experience sampling) would help capture a larger scale of the time course of the response. The development of reliable methods to assess how different emotion regulation strategies affect the time course of the experiential and physiological components of the emotional response could have relevant clinical applications, by eventually allowing the comparison of different interventions for the regulation of emotional symptoms like anxiety. Finally, a question related to individual differences remains regarding the stimuli used in this study. Perhaps pictures are effective at reliably eliciting moderate levels of emotion, but they might not be powerful enough to actually signal the need for habitual regulation to be engaged. Additional studies addressing these questions by a) using different methods to elicit emotion, and b) exploring anticipatory and recovery periods, are needed before confidently concluding that reported preferred regulation style does not interact with instructions to regulate emotion through reappraisal and suppression, or that these two strategies do not differ in their time course.

APPENDIX A

NORMATIVE VALENCE AND AROUSAL RATINGS FOR IAPS IMAGES USED

Image number	Valence Mean	Valence SD	Arousal Mean	Arousal SD
Positive				
1463	7.45	1.76	4.79	2.19
1510	7.01	2.07	4.28	2.47
1540	7.15	1.96	4.54	2.35
1590	7.18	1.64	4.74	2.13
1710	8.34	1.12	5.41	2.34
1811	7.62	1.59	5.12	2.25
2040	8.17	1.60	4.64	2.54
2050	8.20	1.31	4.57	2.53
2070	8.17	1.46	4.51	2.74
2091	7.68	1.43	4.51	2.28
2160	7.58	1.69	5.16	2.18
2340	8.03	1.26	4.90	2.20
4220	8.02	1.93	7.17	2.69
4290	7.61	2.56	7.2	2.63
4599	7.12	1.48	5.69	1.94
4607	7.03	1.84	6.34	2.16
4608	7.07	1.66	6.47	1.96
4609	6.71	1.67	5.54	2.05
4611	6.62	1.82	6.04	2.11
4640	7.18	1.97	5.52	2.28
4652	6.79	2.02	6.62	2.04
4659	6.87	1.99	6.93	2.07
4660	7.40	1.36	6.58	1.88
4664	6.61	2.23	6.72	2.08
4680	7.25	1.83	6.02	2.27
5260	7.34	1.74	5.71	2.53
5470	7.35	1.62	6.02	2.26
5621	7.57	1.42	6.99	1.95
5623	7.19	1.44	5.67	2.32
5629	7.03	1.55	6.55	2.11
7270	7.53	1.73	5.76	2.21

Image number	Valence Mean	Valence SD	Arousal Mean	Arousal SD
7502	7.75	1.4	5.91	2.31
8030	7.33	1.76	7.35	2.02
8034	7.06	1.53	6.3	2.16
8040	6.64	1.56	5.61	2.01
8080	7.73	1.34	6.65	2.2
8090	7.02	1.33	5.71	2.1
8170	7.63	1.34	6.12	2.3
8180	7.12	1.88	6.59	2.12
8190	8.10	1.39	6.28	2.57
8200	7.54	1.37	6.35	1.98
8210	7.53	1.31	5.94	2.07
8350	7.18	1.56	5.18	2.28
8370	7.77	1.29	6.73	2.24
8400	7.09	1.52	6.61	1.86
8420	7.76	1.55	5.56	2.38
8470	7.74	1.53	6.14	2.19
8501	7.91	1.66	6.44	2.29
Neutral				
1112	4.71	1.70	4.6	2.44
1230	4.09	1.63	4.85	2.25
1310	4.60	1.62	6.00	1.80
1390	4.50	1.56	5.29	1.97
2200	4.79	1.38	3.18	2.17
2351	5.49	2.04	4.74	2.05
2410	4.62	1.72	4.13	2.29
2690	4.78	1.43	4.02	2.07
2720	5.43	1.59	3.43	1.91
2840	4.91	1.52	2.43	1.82
4001	5.24	2.45	5.24	2.49
4004	5.14	1.85	4.44	2.14
5010	7.14	1.50	3.00	2.25
5500	5.42	1.58	3.00	2.42
5530	5.38	1.60	2.87	2.29
5533	5.31	1.17	3.12	1.92
5731	5.39	1.58	2.74	1.95
5920	5.16	1.92	6.23	2.08
5940	4.23	1.68	6.29	1.85

Image number	Valence Mean	Valence SD	Arousal Mean	Arousal SD
6150	5.08	1.17	3.22	2.02
6900	4.76	2.06	5.64	2.22
6910	5.31	2.28	5.62	2.46
7000	5.00	0.84	2.42	1.79
7002	4.97	0.97	3.16	2.00
7006	4.88	0.99	2.33	1.67
7009	4.93	1.00	3.01	1.97
7025	4.63	1.17	2.71	2.2
7034	4.95	0.87	3.06	1.95
7050	4.93	0.81	2.75	1.8
7060	4.43	1.16	2.55	1.77
7090	5.19	1.46	2.61	2.03
7100	5.24	1.20	2.89	1.70
7130	4.77	1.03	3.35	1.90
7150	4.72	1.00	2.61	1.76
7170	5.14	1.28	3.21	2.05
7207	5.15	1.46	3.57	2.25
7233	5.09	1.46	2.77	1.92
7283	5.50	1.84	3.81	2.01
7500	5.33	1.44	3.26	2.18
7560	4.47	1.65	5.24	2.03
7820	5.39	1.41	4.21	2.05
8060	5.36	2.23	5.31	1.99
8160	5.07	1.97	6.97	1.62
9070	5.01	1.89	3.63	2.03
9210	4.53	1.82	3.08	2.13
9401	4.53	1.31	3.88	1.98
9402	4.48	2.12	5.07	2.15
9411	4.63	1.58	5.37	1.97
Negative				
1050	3.46	2.15	6.87	1.68
1111	3.25	1.64	5.2	2.25
1274	3.17	1.53	5.39	2.39
1300	3.55	1.78	6.79	1.84
2053	2.47	1.87	5.25	2.46
2205	1.95	1.58	4.53	2.23
2710	2.52	1.69	5.46	2.29

Image number	Valence Mean	Valence SD	Arousal Mean	Arousal SD
2800	1.78	1.14	5.49	2.11
3000	1.45	1.20	7.26	2.10
3010	1.71	1.19	7.16	2.24
3030	1.91	1.56	6.76	2.10
3053	1.31	0.97	6.91	2.57
3060	1.79	1.56	7.12	2.09
3071	1.88	1.39	6.86	2.05
3080	1.48	0.95	7.22	1.97
3110	1.79	1.30	6.70	2.16
3120	1.56	1.09	6.84	2.36
3130	1.58	1.24	6.97	2.07
3140	1.83	1.17	6.36	1.97
3150	2.26	1.57	6.55	2.20
3170	1.46	1.01	7.21	1.99
3220	2.49	1.29	5.52	1.86
3350	1.88	1.67	5.72	2.23
3400	2.35	1.90	6.91	2.22
3500	2.21	1.34	6.99	2.19
3530	1.80	1.32	6.82	2.09
6210	2.95	1.83	6.34	2.14
6260	2.44	1.54	6.93	1.93
6312	2.48	1.52	6.37	2.30
6313	1.98	1.38	6.94	2.23
6360	2.23	1.73	6.33	2.51
6530	2.76	1.86	6.18	2.02
6540	2.19	1.56	6.83	2.14
6570	2.19	1.72	6.24	2.16
6830	2.82	1.81	6.21	2.23
7361	3.10	1.73	5.09	2.48
7380	2.46	1.42	5.88	2.44
9006	2.34	1.59	5.76	2.46
9040	1.67	1.07	5.82	2.15
9120	3.20	1.75	5.77	1.94
9160	3.23	1.64	5.87	1.93
9250	2.57	1.39	6.60	1.87
9252	1.98	1.59	6.64	2.33
9410	1.51	1.15	7.07	2.06

Image number	Valence Mean	Valence SD	Arousal Mean	Arousal SD
9800	2.04	1.57	6.05	2.71
9810	2.09	1.78	6.62	2.26
9911	2.30	1.37	5.76	2.10
9921	2.04	1.47	6.52	1.94

APPENDIX B

SCRIPTS FOR EACH INSTRUCTION CONDITION

"Reappraise" condition

We are interested in studying the emotions that people feel in response to different types of stimuli. We will show you a series of pictures and then ask you to describe how these pictures made you feel. The pictures will appear on the screen one at a time, for a few seconds. Some of them may make you feel positive emotions. Some may make you feel negative emotions. Some may make you feel no emotion at all. There are three things we need you to do:

First, we need you to pay attention to the images. While some of the pictures may be difficult to look at, it is very important that you attend to the picture for the entire period it is presented on the screen. Your eyes should be directed at the monitor for the whole time that the pictures are shown.

Second, while you look at the pictures, we want you to adopt a detached, unemotional attitude as you watch them. In other words, as you look at the pictures, try to think about what you are seeing objectively, so that you do not feel anything t all. Remember, we do want you to watch the pictures carefully, but think about what you see in a way that you don't feel anything at all.

Let me show you some images similar to those that you will be seeing during the experiment. For example, what could you think about this picture in order to no feel anything at all? (Show positive, negative, and neutral images.)

Good. So those are the first two things we need you to do, pay attention to the pictures but thinking about them in a way that you do not feel anything at all. The third thing we need you to do is to describe the way you felt while looking at the picture. After showing you the picture for a few seconds, two different scales will appear on the screen, one at a time. Each scale measures a different dimension of your emotional experience. We will show you how to rate your emotional experience in these two dimensions in a minute, but basically you will give us one number for each scale, depending on how you felt. You just have to say your ratings out loud, so we can hear you over the intercom. It is very important that you rate your emotional experience, that is, what you actually felt while you viewed the picture. You're not rating the picture itself, so don't think, for example, "That's a pretty kitten, so I'll rate it positive," or "That person must be feeling bad, so I'll rate it negative." You're not rating the way you think you're supposed to feel, so don't think, "That's an ice cream cone and I like ice cream, so I'll rate it positive," or "She told me to try not to feel anything, so I will rate it as neutral." You should *only* base your ratings on how you actually felt while viewing the picture.

Do you have any questions?

"Suppress" condition

We are interested in studying the emotions that people feel in response to different types of stimuli. We will show you a series of pictures and then ask you to describe how these pictures made you feel. The pictures will appear on the screen one at a time, for a few seconds. Some of them may make you feel positive emotions. Some may make you feel negative emotions. Some may make you feel no emotion at all. There are three things we need you to do:

First, we need you to pay attention to the images. While some of the pictures may be difficult to look at, it is very important that you attend to the picture for the entire period it is presented on the screen. Your eyes should be directed at the monitor for the whole time that the pictures are shown.

Second, while you look at the pictures, we want you to behave in such a way that a person watching you would not know that you are feeling anything at all. In other words, no matter how good or bad the picture makes you feel, if I look at you, I should not be able to tell that you are feeling anything.

Let me show you some images similar to those that you will be seeing during the experiment. Remember, as I show you these pictures, I want you to act in such a way that I cannot tell what you're feeling.

(Show positive, negative, and neutral pictures).

Good. So those are the first two things we need you to do, pay attention to the pictures but without showing any emotion. The third thing we need you to do is to describe the way you felt while looking at the picture. After showing you the picture for a few seconds, two different scales will appear on the screen, one at a time. Each scale measures a different dimension of your emotional experience. We will show you how to rate your emotional experience in these two dimensions in a minute, but basically, you will give us one number for each scale, depending on how you felt. You just have to say your ratings out loud, so we can hear you over the intercom. It is very important that you rate your emotional experience, that is, what you actually felt while you viewed the picture. You're not rating the picture itself, so don't think, for example, "That's a pretty kitten, so I'll rate it positive," or "That person must be feeling bad, so I'll rate it negative." You're not rating the way you think you're supposed to feel, so don't think, "That's an ice cream cone and I like ice cream, so I'll rate it positive," or "She told me to act as if I'm not feeling anything, so I will rate it as neutral." You should *only* base your ratings on how you actually felt while viewing the picture.

Do you have any questions?

"Watch" condition

We are interested in studying the emotions that people feel in response to different types of stimuli. We will show you a series of pictures and then ask you to describe how these pictures made you feel. The pictures will appear on the screen one at a time, for a few seconds. Some of them may make you feel positive emotions. Some may make you feel negative emotions. Some may make you feel no emotion at all. There are two things we need you to do:

First, we need you to pay attention to the images. While some of the pictures may be difficult to look at, it is very important that you attend to the picture for the entire period it is presented on the screen. Your eyes should be directed at the monitor for the whole time that the pictures are shown. Let me show you a few images similar to those you will be seeing during the experiment. Remember, pay attention to the pictures for the whole time I show them to you.

(Show positive, negative, and neutral images.)

Good. The second thing we need you to do is to describe the way you felt while looking at the picture. After showing you the picture for a few seconds, two different scales will appear on the screen, one at a time. Each scale measures a different dimension of your emotional experience. We will show you how to rate your emotional experience in these two dimensions in a minute, but basically, you will give us one number for each scale, depending on how you felt. You just have to say your ratings out loud, so we can hear you over the intercom. It is very important that you rate your emotional experience, that is, what you actually felt while you viewed the image. You're not rating the picture itself, so don't think, for example, "That's a pretty kitten, so I'll rate it positive," or "That person must be feeling bad, so I'll rate it negative." You're not rating the way you think you're supposed to feel, so don't think, "That's an ice cream cone and I like ice cream, so I'll rate it positive." You should *only* base your ratings on how you actually felt while viewing the picture.

Do you have any questions?

REFERENCES

Barlow, D.H. (2002). *Anxiety and its disorders: The nature and treatment of anxiety and panic* (2^{nd} ed.). New York: Guilford Press.

Bradley, M.M., Codispoti, N., & Lang, P.J. (2006). A multi-process account of startle modulation during affective perception. *Psychophysiology, 43*, 486-497.

Bradley, M.M., Cuthbert, B.N., & Lang, P.J. (1993). Pictures as prepulse: Attention and emotion in startle modification. *Psychophysiology, 30*, 541-545.

Bradley, M.M., Lang, P.J., & Cuthbert, B.N. (1993). Startle reflex habituation in human beings: Emotion, novelty, and context. *Behavioral Neuroscience, 107*, 970-980.

Brown, S., & Schwartz, G.E. (1980). Relationships between facial electromyography and subjective experience during affective imagery. *Biological Psychology, 11*, 49-62.

Burton, K.W. (2003). *Emotional experience, facial expression, and startle reflex modulation in young adults, healthy older adults, and Alzheimer's disease.* Unpublished doctoral dissertation. University of Arizona, Tucson.

Burton, K.W, Kaszniak, A.W., McRae, K.L., & Stevens, J. (2003). Affective chronometry of the emotion-modulated startle reflex. *Psychophysiology, 40*, S30.

Cuthbert, B.N., Bradley, M.M., & Lang, P.J. (1996). Probing picture perception: Activation and emotion. *Psychophysiology, 33*, 103-111.

Davidson, R.J. (1998). Affective style and affective disorders: Perspectives from affective neuroscience. *Cognition and Emotion, 12*, 307-330.

Dichter, G.S., Tomarken, A.J., Baucom, B.R. (2002). Startle modulation before, during, and after exposure to emotional stimuli. *International Journal of Psychophysiology, 43*, 191-196.

Dillon, D.G., & LaBar, G.S. (2005). Startle modulation during conscious emotion regulation is arousal-dependent. *Behavioral Neuroscience, 119*, 1118-1124.

Erickson, L.M. (1996). *Interplay of emotion and attention: An analysis of startle reflex modulation during anticipation and perception of affective slides.* Unpublished doctoral dissertation. Florida State University, Tallahassee.

Frijda, N.H. (1993). Moods, emotion episodes, and emotions. In M. Lewis and J.M. Haviland, (Eds.) *Handbook of Emotions*, (pp. 381-403). New York: Guilford Press

Goldin, P.R., McRae, K., Ramel, W., & Gross, J.J. (in press). The neural bases of emotion regulation: Reappraisal and suppression of negative emotion. *Biological Psychiatry.*

Greenwald, M.K., Cook, E.W. III, & Lang, P.J. (1989). Affective judgment and psychophysiological response: Dimensional covariation in the evaluation of pictorial stimuli. *Journal of Psychophysiology, 3*, 51-64.

Gross, J.J. (1998a). The emerging field of emotion regulation: An integrative review. *Review of General Psychology, 2*, 271-299.

Gross, J.J. (1998b). 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. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology, 39*, 281-291.

Gross, J.J., & John, O.P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology, 85*, 348-362.

Gross, J.J., & Levenson, R.W. (1993). Emotional suppression: Physiology, self-report, and expressive behavior. *Journal of Personality and Social Psychology, 64*, 970-986.

Gross, J.J., & Levenson, R.W. (1997). Hiding feelings: The acute effects of inhibiting positive and negative emotions. *Journal of Abnormal Psychology, 106*, 95-103.

Hamming, R.W. (1977). *Digital Filters.* Englewood Cliffs, N.J.: Prentice-Hall.

Harris, C.R. (2001). Cardiovascular responses of embarrassment and effect of emotional suppression in a social setting. *Journal of Personality and Social Psychology, 81*, 886-897.

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.

Jackson, D.C., Mueller, C.J., Dolski, I., Dalton, K.M., Nitschke, J.B., Urry, H.L., Rosenkranz, M.A., Ryff, C.D., Singer, B.H., & Davidson, R.J. (2003). Now you feel it, now you don't: Frontal brain electrical activity and individual differences in emotion regulation. *Psychological Science, 14*, 612-617.

Kabat-Zinn, J. (1990). *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness.* New York, N.Y.: Delta.

Lang, P.J. (1980). Behavioral treatment and bio-behavioral assessment: Computer applications. In J.B. Sidowski, J.H. Johnson, & T.A. Williams (Eds.), *Technology in mental health care delivery systems* (pp. 119-137). Norwood, NJ: Ablex.

Lang, P.J., Greenwald, M.K., Bradley, M.M., & Hamm, A.O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology, 30*, 261-273.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1990). Emotion, attention, and the startle reflex. *Psychological Review, 97*, 377-395.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1992). A motivational analysis of emotion: Reflex-cortex connections. *Psychological Science, 3*, 44-49.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1997). Motivated attention: Affect, activation, and action. In P.J. Lang, R.F. Simons, & M. Balaban (Eds.), *Attention and orienting: Sensory and motivational processes* (pp. 97-136). Mahwah, NJ: Erlbaum.

Larson, C.L., Sutton, S.K., & Davidson, R.J. (1998). Affective style, frontal EEG asymmetry, and the time course of the emotion-modulated startle response. *Psychophysiology*, *35*, S52.

Manber, R., Allen, J.J.B., Burton, K., & Kaszniak, A.W. (2000). Valence-dependent modulation of psychophysiological measures: Is there consistency across repeated testing? *Psychophysiology, 37*, 683-692.

Nitschke, J.B., Larson, C.L., Smoller, M.J., Navin, S.D., Pederson, A.J.C., Ruffalo, D., Mackiewicz, K.L., Gray, S.M., Victor, E., & Davidson, R.J. (2002). Startle potentiation in aversive anticipation: Evidence for state but not trait effects. *Psychophysiology, 39*, 254-258.

Sabatinelli, D., Bradley, M.M., & Lang, P.J. (2001). Affective startle modulation in anticipation and perception. *Psychophysiology, 38*, 719-722.

Reminger, S.L., Kaszniak, A.W., & Dalby, P.R. (2000). Age-invariance in the asymmetry of stimulus-evoked emotional facial muscle activity. *Aging, Neuropsychology, and Cognition, 7*, 156-168.

Richards, J.M., & Gross, J.J. (1999). Composure at any cost? The cognitive consequences of emotion suppression. *Personality and Social Psychology Bulletin, 25*, 1033-1044.

Richards, J.M., & Gross, J.J. (2000). Emotion regulation and memory: The cognitive costs of keeping one's cool. *Journal of Personality and Social Psychology, 79*, 410-424.

Schwartz, G.E., Ahern, G.L., & Brown, S.L. (1979). Lateralized facial muscle response to positive and negative emotional stimuli. *Psychophysiology, 16*, 561-571.

Sutton, S.K., Davidson, R.J., Donzella, B., Irwin, W., & Dottl, D.L. (1997). Manipulating affective state using extended picture presentation. *Psychophysiology, 34*, 217-226.

Thompson, R.A. (1994). Emotion regulation: A theme in search of definition. *Monographs of the Society for Research in Child Development, 59*, 25-52.

Witvliet, C.O., & Vrana, S.R. (1995). Psychophysiological responses as indices of affective dimensions. *Psychophysiology, 32*, 436-443.

Witvliet, C.O., & Vrana, S.R. (2000). Emotional imagery, the visual startle, and covariation bias: An affective matching account. *Biological Psychology, 52*, 187-204.

Vrana, S.R., Spence, E.L., & Lang, P.J. (1988). The startle probe response: A new measure of emotion? *Journal of Abnormal Psychology, 97*, 487-491.