



## The effects of voluntary regulation of positive and negative emotion on psychophysiological responsiveness

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### ABSTRACT

The acoustic startle reflex can be modulated by positive and negative emotion. There is evidence that this modulation can be influenced by voluntary attempts to regulate emotion, and that startle modulation during emotion regulation is more reflective of changes in arousal than valence. However, whether valence and arousal play similar roles in emotion regulation across different psychophysiological indices is unclear. The goal of this study was to characterize further the relative contributions of valence and arousal to changes in psychophysiological responsiveness during voluntary emotion regulation, using multiple psychophysiological measures including eyeblink startle, skin conductance, and heart rate. We studied 10 healthy adults, and found that voluntary attempts to down-regulate positive and negative emotion resulted in decreased eyeblink startle magnitude, skin conductance responses, and heart rate, relative to attempts to up-regulate emotion. These findings indicate that the volitional regulation of emotion had systematic effects on psychophysiological parameters which were similar for positive and negative emotion, suggesting that psychophysiological responsiveness during emotion regulation is more strongly influenced by the modulation of arousal than by the valence of the regulated emotion.

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### 1. Introduction

Emotion regulation has been broadly defined as “the initiation of new, or the alteration of ongoing, emotional responses through the action of regulatory processes” (Ochsner and Gross, 2005, pp. 242–243). These regulatory processes may be recruited voluntarily (i.e., consciously and deliberately) or without conscious awareness to enhance, reduce, or maintain an emotion (Mauss et al., 2007). The ability to regulate emotion enables humans to maximize the experience of positive emotions while limiting the impact of negative emotions and plays an essential role in allowing humans to adapt to their surroundings, while the dysregulation of emotion has been viewed as a key component in many forms of psychopathology (Davidson, 2000; Machado and Bachevalier, 2003).

Measurement of the acoustic startle reflex is one paradigm that has been widely used to investigate emotional processing, including deliberate emotional regulation. The startle reflex is a highly conserved reflex consisting of a series of muscular contractions, and the neural circuitry underlying this reflex has been well characterized in animal models (Davis et al., 1982; Yeomans and Frankland, 1995). In humans,

this reflex is measured through facial electromyography (EMG) recorded from the orbicularis oculi muscles in response to the sudden onset of an auditory stimulus (Lang et al., 1990). The modulation of the startle reflex by emotion is a widely replicated and robust finding both in animals and in humans (Koch, 1999; Lang et al., 1990) that can be demonstrated using a variety of emotionally arousing stimuli (Bradley and Lang, 2000; Vrana and Lang, 1990). In particular, it has been observed that the magnitude of the reflex is enhanced by the experience of negative emotion, and may be suppressed by positive emotion, although the magnitude of and support for the latter conclusion is less robust.

A number of studies in recent years have characterized the psychophysiological correlates of voluntary emotion regulation (Dillon and Labar, 2005; Gross, 1998; Gross and Levenson, 1997; Jackson et al., 2000). These studies have demonstrated that conscious and deliberate attempts to regulate one's emotions can lead to a variety of physiological changes, including alterations in eyeblink startle magnitude. Jackson et al. (2000) examined the impact of voluntary up- and down-regulation of negative emotion on the startle reflex in healthy adults. The authors found that instructions to decrease emotional responses to unpleasant pictures led to decreased eyeblink startle magnitude, whereas instructions to enhance their responses led to increased startle responses.

More recent work has helped to elucidate the roles of valence and arousal in startle modulation during emotion regulation. According to the motivational priming hypothesis (Lang, 1995), the attenuation and potentiation of the startle reflex during positive and negative

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emotional processing, respectively, reflect differential engagement of appetitive and defensive motivational systems. One possibility is that up-regulating emotion increases motivational priming, resulting in an accentuation of these valence-specific effects, while reduced motivational priming during attempts to down-regulate emotion dampens them. It has been observed (Dillon and Labar, 2005), however, that conscious attempts to increase or decrease emotion produce similar patterns of startle modulation for both positive and negative pictures, with increased startle responses during attempts to increase positive or negative emotion and reduced responses during attempts to down-regulate emotion, irrespective of valence. This pattern of findings suggests that startle modulation during voluntary emotion regulation may be driven more by changes in arousal than by valence.

Measures of autonomic reactivity have been frequently adopted in studies of emotional processing. Skin conductance is widely used to index sympathetic arousal, with larger skin conductance responses (SCRs) typically observed for highly arousing stimuli. This measure generally does not differentiate reliably between positive and negative emotion (Dawson et al., 2007). Heart rate, which reflects sympathetic as well as parasympathetic activation, appears to be sensitive to changes in both arousal and valence. In particular, it has been found that viewing arousing pleasant or unpleasant pictures results in a greater parasympathetically-mediated reduction in heart rate than neutral picture viewing (e.g., Bradley et al., 2001). In addition, unpleasant pictures generally elicit more pronounced deceleration in heart rate than pleasant stimuli, reflecting heightened defensive activation (Lang, 1995). It is also clear that voluntary emotion regulatory attempts can affect autonomic reactivity. For example, attempts to decrease negative emotion through the suppression of expressive behavior (e.g., frowning) have been associated with increased sympathetic arousal and less consistently with decreased heart rate (Gross and Levenson, 1993), whereas emotion reduction through reappraisal (the cognitive reinterpretation of an event so as to change its emotional impact) generally does not increase sympathetic arousal (Gross, 1998). There is also some evidence that the up-regulation of negative emotion is associated with heightened physiological arousal (Eippert et al., 2007). However, the regulation of positive emotion (particularly its up-regulation) has received relatively little attention in psychophysiological studies to date. This is not surprising, given the prominent role of negative emotion in psychopathology and the challenges of eliciting positive emotions in laboratory settings. Further work is needed to clarify the extent to which conscious attempts to regulate positive and negative emotion result in similar patterns of changes in physiological reactivity. In addition, while changes in skin conductance and heart rate typically unfold over the course of several seconds, the startle paradigm can be used to probe relatively rapid changes in emotional state. The use of such measures in parallel may therefore provide additional insight into the time course of emotion regulation effects (e.g., to what degree the contributions of valence and arousal to emotion regulation effects change during picture processing).

The goal of the present study was to further characterize the effects of voluntary up- and down-regulation of emotion on somatic reflexes and autonomic responses. To address this aim, we collected measures of eyeblink startle, heart rate, and skin conductance in 10 healthy adults instructed to passively view or regulate their emotional responses to pleasant and unpleasant pictures. Based on previous work (e.g., Dillon and Labar, 2005; Jackson et al., 2000), it was predicted that attempts to up-regulate positive and negative emotion would result in increased startle responses, while attempts to down-regulate positive and negative emotion would lead to decreased startle responses. Additionally, it was predicted that if arousal contributes more than valence to autonomic changes during emotion regulation, the down-regulation of both positive and negative emotion would result in reduced SCRs and increased heart rate deceleration (consistent with decreased sympathetic activation), as compared to the up-regulation of emotion. If, on the

other hand, autonomic emotion regulation effects are more dependent on valence, then it was expected that attempts to up- and down-regulate emotion would elicit similar patterns of SCRs, due to the greater sensitivity of this measure to general arousal per se. It was further predicted that the up-regulation of negative emotion would evoke greater “defensive” activation, as reflected by a more pronounced deceleration in heart rate compared to down-regulating negative emotion, while the up-regulation of positive emotion would be associated with decreased defensive activation, resulting in reduced heart rate deceleration. We have outlined these specific contrasting predictions in Table 1.

## 2. Methods

### 2.1. Participants

Ten healthy right-handed adults (7 women, 3 men) with a mean age of 35.2 years ( $SD=13.0$ ) were recruited for the study. Participants were recruited from the community through advertisements and received compensation for their participation. All participants were screened for any history of neurological or psychiatric disease and provided informed consent in accordance with the Human Subjects Committee at the University of Iowa prior to their participation in this research.

### 2.2. Materials and design

The stimuli used for this task included 112 color pictures selected from the International Affective Picture System (IAPS; Lang et al., 2005). Stimuli were presented on a PC computer screen 0.5 m in front of the participant using Presentation software. Sixteen of the pictures were neutral, 48 were pleasant, and 48 were unpleasant based on normative ratings. Pleasant and unpleasant pictures were matched as closely as possible on rated arousal. Each picture was presented for 8 s, with an interstimulus interval of 14 s. The acoustic startle probe was a 50-ms burst of white noise with an instantaneous rise time and a magnitude of 95 dB, presented binaurally through headphones. Startle probes were delivered during 75% of picture presentations and were evenly distributed across picture valence categories. To characterize changes in startle modulation that may occur over the course of picture viewing (e.g., Sutton et al., 1997), probes were delivered either at 4 or 7 s following picture onset. Picture trials were organized in two pseudorandomized orders that were counterbalanced for order of presentation, instruction type, and startle probe time. No more than three trials of the same emotion category, regulation instruction, or probe time were presented consecutively.

EMG activity from the orbicularis oculi was collected using two In Vivo Metrics (Healdsburg, CA) recording electrodes placed directly below the left eye using the placement recommended by Fridlund and Cacioppo (1986). Electrode impedances were less than 10,000  $\Omega$ . Raw signals were recorded using Biopac (Biopac Systems, Santa Barbara, CA) EMG150 amplifiers passing 30–500 Hz, with a gain multiplication

**Table 1**

Predicted effects of valence and arousal on the up- and down-regulation of emotion across picture categories

	Measure	Picture category	
		Pleasant	Unpleasant
Arousal-dependent modulation	SCRs	Increase > decrease	Increase > decrease
	Startle magnitude	Increase > decrease	Increase > decrease
	Heart rate deceleration	Increase < decrease	Increase < decrease
Valence-dependent modulation	SCRs	Increase = decrease	Increase = decrease
	Startle magnitude	Increase < decrease	Increase > decrease
	Heart rate deceleration	Increase < decrease	Increase > decrease

Note. SCRs = skin conductance responses.

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