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The effect of cognitive reappraisal on physiological reactivity and emotional memory

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ABSTRACT

We investigated the effect of cognitive reappraisal on emotional arousal, facial expressivity and subsequent memory. Men and women viewed emotionally negative pictures while they attempted to either increase or decrease negative emotions elicited by the pictures, or to simply view the pictures. Neutral pictures were also presented with instructions to simply view the pictures. Concurrent changes in emotional arousal and valence were assessed with skin conductance responses (SCRs) and facial corrugator electromyographic responses (EMG), respectively. Picture memory was assessed with an immediate recall test and a delayed recognition test. Relative to simply viewing pictures, voluntary reappraisal to increase negative emotion generated greater facial corrugator EMG and SCR responses, and reappraisal to decrease negative emotion generated decreased corrugator EMG responses. Men showed enhanced recognition for pictures presented during the increase and decrease conditions, whereas women showed comparable recognition performance across all regulation conditions. The modulation of subsequent recognition memory associated with decreasing emotion was inversely associated with changes in physiological responses. Our results suggest that sex is an important factor to consider in determining how reappraisal-induced physiological changes are associated with subsequent changes in memory. These findings contribute to our understanding of how reappraising emotion exerts both immediate and enduring influences on physiological responses and subsequent memory.

1. Introduction

Humans have the unique ability to monitor and voluntarily modify their emotional states to achieve cognitive goals. The ability to appropriately regulate emotion is critically important to one's mental health and impairments in emotion regulation have been linked to a variety of psychological and somatic disorders (Bonnano et al., 2004; Davidson et al., 2000). One particular form of emotion regulation, cognitive reappraisal, has been a focus of particular recent interest. Reappraisal refers to individuals' cognitive efforts to increase or decrease the emotional impact of emotion-eliciting events by altering cognitive representations (Gross, 1998). For example, one's typical reaction to a picture of a person in distress might be decreased by imagining the person as being an actor. Conversely, one's reaction might be increased by imagining the person as being a close relative. Reappraisal has been theorized to be a less resource-demanding and more effective emotion regulation strategy than other emotion regulation strategies such as emotion suppression (i.e., suppression of overt emotional responses) because it can modulate early stages of emotion generation, before emotional reactions have fully unfolded (Gross, 1998).

Recent investigations of emotion regulation have shown that conscious attempts to increase and decrease emotion result in modulation of physiological and neural responses to emotional events (Dan-Glauser & Gross, 2011; Demaree et al., 2004; Dillon and LaBar, 2005; Driscoll et al., 2009; Jackson et al., 2000; Kim and Hamann, 2007; Lee et al., 2009; Mauss et al., 2007; Moser et al., 2006; Ochsner et al., 2004; Ray et al., 2010; Sheppes et al., 2009). For example, increased and decreased facial frown muscle activity were observed during reappraisal to increase and decrease negative emotions, respectively, in line with subjective affect report (Gross, 1998; Ray et al., 2010). Increased skin conductance responses and heart rate were observed when regulation strategies increased emotional responses compared to decreased emotional responses (Driscoll et al., 2009). Recent functional neuroimaging studies showed that voluntary reappraisal to increase and decrease modulated neural activity in the amygdala (Kim and Hamann, 2007; Ochsner et al., 2004), a neural structure that has been extensively implicated in the experience of emotionally arousing stimuli.

Increased physiological arousal, and amygdala responses to emotionally meaningful stimuli have been widely implicated in enhanced episodic memory for the stimuli (Abercrombie et al., 2008; Bradley et al., 1992; Cahill and McGaugh, 1995; Hamann et al., 1999). For example, research participants better remembered stimuli that felt more arousing than those felt less arousing (Bradley et al., 1992). When the identical images were presented with more arousing stories, participants' episodic memory was enhanced compared to when the images were presented with less arousing stories (Cahill and McGaugh, 1995). Moreover, functional

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neuroimaging studies have found that increased activity in the amygdala in response to emotional pictures was positively associated with enhanced memory recall and recognition for the pictures (Cahill et al., 2001; Hamann et al., 1999). Given the close relationship between emotional arousal and subsequent memory, and the modulatory influence of cognitive reappraisal on emotional arousal, one may predict that reappraisal-induced changes in arousal would also be associated with alteration of episodic memory of the reappraised events.

Previous studies investigating cognitive consequences of emotion regulation have shown mixed results. Reappraisal efforts to increase emotional relevance produced enhanced episodic memory; whereas reappraisal to decrease emotional relevance produced either enhanced (Dillon et al., 2007) or unchanged (Richards and Gross, 2000; Sheppes and Meiran, 2008) memory performance. Examples of memory enhancement despite decreased emotional arousal suggest that reappraisal may influence emotional memory via pathways external to its modulatory effect on arousal. This study was designed to better characterize the relationship between cognitive reappraisal and memory for the reappraised event.

The retention interval between encoding and retrieval may play a role in modulation of emotional memory by cognitive reappraisal. Previous studies investigating the effect of emotion regulation on memory have typically tested memory performance shortly after the encoding regulation task (Bonnano et al., 2004; Dillon et al., 2007; Richards and Gross, 2000; Sheppes and Meiran, 2008). However, the enhancing effect of emotion on memory often increases at longer delays, and this time-dependent effect has been hypothesized to result from the critical contribution of memory consolidation, a process that unfolds gradually over days and weeks (McGaugh, 2000). Therefore studies using longer retention intervals would be more appropriate in investigation of reappraisal-associated memory modulation. In line with this, a study of the modulation of emotional memory by arousal and reappraisal found significant emotional memory and modulation effects. That is, individuals who used reappraisal more often reported lower levels of emotional arousal for emotional words than those who used reappraisal less often (Nielson and Lorber, 2009). When a surprise recognition test was conducted one week after the initial encoding, the emotion-dependent memory enhancement for words was smaller for frequent reappraisers less frequent reappraisers.

In addition to these factors, the type of episodic memory test administered may also have an important role in determining the modulation effect of reappraisal on memory. Studies of emotion regulation and memory have typically tested memory using either a free recall or a recognition task. Recall and recognition tasks are known to differ in task difficulty as well as in the relative contribution of two underlying memory processes. That is, recall is dependent on recollection, a process mediated by hippocampal and prefrontal regions whereas recognition can be performed on the basis of recollection or familiarity (Kim and Cabeza, 2009; Yonelinas, 2002). Because reappraisal may differentially influence component processes contributing to episodic memory, and recall typically is considered more difficult than recognition, the effects of reappraisal may be observed differentially for recall vs. recognition tasks.

In addition to retention interval and types of memory, sex may also play in important role in influencing how reappraisal affects emotional memory. Sex differences in the frequency of emotion regulation strategies have been reported (Gross and John, 2003; Welborn et al., 2009). In addition, neuroimaging studies have reported that men and women engage prefrontal neural resources differentially when successfully regulating responses to negatively charged emotional stimuli (Domes et al., 2010; Mak et al., 2009; McRae et al., 2008). Moreover, substantial evidence suggests that men and women engage different neural and cognitive mechanisms underlying emotional memory (Buchanan and Tranel, 2009; Cahill, 2006; Cahill et al., 2001; Canli et al., 2002; Ferree and Cahill, 2009; Kring and Gordon, 1998; Seidlitz and Diener, 1998).

These findings suggest that the neural resources available for successful memory encoding may differ between men and women, and this differential availability could interact with the effects of regulation on memory. Accordingly, in this study we anticipated that men and women might differ in their ability to regulate emotion, as measured by physiological responses. Because few laboratory studies have examined sex differences in emotion regulation, we did not have strong *a priori* predictions regarding which sex would exhibit better emotion regulation ability. Current evidence is equivocal with regard to whether men or women are better able to regulate emotions. For example, a neuroimaging study found that men were better able to down regulate activity in regions associated with emotional arousal, including the amygdala, and also exhibited less activation in regions associated with effortful processing, suggesting that men are more efficient at emotion regulation (McRae et al., 2008). However, another neuroimaging study found that women recruited prefrontal regions associated with emotion regulation to a lesser extent than men during the regulation of emotion (Domes et al., 2010).

The goal of this study was to assess the effect of cognitive reappraisal on emotional reactions and emotional memory and to determine whether sex differences modulate these processes, particularly the effects of reappraisal on emotional memory. We obtained and analyzed both physiological emotional responses and emotional memory to examine the relationships between reappraisal and its influences on emotional memory. In the current study, participants viewed a series of unpleasant pictures and neutral pictures while performing a reappraisal task. The task for negative pictures included three conditions where participants were asked to either increase or decrease negative emotions elicited by the pictures, or to simply view the pictures. Neutral pictures were presented with instructions to simply view the pictures.

We assessed emotional arousal via skin conductance responses (SCRs) and emotional valence via facial corrugator electromyographic responses (EMG) (Lang et al., 1993). Recording both SCRs and facial EMG concurrently enabled assessment of the effects of cognitive reappraisal on both arousal and valence. Memory for the emotional and neutral pictures was subsequently assessed with free recall and recognition tests.

We predicted that reappraisal to increase emotion would increase physiological responses to negative pictures and reappraisal to decrease emotion would decrease physiological responses. We also predicted that men and women might differ in their ability to regulate emotion, as measured by SCRs and EMGs. Further, based on the close relationship between emotional arousal and enhanced subsequent memory, we predicted that these sex differences in emotion regulation would be associated with corresponding differences in subsequent memory for the stimuli for which emotional responses were regulated.

2. Methods

2.1. Participants

18 women (mean age = 20.50, *SEM* = 1.57) and 18 men (mean age 19.88, *SEM* = .34) participated in this study. All participants gave written informed consent for a research protocol approved by the Emory University Institutional Review Board and performed in accordance with the Declaration of Helsinki. All participants were undergraduate students who received either class credits or monetary compensation for their participation. The ethnic composition of the participant sample was varied: 5.6% African-American (2 M), 22.2% Asian-American (2 M, 6 F), 63.9% Caucasian (12 M, 11 F), 5.6% Latin American (2 M), and 2.8% other (1 F). There were no statistical sex differences in ethnic composition (*Mann–Whitney* $U = 162.00$, $p = 1.0$).