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Research report

Prefrontal engagement by cognitive reappraisal of negative faces

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HIGHLIGHTS

- Examined brain activation during reappraisal of negative facial expressions.
- Reappraisal reduced negative affect, engaged prefrontal cognitive control regions.
- Habitual reappraisal use correlated with prefrontal engagement during reappraisal.
- Faces effective alternative 'targets' of prefrontal engagement during reappraisal.

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ABSTRACT

Cognitive reappraisal has been associated with increased activation in prefrontal cortex (PFC) and cingulate regions implicated in cognitive control and affect regulation. To date, neuroimaging studies of reappraisal have primarily used emotionally evocative scenes, and it remains unclear whether the same cognitive strategy applied to emotional facial expressions would involve similar or different neural underpinnings. The present study used fMRI to examine brain activation during cognitive reappraisal of negatively valenced facial expressions relative to passive viewing of negative and neutral facial expressions. Twenty-two healthy adults completed a cognitive reappraisal task comprised of three different conditions (Look-Neutral, Maintain-Negative, Reappraise-Negative). Results indicated that reappraisal was associated with a decrease in negative affect and engagement of PFC brain regions implicated in cognitive control and affect regulation (DLPFC, mPFC, and VLPFC). Furthermore, individual differences in habitual reappraisal use were associated with greater DLPFC and mPFC activation, while suppression use was associated with greater amygdala activation. The present study provides preliminary evidence that facial expressions are effective alternative 'targets' of prefrontal engagement during cognitive reappraisal. These findings are particularly relevant for future research probing the neural bases of emotion regulation in populations for whom aversive scenes may be less appropriate (e.g., children) and illnesses in which aberrant responses to social signals of threat and negative feedback are cardinal phenotypes.
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1. Introduction

Emotion regulation refers to the processes involved in the evaluation and modification of emotional experience and expression [1]. While several different types of emotion regulation strategies have been identified, reappraisal has been one of the most widely studied and better understood approaches to volitionally modulate affect [2]. Reappraisal is a cognitive-linguistic approach that involves consciously reinterpreting or re-framing the meaning of a stimulus with the intention of modifying its initial emotion-eliciting characteristics and response [3]. The ability to effectively reappraise negative emotion has been associated with better physical, psychological, and social outcomes [4,5] and is the foundation of most forms of cognitive therapy [6]. In contrast, difficulties with cognitive reappraisal have been

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associated with several psychopathological conditions [7] and suggested to be a core mechanism of mood and anxiety disorders [8].

Over the past decade imaging neuroscience research has begun to identify the neural substrates of cognitive reappraisal. These studies have consistently reported that reappraisal involves increased activation of specific areas within the prefrontal cortex (PFC) and anterior cingulate cortex (ACC) ([9]; see [10] for review). Specifically, reappraisal has been posited to engage a network of regions associated with several important 'cognitive' functions, including allocation of attention and working memory implemented by dorsolateral PFC (DLPFC), interpretation of internal and external emotional states implemented by medial PFC (mPFC), response inhibition and selection of information from memory implemented by ventrolateral PFC (VLPFC), and performance monitoring implemented by dorsal ACC ([11–13]; see [14] and [15] for meta-analyses). Reappraisal has also been shown to decrease activation in limbic regions, such as the amygdala [14,15].

Neuroimaging studies on emotional processing in general have used several different types of emotional stimuli. Initial studies on the neural correlates of emotional processing often used emotional facial expressions [16–18], which were associated with increased activation in a number of prefrontal (ACC, MPFC), limbic (amygdala, insula) and visual regions (inferior occipital gyrus, fusiform gyrus) [19]. A parallel line of research has used complex emotionally evocative scenes taken from the International Affective Picture System (IAPS; [20]). A meta-analysis of studies examining the processing of emotionally-valenced (both positive and negative) scenes and facial expressions identified increased activation in several overlapping regions, including the amygdala, mPFC, inferior frontal cortex, inferior temporal cortex, and extrastriate occipital cortex [21].

Neuroimaging research on cognitive reappraisal noted above has primarily used aversive, negatively valenced scenes (e.g., IAPS images) to probe the neural correlates of reappraisal, and less often employed emotional faces as 'target' stimuli which may have different properties, utility, and advantages. For example, facial expressions can engage attention and cognitive processes without over-activating autonomic and somatic reactions indicative of intense emotional responding [22]. In addition, facial expressions may be more suitable for child and adolescent populations relative to the more vivid, complex, and provocative content (e.g., violent scenes) often depicted in IAPS stimuli to evoke negative affect. Indeed, late childhood and early adolescence is a high risk period for the emergence of psychopathology [23,24], and future investigations may prefer to use more age-appropriate emotional stimuli (e.g., facial expressions). Lastly, emotional faces that convey threat and/or negative social feedback may have more ecological validity for certain forms of psychopathology (e.g., social phobia, schizophrenia) and future studies examining the neural bases of reappraisal in illnesses in which aberrant responses to aversive social signals are cardinal phenotypes. Thus, it is important to understand the neural correlates of cognitive reappraisal of facial expressions.

To our knowledge, only two studies examining the neural substrates of cognitive reappraisal have used facial expressions. McRae and colleagues [25] found that, relative to passive viewing, reappraisal of negative faces was associated with *increased* amygdala activation. Goldin and colleagues [26] compared individuals with social anxiety disorder (SAD) and healthy controls on the neural correlates of cognitive reappraisal using social ('harsh' facial expressions) and physical (violent scenes) threat, and the authors reported that healthy control participants exhibited activation of ACC, DLPFC, mPFC, and VLPFC when reappraising harsh facial expressions (and to a greater degree in controls relative to SAD participants). However, there were important limitations to these studies. Specifically, McRae et al. used an ROI-approach and only examined neural activity in the amygdala, and Goldin et al. did not report results for the neural correlates of reappraisal in controls only and used neutral scenes (rather than neutral faces) as a comparison condition, precluding any definitive conclusions about cognitive reappraisal of facial expressions.

The present study used functional magnetic resonance imaging (fMRI) and examined the neural substrates of cognitive reappraisal to negatively valenced facial expressions. Twenty-two healthy adults completed a cognitive reappraisal task of facial expressions, adapted from a prior task that employed evocative scenes [12,13,27], and self-report affect was measured after every block of trials. Based on prior research, we hypothesized that, similar to negative scenes, there would be decreased negative affect and increased activation in prefrontal regions implicated in cognitive control (ACC, DLPFC, mPFC, and VLPFC) during reappraisal of negative facial expressions. Several investigations have reported decreased amygdala activation during cognitive reappraisal of negative scenes ([12]). Thus, it is likely that reappraisal of negative facial expressions will also be accompanied by a decrease in amygdala activation. However, the only other study to specifically examine emotion regulation of negative facial expressions found *increased* amygdala activation during cognitive reappraisal [25]. Therefore, it is also possible that reappraisal of negative facial expressions will be associated with an increase in amygdala activation. Given these conflicting results, we did not make specific hypotheses regarding amygdala activation during reappraisal of negative facial expressions, but the present study may provide further support for either of these perspectives.

Finally, the present study also examined the association between individual differences in habitual emotion regulation strategy use and brain activation during the cognitive reappraisal of negative facial expressions. As previously mentioned, reappraisal is one of the most widely studied approaches to volitionally modulate affect [2]; however, there are other strategies available. For instance, expressive suppression is another form of emotion regulation that is associated with poor physical and psychosocial outcomes [28,29]. To examine individual differences in typical emotion regulation strategy use, participants completed the Emotion Regulation Questionnaire (ERQ; [5]), which provides separate indices of the tendency to use cognitive reappraisal and expressive suppression when regulating emotions. We hypothesized that greater use of reappraisal (and not suppression) would be associated with increased activation in prefrontal cognitive control regions (ACC, DLPFC, mPFC, and VLPFC) during reappraisal of negative facial expressions

2. Methods

2.1. Participants

The sample included 22 right-handed adults (50% female, 81.8% Caucasian) between the ages of 18 and 55 ($M = 25.2$, $SD = 5.8$) recruited via community advertisements. Participants were interviewed by a licensed clinician using the structured clinical interview for DSM-IV [30] and examined by a board-certified psychiatrist. Exclusion criteria included current use of psychoactive medications, a history of any Axis I diagnosis, or history of major medical or neurological illnesses. No participant tested positive for alcohol or illegal substances as screened by breathalyzer and urine drug screen at the time of scanning. All participants provided written informed consent as approved by the local Institutional Review Board.

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