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Research report

Activity in medial prefrontal cortex during cognitive evaluation of threatening stimuli as a function of personality style

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Abstract

Cognitive evaluation of emotional stimuli involves a network of brain regions including the medial prefrontal cortex (mPFC). However, threatening stimuli may be perceived with differential salience in different individuals. The goal of our study was to evaluate how different personality styles are associated with differential modulation of brain activity during explicit recognition of fearful and angry facial expressions. Twenty-eight healthy subjects underwent fMRI. Based on a cognitivist model, subjects were categorized according to how they attribute salience to emotional stimuli and how they regulate their emotional activation. We compared 14 phobic prone (PP) subjects, whose identity is more centered on the inner experience ("inward") and around control of environmental threat, and 14 eating disorders prone (EDP) subjects, whose identity is more centered on external referential contexts ("outward") and much less around control of threatening stimuli. During fMRI subjects either matched the identity of one of two angry and fearful faces to that of a simultaneously presented target face or identified the expression of a target face by choosing one of two simultaneously presented linguistic labels. The fMRI results indicated that PP subjects had greater mPFC activation when compared with EDP subjects during cognitive labeling of threatening stimuli. Activity in the mPFC also correlated with personality style scores. These results demonstrate that PP subjects recruit greater neuronal resources in mPFC whose activity is associated with cognitive aspects that are closely intertwined with emotional processing. These findings are consistent with the contention that cognitive evaluation and salience of emotional stimuli are associated with different personality styles.

Keywords: Emotion recognition; Fear; Prefrontal cortex; fMRI; Personality

1. Introduction

Emotion recognition in humans has been considered as an innate ability which is critical for social communication and survival [23,57]. Among others, facial expressions represent salient signals for emotion recognition, providing a means for dynamic nonverbal language and social interactions [23,28]. In particular, facial expressions of fear and anger are universally recognized as signals of potential threat. Recognition of these signals in humans involves both perceptual processing of facial features and interpretation of the emotional meaning of the expression [1]. The latter process varies in the degree to which it is implicit (relatively automatic, reflexive and, perhaps, unconscious) or more explicit (deliberate and conscious) [31], therefore requiring additional cognitive processing.

Converging evidence from studies in animals and neuroimaging studies in humans shows that the amygdala is centrally involved in implicit processing of emotional stimuli. More specifically, amygdala activity is elicited by passive viewing

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of faces [30,38], especially with fearful expression [7,15,73], by implicit processing of fearful faces (e.g., gender discrimination or matching expressions) [34,50,62], and by masked fearful faces [51,65,75,76]. These findings suggest that the amygdala is implicated in automatic (even unconscious) processing of salient threatening stimuli and confirm its role in detecting danger [43].

On the other hand, cognitive evaluation of emotional stimuli, including explicit recognition of fearful facial expressions (e.g., cognitive labeling) has been associated with attenuated responses in the amygdala [35,42,53,54] and with greater activity in the prefrontal cortex (PFC) relative to implicit processing. Also, the medial part of the prefrontal cortex (mPFC) has been associated with cognitive evaluation of emotional stimuli [56] and with judgement of their emotional valence [36]. Furthermore, this prefrontal region is engaged to a greater degree when more complex, conscious appraisal is required by asking evaluation of the extent of personal relatedness of the stimuli [60].

The above-described studies may suggest a relative functional specialization within the neuronal network involved in emotion recognition, with medial prefrontal cortical nodes more involved in the conscious explicit evaluation on the one hand, and the amygdala, on the other, more associated with automatic implicit processing of emotional stimuli. Moreover, these brain regions seem to interact. Relative disengagement of the amygdala is simultaneous to greater engagement of the prefrontal cortex during cognitive labeling of emotional stimuli, possibly reflecting cognitive control of emotional responses through appraisal and evaluation of emotional stimuli [35].

Individual variability in implicit processing of emotional stimuli has been highlighted by previous studies [55]. For example, fMRI studies have indicated association between amygdala activity during implicit processing of emotions and personality traits such as extraversion, neuroticism [18,19], or inhibited temperament [68]. More recently, Bertolino et al. [8] have also demonstrated that amygdala activity during perceptual processing of fearful and angry faces varies as a function of personality style.

The most widely accepted theories of personality focus upon the necessity of integrating biological determinants with the environment. A model that can take into account both aspects of personality is the post-rationalist approach developed from within the cognitive school of thought [32]. One of the most important theories on which this model is developed is the attachment theory [2,9–14,17]. Recognizing an ontological value to the attachment relationships, the concept of personality style [3,4,32] has been elaborated based on the style with which individuals organize their emotional and cognitive domains in relationship to their attachment patterns. Based on this framework, two general categories of constructing identity are identified which differ in regulation of emotional and cognitive processes: the "inward", more focused on the inner experience; and the "outward" more focused on external referential contexts or figures to control and regulate their emotional experiences [4]. Within these two categories, four personality styles are identified among which "phobic prone" (PP, inward) and "eating disorders prone" (EDP, outward) individuals. The "phobic prone" personality style is more focused on inner bodily references; that is, they primarily focus on emotions using bodily reactions to evaluate events in the world, especially emotions. For instance, PP subjects tend to use their bodily reactions to automatically evaluate how dangerous may be stimuli that are implicitly threatening. Therefore, these subjects preferentially show automatic appraisal [27], rapid and intense responses to emotional signals. Basic emotions (especially fear) play a central role in the development of personality and they are usually perceived with immediacy [4,32]. Emotions are generated through automatic appraisal [27] so that they begin without the individuals being necessarily aware of the processes involved which also induce emotional activation (arousal). For these individuals it is also important to keep intensity of internal reactions within a manageable range because it allows a clearer demarcation of one's own experience from the experience of others. Moreover, when the stimuli are explicitly dangerous, PP subjects tend to use cognitive resources to match the saliency of the stimulus with bodily reactions to control their intensity. Accordingly, control of bodily reactions becomes an important constituent of the phobic prone identity when the stimuli are implicitly and/or explicitly dangerous. Therefore, the only difference between evaluation of implicit and explicit stimuli is the more or less automatic appraisal afforded by the stimuli. In sum, the emotion of fear and its control are centrally salient to PP individuals to regulate their emotional life.

On the other hand, the "Eating disorders prone" personality style is more focused on an external frame of reference, such as contexts or persons, to discriminate among its own internal emotional states. Since these persons are constantly centered on the external environment, they have a limited ability to discriminate among internal emotional states and reactions. Therefore, an undifferentiated arousal prevails, which can only be interpreted with the aid of specific circumstances and external contexts. On the other side, these persons tend to be more apt in the discrimination of "cognitive" and "self-conscious" emotions [3,4,32,46,67]. In other words, these individuals will build inner stability by continuously referring to the outside world, attempting to match their own feelings and emotions with it. In sum, EDP individuals tend to be more consciously aware of the evaluative processes generating an emotion, while their emotional life is much less centered around fear. In conclusion, PP and EDP subjects seem to differ prominently in terms of the immediacy with which they process basic emotions such as fear. Of note, it is necessary to underline that the terms "phobic prone" and "eating disorders prone" do not necessarily implicate that these subjects are at higher risk of pathological phobias or of eating disorders.

The goal of this fMRI study was to explore how different personality styles may be associated with differential modulation of brain activity during explicit recognition (cognitive labeling) of threatening emotional facial expressions. Since threatening stimuli may have greater salience in healthy PP subjects [8], we hypothesized that these individuals would engage greater neuronal resources in brain regions associated with explicit cognitive labeling of angry and fearful faces.