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BRAIN RESEARCH

Research Report

Amygdala activity in response to forward versus backward dynamic facial expressions

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ABSTRACT

Observations of dynamic facial expressions of emotion activate several brain regions, but the psychological functions of these regions remain unknown. To investigate this issue, we presented dynamic facial expressions of fear and happiness forwards or backwards, thus altering the emotional meaning of the facial expression while maintaining comparable visual properties. Thirteen subjects passively viewed the stimuli while being scanned using fMRI. After image acquisition, the subject's emotions while perceiving the stimuli were investigated using valence and intensity scales. The left amygdala showed higher activity in response to forward compared with backward presentations, for both fearful and happy expressions. Amygdala activity showed a positive relationship with the intensity of the emotion experienced. These results suggest that the amygdala is not involved in the visual but is involved in the emotional processing of dynamic facial expressions, including specifically the elicitation of subjective emotions.

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1. Introduction

Dynamic facial expressions of emotions are natural and powerful cues in our daily interactions. Psychological studies have indicated that dynamic facial expressions, as compared with static expressions, enhance a variety of psychological processes, including perception (Yoshikawa and Sato, 2008), identity recognition (e.g., Bruce and Valentine, 1988), facial mimicry (e.g., Sato and Yoshikawa, 2007b), emotion recognition (e.g., Harwood et al., 1999), and emotion elicitation (Sato and Yoshikawa, 2007a).

Some neuroimaging studies have depicted brain activity in response to dynamic facial expressions of emotion, comparing brain activity in response to dynamic emotional facial expressions with activity in response to static expressions (Kilts et al., 2003; LaBar et al., 2003; Sato et al., 2004a; Pelphrey et al., 2007). Although the details differ among the studies, the results generally indicated that several brain regions were more active when viewing dynamic facial expressions compared with static facial expressions; these regions included the posterior superior temporal sulcus (STS) and adjacent regions (Kilts et al., 2003; LaBar et al., 2003; Sato et al., 2004a; Pelphrey et al., 2007), the posterior fusiform gyrus (Kilts et al., 2003; LaBar et al., 2003; Sato et al., 2004a; Pelphrey et al., 2007), the inferior occipital gyrus (Sato et al., 2004a), the inferior frontal gyrus (LaBar et al., 2003; Sato et al., 2004a), and the

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amygdala (LaBar et al., 2003; Sato et al., 2004a; Pelphrey et al., 2007). As these regions are related to the processing of faces and facial expressions (Hoffman and Haxby, 2000; Rizzolatti et al., 2001), enhanced activity of this neural substrate is consistent with enhanced manifold psychological processes for dynamic facial expressions.

Nevertheless, the specific psychological functions of these brain regions remain unknown. The most prominent feature of dynamic facial expressions, as compared with static facial expressions, is dynamic visual information. Most brain regions activated by dynamic facial expressions have been shown to contain visual-responsive neurons (e.g., Ono and Nishijo, 1999). Thus, it is possible that the processing of visual motions may be the primary correlate in these regions. Alternatively, as dynamic facial expressions enhance various psychological processes such as emotion elicitation, some of these processes may be related to the activity in these regions.

To investigate the neural activity for dynamic biological stimuli while controlling for visual features, Brothers (1990) proposed the interesting strategy of presenting the stimuli backwards. Brothers insisted that if the stimuli were shown backwards, they would have the same visual features, but the meaning would be reduced. This would likely be the case for dynamic facial expressions, because dynamic facial expressions presented forwards and backwards would have comparable visual motions but quite different emotional meanings. The forward presentations would exhibit appearing emotional expressions, whereas the backward presentations would indicate disappearing emotional expressions. To investigate the neural activity related to emotional processing, and not visual processing, for dynamic facial expressions, we adopted the backward presentation strategy.

The amygdala is a plausible neural substrate candidate for the emotional processing of dynamic facial expressions. Single unit recording studies in monkeys have shown that amygdala neurons discharged in response to significant aversive and rewarding stimuli (Ono and Nishijo, 1992). Lesion studies in monkeys have indicated that selective damage to the amygdala impaired the emotional responses to significant environmental stimuli (Aggleton and Young, 2000). In neuroimaging studies in humans, amygdala activity was associated with the intensity or arousal of emotions experienced in response to olfactory (Anderson et al., 2003) and gustatory stimuli (Small et al., 2003), for both negative and positive valences. A previous neuroimaging study also reported that amygdala activity was related to the intensity of negative emotion experienced while viewing static negative facial expressions (Sato et al., 2004b). Based on this evidence, we hypothesized that the amygdala is involved in the emotional processing of dynamic facial expressions of emotion, including the elicitation of subjective emotions while viewing the expressions.

In the present fMRI study, we examined the brain activity in subjects while they viewed forward and backward presentations of dynamic facial expressions (cf. Fig. 1). We used a computer morphing technique to present dynamic expressions and prepared facial expressions of both negative (fearful) and positive (happy) emotional valences. To assess the emotion that the subjects experienced while viewing the facial expressions, we presented the same stimuli again after image acquisition and required the subjects to rate their subjective emotional experience, in terms of valence and intensity. Based on the aforementioned evidence regarding amygdala activity, we predicted that amygdala activity would be higher in response to forward compared with backward presentations for both valences, and that amygdala activity would correspond to the intensity of the experienced emotion. We also analyzed the activity of other brain regions that have

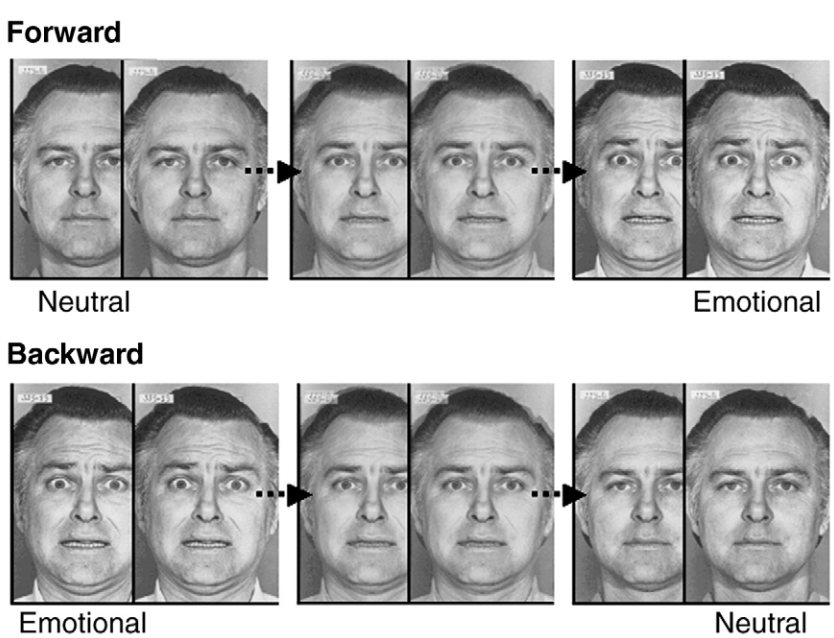

Fig. 1 – Illustrations of stimulus presentations, forward (upper) and backward (lower). Note that the frames were the same for the two conditions.

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