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Beauty in a smile: the role of medial orbitofrontal cortex in facial attractiveness

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Abstract

The attractiveness of a face is a highly salient social signal, influencing mate choice and other social judgements. In this study, we used event-related functional magnetic resonance imaging (fMRI) to investigate brain regions that respond to attractive faces which manifested either a neutral or mildly happy face expression. Attractive faces produced activation of medial orbitofrontal cortex (OFC), a region involved in representing stimulus-reward value. Responses in this region were further enhanced by a smiling facial expression, suggesting that the reward value of an attractive face as indexed by medial OFC activity is modulated by a perceiver directed smile.

Keywords: Facial attractiveness; Face expression; Reward; Orbitofrontal cortex; fMRI

1. Introduction

Neuropsychological and functional neuroimaging investigations frequently use face expressions to probe brain regions involved in affect, highlighting regions such as the amygdala, insula and orbitofrontal cortex (OFC) [2,7,30,43]. One feature of a face that can elicit a strong affective response in an observer is its attractiveness or beauty. Attractiveness impacts not only on mating success, but also on kinship opportunities, evaluations of personality and performance, as well as employment prospects [12,13,27,54]. Indeed a sociobiological perspective on attractiveness suggests it has an evolutionary basis that provides a marker of reproductive fitness [53,54]. Consistent with this is the finding that ratings of facial attractiveness have a high degree of consistency between cultures [40]. Furthermore, preference for attractive faces is found in infants indicating that this phenomenon emerges early in development [28]. Facial attributes that contribute to attractiveness include facial symmetry and the extent to which an individual face conforms to an average prototype [23,29,37]. Sexually dimorphic features, which in males corresponds to thick brow ridges and a large jaw structure, and in females corresponds to a small lower face, high cheekbones and thick lips, also contribute to facial attractiveness [39].

Little is known about how the human brain represents facial attractiveness. An early PET study reported activity of inferior prefrontal cortex during the assessment of facial attractiveness [31]. A recent study has reported an interaction between facial attractiveness and eye-gaze in ventral thalamus extending into striatum, wherein eye-gaze directed at the observer produced enhanced activation in this region relative to the response elicited by faces with eye-gaze averted [25]. This study failed to identify brain regions sensitive to the main effect of attractiveness perhaps reflecting the limited number of face stimuli which were also not optimised to measure responses to attractiveness per se.

The approach taken in the present study is to assume that an attractive face functions as a reward. Evidence from single-cell neurophysiology studies in non-human primates and from neuroimaging studies in humans suggests that one brain region in particular is involved in representing the reward value of stimuli in diverse modalities: the orbitofrontal cortex [45]. OFC is involved in representing the reward value of gustatory, olfactory, auditory and somatosensory stimuli [8,11,19,34,47]. This region is also sensitive to abstract reinforcers such as winning or losing money, or positive and negative verbal feedback [9,16,17,33]. OFC is also known to be involved in processing at least some facial emotional expressions [7,24].

Consistent with this approach, Aharon et al. [3] explored the hypothesis that attractive faces act as a reward and showed that male subjects were prepared to exert effort by means of key presses in order to gain access to attractive

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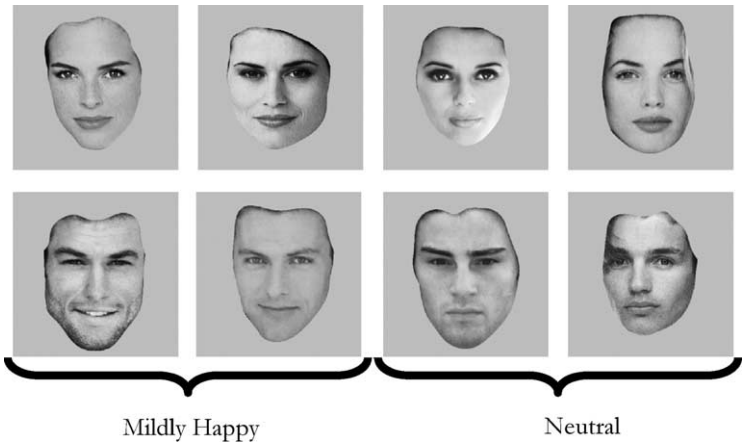

Fig. 1. Examples of face stimuli used in the study. The stimulus set consisted of 12 male and 12 female faces rated as high in attractiveness, and 12 male and 12 female faces rated as low in attractiveness on the basis of prior behavioural ratings. Faces are equated for luminance, eye-gaze is directed towards the observer and the stimuli are approximately balanced across conditions with neutral to mildly happy face expressions. Examples of faces rated by subjects as displaying a happy face expression, are shown on the left of the figure, whereas faces rated by subjects as displaying a neutral face expression are shown on the right. The degree of happiness of faces in the happy condition is quite subtle in comparison to a canonical happy face expression such as that used in the Ekman and Friesen series [14].

female faces indicating that they were prepared to work to obtain views of such faces. In a follow up block design functional magnetic resonance imaging (fMRI) study, Aharon et al. reported activity in the nucleus accumbens in a small group of male subjects to the presentation of attractive female faces, as well as in other brain regions such as OFC in a post-hoc analysis. The use of a block design means that it is not possible to determine whether responses observed were due to the presentation of the attractive faces or to an expectation of reward encompassed within the period in which attractive faces were expected and actually presented.

In the present study, we used an event-related functional magnetic resonance imaging design to measure neural responses while subjects were presented with both male and female faces that were either high or low in attractiveness (see Fig. 1). The use of event-related fMRI enabled us to determine responses directly related to the presentation of the attractive face stimulus without any confound of expectancy as the order of presentation of faces from each condition was fully randomised.

We postulated that facial attractiveness as a reward in the visual modality would evoke event-related responses in orbitofrontal cortex. We also considered a priori that responses to attractive faces could occur in two other brain regions implicated in reward processing, namely the ventral striatum and amygdala [6,18,50]. Given the salience of facial attractiveness, we hypothesised that the attractiveness of a face would be processed automatically irrespective of the task performed by the subject, as has already been shown for emotional face expressions [30]. Consequently, the task was for subjects to determine the gender of each face presented in the scanner in the absence of explicit instructions as to the nature of the experimental question until after the scanning was completed. At this point we asked subjects to provide attractiveness ratings for each face. In order to investigate gender-specific responses, we scanned a total of 25 subjects of which 12 were female, allowing a comparison between genders at the random effects level. Furthermore, the fact that faces in the stimulus set displayed either neutral or mildy happy face expressions (expressed as a smile) enabled us to address the issue of the extent to which positive face expression modulates attractiveness responses.

2. Methods

2.1. Subjects

A total of 25 healthy right-handed normal subjects were included in the experiment of which 13 were male. Twenty-four subjects were Caucasian. The mean age of the male subjects was 24.5 ± 5.1 (S.D.), and of the female subjects was 23.1 ± 3.4 (S.D.). There were no significant differences in the ages of the subject groups. The subjects were pre-assessed to exclude those with a prior history of neurological or psychiatric illness. All subjects gave informed consent and the study was approved by the local research ethics committee.

2.2. Stimulus set

Forty-eight face stimuli were selected from a larger pool of 138 Caucasian faces (depicting healthy normal adults aged between 20 and 35 years) that had been rated by a separate group of subjects ($n = 64$ of which 31 were female) for attractiveness in behavioural pilot studies conducted outside the scanner. Attractiveness was rated using a scale from 1 to 7, where 1: 'not attractive' and 7: 'highly attractive'. Twenty-four faces (of which 12 were female) were selected to form the high attractiveness condition and 24 faces (of which 12 were female) were selected to form the