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Shared brain activity for aesthetic and moral judgments: implications for the Beauty-is-Good stereotype

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The Beauty-is-Good stereotype refers to the assumption that attractive people possess sociably desirable personalities and higher moral standards. The existence of this bias suggests that the neural mechanisms for judging facial attractiveness and moral goodness overlap. To investigate this idea, we scanned participants with functional magnetic resonance imaging while they made attractiveness judgments about faces and goodness judgments about hypothetical actions. Activity in the medial orbitofrontal cortex increased as a function of both attractiveness and goodness ratings, whereas activity in the insular cortex decreased with both attractiveness and goodness ratings. Within each of these regions, the activations elicited by attractiveness and goodness judgments were strongly correlated with each other, supporting the idea of similar contributions of each region to both judgments. Moreover, activations in orbitofrontal and insular cortices were negatively correlated with each other, suggesting an opposing relationship between these regions during attractiveness and goodness judgments. These findings have implications for understanding the neural mechanisms of the Beauty-is-Good stereotype.

Keywords: fMRI; face; moral; orbitotofrontal cortex; insula

INTRODUCTION

'Physical beauty is the sign of an interior beauty, a spiritual and moral beauty' [Schiller, 1882, cited by Dion *et al.* (1972)]. This quote illustrates the Beauty-is-Good stereotype, which is pervasive in human societies, and has been the focus of social psychological research for over three decades (Dion *et al.*, 1972). Compared to unattractive people, attractive individuals are assumed to have better personalities and be morally good (Dion *et al.*, 1972; Eagly *et al.*, 1991; Langlois *et al.*, 2000). For example, one study found that facial attractiveness was positively linked to socially desirable personality traits, such as kindness, honesty, friendliness, trustworthiness, etc. (Dion *et al.*, 1972). The Beauty-is-Good stereotype has been demonstrated in a variety of everyday domains, such as undergraduates' teaching evaluations of instructors (Hamermesh and Parker, 2005) and voters' preferences for political candidates (Efran and Patterson, 1974). Attractive people are more likely to get hired (Marlowe *et al.*, 1996) and earn on average 12% more than unattractive people (Hamermesh and Biddle, 1994). Unlike the case of race, gender, ethnicity, disability and age, there is no legislation against attractiveness-related discrimination. However, the most somber social impact of the Beauty-is-Good stereotype is within the justice system, as studies of mock trials have shown that defendants who are less attractive are more likely to be found guilty (Efran, 1974; Piehl, 1977; Kulka and Kessler, 1978; Burke *et al.*, 1990) and receive longer sentences(Friend and Vinson, 1974; Seligman *et al.*, 1977; Weiten, 1980; Burke *et al.*, 1990; Castellow *et al.*, 1990; Wuensch *et al.*, 1993).

Although the Beauty-is-Good stereotype has been the focus of many studies in social psychology, very little is known regarding the neural mechanisms involved. By definition, the Beauty-is-Good stereotype reflects the influence of aesthetic evaluation on moral evaluation. One possibility is that brain regions involved in the aesthetic processing influence brain regions involved in the moral judgments. A second possibility is that interaction between aesthetic and moral processing occurs because a set of brain regions mediates both types of judgments. The present functional magnetic resonance imaging (fMRI) study investigated the second alternative by identifying overlaps between activations elicited by aesthetic judgments and by moral judgments. Although several regions have been associated with 'one' of these domains, such as the amygdala with facial attractiveness (Kranz and Ishai, 2006), and medial prefrontal cortex with moral evaluation (Greene *et al.*, 2001, 2004; Moll *et al.*, 2002, 2007; Heekeren *et al.*, 2005; Schaich Borg *et al.*, 2008),

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we focused on two brain regions that have been associated with ‘both’ aesthetic and moral domains: the medial orbitofrontal cortex and the insular cortex.

The medial orbitofrontal cortex (OFC) has been associated with processing ‘positive stimuli’. Within the aesthetic domain, functional neuroimaging studies have shown that the medial OFC shows greater activity when people view attractive faces rather than unattractive faces (O’Doherty *et al.*, 2003b; Kranz and Ishai, 2006; Bray and O’Doherty, 2007; Ishai, 2007), as well as beautiful pictures rather than ugly pictures (Kawabata and Zeki, 2004). Within the moral domain, medial OFC activations have been reported during the processing of morally positive stimuli (Moll *et al.*, 2006; Zahn *et al.*, 2008). Beyond functional neuroimaging, patients with OFC lesions show poor practical judgments (Damasio *et al.*, 1994) and impaired moral behavior (Anderson *et al.*, 1999), and people with smaller OFC gray matter volume display higher psychopathy scores (de Oliveira-Souza *et al.*, 2008). Although the medial OFC has been independently linked to aesthetic and moral judgments, it is unclear if exactly the same OFC regions mediate both types of judgments and show similar activation patterns within participants.

In contrast with the medial OFC, the insular cortex has been associated with processing ‘negative stimuli’. Within the aesthetic domain, there is evidence that insular activity is greater for viewing unattractive than attractive faces (O’Doherty *et al.*, 2003b; Krendl *et al.*, 2006).Within the moral domain, insular activations have been reported during the processing of morally negative stimuli (Krendl *et al.*, 2006; Hsu *et al.*, 2008; Zahn *et al.*, 2008). Moreover, the insular cortex has been linked to the feeling of being hurt emotionally during a social interaction, or ‘social pain’ (Eisenberger *et al.*, 2003; Sanfey *et al.*, 2003), and socially negative signals from faces (Phillips *et al.*, 1997; Winston *et al.*, 2002). As in the case of the medial OFC, although insular activations have been found in both aesthetic and moral judgments, it is uncertain whether or not the regions are involved in and the activation patterns are same for both types of judgments.

To investigate whether the same medial OFC and insular regions show similar activation patterns in response to aesthetic and moral judgments, we scanned participants while rating the attractiveness of faces and the goodness of hypothetical actions, and then used these ratings as parametric regressors to indentify brain regions where activity increased or decreased as a function of both types of ratings. On the basis of separate studies in aesthetic and moral domains, we predicted that (i) medial OFC activity would ‘increase’ as a function of both attractiveness and goodness ratings, whereas (ii) insular activity would ‘decrease’ as a function of both types of ratings. Finally, assuming an opposing relationship between these two regions, we predicted (iii) a negative correlation between OFC and insula activities during both attractiveness and goodness ratings.

MATERIALS AND METHODS

Subjects

Twenty-two right-handed, college-aged female Caucasian participants were recruited from the Duke University community and paid for their participation. All subjects were English native speakers. The data from two subjects were excluded from analyses because of equipment malfunction. Thus, our analyses included data from 20 subjects with an average age of 23.4 years (s.d. = 3.1). All participants gave informed consent to a protocol approved by the Duke University Institutional Review Board.

Stimuli

The fMRI study included three tasks: (i) face attractiveness rating task, (ii) action goodness rating task and (iii) brightness rating task. For the ‘face attractiveness rating task’, we selected photos of 270 different Caucasian male faces from several face databases, including the NimStim Face Stimulus Set (Tottenham *et al.*, 2009), the AR Face Database (Martinez and Benavente, 1998), the CVL Face Database (http://www.lrv.fri.uni-lj.si/facedb.html), the PICS database (pics.psych.stir.ac.uk/), FERET Database (Phillips *et al.*, 1998, 2000) and the Frontal Face Dataset (http://www.vision.caltech.edu/archive.html). To have enough faces in the highly attractive range, we also included photos from male fashion models found in online catalogs. Given that most of our participants are Caucasian, we decided to limit the study to Caucasian participants and Caucasian faces to avoid potential differences in perceiving faces across races [‘other race effect’ (Rhodes *et al.*, 2005)]. The reason for using only male faces and female participants is that our pilot studies showed that attractiveness ratings were most consistent across participants when female participants rated male faces. All stimuli were converted into grayscale images with dimensions of 256 × 256 pixels on a white background. For the ‘action goodness rating task’, we created 270 short sentences describing hypothetical past actions performed by men that varied from very negative (e.g. ‘He raped a little girl.’) to very positive (e.g. ‘He saved his sister from drowning.’). These sentences were 3–11 words in length and used only familiar words. A pilot study with female participants confirmed that attractiveness ratings for faces (very unattractive to very attractive) and goodness ratings for actions (very bad to very good) were widely distributed across an 8-point scale. For the ‘brightness rating task’ as a control for stimulus perception and motor response, we used eight grayscale swatches (256 × 256 pixels) with different levels of brightness evenly spread from black to white. Examples of experimental stimuli are illustrated by Figure 1.

Experimental tasks

Stimuli were presented for 2.5 s (brightness and attractiveness rating tasks) or 4 s (goodness rating task) with a jittered 0.5–5 s intertrial interval, and participants rated them in an 8-point scale. Trial duration was decided on the basis

Fig. 1 Behavioral paradigm. (**A**) An example in the 'face attractiveness judgment task'. Female participants were presented with faces of Caucasian young males for 2.5 s each, and judged each face in an attractiveness 8-point scale from very unattractive to very attractive. (**B**) An example of the 'action goodness judgment task'. Participants were presented with sentences describing hypothetical actions for 4 s each, and judged each action in a goodness 8-point scale from very bad to very good. (**C**) An example of the 'brightness judgment task', which was used as control task. Subjects were presented with swatches of varying brightness for 2.5 s each and judged each swatch in a brightness 8-point scale from very dark to very bright. In all tasks, trials were separated by a jittered fixation interval (0.5–5 s).

of the results of a behavioral pilot study, which showed that participants needed more time to read sentences in the goodness rating task than to see faces in the attractiveness task or to see swatches in the brightness task. In the 'brightness rating task' (scan 1), 90 grayscale swatches were presented, and participants rated them from very dark (level 1) to very bright (level 8). In the 'face attractiveness rating task' (scans 2–4), 270 faces were presented, and participants rated them from very unattractive (level 1) to very attractive (level 8). Each face was rated only once. In the 'action goodness rating task' (scans 5–7), 270 sentences of hypothetical actions were presented, and participants rated them from morally very bad (level 1) to very good (level 8). The presentation order of experimental stimuli was randomized between subjects in all tasks. Trials in which no response was made were not included in fMRI analyses.

The sensory properties of attractiveness and goodness rating tasks were very different (i.e. faces *vs* sentences), but this is an advantage for our goals because overlaps in activation are more likely to reflect similarities in processes rather than similarities in stimuli. To ensure that overlaps were not due to similarities in simple decision or motor processes, the brightness rating task was employed as a control task.

Image acquisition and data analysis

All MRI data acquisition was conducted using a 4-T GE scanner. Stimuli were presented using liquid crystal display goggles, and behavioral responses were recorded using an 8-button fiber optic response box. Scanner noise was reduced with earplugs, and head motion was minimized using foam pads and a headband. Anatomical scans began by first acquiring a T1 weighted sagittal localizer series. Second, high-resolution T1-weighted structural images (256×256 matrix, TR = 12 ms, TE = 5 ms, FOV = 24 cm, 68 slices, 1.9 mm slice thickness) were collected. Coplanar functional images were subsequently acquired utilizing an inverse spiral sequence (64×64 matrix, TR = 1500 ms, TE = 31 ms, Flip angle = 60°, FOV = 24 cm, 34 slices, 3.8 mm slice thickness).

The preprocessing and statistical analyses for all images were performed using SPM5 (Wellcome Department of Cognitive Neurology, London, UK). In the preprocessing analysis, after discarding the first four volumes, images were corrected for slice-timing and motion, then spatially normalized into the Montreal Neurological Institute (MNI) template and spatially smoothed using a Gaussian kernel of 8 mm FWHM. For each subject trial-related activity was modeled by convolving a vector of trial onsets with a canonical hemodynamic response function (HRF) within the context of the General Linear Model (GLM). Confounding factors (head motion, magnetic field drift) were also included in the model.

To identify regions where activity increased or decreased simply as a function of attractiveness, goodness and brightness ratings at the subject level, the ratings of each participant were entered as first-order parametric modulators in SPM5 in their original (i.e. 1, 2, 3, 4, 5, 6, 7, 8) and reverse formats. Additionally, given evidence that the amygdala activity may show a quadratic function in response to facial attractiveness and trustworthiness (Winston *et al.*, 2007; Said *et al.*, 2009), we conducted exploratory analyses with a U-shaped regressor (i.e. 8, 4, 2, 1, 1, 2, 4, 8). For sake of completeness and because of the relationship to reaction times (see below), we also investigated an inverted-U regressor (i.e. 1, 2, 4, 8, 8, 4, 2, 1). Following subject-level analyses, regions shared by attractiveness and goodness ratings were identified at the group level using random effects analyses. To be considered significant, an activation had to increase (or decrease) parametrically (i) for attractiveness and goodness judgments taken together ($P < 0.05$, uncorrected); (ii) for attractiveness judgments to a greater extent than for brightness judgments ($P < 0.05$, uncorrected) and (iii) for goodness judgments to a greater extent than for brightness judgments ($P < 0.05$, uncorrected). In the statistical analysis, the first contrast was masked inclusively by the second and third contrasts. By using this procedure, we isolated activations reflecting processes shared by the attractiveness and goodness judgments but not by the brightness judgment. Similar procedures were used to examine U and inverted-U responses in the amygdala. Given that the last two contrasts are independent, the joint probability of the conjunction can be estimated at $P < 0.0025$. Additionally, because a minimum spatial extent of 15 contiguous voxels was required, Monte Carlo simulations of spatially correlated data yield a probability estimate of $P < 0.0001$ (Forman *et al.*, 1995). All coordinates of activations were converted from MNI to Talairach space (Talairach and Tournoux, 1988) using the MNI2TAL tool (http://www.mrc-cbu.cam.ac.uk/Imaging/Common/mnispace.shtml).

To further examine if the regions identified by parametric analyses play a similar role in face attractiveness and action goodness ratings, we measured correlations between the two tasks across participants. We extracted for each participant the peak activity level (effect size) in the contrasts of attractiveness *vs* brightness and of goodness *vs* brightness (all levels collapsed), and then, we computed Pearson correlations between the two effect-size vectors across participants. These analyses answered the question of whether regions identified in the parametric modulation analyses showed a same pattern across participants for attractiveness and goodness tasks. Additionally, to examine functional connectivity between the regions identified in the parametric modulation analysis, we calculated Pearson correlations between activations in these regions.

To examine if regions showing simply increased or decreased activations make different directions of contributions to rating performance, we conducted a three-step correlation analysis based on activity extracted from individual trials (Rissman *et al.*, 2004). As a first step, we created GLM, in which each individual trial was modeled by a separate covariate, yielding different parameter estimates for each individual trial from all subjects. Second, mean activity (effect sizes of difference between trial and fixation baseline) was extracted from regions-of-interest (ROIs) in the medial OFC and insular cortex, with each ROI defined as a sphere with 5 mm radius centered at the peak of the parametric activation. Finally, the Spearman's rank correlation between activations (effects sizes) extracted from individual trials and rating scores were computed for each region and for each judgment task, and then were analyzed to evaluate their significance at a threshold of $P < 0.05$.

RESULTS

Behavioral data

Consistent with the way in which stimuli were selected, attractiveness and goodness ratings were widely distributed, yielding a substantial number of trials in each of the eight levels of both attractiveness and goodness scales (Table 1). Mean numbers of 'No Response' trials were very small in both attractiveness (M : 8.7, s.d. : 15.3) and goodness (M : 5.7, s.d. : 11.6) tasks. Whereas the distribution of ratings reflects the selection of the stimuli, response times (RTs) are more interesting because they provide an indirect measure of judgment at different points of each scale. An observation of Figure 2A and B suggests that RTs were faster in the attractiveness than in the goodness task (compare y-axes) and that both tasks showed a similar inverted-U pattern with slower RTs for intermediate ratings and faster RTs for extreme ratings. To investigate these ideas, we conducted a 2 (task) × 8 (levels) ANOVA, which yielded significant main effects of task [$F(1,19) = 522.6$, $P < 0.001$] and levels [$F(7,133) = 29.9$, $P < 0.001$] and a significant task × level

Table 1 Mean number of trials for each level in attractiveness and goodness rating tasks

Task	L1	L2	L3	L4	L5	L6	L7	L8
Face attractiveness	19.5	42.0	50.5	46.8	38.6	31.5	22.2	10.4
Action goodness	29.8	29.9	23.9	27.0	44.6	41.6	37.8	30.0

L, Scaling Levels

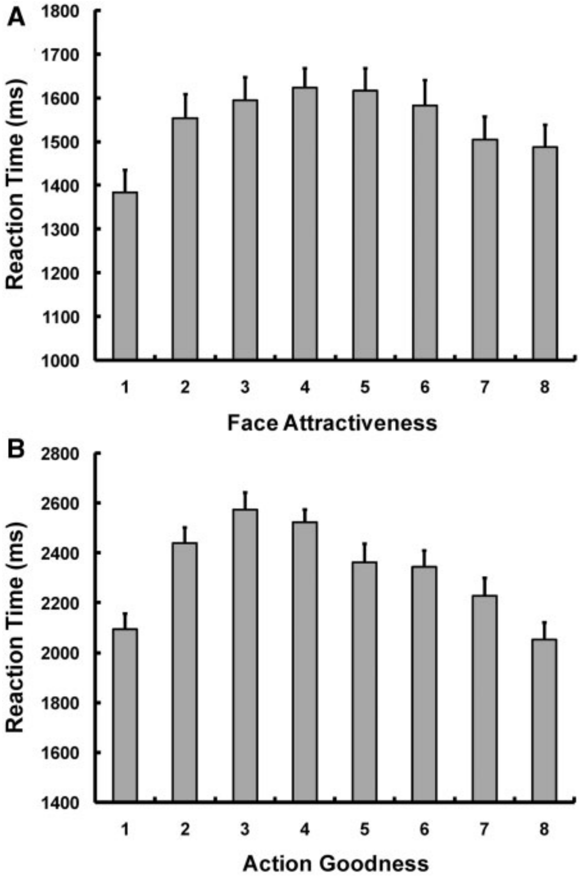

Fig. 2 Results of reaction time data. (**A**) Participants rated the attractiveness of faces from very unattractive (level 1) to very attractive (level 8). Reaction times in this task showed an inverted-U function indicating greater difficulty for intermediate judgments. (**B**) Participants rated sentences of hypothetical actions from morally very bad (level 1) to very good (level 8). Reaction times in this task also showed an inverted- U function. All error bars represent standard errors.

interaction [$F(7,133) = 13.4$, $P < 0.001$]. To confirm the inverted-U pattern, we conducted post-hoc tests comparing intermediate ratings (mean of levels 4 and 5) to extreme ratings (mean of levels 1 and 8) in each task. These tests yielded significant differences for both attractiveness ratings [intermediate: 1619 ms, s.d. : 205; extreme: 1425 ms, s.d. : 229; $t(19) = 5.02$, $P < 0.01$] and goodness ratings [intermediate: 2406 ms, s.d. : 279; extreme: 2072 ms, s.d. : 288; $t(19) = 7.07$, $P < 0.01$]. These RT effects suggest that the judgments were more demanding for intermediate than extreme judgments, possibly because stimuli in the middle of the scale were ambiguous regarding attractiveness and goodness. This finding is important because it indicates that fMRI analyses focused on linear increases or decreases in activation are not confounded with differences in task difficulty (which shows an inverted-U rather than a linear increase or decrease). It is worth noting that this RT pattern differs from the pattern found in a few studies where RTs were longer for highly attractive than for medium and low attractive faces (Aharon *et al.*, 2001; Kranz and Ishai, 2006). This discrepancy can be easily explained by procedural differences. For example, in the study by Aharon *et al.* (2001), RTs were measured during a task, in which participants increased or decreased viewing time by themselves, whereas in our task, viewing time was fixed. In the study by Kranz and Ishai (2006), the task was similar to ours but the rating scale had only 3 points, which probably made the task easier than ours.

fMRI data

Consistent with our first prediction, OFC activity increased as a function of linearly increased format in both types of ratings (Table 2). Activity within the right medial OFC region (Figure 3A) increased as a function of ratings in the facial attractiveness task (Figure 3B) and in the action goodness task (Figure 3C). These changes in activity cannot be attributed to decision difficulty because the most difficult judgments, as indicated by slower RTs, were those in the middle of the scale, not in the extremes. To confirm a similar role of the medial OFC in attractiveness and goodness judgments, we calculated the correlation between the OFC activities during the two tasks across participants. As illustrated by Figure 3D, we found a highly significant positive correlation ($r = 0.86$, $P < 0.01$), indicating that participants with stronger medial OFC activation for face attractiveness ratings also showed stronger medial OFC activations for action goodness ratings. To confirm that the correlation was not driven by two potential outliers (Figure 3D), we redid the analysis without these points and the correlation remained significant ($r = 0.65$, $P < 0.01$). Also, the correlations remained significant when performed on unsubtracted data. Another region where activity increased as function of both type of judgments was the posterior cingulate cortex (Table 1). This region also showed a highly positive correlation between activations during the attractiveness and goodness judgment tasks ($r = 0.62$, $P < 0.01$).

Consistent with our second prediction, insular activity decreased as a function of both attractiveness and goodness (Table 2). Activity within the right insular region (Figure 4A) decreased as a function of ratings in the face attractiveness task (Figure 4B) and in the action goodness task (Figure 4C). As in the case of the medial OFC, these changes cannot be attributed to difficulty, which was greater in the center of the scale. Confirming a similar role of the insular cortex in the two types of judgments, we found a highly significant positive correlation in insular activations during attractiveness and goodness ratings across participants (Figure 4D, $r = 0.78$, $P < 0.01$). To confirm that the correlation was not driven by two possible outliers (see Figure 4D), we recalculated the correlation without these points and it remained significant ($r = 0.63$, $P < 0.01$). As in the case of medial OFC correlations, insula correlations remained significant when

Table 2 Regions showing similar activation patterns in response to judgments of face attractiveness and action goodness

Regions	L/R	BA	Coordinates			*Z*-value	Voxel size
			x	*y*	*z*		
Linear increases for both attractiveness and goodness ratings							
Medial OFC	R	25	8	3	−16	4.26	19
Posterior cingulate cortex	L	30	−8	−51	13	3.89	91
Linear decreases for both attractiveness and goodness ratings							
Insular cortex	R		34	−15	−6	4.80	25
Inferior frontal gyrus	L	44	−53	19	10	4.41	32
Supramarginal gyrus	L	40	−60	−45	−4	5.12	111
Supramarginal gyrus	R	40	53	−50	24	3.07	64
U-shaped responses for both attractiveness and goodness ratings							
Anterior cingulate cortex	L	32	−4	44	1	5.27	96
Lingual gyrus	R	18	15	−71	−9	3.70	35
Cerebellum	L		−4	−64	−29	3.55	21
Inverted-U responses for both attractiveness and goodness ratings							
No significant activation							

R, Right; L, Left; BA, Brodmann area.

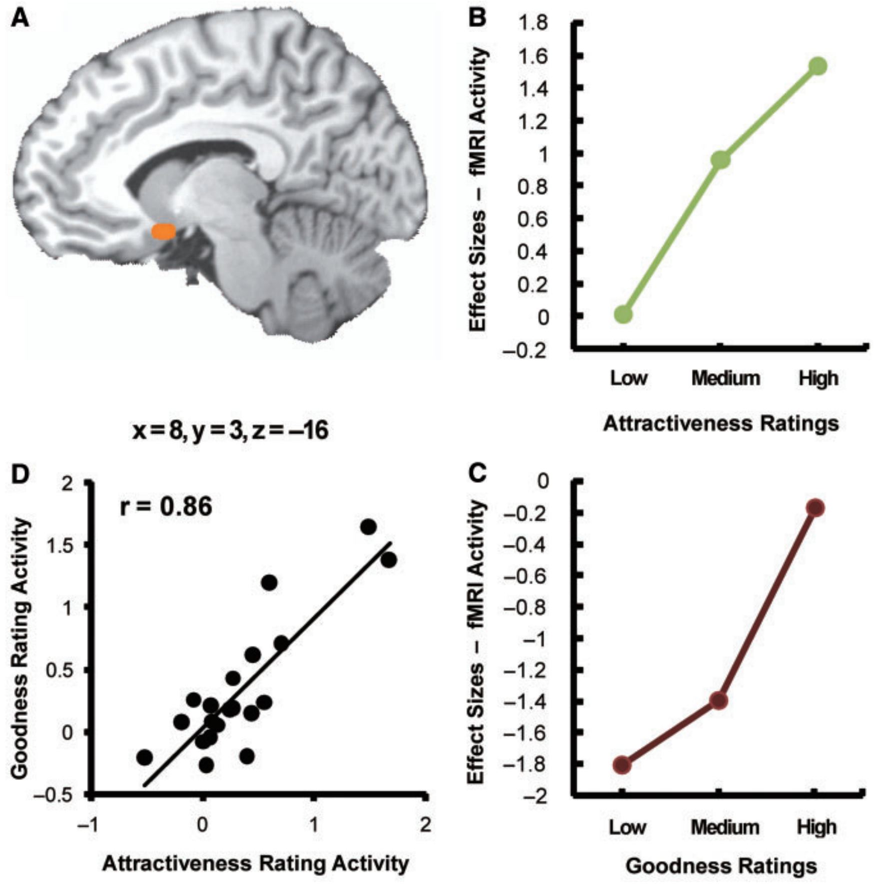

Fig. 3 (**A**) Right medial OFC region where activity increased simply as a function of both attractiveness and goodness ratings. (**B**) Increase in OFC activity as a function of attractiveness ratings. 'Low' corresponds to ratings 1–3, 'Medium' to ratings 4–5 and 'High' to ratings 6–8. (**C**) Increase in OFC activity as a function of goodness ratings. 'Low', 'Medium' and 'High' correspond to ratings 1–3, 4–5 and 6–8, respectively. (**D**) Changes in OFC activity as a function of attractiveness and goodness ratings were highly correlated ($r = 0.86$, $P < 0.01$).

performed on unsubtracted data. Other regions where activity decreased as function of both types of judgments were the left inferior frontal gyrus and the supramarginal gyrus in both hemispheres (Table 2). These regions also showed highly positive correlations between activities during the attractiveness and goodness judgment tasks (left inferior frontal gyrus: $r = 0.63$, $P < 0.01$; left supramarginal gyrus: $r = 0.61$, $P < 0.01$; right supramarginal gyrus: $r = 0.83$, $P < 0.01$).

In addition to the main linear analyses, we conducted analyses to identify brain regions showing U-shaped or inverted-U activation patterns as a function of both attractiveness and goodness ratings. As indicated by Table 2, U-shaped responses were found in the anterior cingulate gyrus, lingual gyrus and cerebellum. The lack of U-shaped responses in the amygdala is interesting because U-shaped amygdala responses have been previously found for facial attractiveness and trustworthiness (Winston *et al.*, 2007; Said *et al.*, 2009). Inverted-U responses were not found in any region.

Finally, given medial OFC and insular regions showed increased or decreased responses to the attractiveness and goodness, we tested whether the OFC and insular regions should interact during both judgments of attractiveness and goodness. Confirming this prediction, in the correlation analysis between right medial OFC and right insular activations, they were negatively correlated across participants (Figure 5, $r = –0.41$, $P < 0.01$). This correlation is consistent with the existence of direct anatomical connections between the OFC and insular cortex (Van Eden *et al.*, 1992). Moreover, when we extracted activity from individual trials within participants and calculated Spearman's rank correlation, we found that the medial OFC activations were positively correlated with both beauty and goodness ratings, whereas the insular activations were negatively correlated with both types of ratings (Table 3). Thus, these two regions have opposing effects on attractiveness and goodness judgments.

DISCUSSION

Three main findings emerged from the present study. First, medial OFC activity increased as a function of perceived attractiveness and goodness, and the activity was significantly correlated between the two judgment tasks. Second, insular activity decreased as a function of perceived attractiveness

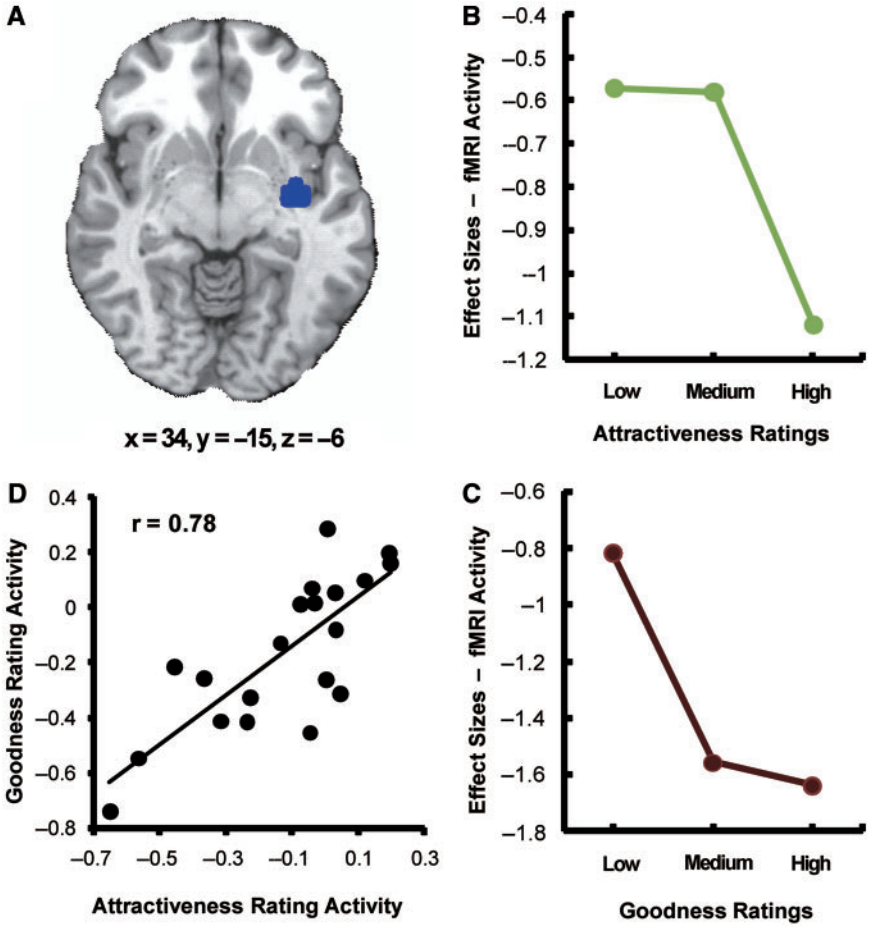

Fig. 4 (**A**) Right insular cortex region where activity decreased as a function of both attractiveness and goodness ratings. (**B**) Decrease in insular activity as a function of attractiveness ratings. For ratings groupings, see caption of Figure 3. (**C**) Decrease in insular activity as a function of goodness ratings. For ratings groupings, see caption of Figure 3. (**D**) Changes in insular activity as a function of attractiveness and goodness ratings were highly correlated ($r = 0.78$, $P < 0.01$).

and goodness, and the activity showed a significant correlation between the two judgment tasks. Third, medial OFC and insular cortex displayed an opposing relationship during attractiveness and goodness judgments. These findings are discussed in separate sections below.

Medial OFC: attractiveness and goodness

Activity in the medial OFC, which has been known as a region associated with processing positive emotions and reward, increased as a function of both attractiveness and goodness ratings, and was correlated across participants between these ratings (Figure 3). The findings in Figure 3 are in harmony with evidence from separate fMRI studies that OFC activity increases as a function of facial attractiveness (O'Doherty *et al.*, 2003b; Kranz and Ishai, 2006; Winston *et al.*, 2007; Ishai, 2007; Bray *et al.*, 2008; Cloutier *et al.*, 2008;) and as a function of moral goodness (Moll *et al.*, 2006; Zahn *et al.*, 2008). Also, patients with OFC lesions show poor practical judgments (Damasio *et al.*, 1994) and impaired moral behavior (Eslinger and Damasio, 1985; Anderson *et al.*, 1999; Ciaramelli *et al.*, 2007), and people with smaller OFC gray matter volume display higher psychopathy scores (de Oliveira-Souza *et al.*, 2008). However, our study is the first one to clearly show that medial OFC activations for positive aesthetic and moral judgments overlap within the same participants and are significantly correlated with each other.

Given the strong link between medial OFC and reward processing (Rolls, 2000; Martin-Soelch *et al.*, 2001; McClure *et al.*, 2004; O'Doherty, 2004), one possible explanation of increased activity for both facial attractiveness and action goodness is that both are rewarding. This idea is consistent with several lines of evidence, including neuroimaging (Aharon *et al.*, 2001; Cloutier *et al.*, 2008) and developmental research. For example, infants who are presented with pairs of faces spend more time looking at the most attractive face in each pair (Langlois *et al.*, 1987, 1991). Evolutionary accounts suggest that physical beauty may be associated with better genetic fitness and reproductive capacities (Fink and Penton-Voak, 2002; Rhodes, 2006). Sexual preference may also play a role. For instance, an fMRI study found that medial OFC activity was greater for male than

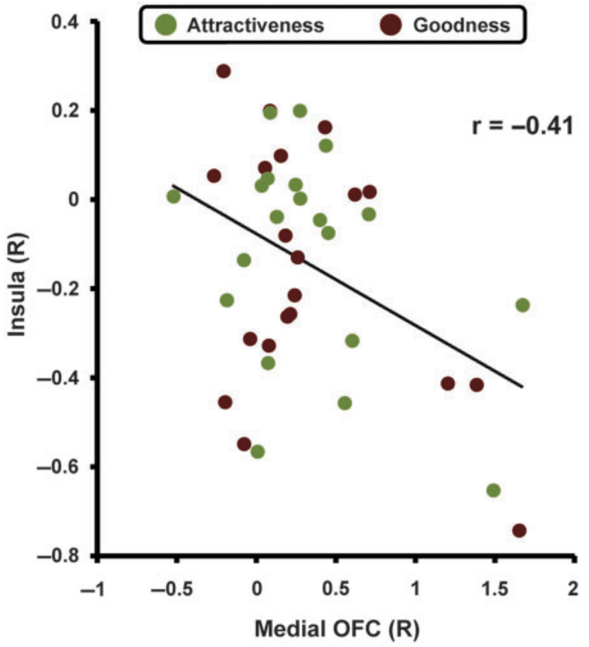

Fig. 5 Significantly negative correlation ($r = -0.41$, $P < 0.01$) between right medial OFC activity and right insular cortex activity during attractiveness and goodness ratings tasks. Activations during the attractiveness rating task are plotted in green and activations during the goodness rating task are plotted in brown.

Table 3 Results of the Spearman's rank correlation between activity in the medial OFC and insular cortex and rating score during the face attractiveness and action goodness ratings

Regions	Face attractiveness		Action goodness	
	Z-value	*P*-value	*Z*-value	*P*-value
OFC	2.27	0.02	2.64	<0.01
Insular cortex	−3.54	<0.001	−3.62	<0.001

female faces when the participants were heterosexual females and homosexual males, but showed the opposite pattern when the participants were heterosexual males and homosexual females (Kranz and Ishai, 2006). The link between positive moral judgments and reward is also supported by several neuroimaging studies (Bartels and Zeki, 2004; Singer *et al.*, 2004a; Izuma *et al.*, 2008) that suggest positive social impressions about people are processed within reward-related circuits, including OFC and the striatum. In addition, neuropsychological studies have reported that patients with OFC damages are impaired in the judgment of moral behaviors (Eslinger and Damasio, 1985; Ciaramelli *et al.*, 2007). In the present study, increasing activity as a function of both facial attractiveness and action goodness was identified in the medial OFC region, which is one of areas associated with approaching social rewards (Davey *et al.*, in press; Lebreton *et al.*, 2009). However, it is worth noting that a few studies have associated medial OFC with the processing of morally-negative actions (e.g. Moll *et al.*, 2007). The reasons for the inconsistency with the present study and evidence linking medial OFC to processing moral goodness (Moll *et al.*, 2006; Zahn *et al.*, 2008) and rewarding stimuli (Rolls, 2000; Martin-Soelch *et al.*, 2001; McClure *et al.*, 2004; O'Doherty, 2004) are uncertain and deserve further research.

Insular cortex: unattractiveness and badness

Activity in the insular cortex, which has been known as a region associated with processing negative emotions and pain, increased as a function of both negative attractiveness and goodness ratings, and was correlated across participants between these ratings (Figure 4). The findings in Figure 4 are consistent with evidence from separate fMRI studies that insular activity is greater for unattractive than attractive faces (O'Doherty *et al.*, 2003b; Krendl *et al.*, 2006) and for negative than positive moral stimuli (Krendl *et al.*, 2006; Hsu *et al.*, 2008; Zahn *et al.*, 2008). However, this study is the first one to demonstrate that insular activations for negative aesthetic and moral judgment overlap within the same participants and are significantly correlated across participants.

One possible explanation of the increasing insular activity for both unattractiveness and badness mediated is in terms of the role of this region in the processing of punishment (O'Doherty *et al.*, 2003a). Functional neuroimaging studies have linked insular activations to emotions of disgust and fear (Phan *et al.*, 2002), as well to a variety of negative social situations, including social exclusion (Eisenberger *et al.*, 2003), unfairness (Sanfey *et al.*, 2003), socially negative signals from faces (Phillips *et al.*, 1997; Winston *et al.*, 2002) and unreciprocated cooperation (Rilling *et al.*, 2008). The insula has also been linked to the processing of pain (Critchley *et al.*, 2000), and aversive conditioning (Seymour *et al.*, 2004). The posterior insular region identified in the present study could be one of areas associated with both disgust and pain (Benuzzi *et al.*, 2008), and with self-experienced pain but not with empathy for the pain experienced by others, which has been associated with the anterior insula (Singer *et al.*, 2004b). The present findings suggest that the posterior insular cortex, which showed responses to unattractive faces and bad actions, could mediate avoidance of socially negative stimuli.

Opposing relationship between medial OFC and insular activities

The third finding of the study was a contrasting relationship between medial OFC and insular cortex during aesthetic and moral judgments. Activations in these regions were negatively correlated with each other (Figure 5) and had opposite-sign correlations between attractiveness and goodness ratings (Table 2). This finding has implications for theoretical accounts of the Beauty-is-Good stereotype, i.e. the assumption that attractive individuals have better personalities and higher moral standards (Dion *et al.*, 1972; Eagly *et al.*, 1991; Langlois *et al.*, 2000). This stereotype could reflect (i) a positive bias toward attractiveness, (ii) a negative bias against unattractiveness or (iii) a combination of both mechanisms (Griffin and Langlois, 2006). Although this issue has been examined by various lines of behavioral studies (Wilson and Daly, 2004; Olson and Marshuetz, 2005; Hayden *et al.*, 2007), fMRI data can be more informative. The 'positive bias hypothesis' suggests that the mechanisms of aesthetic and moral judgments are likely to overlap in brain regions associated with processing positive stimuli, whereas the 'negative bias hypothesis' suggests that the overlap should occur in regions associated with processing negative stimuli. The 'dual process hypothesis' predicts that both types of regions should be involved, possibly in opposition to each other. Thus, the current results are consistent with the dual process account of the Beauty-is-Good stereotype.

One way of explaining the opposition between medial OFC and insular cortex is in terms of approach and avoidance. The Beauty-is-Good stereotype could reflect an approach response toward beauty and goodness, mediated by medial OFC, combined with an avoidance response away from unattractiveness and badness, mediated by the insular cortex. The link between medial OFC and approach responses is supported by evidence that this region shows greater activity when people approach friends rather with other people (Guroglu *et al.*, 2008), and when hungry participants perceive food-related rather than food-unrelated stimuli under hunger conditions (Fuhrer *et al.*, 2008). The link between insular cortex and avoidance responses is consistent with findings that insular activity is associated with the anticipation of threat (Seymour *et al.*, 2007), the avoidance of risky options in decision-making tests (Kuhnen and Knutson, 2005) and the individual differences in avoidance learning (Samanez-Larkin *et al.*, 2008).

It is worth noting, however, that the implications of the current findings for the Beauty-is-Good stereotype are indirect. Although we identified overlaps in the neural mechanisms of attractiveness and goodness judgments, we did not observe an interaction between these two types of judgments within the same task. Thus, further research is required to corroborate the direct involvement of OFC and insular cortex in the Beauty-is-Good stereotype.

CONCLUSION

In sum, the goal of the present study was to identify shared neural mechanisms of aesthetic and moral judgments. Activity in region previously associated with reward, medial OFC, increased as a function of both attractiveness and goodness ratings, whereas activity in a region previously associated with disgust, pain and punishment, the insula, decreased as a function of both attractiveness and goodness ratings. In both regions, activations for attractiveness and goodness judgments were positively correlated across participants. This second finding is independent from the first one and it strengthens the link between aesthetic and moral processing by showing that individual differences in the reactivity of these regions are similar for attractiveness and goodness judgments. Finally, we found an opposing relationship between medial OFC and insular activity during aesthetic and moral judgments. These findings are consistent with the idea that the Beauty-is-Good stereotype involves a positive bias toward attractiveness and goodness coupled with a negative bias against unattractiveness and badness. The notion of opposing mechanism fits with the roles of medial OFC activity in approaching rewards and the role of insular cortex in avoiding punishment.

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