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Ventral medial prefrontal cortex and person evaluation: Forming impressions of others varying in financial and moral status

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ABSTRACT

The current study investigated ventromedial prefrontal cortex (VMPFC) activity during impression formation of individuals varying on distinct dimensions of social status. In a block-design functional magnetic resonance imaging (fMRI) experiment, participants were presented with photographs of faces paired with a colored background indicating their lower, same, or higher financial status, or lower, same, or higher moral status. Participants were asked to form an impression of the targets, but were not instructed to explicitly evaluate them based on social status. Building on previous findings (Cloutier, Ambady, Meagher, & Gabrieli, 2012), a region of interest analysis revealed the interaction of status dimension and level in VMPFC, finding not only preferential response to targets with higher compared to lower moral status as previously demonstrated, but also greater response to targets with lower compared to higher financial status. The implications of these results are discussed with an emphasis towards better understanding the impact of social status on social cognition and uncovering the neural substrates of person evaluation.

Introduction

Knowledge of others' social status plays a central role in guiding social interactions (Cheney and Seyfarth, 2008; Fiske, 2010; Hare and Tomasello, 2004; Magee and Galinsky, 2008; Sapolsky, 2004; Stephens et al., 2007). Social status is generally believed to impact how we evaluate others, such that higher social status is associated with positive evaluations; for example being perceived as more competent, valuable to the group, prominent, generous, and reputable (Anderson and Kilduff, 2009; Fiske, 2010; Flynn et al., 2006; Ridgeway and Walker, 1995). Positive evaluations of higher status individuals are in turn believed to motivate greater achievement of group members who seek improved status and, therefore, may help maintain the relevance of social hierarchies (Henrich and Gil-White, 2001; Hogg, 2001; Huberman et al., 2004). Interestingly, however, a recent study suggests that lay theories concerning the impact of social status on personal characteristics relevant to social evaluations are not particularly accurate (Varnum, 2013).

Despite the evidence suggesting that greater status may confer greater prestige, it is still unclear whether individuals possessing high social status will be positively evaluated regardless of the social dimension upon which it is based. In contrast to several non-human primate species, where social hierarchies are based on physical dominance (Cheney and Seyfarth;, 2008; Hare and Tomasello, 2004), humans can infer social status from a variety of dimensions (Berger et al., 1972; Fiske, 2010; Magee and Galinsky, 2008). Conceivably, the impact of social status on person evaluation may depend on the social dimension from which it is inferred (Cloutier et al., 2012; Fiske et al., 2002).

Financial standing is commonly thought of as a salient dimension from which status is inferred. Possessing a higher financial status is believed to lead to better mating prospects, fewer physical and mental health problems, better education opportunities, higher living standards, greater access to scarce resources, better social support, and greater degree of control over one's life (Boushey, and Weller, 2008; Ellis, 1993; Marmot, 2004; Singh, 1995; Werner et al., 2007). However, although high status individuals may generally be evaluated more positively, as a group, rich people tend to be seen as higher in competence but lower in warmth compared to poor people (Fiske et al., 2002). Furthermore, individuals with highest financial status, such as business leaders, may often be perceived negatively (Ribstein, 2009).

On the other hand, morality is believed to have become central to the maintenance of human social hierarchies (Boehm, 2012; Rai and Fiske, 2011). Sensitivity to the relative moral standing of others is evident from an early age, and even infants have been shown to prefer pro-social individuals (Hamlin and Wynn, 2011; Hamlin et al., 2010). In adults, perceived morality guides social interactions (Miller, 2007; Rai and Fiske, 2011; Weiner et al., 2011) and shapes neural responses to others (Cloutier et al., 2012; Decety et al., 2012; Moll and de Oliveira-Souza, 2007; Moll et al., 2002; Singer et al., 2004). Taken

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together, this suggests that morality may represent a salient dimension from which social status can be inferred (see also Swencionis and Fiske, 2014).

When contrasting financial and moral status dimensions, it is conceivable that financial wealth may confer higher status, but also lead to negative evaluations by other group members (Fiske et al., 2002; Ribstein, 2009), whereas higher moral status, which confers the respect often required to maintain one's standing within hierarchies (Boehm, 2012; Ridgeway and Walker, 1995; Yzerbyt and Demoulin, 2010), may more consistently lead to positive evaluations. In sum, the association between higher levels of social status and positive evaluations (Cheng et al., 2012; Fiske et al., 2002) may depend on the social dimensions from which status is inferred (Cloutier et al., 2012).

Previous brain-imaging studies have identified a number of regions (i.e., ventromedial prefrontal cortex [VMPFC], intraparietal sulcus [IPS], and Nucleus Accumbens [NAcc]) to be responsive to cues conveying social status or dominance information about conspecifics (Chiao et al., 2009; Cloutier and Gyurovski, 2013; Freeman et al., 2011; Karafin et al., 2004; Ly et al., 2011; Marsh et al., 2009; Zink et al., 2008). Guiding the current investigation, one recent study found that perceiving individuals paired with knowledge indicating higher moral status elicits greater activity in the VMPFC (Cloutier et al., 2012).

Lesion studies have also denoted the importance of the VMPFC for social cognitive processes such as mentalizing, emotion processing, decision-making, and person evaluation (Adolphs, 2009; Gläscher et al., 2012; Leopold et al., 2012; Shamay-Tsoory et al., 2003). For instance, individuals with damage to the VMPFC show an impaired ability to perform moral judgments about unfamiliar others (Croft et al., 2010) and demonstrate deficiencies in recognizing facial expressions of emotion (Heberlein et al., 2007; Hornak et al., 1996).

In multiple contexts, the VMPFC also appears to play a role in assessing the value of a variety of stimuli (Berridge and Kringelbach, 2008; Bouret and Richmond, 2010; Chib et al., 2009; Fellows, 2007; Fellows and Farah, 2007; Frith and Frith;, 2012; Henri-Bhargava et al., 2012; Valentin et al., 2007). Using fMRI, the VMPFC is shown to be involved when human perceivers evaluate conspecifics (Bzdok et al., 2012; Cloutier et al., 2012; Mende-Siedlecki et al., 2013). Interestingly, differential VMPFC activity is not only seen in response to the evaluation of others, but also when participants report their own affective state (Gusnard et al., 2001; Moran et al., 2006). This suggests that this region could act as an interface between affective and social information both when forming impressions of others or introspecting about oneself (Adolphs, 2009; Roy et al., 2012).

In light of the reviewed evidence for VMPFC involvement in person evaluation, the current study focuses on this region's response to the presentation of targets varying in social status. More precisely, and contrary to suggestions that prestige associated with the possession of high status may systematically lead to more positive evaluations (Anderson and Kilduff, 2009; Fiske, 2010; Flynn et al., 2006; Ridgeway and Walker, 1995), greater VMPFC activity was expected in response to targets paired with higher moral status, but not to those paired with higher financial status (Cloutier et al., 2012; Fiske et al., 2002; Ribstein, 2009).

Manipulating the person-knowledge available about others (Adolphs, 2009; Cloutier et al., 2011; Mason et al., 2004; Mitchell et al., 2002; Todorov et al., 2007) has previously added to our understanding of the impact of social status on brain responses during person evaluation (Cloutier et al., 2012; Kumaran et al., 2012; Ly et al., 2011). Nonetheless, this approach may have provided perceivers with information other than the targets' social status. Given the difficulty of disentangling social status from constructs such as power, dominance, prestige, and reputation (Anderson and Shirako, 2008; Fiske, 2010; Magee and Galinsky, 2008; Thomsen et al., 2011), such limitations deserve further consideration. In contrast to the use of elaborate forms of person-knowledge (Cloutier et al., 2012), the current study was designed to investigate the impact of distinct levels (Lower, Same, and Higher) and dimensions (Moral and Financial) of social status by simply pairing faces with status labels and examining brain responses to these targets (Cloutier and Gyurovski, 2013; Cloutier et al., 2013).

Methods

Participants

Twenty male participants between the ages of 19 and 31 (M_{age} = 24.3, SD = 3.9) were recruited from the greater Chicago area. No participants were excluded from data analysis. All participants had normal or corrected to normal vision and none reported significant abnormal neurological history. Participants were paid $50 for their participation and gave informed consent in accordance with the guidelines set by the Social and Behavioral Sciences Institutional Review Board at the University of Chicago.

Stimuli and procedure

Participants first answered a series of questionnaires, which included fMRI pre-screening material, demographic information and measures of objective and subjective status information. The subjective measures of financial and moral status were modifications of the MacArthur Subjective Social Status ladder scale, which has been extensively used to evaluate subjective socio-economic status (SES) (Adler et al., 2000; Singh-Manoux et al., 2003, 2005) and were designed to assess participants' subjective financial and moral status amongst the university undergraduate population of the greater Chicago area, a procedure similarly used in previous research (Cloutier and Gyurovski, 2013; Cloutier et al., 2013). The administration of this series of measures as part of the initial cover story for the experiment served in part to convey the intended meaning of the financial and moral status conditions. The measures were also meant to ostensibly assess the relative status of participants. Indeed, at the end of the pre-test session, participants were informed of their own status in relation to the other participants in the study. In reality, participants were always assigned an average status. Importantly, they were told that the distribution of the financial and moral status of all participants was not necessarily representative of the distribution of the student population of the greater Chicago area. This allowed for the subsequent presentation of social targets with higher, equal, or lower financial and moral status than the participant's.

Participants completed a computer-based training task (adapted from Cloutier et al., 2013; Cloutier and Gyurovski, 2013) to learn the association between colors (blue and red) and specific social status dimensions (financial and moral). Shades of each color (Darker, Medium, and Lighter) were associated with different levels of social status (Higher, Same, and Lower). For example, light blue may indicate higher moral status whereas dark red may indicate lower financial status. The association between color and status was counterbalanced across participants. Furthermore, the face assigned to each condition was counterbalanced across participants. Together, this eliminates the possibility that any of the subsequently observed effects on brain activation can be explained by the variation in color alone. During the encoding phase of the training task, participants were presented with the different backgrounds (without any faces) with a text box indicating the social status dimension and level with which the shade of each color was paired. Seventy trials were presented for each of the six conditions, for a total of 420 trials. Following the encoding phase, participants were again exposed to the different shades of colors and the status dimensions and levels. This time they were required to provide accurate response on at least 30 sequential trials of randomly presented different shades of colors. Participants were informed that they would later be presented with faces paired with these color backgrounds and were reminded that the depicted individuals were also participants in the study. Having an extensive training procedure of 420 encoding trials and a subsequent test, requiring 100% accuracy to proceed, ensured that participants acquired strong associations between the color backgrounds and the status dimension and level they represent.

For the fMRI scanning session, participants were instructed to simply form impressions of the presented individuals, each of them associated with a single status dimension and level. Stimuli were presented with E-prime software (Psychology Software Tools, Inc., Pittsburgh, PA) using a back-projection system. The stimuli were composed of 30 color photographs of college-age white males (approximately 18–25 years old) who were ostensibly from the same participant pool from which participants were recruited. All stimuli displayed a neutral facial expression, wore gray shirts, and were photographed against a white background. The pictures were randomly assigned to six groups of five photographs each, and were counterbalanced across the six conditions (Higher Moral, Same Moral, Lower Moral, Higher Financial, Same Financial, Lower Financial). The images in each of the six groups were counterbalanced across participants to ensure that the faces themselves presented no possibly confounding artifacts. Each of the six sessions (duration of 126 s each) included the blocked presentation of five unique faces from each condition (duration of 18 s each) and of two resting blocks composed of a white fixation cross on a black background (duration of 9 s each) (see Fig. 1). The presentation order of conditions was counterbalanced across runs and the faces ascribed to each condition were counterbalanced across subjects. Within each block, faces were presented for 3000 ms with an inter-stimulus interval of 500 ms, during which a white fixation cross was presented against a black background. Following this task, participants took part in an additional fMRI experimental task before coming out of the scanner.

Following the fMRI session, participants were asked to fill out additional questionnaires and to take part in a short computer-based task during which they were asked to rate all faces on likeability and similarity (where 1 indicated "Not at all Likeable" or "Not at all Similar" and 7 indicated "Very Much Likeable" or "Very Much Similar"). Importantly, participants were only exposed to the faces without the background colors when they provided the post-scan ratings.

fMRI data acquisition and analysis

MRI was performed on a 3 T Philips Achieva Quasar scanner at the University of Chicago Brain Research Imaging Center. The fMRI pulse sequence parameters included time repetition/time echo (TR/TE) 3000/25, flip angle = 85, contiguous slices with 3 mm thickness, gap 0.3 mm, 212 × 212 mm field of view (FOV), approximately 72 × 70 matrix. High resolution structural images were acquired in the sagittal plane using a T1-weighted 3D Turbo Field Echo (TFE/MP-RAGE) anatomical scan with the following parameters: TR = 8.5 ms, TE = 4.0 ms, FOV = 240 × 228 mm, 1.0 mm slice thickness, no gap, 240 × 228 mm matrix, and 1.0 × 1.0 × 1.0 mm voxel size.

Functional MRI data were analyzed using the general linear model (GLM) for block designs in SPM8 (Wellcome Department of Cognitive Neurology, London, UK). For each functional run, data were preprocessed to remove sources of noise and artifact. Images were realigned within and across runs via a rigid body transformation in order to correct for head movement. Images were then unwarped to reduce residual movement-related image distortions not corrected by realignment. Functional data were normalized into a standard stereotaxic space (3 mm isotropic voxels) based on the SPM8 echo planar imaging template that conforms to the ICBM 152 brain template space (Montreal Neurological Institute) and approximates the Talairach and Tournoux (1988) atlas space. Finally, normalized images were spatially smoothed (8 mm full-width at half-maximum) using a Gaussian kernel to increase the signal to noise ratio and to reduce the impact of anatomical variability not corrected for by stereotaxic normalization.

For each participant, a GLM was constructed to investigate status condition-specific brain activity. This GLM, incorporating task effects and covariates of no interest (a session mean, a linear trend to account for low-frequency drift, and 6 movement parameters derived from realignment corrections), was convolved with a canonical hemodynamic response function (HRF) and used to compute parameter estimates (β) and contrast images (containing weighted parameter estimates) for each status condition at each voxel.

A region of interest (ROI) analysis was conducted to identify the hypothesized dissociation between VMPFC response to social targets varying on levels of financial and moral status. The eight millimeter VMPFC spherical ROI (MNI: 0, 52, −6) was based on coordinates taken from a previous study designed to investigate the impact of social status on person perception (Cloutier et al., 2012). Parameter estimates for each condition were extracted and submitted to an offline 2 (Status Type: Financial, Moral) by 3 (Status Level: Lower, Same, Higher) repeated measures analysis of variance (ANOVA). Based on a previous study (Cloutier et al., 2012), the VMPFC was expected to be involved in the

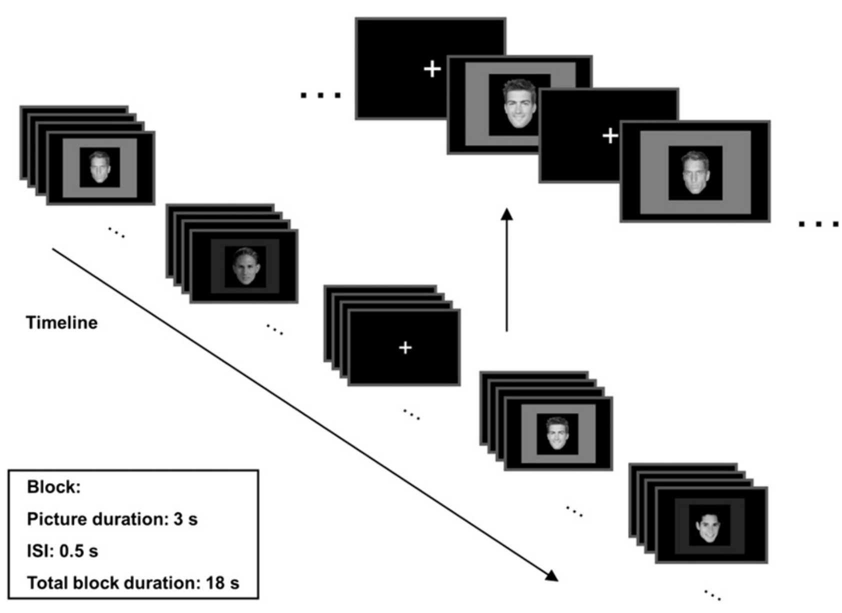

Fig. 1. Impression Formation Task. Schematic representation of the task structure. The task consisted of six scanning sessions, each 126 s long. Each session included six blocks (18 s each) of five faces from each status condition and two fixation (rest) blocks (9 s each). Within each block face stimuli were presented for 3000 ms with an inter-stimulus interval of 500 ms.

evaluation of targets based on both the dimension and level of social status with which they were paired. Nonetheless, additional ROI analyses were performed to identify the potential involvement of regions previously involved in person evaluation based on perceptual characteristics (right NAcc; MNI: 9, 14, −3, left NAcc; MNI: −9, 8, −5; and orbitofrontal cortex (OFC); MNI: −9, 40, −15; coordinates taken from Cloutier et al., 2008).

Additionally, an exploratory whole-brain analysis (with a threshold = $p < .005$, uncorrected; clusters = 5 voxels) was performed using contrast images comparing each condition to the baseline control (fixation). These images were used to compute a whole-brain voxelwise ANOVA that yielded F-statistical maps for both main effects (status dimension and status level) and the interaction.

Results

Behavioral results

On average, participants reported a higher moral subjective status ($M = 6.85$, $SD = 1.22$) than financial subjective status ($M = 4.55$, $SD = 2.56$), $t_{(19)} = 3.138$, $p = 0.005$, $\eta^2 = 0.341$.

A 2 (Status Type: Financial, Moral) by 3 (Status Level: Lower, Same, Higher) repeated measures ANOVA was performed on post-scan likeability and similarity ratings of the faces. For likeability ratings, analysis revealed no main effect of Status Type, $F_{(1,19)} = 0.11$, $p = 0.918$, $\eta^2 = 0.001$. However, there was a significant main effect of Status Level, $F_{(2,38)} = 7.845$, $p = 0.001$, $\eta^2 = 0.292$, and a significant Status Type by Status Level interaction, $F_{(2,38)} = 5.862$, $p = 0.006$, $\eta^2 = 0.236$. Subsequent analysis revealed that Lower Moral targets ($M = 3.27$, $SD = .831$) were rated significantly lower than Same Moral targets ($M = 4.06$, $SD = .751$), $t_{(19)} = 3.406$, $p = 0.003$, $\eta^2 = 0.379$, and Higher Moral targets ($M = 4.14$, $SD = .838$), $t_{(19)} = -3.437$, $p = 0.003$, $\eta^2 = 0.383$. (with no significant differences between Higher [$M = 4.14$, $SD = 0.838$] and Same [$M = 4.06$, $SD = 0.751$], $t_{(19)} = -.604$, $p = 0.553$, $\eta^2 = 0.018$). On the other hand, Lower Financial status targets ($M = 3.69$, $SD = 0.634$) were rated as significantly less likeable than Same Financial Status targets ($M = 4.01$, $SD = .675$), $t_{(19)} = 2.235$, $p = 0.038$, $\eta^2 = 0.208$ (with no significant differences between Higher [$M = 3.74$, $SD = 0.636$] and Same [$M = 4.01$, $SD = .675$], $t_{(19)} = 1.630$, $p = 0.19$, $\eta^2 = 0.122$ or Higher [$M = 3.74$, $SD = 0.636$] and Lower [$M = 3.69$, $SD = 0.634$], $t_{(19)} = -.256$, $p = 0.801$, $\eta^2 = 0.003$). A different pattern of results was observed for similarity ratings. No main effect of Status Type, $F_{(1,19)} = 1.749$, $p = 0.202$, $\eta^2 = 0.084$, and no significant status by level interaction $F_{(2,38)} = 1.269$, $p = 0.293$, $\eta^2 = 0.063$ were observed. However, a significant Status Level main effect, $F_{(2,38)} = 6.456$, $p = 0.004$, $\eta^2 = 0.254$ revealed that participants rated targets of Same status as more similar to themselves ($M = 3.75$, $SD = .767$) than both Lower ($M = 3.20$, $SD = .659$), $t_{(19)} = -3.032$, $p = 0.007$, $\eta^2 = 0.326$, and Higher ($M = 3.46$, $SD = .722$), $t_{(19)} = 2.301$, $p = 0.033$, $\eta^2 = 0.217$, status targets.

Brain-imaging results

ROI analysis

A 2 (Status Type: Financial, Moral) by 3 (Status Level: Lower, Same, Higher) repeated measures ANOVA was performed on parameter estimates extracted from the VMPFC ROI. No main effect of Status Type $F_{(1,19)} = 2.471$, $p = 0.132$, $\eta^2 = 0.115$ or Status Level $F_{(2,38)} = 0.063$, $p = 0.939$, $\eta^2 = 0.003$ were obtained, but a significant status by level interaction $F_{(2,38)} = 5.091$, $p = 0.011$, $\eta^2 = 0.211$ was observed. Inspection of Fig. 2 and subsequent analysis revealed significantly greater VMPFC activity to Higher ($M = 0.175$, $SD = 0.358$) compared to Lower ($M = -0.168$, $SD = 0.466$) Moral Status Targets $t_{(19)} = -2.135$, $p = .046$, $\eta^2 = 0.193$, and to Lower ($M = 0.367$, $SD = .331$) compared to Higher ($M = -0.127$, $SD = .399$) Financial Status Targets, $t_{(19)} = 2.431$, $p = 0.025$, $\eta^2 = 0.237$. Despite trends in the expected direction,

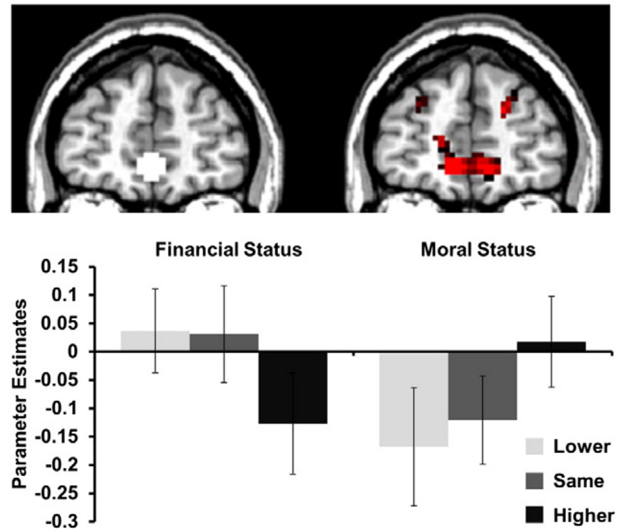

Fig. 2. The top panel of the figure presents Coronal sections illustrating the selected spherical ROI in VMPFC (left) and the VMPFC activation obtained from the whole brain interaction analyses (right). The graph at the bottom of the image displays signal change (parameter estimates) in the ROI for each trial type (lower moral status, same moral status, higher moral status, lower financial status, same financial status, higher financial status). Inspection of this figure reveals an interaction between status dimensions and levels, indicating preferential activity in response to individuals of higher compared to lower moral status and to individuals of lower compared to higher financial status.

no significant differences were observed when comparing Higher ($M = 0.175$, $SD = .358$) with Same Moral Status targets ($M = -0.121$, $SD = .348$) $t_{(19)} = -1.517$, $p = 0.146$, $\eta^2 = 0.108$, or Same ($M = -0.121$, $SD = .348$) with Lower Moral Status targets ($M = -0.168$, $SD = 0.466$) $t_{(19)} = -0.584$, $p = 0.566$, $\eta^2 = 0.017$, or when comparing Lower ($M = 0.367$, $SD = .331$) with Same ($M = 0.031$, $SD = .382$) Financial Status targets $t_{(19)} = 0.070$, $p = 0.945$, $\eta^2 = 0.0002$, or Same ($M = 0.031$, $SD = .382$) with Higher Financial Status targets ($M = -0.127$, $SD = .399$) $t_{(19)} = 1.765$, $p = 0.094$, $\eta^2 = 0.140$.

A 2 (Status Type: Financial, Moral) by 3 (Status Level: Lower, Same, Higher) repeated measures ANOVA was also performed on parameter estimates extracted from ROIs previously shown to be involved in the evaluation of others based on perceptually available characteristics such as attractiveness (Mende-Siedlecki et al., 2013); namely the medial OFC, right NAcc, and left NAcc (Cloutier et al., 2008). The data revealed no main effects of Status Type (OFC: $F_{(1,19)} = 0.705$, $p = 0.412$, $\eta^2 = 0.036$; right NAcc: $F_{(1,19)} = 0.540$, $p = 0.475$, $\eta^2 = 0.027$; left NAcc: $F_{(1,19)} = 0.005$, $p = 0.944$, $\eta^2 = 0.000$) and Status Level (OFC: $F_{(2,38)} = 0.250$, $p = 0.780$, $\eta^2 = 0.013$; right NAcc: $F_{(2,38)} = 0.207$, $p = 0.814$, $\eta^2 = 0.011$; left NAcc: $F_{(2,38)} = 0.142$, $p = 0.869$, $\eta^2 = 0.007$) and not significant status by level interaction (OFC: $F_{(2,38)} = 1.581$, $p = 0.219$, $\eta^2 = 0.077$; right NAcc: $F_{(2,38)} = 0.249$, $p = 0.781$, $\eta^2 = 0.013$; left NAcc: $F_{(2,38)} = 0.175$, $p = 0.840$, $\eta^2 = 0.009$).

Finally, a 2 (Status Type: Financial, Moral) by 3 (Status Level: Lower, Same, Higher) repeated measures ANOVA was also performed on parameter estimates extracted from an IPS ROI, a region believed to be involved in the assessment of social distance (Chiao et al., 2009; Yamakawa et al., 2009) and previously shown to be recruited during the perception of targets varying in social status (Chiao et al., 2009; Cloutier et al., 2012; Ly et al., 2011; Zink et al., 2008). The data revealed no main effect of Status Type, $F_{(1,19)} = 2.940$, $p = 0.103$, $\eta^2 = 0.134$, or Status Level, $F_{(2,38)} = 0.796$, $p = 0.458$, $\eta^2 = 0.040$, and no significant status by level interaction, $F_{(2,38)} = 0.271$, $p = 0.764$, $\eta^2 = 0.014$. The lack of differential IPS activity when comparing the blocked presentation of targets from each condition may not be surprising when considering the previously mentioned hypothesized role of the IPS in assessing relative social distances.

Exploratory whole-brain analysis

A whole-brain exploratory analysis confirmed the presence of a VMPFC interaction between dimensions and levels of social status (see Table 1 and Fig. 3). In addition, a number of temporal, parietal, and prefrontal areas were identified in this interaction analysis. The involvement of many of these areas in response to targets of varying dimensions and levels of social status may be explained by their role as part of the greater attention networks (Corbetta and Shulman, 2002; Desimone and Duncan, 1995; Klein et al., 2009; Posner and Rothbart, 2007; Raz and Buhle, 2006). Such interpretation is further bolstered by previous research demonstrating differential attention allocation to social targets as a function of their status (Dalmaso et al., 2012; Deaner et al., 2005; Fiske, 2010; Foulsham et al., 2010; Maner et al., 2008). Finally, it is noteworthy that this exploratory analysis revealed no significant activity in brain regions previously involved in person evaluation based on perceptual features such as attractiveness (i.e., NAcc and OFC).

Discussion

The current study provides further evidence towards better understanding the differential involvement of VMPFC during the perception of others who vary in both their level of social status and the social dimension from which their status is inferred. The observed preferential VMPFC activity in response to targets of higher moral status replicates results suggesting a role for that region in evaluating targets based on person-knowledge indicative of social status (Cloutier et al., 2012). These findings are further corroborated by explicit behavioral ratings revealing that targets with higher moral status are judged to be more likeable. In contrast, the greater VMPFC activity observed in response to targets with lower financial status suggests that, at least in some contexts, lower financial status individuals may be construed more positively than higher financial status targets (Fiske et al., 2002; Ribstein, 2009). However, this finding is only partially corroborated by explicit likeability ratings indicating that targets paired with "same" financial statuses were judged to be most likeable. In addition to being potentially susceptible to self-presentation bias or experimental demand, it is important to note that contrary to the presentations during the fMRI session, the explicit behavioral ratings were obtained after the fMRI session during which the faces were presented without the background colors indicative of social status.

More generally, these neuroimaging findings are in line with existing evidence involving the VMPFC in a range of social cognitive tasks. Notably, the VMPFC has been reported to support person evaluation (Karafin et al., 2004; Mende-Siedlecki et al., 2013) and is believed to underlie the affective component of moral judgments (Adolphs, 2009; Anderson et al., 1999; Decety et al., 2012; Greene, 2007; Harenski and Hamann, 2006; Koenigs et al., 2007; Moll and de Oliveira-Souza, 2007; Moll et al., 2002). The VMPFC has also been shown to be responsive to the value of a range of stimuli (Berridge and Kringelbach, 2008; Bouret and Richmond, 2010; Chib et al., 2009; Fellows, 2007; Fellows and Farah, 2007; Henri-Bhargava et al., 2012; Valentin et al., 2007) and to contribute to the generation of affective meaning across various tasks related to memory, social cognition, and emotion (Roy et al., 2012).

An alternative interpretation of the current findings may be found in the hypothesized involvement of the VMPFC in the implementation of simulation processes during impression formation (Jenkins et al., 2008; Mitchell et al., 2005, 2006). Indeed, differential VMPFC activity has been observed when participants reflect on their own preferences and personalities (Kelley et al., 2002; Schmitz et al., 2004; Zysset et al., 2002) or use a first person perspective (Vogeley et al., 2004). Such self-referential processes could also have been recruited if perceivers were engaging in social comparison during the task (Swencionis and

Table 1
Identification of BOLD signal as a function of social Status Type and Level.

Brain region		P_{uncorr}	K	F	x	y	z
Status Type by Status Level interaction							
BA 6	L paracentral lobule	0.000	138	13.06	−9	−15	66
BA 4	R precentral gyrus	0.000	10	10.72	42	−15	30
BA 7	L superior parietal lobule	0.000	64	10.17	−21	−60	60
BA 2	L precentral gyrus	0.001	36	9.32	−57	−12	30
BA 17	R cuneus	0.001	46	9.08	21	−99	−6
BA 17	L cuneus	0.002	76	7.47	−18	−99	−3
BA 31	R posterior cingulate gyrus	0.001	7	8.84	15	−39	48
BA 22	L superior temporal gyrus	0.001	15	8.66	−39	−36	21
BA 8	L superior frontal gyrus	0.002	8	7.40	−21	39	33
BA 32	L ventromedial prefrontal cortex	0.002	8	7.31	−9	48	−6
BA 7	R Postcentral Gyrus	0.002	6	7.11	18	−51	69
Status Type main effect							
BA 20	R anterior inferior temporal gyrus	0.000	14	19.27	42	−12	−27
BA 37	R posterior inferior temporal gyrus	0.000	15	16.97	60	−45	−15
BA 37	R middle temporal gyrus	0.001	17	14.02	42	−60	24
Status Level main effect							
BA 17	R cuneus	0.000	262	14.37	18	−72	21
BA 41	R posterior insula	0.000	113	12.91	39	−9	12
BA 2	R postcentral gyrus	0.000	96	11.74	60	−24	48
BA 19	L thalamus	0.000	10	11.64	−15	−27	3
BA 17	L cuneus	0.000	118	10.10	−27	−72	18
BA 19	L precuneus	0.001	22	9.16	−18	−84	42
BA 42	R insula	0.001	8	8.35	39	−3	−6
BA 41	L insula	0.001	19	8.30	−36	−12	9
BA 5	L inferior parietal Lobule	0.002	15	7.82	−39	−42	57
BA 37	R middle temporal gyrus	0.002	35	7.72	48	−66	12
BA 2	L postcentral gyrus	0.002	21	7.55	−51	−21	45
BA 18	L middle occipital gyrus	0.002	9	7.28	−42	−81	6
BA 18	L lingual gyrus	0.002	7	7.20	−18	−72	0
BA 22	R superior temporal gyrus	0.003	19	6.98	60	−21	9

Exploratory whole-brain analyses reporting activations with a threshold = $p < .005$, uncorrected; clusters = 5 voxels; (actual values are reported in the table). BA = approximate Brodmann's area location. Coordinates are from the MNI atlas. Locations of the activations are determined based on the functional responses superimposed on averaged anatomical MRI images.

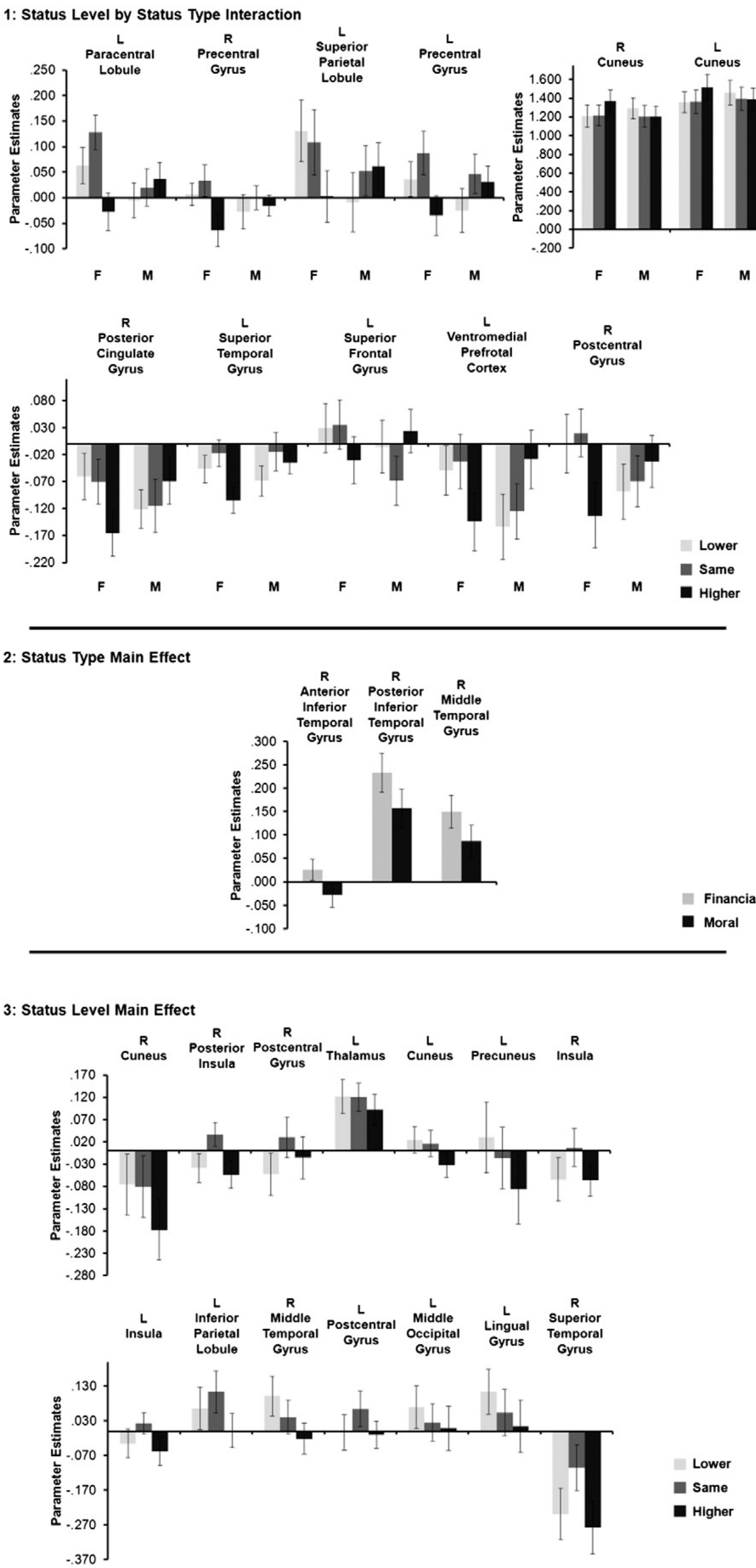

Fig. 3. Graphical displays of signal change (parameter estimates) provided to interpret the results of the whole brain analysis. Panel 1: interaction between Status Level and Status Type; Panel 2: main effect of Status Type; Panel 3: main effect of Status Level.

Fiske, 2014). However, bearing in mind potential reporting biases, the post-scan similarity ratings indicating greater perceived similarity to both same financial and moral status targets do not support this interpretation of our findings.

Surprisingly, few studies have systematically investigated the impact of social status on the so-called social brain (Chiao, 2010; Kumaran et al., 2012; Marsh et al., 2009). In contrast to previous studies providing more detailed information about the targets in order to confer their relative status (Chiao et al., 2009; Cloutier et al., 2012; Ly et al., 2011; Zink et al., 2008), the current study assigned status dimensions and levels to faces with the use of colored backgrounds. Thus, targets' status dimensions and levels served as the only information available to the perceivers, which limited the potential influence of extraneous factors. Beyond demonstrating the impact of status information on the neural substrates of person perception, the current findings highlight the necessity to investigate how the dimensions from which status is inferred within specific social hierarchies may shape person perception and social cognition (Fiske, 2010; Magee and Galinsky, 2008). In addition to financial and moral status, status inferred from intellectual abilities and physical dominance, for example, may differentially impact person perception (Marsh et al., 2009; Stephens et al., 2007). Future research will be necessary to assess the importance given to these or other status dimensions in various hierarchies and contexts in which individuals are evaluated.

Generalization of the current findings is limited by the inclusion of only male perceivers and the use of only male stimuli. Previous research suggests the existence of gender differences associated with the perception and expression of social status (Eagly and Johnson, 1990; Eagly et al., 2003; Fiske, 2010; Holden and Smock, 1991; Martin and Ruble, 2010; Van Engen and Willemsen, 2004). For example, female leaders seem to be more democratic, participative, and use more reward-based incentives for their subordinates, relative to males who tend to be less democratic and participative, and to rely on threat-based incentives (Eagly and Johnson, 1990; Eagly et al., 2003; Van Engen and Willemsen, 2004). Accordingly, further research including female perceivers and stimuli is required to address this limitation and increase the generalizability of the obtained results.

Considering that gender, race, and age are often used as cues to infer the status of others (Fiske, 2010), it will also be important to expand research efforts to explore the interaction between knowledge of an individual's social status and perceptually available social characteristics. Future studies, with a larger sample size, should also identify the impact of individual differences, such as the status of perceivers (Cloutier et al., 2013; Ly et al., 2011; Muscatell et al., 2012; Varnum et al., 2012), on the neural response to targets varying in social status. These studies would be particularly informative when exploring the dynamics underlying the interaction of distinct status dimensions guiding person perception in various contexts.

Notwithstanding the accumulation of evidence suggesting that the VMPFC plays an important role in social cognition, much remains to be learned about its function within the extended network of brain regions supporting person perception (Cloutier et al., 2011; Gobbini and Haxby, 2007; Todorov et al., 2007). In light of a large body of evidence suggesting a link between social status and a number of health outcomes (Marmot, 2004; Sapolsky, 2004), the use of psychophysiological measures (i.e., sympathetic and parasympathetic autonomic nervous system responses) could improve our understanding of the VMPFC's potential role in modulating responses to stressors during social interactions (Cloutier et al., 2013; Eisenberger et al., 2011; Mobbs et al., 2010; Phelps et al., 2004). Given the hypothesized role for VMPFC in enacting control on ANS responses (Thayer et al., 2011; Urry et al., 2006), one possibility is that positive evaluations of others may provide “safety signals” modulating stress-related responses typical of everyday social interactions.

Our findings highlight the importance of considering social status as a multi-faceted construct likely to differentially influence the way conspecifics are evaluated depending on the social dimension from which status is inferred and the context of the interaction. Greater social status only leads to positive evaluations in some instances, and the bases of one's social status (e.g. greater wealth or morality) may be central to how one is perceived by others. Distinctions between the types of social status may not only impact basic person perception processes, but also the dynamics underlying complex social interactions. Some differences identified across cultures, countries, social classes, and gender may also be explained by the variability in social dimensions conferring status across groups (Eagly and Steffen, 1984; Fiske, 2010; Fiske and Markus, 2012; Markus and Kitayama, 1994).

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