Neural research on social cognition has not examined motivations known to influence social cognition. One fundamental motivation in social cognition is positivity motivation, that is, the desire to view close others in an overly positive light. Positivity motivation does not extend to non-close others. The current functional magnetic resonance imaging study is the first to identify neural regions modulated by positivity motivation. Participants compared the personalities of a close other (i.e., romantic partner) and a non-close other (i.e., roommate) with their average peer. Romantic partners were perceived as above average under certain conditions; roommates were perceived as similar to an average peer across conditions. Neural regions previously associated with social cognition did not significantly relate to positivity motivation. Instead, orbitofrontal cortex (OFC) and, to a lesser extent, dorsal anterior cingulate cortex (ACC) activation increased when social targets were perceived as similar to an average peer. Furthermore, OFC activity negatively correlated with the extent to which a social target was perceived as above average. Intimacy with the social target modulated the extent to which ventral ACC distinguished positive from negative stimuli. The results expand current knowledge about neural regions associated with social cognition and provide initial information needed to create neural models of social cognition.

Keywords: emotion, fMRI, orbitofrontal cortex, positivity motivation, social cognition

Introduction

Researchers have begun to lay the groundwork for creating neural models of social cognition by identifying the neural regions associated with perceptions of other people and the self (Amodio and Frith 2006; Beer and Ochsner 2006; Mitchell 2009). One important next step in this endeavor is to identify the neural regions associated with the motivational influences known to pervade social cognition (Beer 2007). Decades of behavioral research have demonstrated that people’s perceptions of others are often colored by what they wish to see (Kunda 1990). One example is positivity motivation, that is, the desire to view close others in an overly positive light (e.g., Taylor and Brown 1988; Murray 1999). The influence of positivity motivation is reflected in the tendency for most people to view their close others (i.e., romantic partner, closest friend) as having more positive characteristics and fewer negative characteristics than an average person (Buunk and Van Yperen 1991; Van Lange and Rusbult 1995; Murray and Holmes 1997; Gagne and Lydon 2001; Suls et al. 2002), the tendency for people to view their romantic partner more favorably than the partner views themselves (Neff and Karney 2002, 2005), and the tendency to excuse their romantic partners’ failures by attributing them to external causes rather than dispositional characteristics of the romantic partner (e.g., Taylor and Koivumaki 1976). In contrast, perceptions of non-close others (i.e., friends, student peers) are less likely to reflect positivity motivation. For example, non-close others tend to be perceived as having positive and negative characteristics that are similar to an average peer (Suls et al. 2002) and failures of familiar but less intimate others tend to be attributed to dispositional characteristics of that person (Taylor and Koivumaki 1976). As a pervasive characteristic of social cognition, positivity motivation will need to be included in a comprehensive neural model of social cognition. However, current neural research has yet to examine motivational influences known to characterize social cognition. The present study is the first to identify neural regions associated with positivity motivation.

Most of the current neural research on social cognition has primarily focused on identifying neural regions that are associated with evaluations of people compared with evaluations of self or inanimate objects (Gallagher and Frith 2003; Mitchell et al. 2005; Amodio and Frith 2006; Uddin et al. 2007; Van Overwalle and Baetens 2009). Generally, these studies find that evaluations of people and evaluations of self are associated with medial prefrontal cortex (MPFC) and posterior cingulate cortex (PCC) activity (e.g., Vogeley et al. 2001; Harris et al. 2005; Mitchell et al. 2005; Ochser et al. 2005; Lindner et al. 2008; Krienen et al. 2010 but see Kelley et al. 2002). In addition, recent work has begun to examine the neural regions involved in perceptions of romantic partners compared with others kinds of people (Bartels and Zeki 2000, 2004; Aron et al. 2005; Ortigue et al. 2007; for a review, see Fisher et al. 2006). These studies find activity in reward-related neural regions such as the caudate nucleus in relation to perceptions of romantic partners as compared with familiar others. This previous research provides important information about the neural regions that are associated with social cognition but does not yet address motivational influences known to pervade social cognition. In order to conceptualize how social cognition might be supported by MPFC, PCC, and the caudate, it will be helpful to know whether their association extends to motivated social cognition. For example, is a particular kind of motivation, positivity motivation, associated with MPFC, PCC, and caudate activation? Do researchers need to expand the neural regions included in discussions of social cognition in order to incorporate those associated with positivity motivation?

Although nothing is known about the neural regions associated with positivity motivation in the perceptions of other people, some recent neural studies have begun to examine the neural regions associated with the influence of positivity motivations on self-perceptions. These studies have...
found that positivity motivation reflects the reduced recruitment of orbitofrontal cortex (OFC) and, to a lesser extent, dorsal anterior cingulate cortex (dACC). For example, patients with OFC damage have overly positive self-perceptions about the appropriateness of their social behavior when compared with the perceptions of trained judges (Beer, John, et al. 2006). Neuroimaging studies have found that positivity motivation is negatively associated with the recruitment of OFC and, to a lesser extent, dACC (Blackwood et al. 2003; Krusemark et al. 2008; Beer and Hughes 2010; Beer et al. 2010). Just as the majority of people tend to believe that their romantic partners are “above average” (Buunk and Van Yperen 1991; Van Lange and Rusbult 1995; Murray and Holmes 1997; Gagne and Lydon 2001; Suls et al. 2002), the majority of people tend to believe they compare favorably with their average peer, and these above average self-evaluations are associated with reduced OFC and dACC activity (Beer and Hughes 2010). Additionally, people who overestimate their task performance are less likely to recruit OFC when making estimates of task performance than people who make confidence estimates that are consistent with actual performance (Beer et al. 2010). Furthermore, this study found that high confidence on incorrect task trials was associated with less OFC activation. Lastly, self-serving attributions of task performance (i.e., internal attributions about positive outcomes and external attributions about negative outcomes) have been associated with decreased OFC (Blackwood et al. 2003) and possibly less dACC activity (Kruisemark et al. 2008). Self-perceptions and perceptions of other people often share neural correlates (for a review, see Beer and Ochsner 2006). Therefore, the influence of positivity motivation on social perception may involve many of the neural regions identified in the neural research on the influence of positivity motivation on self-perception. More specifically, greater OFC activation and possibility greater dACC activation should be associated with a reduction in the influence of positivity motivation on social perceptions.

One way to examine whether OFC and dACC are modulated by positivity motivation in social perception is to investigate their involvement across social perceptions that are likely to vary in their susceptibility to positivity. Previous behavioral research has shown that perceptions of close others and non-close others vary in their susceptibility to positivity motivation (Taylor and Koivumaki 1976; Murray and Holmes 1997; Epley and Dunning 2000; Suls et al. 2002). For example, one way researchers have operationalized the influence of a positivity motivation on social perception is to examine the degree to which a social target is perceived to be better than the average peer. Although a social target may be distinct from the average peer on some traits, the majority of people in a sample are unlikely to be better than the average peer across a large number of traits. Therefore, researchers have argued that perceptions of social targets across a large number of traits should be centrally distributed around the average peer (Chambers and Windschitl 2004). However, people perceive their romantic partners and best friends as above average when compared with an average peer (Buunk and Van Yperen 1991; Van Lange and Rusbult 1995; Murray and Holmes 1997; Gagne and Lydon 2001; Suls et al. 2002). That is, the majority of people report that their close others have more desirable traits and less undesirable traits than the average peer. These above average perceptions are not extended to non-close others (Suls et al. 2002). Instead, non-close others tend to be perceived as similar to the average peer. Therefore, the negative association between OFC and dACC activation with positivity motivation suggests several predictions about how these regions will be modulated by perceptions of close others and non-close others. Specifically, social comparisons of non-close others should be more likely to engage OFC and dACC than social comparison of close others.

However, in addition to differing in their susceptibility to positivity motivation, perceptions of close others and non-close others may differ in their degree of familiarity. Therefore, differences in neural activity derived from direct contrasts between perceptions of close others and non-close others could be interpreted as important for differences in positivity motivation or familiarity. One way around this issue is to compare perceptions of a close other that vary in their susceptibility with positivity motivation. Behavioral research has shown that not all perceptions of close others are influenced by positivity motivation. For example, the influence of positivity motivation on perceptions of close others varies depending on the breadth of a trait’s construal (Neff and Karney 2002, 2005). Personality traits serve as basic categories of behaviors, and trait breadth refers to the diversity of behavioral manifestations that characterize a trait (e.g., Buss and Craik 1983; Hampson et al. 1986). Positivity motivation is evident in judgments of a close other’s broad traits like “talent” where there are many possible ways for someone to be talented. However, the influence of positivity motivation is not as evident in judgments of a close other’s specific traits like “tidiness” where there are fewer possible ways for someone to be tidy. This research shows that a paradigm that compares social perceptions of a close other’s specific versus broad traits makes it possible to study varying influences of positivity motivation even within judgments of a close other. However, this comparison raises the concern that any neural differences across perceptions of specific and broad traits may reflect the breadth of the trait rather than the influence of a positivity motivation. This confound can be avoided by including a non-close other condition that involves both specific and broad traits. Regardless of trait breadth, judgments of non-close others are less likely to be influenced by positivity motivation. Therefore, any neural regions that are associated with the reduced influence of positivity motivation in judgments of close other’s specific traits should be activated for all judgments of a non-close other, regardless of trait breadth.

Study Overview

The present study used functional magnetic resonance imaging (fMRI) to examine the neural regions modulated by motivational influences in social perception. Participants compared Close Others (Romantic Partner) and Non-Close Others (Roommate) with their average peer on personality traits that differed in their susceptibility to positivity motivation based on trait Breadth (Broad, Specific). Based on previous research, perceptions of Close Others should tend to be “above average” for broad traits, whereas perceptions of Close Others for specific traits and perceptions of Non-Close Others for all traits should be rated as more similar to the average peer.

The neural research on positivity motivation in self-perceptions suggests several predictions for the neural regions associated with positivity motivation in social perceptions. The self-research shows that OFC and, to a lesser extent, dACC are engaged as the influence of positivity motivation is reduced (Beer and Hughes 2010). Therefore, social perceptions that are less susceptible to positivity motivation should more strongly
engage OFC and dACC. In particular, OFC and dACC activation should be greater for judgments of Close Other’s Specific versus Broad traits. Furthermore, if these regions are modulated by positivity motivation rather than trait breadth, then they should be significantly activated across trait judgments for Non-Close Others. Finally, individual differences in the degree to which people view their Close Others and Non-Close Others as “above average” should be negatively correlated with OFC and dACC activity.

Materials and Methods

Participants
Twenty right-handed participants (15 females, M age = 18.7 years, standard deviation [SD] = 0.8 years) were recruited in compliance with the human subjects regulations of the University of Texas at Austin and compensated with $15/h or course credit. All participants were native English speakers and free from medications or psychological and/or neurological conditions that might influence the measurement of cerebral blood flow. In addition, all participants were prescreened to ensure that each had a romantic partner and a roommate. Participants with more than 1 roommate were instructed to select one of them for the purpose of the study. Participants whose roommates were biologically related to them (i.e., siblings, cousins, etc.) were excluded from participation.

Behavioral Paradigm
Participants completed a modified version of a social comparison task (Dunning et al. 1989; Beer and Hughes 2010). In the task, participants compared the personality traits of a Close Other (i.e., their romantic partner) and a Non-Close Other (i.e., their roommate) with the personality traits of an average peer of their same age and gender at their university (see Fig. 1). Comparisons were made in relation to an average peer of the same age and gender as the Close Other and Non-Close Other to ensure that there was a comparable “average peer” across our sample. Participants were presented with personality trait words and had to make comparisons for Close Others and Non-Close Others (see Fig. 1) using a 5-point scale (-2 = much less than the average UT student; -1 = slightly less than the average UT student; 0 = about the same as the average UT student; 1 = slightly more than the average UT student; 2 = much more than the average UT student).

Following previous research on social cognition (e.g., Kelley et al. 2002; Ochsner et al. 2005), we used 2 different cues to remind participants which Target (Close Other, Non-Close Other) they were comparing with an average peer. First, participants were presented with a 2 s instruction screen that indicated the Target for comparison (Close Other, Non-Close Other) (see Fig. 1). Second, each instruction screen was followed by a set of probes from the social comparison task for that Target. Each probe reminded the participants which Target was of interest and indicated the personality trait word of interest (see Fig. 1). Within a set of probes, personality trait words were 1) randomly sampled from 4 trait categories described below (see Stimuli) and 2) jittered with screens depicting a fixation point. Participants were instructed to clear their minds when they saw a screen with a fixation point. These fixation screens were randomly jittered (2 s [50%], 4 s [25%], 6 s [25%]) to maximize independence across experimental conditions (Donaldson et al. 2001). This approach provides strong reminders of the Target of interest and allows independent modeling of the neural activation for each social comparison rating.

fMRI data were collected while participants performed 4 functional runs of the social comparison task described above. Each functional run lasted 10 min 4 s. Within a run, participants rated 4 sets of probes for each of the Close Other and Non-Close Other condition. The presentation order of the probe sets was randomly assigned within a run. In order to present the 200 traits words (50 words each for 4 categories, see Stimuli below) for each Target across 4 runs which were each divided into 4 sets of probes, it was necessary to have 50% of the probe sets include 12 probes and the other 50% include 13 probes (e.g., 200/16 = 12.5). Stimuli were projected onto a screen mounted on the

![Figure 1](https://academic.oup.com/cercor/article-abstract/22/6/1372/303834)
The trait words were equally distributed across Valence (Positive, Negative) and tendency to elicit above average responses based on trait breadth (Specific, Broad). Greater breadth is expected to elicit greater degree of above average judgment (Dunning et al. 1989) according to standardized lists of personality trait words widely used in studies of behavioral and neural self- and person perception (Anderson 1968; Kirby and Gardner 1972; Dunning et al. 1989; Kelley et al. 2002; Mitchell et al. 2002; Neff and Karney 2002, 2005; Suls et al. 2002; Ochsner et al. 2005; Moran et al. 2006; Beer and Hughes 2010). These words have been standardized on a number of dimensions including valence (i.e., social desirability), range of associated behaviors (i.e., trait breadth), frequency of use, and number of syllables (Anderson 1968; Kirby and Gardner 1972). To ensure that this information was not outdated, we pretested our stimuli with a sample of 10 student judges who would be representative of our fMRI study population. These judges rated 250 words for social desirability, trait breadth, familiarity, and judgment certainty. Their social desirability, trait breadth, and familiarity ratings were generally consistent with the categories provided in the original publications of these standardized lists. The final stimuli list of 200 words was created using several constraints. Words that were not familiar to at least one of our judges were eliminated. Four sets of 50 words based on the published norms and our student judges were equated for 1) social desirability within valence level (e.g., the positive-broad traits were not significantly different in their positivity from the positive-specific traits and the same was true for the negative-broad vs. negative-specific words, P > 0.05) and 2) judgment certainty (P > 0.05) but 3) differed in trait breadth (positive-broad vs. positive-specific, t = 11.4, P < 0.05; negative-broad vs. negative-specific, t = 26.7, P < 0.05). These criteria supported the creation of 4 sets of trait words that differed in their susceptibility to bias because of their trait breadth and not because of additional factors such as familiarity, social desirability, or judgment certainty.

The Positive-Specific condition consisted of trait words such as prompt, talkative, tactful, coolheaded, mathematical, well spoken, witty, modest, energetic, and lighthearted. The Positive-Broad condition consisted of trait words such as likable, mature, decent, positive, capable, understanding, educated, competent, disciplined, and ethical. The Negative-Specific condition consisted of trait words such as stingy, materialistic, hashful, high strung, rigid, gullible, timid, jumpy, boastful, and messy. The Negative-Broad condition consisted of trait words such as looking, bad, weak, maladjusted, irritating, unreliable, phony, narrow minded, aggressive, and showy (for complete stimuli list, see Supplementary Table 1).

MRI Data Acquisition

All images were collected on a 3.0-T GE Signa EXCITE scanner at the University of Texas at Austin Imaging Research Center. Functional images were acquired with a GRAPPA sequence (time repetition = 2000 ms, time echo = 30 ms, field of view = 240, voxel size 2.5 × 2.5 × 3.3 mm) with each volume consisting of 35 axial slices oriented to the AC-PC line. These parameters were implemented to optimize coverage of the OFC without sacrificing whole-brain acquisition. A high-resolution SPGR T1-weighted image was also acquired from each subject.

MRI Data Analysis

All statistical analyses were conducted using SPM2 (Wellcome Department of Cognitive Neurology). Functional images were reconstructed from k-space using a linear time interpolation algorithm to double the effective sampling rate. Image volumes were corrected for slice-timing skew using temporal sinc interpolation and for movement using rigid-body transformation parameters. Functional data and structural data were coregistered and normalized into a standard anatomical space (2-mm isotropic voxels) based on the echo planar imaging and T1 templates (Montreal Neurological Institute), respectively. Images were smoothed with an 8-mm full-width at half-maximum Gaussian kernel. To remove drifts within sessions, a high-pass filter with a cutoff period of 128 s was applied.

A fixed-effects analysis modeled event-related responses for each participant. For each Target (Close Other, Non-Close Other), the Positive-Specific, Positive-Broad, Negative-Specific, and Negative-Broad conditions were modeled as events using a canonical hemodynamic response function with a temporal derivative. A general linear model analysis created contrast images for each participant. Contrasts relevant to the hypotheses were calculated. First, contrast images were calculated to examine the interaction of trait Breadth (Specific, Broad) and Target (Close Other, Non-Close Other) collapsed across Valence (Positive, Negative) on neural activation. Based on previous research, judgments of Close Other Broad traits are more likely to be influenced by positivity motivation as compared with judgments of Close Other Specific and all Non-Close Other traits (Neff and Karney 2002; Suls et al. 2002). Therefore, the Target × Breadth interaction contrast was modeled as (Close Other Broad −3; Close Other Specific +1; Non-Close Other Specific +1; Non-Close Other Broad +1). The Target × Breadth interaction contrast introduces the potential confound of Non-Close Other Intimacy. Previous research suggests that the motivation to cast others in a positive light (positive valence) is positively linked to the extent that they are more intimate and well liked (Taylor and Koivumaki 1976; Suls et al. 2002). For the minority of participants who rated their roommates high on intimacy, the neural hypotheses for the Non-Close Other (i.e., roommate) condition would more closely resemble the hypotheses for the Close Other condition. More specifically, neural regions that differentiate Broad from Specific traits for Close Others may also differentiate Broad from Specific traits for Non-Close Others (i.e., roommates) to the extent that they are more intimate and well liked. Therefore, the Target × Breadth interaction contrast controlled for Non-Close Other Intimacy once they were entered into group level analysis (see below). In addition, contrast images were calculated to examine the effect of Valence collapsed across Target and Breadth (Positive vs. Negative: all trials of Positive traits +1, all trials of Negative traits −1; Negative vs. Positive: all trials of Negative traits +1, all trials of Positive traits −1). Finally, a contrast compared the effect of Target collapsed across Valence and Breadth (all trials for Close Other +1, all trials for Non-Close Other −1).

Contrasts from each participant were used in a second-level analysis treating participants as a random effect. The group average SPM(T) maps were corrected for multiple comparisons (P < 0.05 familywise error [FWE], k = 10) in a priori regions of interest (ROIs). The ROIs were based on the previous study of positivity motivation in self-perception using this social comparison task (Beer and Hughes 2010) and were defined by 8-mm-radius spheres around the peaks of activation clusters: MFFC (Brodman’s Area [BA] 9: 12, 54, 34; BA 10: 8, 64, 24), medial OFC (MORP) (BA 11: −2, 56, −16 and −4, 46, −10), bilateral lateral OFC (LOFC) (left BA 47: −32, 34, −14; right BA 47: 28, 28, −20), dACC (10, 26, 34), PCC (−4, −38, 28), ventral ACC (vACC) (14, −38, −1), and insula (38, −14, 6). Additionally, the caudate nucleus ROI was defined by an 8-mm-radius sphere in the anterior portion of the caudate by referencing previous research on mental representations of romantic partners (e.g., Ortigue et al. 2007) and the caudate boundaries defined in the Automated Anatomical Labeling map (Tzourio-Mazoyer et al. 2002). Parameter estimates from significantly activated clusters from relevant contrasts were extracted using Marshell (Brett et al. 2002). The parameter estimates extracted by Marshall represent the regression coefficients.
(i.e., beta weights) from the main contrasts in the general linear model predicting MR signal. The parameter estimates were then used to test for significant correlations between brain activation identified by our main contrasts and individual differences in behavioral ratings (Kriegeskorte et al. 2009; Poldrack and Mumford 2009; Vul et al. 2009).

A test for significant correlation examined whether reduced neural activation for the Close Other Broad condition as compared with the other 3 conditions was driven by individuals who also tended to rate Close Other Broad traits more above average compared with their ratings of the other 3 conditions. Therefore, parameter estimates from significantly activated clusters from the Target x Breadth interaction contrast were tested for significant correlation with individual differences in Close Other Broad ratings compared with the Close Other Specific and all Non-Close Other ratings (i.e., Differences in Social Comparison Ratings). First, judgments of Negative traits were reverse scored so that ratings could be collapsed across valence to reflect deviation from the average peer for the Specific and Broad trait conditions. When reverse scoring is applied to social comparisons of negative traits, higher values indicate greater above average ratings (e.g., more positive traits, fewer negative traits), whereas values closer to zero indicate greater similarity to the average peer. Individual differences in Close Other Broad ratings compared with ratings of the other 3 conditions was calculated by applying the same weights of the Target x Breadth interaction contrast to the behavioral ratings (Close Other Broad Rating – Close Other Specific Rating + 1; Close Other Specific Rating + 1; Non-Close Other Broad Rating + 1). With this coding scheme, high scores were closer to zero and indicated that Close Other Broad trait ratings did not differ from ratings of the other 3 conditions. On the low end, scores tended to be more negative and indicated greater above average ratings in the Close Other Broad condition compared with the other 3 conditions. Therefore, a negative correlation between this behavioral index and neural activation indicates less activation in relation to positivity motivation. Additionally, individual differences in Non-Close Other Intimacy were tested for significant correlation with neural activation identified in the Valence contrast (for a description, see Results).

Results

Differences between Close Other and Non-Close Other Relationships

As a manipulation check, individual differences in Duration of Relationship, Liking, Closeness, and Similarity of Close Others were compared with Non-Close others. Duration of Relationship was significantly longer for Close Others than Non-Close Others (Close Other: mean = 37.89 months, SD = 23.33; Non-Close Other: mean = 20.00 months, SD = 33.93; t19 = 2.23, P < 0.05). Close Others were rated more highly than Non-Close Others on Liking (Close Other: mean = 5.0, SD = 0; Non-Close Other: mean = 3.7, SD = 1.3; t19 = 4.47, P < 0.05), Closeness (Close Other: mean = 5.0, SD = 0; Non-Close Other: mean = 3.2, SD = 1.4; t19 = 5.28, P < 0.05), and Similarity (Close Other: mean = 4.1, SD = 0.9; Non-Close Other: mean = 2.7, SD = 1.5; t19 = 3.56, P < 0.05).

Task Performance

Consistent with previous research, no gender differences were found in responses or reaction times (F < 1), so all results are reported collapsed across gender (Dunning et al. 1989; Kenny and Acitelli 2001; Beer and Hughes 2010). Social comparisons were characterized by a significant interaction between Valence (Positive, Negative), Breadth (Specific, Broad), and Target (Close Other, Non-Close Other, Self). 3-way interaction: F1,19 = 6.39, P < 0.05; see Fig. 2A). As expected, judgments in the Broad condition were associated with greater deviations from about average in the Close Other and the postscan Self-condition but not in the Non-Close Other condition. Both Close Others and Self were judged as significantly more likely to have Positive-Broad traits (Close Other: t19 = 5.70, P < 0.05; Self: t19 = 7.36, P < 0.05) and significantly less likely to have Negative-Broad traits (Close Other: t19 = -9.89, P < 0.05; Self: t19 = -8.89, P < 0.05) when compared with their respective Specific conditions. Participants did not just claim positive traits and downplay negative traits for their Close Others and the Self; they were most likely to exhibit bias in relation to broad traits.

In contrast, judgments of Non-Close Others were significantly differentiated by Valence (t19 = 2.61, P < 0.05) but were not significantly differentiated by Breadth (see Fig. 2A). Ratings either did not significantly differ from the about average point on the scale (e.g., Positive-Broad: t19 = 1.81, P > 0.05; Positive-Specific: t19 = 0.78, P > 0.05) or fell within the same range as the Specific ratings for the other targets (all Fs < 1).

Positive ratings were faster than Negative ratings in the Close Other and Non-Close Other conditions (F1,19 = 4.93, P < 0.05; see Fig. 2B). No significant effects were found for Breadth (F1,19 = 1.13, P > 0.05), Target (F1,19 = 0.13, P > 0.05), or any pairwise interaction of these variables (F < 1.5). The 3-way interaction was marginally significant (F1,19 = 3.73, P = 0.07); this effect was driven by the especially fast reaction times for the Positive-Broad ratings of Close Other.

Imaging Results

Caudate Nucleus Differentiates Perceptions of Close Others from Non-Close Others

In an exploratory analysis, we examined whether activation in the caudate nucleus differentiates Close Others from Non-Close Others in the present study as it has in previous research (e.g., mental representations: Ortigue et al. 2007; pictures: Bartels and Zeki 2000, 2004; Aron et al. 2005). Consistent with this previous
research, the Close Other > Non-Close Other contrast showed significant activation in the left caudate nucleus (Left Caudate: peak = –10, 20, –4; t-stat = 3.63, k = 54, P < 0.05 FWE).

OFC and, to a Lesser Extent, dACC Are Associated with Judgments that Are Closer to Average

No significant activation was found for MPFC, PCC, or Caudate in the Target × Breadth interaction contrast. Instead, the neural regions that differentiated Close Other Broad trait judgments from Close Other Specific and all Non-Close Other trait judgments (Fig. 3) were the same as those associated with differentiating Broad from Specific trait judgments for the self in previous research (Beer and Hughes 2010). The Target × Breadth interaction contrast showed significant activation in the 1) MOFC (BA 11: peak = –10, 48, –14; t-stat = 4.08, k = 129, P < 0.05 FWE), 2) left LOFC (BA 47: peak = –24, 42, –14; t-stat = 4.21, k = 77, P < 0.05 FWE), and marginally significant activation in the 3) dACC (BA 24: peak = 14, 28, 30; t-stat = 3.16, k = 75, P = 0.08 FWE). MOFC, LOFC, and, to a lesser extent, dACC, were associated with reduced activity in the Close Other Broad condition compared with the Close Other Specific and all Non-Close Other conditions.

OFC Is Negatively Modulated by Individual Differences in “Above Average” Judgments

The reduced neural activation for the Close Other Broad condition compared with the other 3 conditions was driven by individuals who tended to rate Close Other Broad traits as above average compared with their ratings of the other 3 conditions. Parameter estimates from the Target × Breadth interaction contrasts were negatively correlated with behavioral indices of how much participants expressed positivity motivation when comparing close others on broad traits compared with all other conditions. The more participants viewed their Close Others as better than the average peer in the Broad trait condition (compared with the other 3 conditions), the less they recruited MOFC (r = –0.56, P < 0.05) and LOFC (r = –0.45, P < 0.05) (see Fig. 4).

vACC, Caudate, and Insula Are Associated with Positive and Negative Valence of Judgment Stimuli

Neural regions that differentiated Positive from Negative trait judgments for Close Others and Non-Close Others (Fig. 5A) were the same as those associated with differentiating Positive from Negative trait judgments for the self in previous research (Beer and Hughes 2010). The Positive > Negative contrast showed significant vACC activation (BA 25: peak = 12, 40, –6; t-stat = 5.26; k = 105, P < 0.05 FWE) for Close Others and Non-Close Others. The Negative > Positive contrast showed significant insula activation (peak = –36, 18, 2; t-stat = 4.87; k = 91, P < 0.05 FWE) for Close Others and Non-Close Others. In addition, caudate activity differentiated Positive from Negative trait judgments for Close Others and Non-Close Others. The Positive > Negative contrast showed significant caudate activation (Left Caudate: peak = –14, 22, –8; t-stat = 4.72; k = 219, P < 0.05 FWE) for Close Others and Non-Close Others.

vACC Activation Is Modulated by Intimacy with Non-Close Others

One remaining question is how individual differences in intimacy with social targets modulated neural activity identified in the main contrasts. There was a ceiling effect of Closeness and Liking for Close Others so no individual difference analyses

Figure 3. Neural regions identified by the Target × Breadth interaction contrast and parameter estimates in relation to baseline extracted for each condition of Close Other and Non-Close Other (x = –10: MOFC [BA 11]; y = 42: LOFC [BA 47]; z = 14: dACC [BA 24]). MOFC, LOFC, and, to a lesser extent, dACC, are associated with reduced activity in the Close Other Broad condition as compared with Close Other Specific and all Non-Close Other conditions.
could be conducted. Similarity between Self and Close Other did not significantly modulate any of the neural activations found in the main contrasts. This suggests that despite the similarity between neural regions associated with judgments that are similar to the average peer in the previous self-study, people in the current study did not just use information about the Self when judging their Close Others.

Individual differences in Non-Close Other Intimacy predicted neural activations from the Positive > Negative main effect contrast. Greater Intimacy was significantly correlated with 1) greater differences in vACC activation ($r = 0.50$, $P < 0.05$; see Fig. 5B) and with 2) behavioral ratings in the Positive > Negative contrast for Non-Close Other ($r = 0.63$, $P < 0.05$). The more Intimacy felt toward Non-Close Others, the more people differentiated the social desirability of traits at the neural and behavioral level even though it was not explicitly part of the task.

**Discussion**

Current neural research on social cognition has focused on identifying neural regions associated with perceptions of different social targets (i.e., other people, self) without regard for the motivational influences known to color social cognition (Beer 2007). The present study represents a first step toward addressing this limitation by identifying neural regions associated with positivity motivation, one motivation known to pervade perceptions of close others and the self (Taylor and Brown 1988; Kunda 1990; Murray 1999). OFC and, to a lesser extent, dACC were associated with social perceptions that were less susceptible to positivity motivation. Furthermore, OFC was negatively modulated by individual differences in the extent to which social perceptions exhibited an influence of positivity motivation. Medial and lateral OFC negatively correlated with the extent to which close others and non-close others were rated as above average. The neural regions modulated by positivity motivation were distinct from neural regions modulated by the social desirability of the traits (i.e., Positive Valence: vACC, Caudate; Negative Valence: insula) and neural regions that differentiated social target (i.e., Close Other vs. Non-Close Other: Caudate). Finally, intimacy with non-close others predicted the extent to which vACC differentiated the social desirability of traits. These neural findings were mirrored at the behavioral level: Intimacy also predicted discrepancies between ratings for the Positive > Negative traits. The present findings expand current knowledge about the neural regions associated with social cognition and provide information that will be needed to develop comprehensive neural models of social cognition.

The current study is the first to examine the neural regions that are modulated by positivity motivation, one motivation that frequently impacts social cognition (Taylor and Brown 1988; Kunda 1990; Murray 1999). Research was needed to test whether the neural regions frequently discussed in relation to social cognition (i.e., MPFC, PCC, caudate: Bartels and Zeki...
The current study did not find support for a relation between positivity motivation and MPFC, PCC, and caudate. Instead, OFC and, to a lesser extent, dACC were modulated by the influence of positivity motivations in social perception. OFC and, to a lesser extent, dACC were found in social perception conditions that were least susceptible to positivity motivation (Specific Traits for Close Others, Broad and Specific Traits for Non-Close Others). It is important to note that the OFC and dACC activation cannot simply be explained by differences in intimacy with the target or the breadth of the trait stimuli. OFC and, to a lesser extent, dACC were associated with the conditions that were least susceptible to positivity motivation, which included both trait breadth conditions for Non-Close Others (i.e., Specific traits for Close Other; Broad and Specific traits for Non-Close Others). Furthermore, the individual differences analyses showed that OFC activation was driven by individuals whose social perceptions of Close Others and Non-Close Others were least susceptible to positivity motivation. These findings suggest that discussions of social cognition should include MPFC, PCC, and caudate as well as OFC and dACC. The current study represents a first step toward identifying neural regions associated with motivated social cognition. In future studies, OFC and dACC would be expected to attenuate the influence of positivity motivation in other social perception tasks such as attributions for the success and failures of close and non-close others (Taylor and Koivumaki 1976) but there may be additional regions involved. Furthermore, there are numerous other motivations that influence social perceptions (Kunda 1990), and research examining other motivations is needed to more comprehensively identify the neural regions modulated by motivated social cognition.

The consistent negative relation between OFC and positivity motivation raises the question of what role OFC might play in modulating the influence of positivity motivation. One possibility is suggested by research on non-social judgments, which has found that OFC activation may be associated with more careful processing of emotional information (Beer, Knight, et al. 2006; De Martino et al. 2006). Medial and lateral OFC regions are associated with deciding how much weight positive and negative information has in a final decision. For example, the OFC is helpful for choosing between apartments that vary in price and quality (Fellows 2007) or gambles in relation to an average peer (Beer and Hughes 2010), confidence estimates of performance that exceed actual task performance (Beer et al. 2010), and self-serving attributions for hypothetical life events (Blackwood et al. 2003). In addition, patients with OFC lesions hold self-perceptions of their social skills that are more favorable than trained observers’ perceptions (Beer, John, et al. 2006). In the current study, a consistent negative relation between OFC activation and the influence of positivity motivation was found in 1) comparisons within the Close Other condition, 2) comparisons across social targets that varied in their susceptibility to positivity motivation, and 3) individual differences analyses. It was not the case that the parallels in the current study can be explained by the possibility that participants just used self-perceptions to rate close others but not non-close others. Similarity between the self and close others did not modulate OFC activation in the Close Other condition or the Non-Close Other condition. These findings raise the possibility that common neural regions may support social cognitive processes involving the self and other people (Beer and Ochsner 2006).

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characterized by a mix of reward and loss (Beer, Knight, et al. 2006; De Martino et al. 2006). In the present study, social perceptions that were more similar to the average peer may represent greater integration of both flattering and unflattering information about the social target. This explanation would be consistent with psychological models that suggest that positivity motivation influences social perceptions to the extent that positive information is easily available (Kunda 1990; Rusbult et al. 2000). Information about close others tends to be positive which may make it easy to come up with some relevant characteristic for broad traits of close others (Buunk and Van Yperen 1991). In contrast, positive information in relation to specific traits for close others may not be readily accessible leading to the retrieval of mixed information. Similarly, available information about non-close others tends to be less slanted toward positivity (Buunk and Van Yperen 1991). However, the OFC is involved in many different psychological processes, and future research is needed to more deeply investigate its role in modulating the influence of positivity motivation. One possible future direction is to examine whether the degree of flattering and unflattering person information modulates OFC activation in relation to social perceptions influenced by positivity motivation. Another fruitful future direction will be to examine whether there are neural regions that are positively associated with the influence of positivity motivation; positive relations were not found in the present study or in previous research on the influence of positivity motivation on self-perception (Beer and Hughes 2010).

The present study found that Intimacy with Non-Close Others drove the extent to which the Valence (i.e., social desirability) of personality traits was differentiated at the neural and behavioral levels of analysis even though detecting the valence of stimuli was not explicitly part of the task. Consistent with previous studies, vACC was associated with detecting positive valence (Bush et al. 2000; Moran et al. 2006; Somerville et al. 2006; Sharot et al. 2007; Beer and Hughes 2010).

Psychological models of social evaluation posit that intimacy increases the motivation to see someone positively (e.g., Suls et al. 2002). It may be that when positivity motivations are activated, people are more sensitive to whether a trait is socially desirable. In this case, this finding may further support the claim that motivation to see someone positively influences the processing strategies that are engaged to make judgments (Kunda 1990). If the vACC's differentiation of social desirability does reflect the motivation to view someone positively, then it should be recruited less as positivity motivation is reduced within relationships (e.g., in unhappy relationships) or for the self (e.g., individuals with low self-esteem).

In conclusion, the present study extends neural research on social cognition by identifying a set of neural regions that are modulated by the influence of positivity motivations that pervade social cognition. The current study is the first study to examine the neural regions associated with overly positive perceptions of other people and suggests that social perceptions that are less susceptible to positivity motivation are associated with OFC activation and, to a lesser extent, dACC activation. These findings cannot be accounted for by familiarity with the social perception target or trait breadth. The OFC and dACC regions that differentiated susceptibility to positivity motivation within the Close Other condition (i.e., Specific > Broad traits) were engaged across the Non-Close Other condition (i.e., both Specific and Broad traits), which exhibited low susceptibility across trait conditions. Furthermore, individual differences in positivity motivation drove the negative modulation of OFC activation. These findings parallel research showing that positivity motivation in self-evaluation modulates OFC activation (Blackwood et al. 2003; Beer, John, et al. 2006; Beer and Hughes 2010; Beer et al. 2010). Finally, future research may want to investigate whether the magnitude of positivity motivation is reflected in the vACC's sensitivity to stimulus valence. In the current study, vACC differentiated positive from negative traits and the magnitude of this differentiation was increased as Intimacy with the target increased.

**Supplementary Material**

Supplementary material can be found at: http://www.cercor.oxfordjournals.org/

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**References**


