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Forming impressions of people versus inanimate objects: Social-cognitive processing in the medial prefrontal cortex

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Recent neuroimaging research has linked the task of forming a "person impression" to a distinct pattern of neural activation that includes dorsal regions of the medial prefrontal cortex (mPFC). Although this result suggests the distinctiveness of social cognition – the processes that support inferences about the psychological aspects of other people – it remains unclear whether mPFC contributions to this impression formation task were person specific or if they would extend to other stimulus targets. To address this unresolved issue, participants in the current study underwent fMRI scanning while performing impression formation or a control task for two types of target: other people and inanimate objects. Specifically, participants were asked to use experimentally-provided information either to form an impression of a person or an object or to intentionally encode the sequence in which the information was presented. Results demonstrated that activation in an extensive region of dorsal mPFC was greater for impression formation of other people than for all other trial types, suggesting that this region specifically indexes the *social-cognitive* aspects of impression formation (i.e., understanding the psychological characteristics of another mental agent). These findings underscore the extent to which social cognition relies on distinct neural mechanisms.

Keywords: Social; Cognitive; Medial prefrontal cortex

Introduction

As part of a current upsurge of interest in understanding how the brain gives rise to the remarkable human capacity for social interaction, a number of recent studies have examined the neural basis of social cognition – the mental processes that allow one person to apprehend the psychological properties of another, including his or her transient beliefs and feelings as well as more stable person-specific characteristics, such as personality traits and dispositions. One question that has been central to this emerging enterprise considers whether social cognition draws on a unique set of cognitive processes dedicated to navigating the social world or instead represents a special instance of more general-purpose cognitive processes. As Blakemore et al. (2004) recently asked, are the "general cognitive processes involved in perception, language, memory and attention… sufficient to explain social competence or, over and above these general processes, are there specific processes that are special to social interaction?" (p. 216). In other words, is an understanding of the mental states and behaviors of other people governed by distinct cognitive mechanisms dedicated to social cognition or by a subset of the processes that give rise to other human faculties?

Interestingly, the present-day challenge to address this question directly parallels one confronted by social psychologists more than a quarter-century ago. Beginning in the late 1970s, researchers described a number of ways in which information processing could be affected by tasks that oriented perceivers to the socially relevant aspects of stimuli (Hamilton et al., 1980, 1989; Hastie and Kumar, 1979; Srull and Wyer, 1989; Wyer et al., 1984). One of the most intriguing avenues of investigation considered the effect of impression formation on episodic memory. In work of this kind, participants were presented with information about unfamiliar target individuals and were either instructed to use that information to *form an impression* of the person (i.e., to attend to the stable psychological characteristics of another person) or simply to *commit the information to memory*. These studies revealed that tasks that direct attention to the socially relevant aspects of other people produce memory performance that differs from nonsocial tasks in a number of important ways, both quantitatively (e.g., better recall) as well as qualitatively (e.g., recall clustered around spontaneously inferred personality traits of the targets, better memory for information inconsistent with expectations about the target, etc.).

Nevertheless, despite these consistent observations that impression formation prompts qualitatively different cognitive processing than nonsocial tasks, earlier researchers failed to draw strong

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conclusions regarding the distinctiveness of the mechanisms that support social cognition. By and large, explanations for the unique patterns of memory associated with social-cognitive tasks have suggested that social and nonsocial processing simply call upon different aspects of a general memory system. That is, in accounting for both the quantitative and qualitative shifts in memory performance following impression formation, researchers have generally invoked concepts developed earlier in the study of cognition, for example, by suggesting that social-cognitive tasks may result in greater development and use of schemas, deeper (i.e., more elaborative) encoding, or more pronounced formation of inter-item associations (Hamilton et al., 1980, 1989; Hastie and Kumar, 1979; Srull and Wyer, 1989; Wyer et al., 1984).

To help resolve the outstanding question of whether impression formation relies on distinct cognitive processing, a recent study (Mitchell et al., 2004) used fMRI to examine the neural basis of impression formation effects on memory. The logic of this study suggested that, if impression formation does indeed draw on uniquely social-cognitive processes, then distinct brain regions should be engaged during attempts to form an impression of a person (relative to a comparable nonsocial orienting task). Further, activity in distinct regions should be associated with successful memory for stimuli encoded during impression formation. During scanning, participants were presented with a series of unfamiliar targets, each of which was paired with a number of statements that ostensibly described a recent event in the person's life (e.g., "He stepped on his girlfriend's feet while dancing"). For some targets, participants used the statements to form an impression of the person being described (impression formation task), whereas for other targets, participants intentionally encoded the sequence of the statements (sequencing task). Despite the fact that stimuli were identical across orienting tasks, results indicated that impression formation was associated with greater activity than sequencing in a single brain area, namely, an extensive region of dorsal mPFC. Participants also completed a test of associative memory following scanning, allowing comparison of the fMRI signal associated with the encoding of items that were subsequently remembered and those that were subsequently forgotten, as a function of orienting task. Extending the primary analyses, activity in a single region was observed to differentiate between to-be-remembered (hits) and to-be-forgotten (misses) items that were initially encoded during the impression formation task: a locus of dorsal mPFC (MNI coordinates = −9, 60, 33). In contrast, medial temporal lobe areas were the only brain regions to differentiate hits from misses for items that were encoded during the sequencing task.

To the extent that discrete brain regions generally subserve different mental operations, these data suggest that impression formation influences episodic memory by engaging a qualitatively different set of cognitive processes than nonsocial orienting tasks. Against the backdrop of extant research linking mPFC activity to various aspects of social cognition (for reviews, see Adolphs, 1999, 2001; Frith and Frith, 2001; Gallagher and Frith, 2003), the results of this study suggest that dorsal mPFC: (i) plays a central role in instantiating distinct processes that support social cognition, and (ii) that such social-cognitive processes contribute importantly to successful episodic memory following impression formation.

However, an important ambiguity remains from this work. While Mitchell et al. (2004) linked mPFC activity to participants' attempts to form an impression, it remains unclear whether such activity is specifically associated with the *social-cognitive* aspects of the task. Although impression formation and sequencing formally required many of the same cognitive processes (e.g., integrating information into a coherent representation of the target), these two orienting tasks might have differed in a number of ways beyond their relative requirements for understanding the psychological characteristics of other mental agents. For example, impression formation may have provoked more systematic or more elaborative encoding of presented information or may have prompted participants to attend preferentially to the evaluative aspects of the targets (i.e., whether each was predominantly described by positive or negative statements). Although the choice of impression formation was directly motivated by its use in earlier behavioral studies (Hamilton et al., 1980, 1989; Hastie and Kumar, 1979; Srull and Wyer, 1989; Wyer et al., 1984), it remains possible that the dorsal mPFC activity observed during this task may have indexed some difference between impression formation and sequencing other than the relative social-cognitive demands of the two tasks. In other words, perhaps dorsal mPFC activity did not specifically index forming an impression about another person per se (i.e., engaging in social-cognitive processing of the psychological aspects of another mental agent), but rather the process of impression formation more generally (i.e., forming an impression of any stimulus object, not just other people). If it is indeed the case, then forming an impression of any object would be expected to prompt activity in dorsal mPFC. Thus, to establish the specific role of mPFC in social cognition, it is necessary to demonstrate that the activity observed by Mitchell et al. (2004) is not generally engaged by forming impressions (e.g., of inanimate objects).

To address this outstanding question, participants in the current study were asked to perform impression formation and sequencing tasks for two different types of target: people and inanimate objects. This design permitted an examination of whether activity in dorsal mPFC might be modulated generally by attempts to form impressions (i.e., for inanimate objects as well as people) or might be specific to understanding the psychological aspects of other mental agents. If dorsal mPFC activity observed during earlier impression formation tasks is indeed specific to social cognition, then greater mPFC activation should be associated with forming an impression of another person than the three other conditions (forming impressions of inanimate objects or encoding the sequence of information for either people or objects). In contrast, if dorsal mPFC activity indexes some aspect of impression formation other than understanding the psychological characteristics of other mental agents per se, equivalent activity should be observed in this region regardless of the target of impression formation.

Materials and method

Participants

Participants were 14 (8 female) right-handed, native English speakers with no history of neurological problems (mean age, 20.6 years; range, 18.3–23.7). Informed consent was obtained in a manner approved by the Human Studies Committee of the Massachusetts General Hospital.

Stimuli and behavioral procedure

During scanning, participants responded to a total of 384 trials, each consisting of a target-statement pair presented for 5500 ms.

Targets were 24 photographs of male faces (assembled from various publicly available databases), 12 photographs of computers, and 12 photographs of cars (photographs of computers and cars were downloaded from an internet auction website). Statements were 192 person-descriptive ("promised not to smoke in his apartment since his roommate was trying to quit"), 96 computer-descriptive ("had coffee spilled on it last month"), and 96 car-descriptive ("recently had new fog lights installed") sentences. Half the statements in each set were positively valenced and half were negatively valenced; however, statement valence did not qualify the results reported here.

Each photograph–statement pair was accompanied by one of two cues (*Form Impression*, *Remember Order*) that indicated, respectively, whether the impression formation or sequencing task was to be performed on that trial. In line with earlier behavioral (Hamilton et al., 1980, 1989; Hastie and Kumar, 1979; Srull and Wyer, 1989; Wyer et al., 1984) and neuroimaging (Mitchell et al., 2004) studies, for impression formation trials, participants were instructed to use the statement to generate an opinion about the person or object. Participants were told that, for these trials, their opinion about each target would later be measured. For sequencing trials, participants were instructed to encode the order in which statements were paired with each target. Participants were told that, for these trials, their memory for the sequences would later be tested. In actual fact, no such tests were administered.

Participants completed 8 functional runs, each lasting 5 min 48 s. People served as targets in 4 runs, computers in 2 runs, and cars in 2 runs. The target of the first run was selected in counterbalanced order; subsequently, person and object runs were interdigitated (e.g., person, car, person, computer, person, car, person, computer). In each run, 6 targets were each presented 8 times (24 impression formations and 24 sequencing trials). A different descriptive statement accompanied each presentation of a target; however, across presentations, a given target was consistently associated with the same orienting task. To optimize estimation of the event-related fMRI response, trials were intermixed in a pseudo-random order and separated by a variable interstimulus interval (500–7500 ms) (Dale, 1999), during which participants passively viewed a fixation crosshair.

Imaging procedure

Imaging was conducted using a 1.5 T Siemens Sonata scanner. We first collected a high-resolution T1-weighted structural scan (MP-RAGE) followed by 8 functional runs of 174 volume acquisitions (25 axial slices; 5 mm thick; 1 mm skip). Functional scanning used a gradient-echo echo-planar pulse sequence (TR = 2 s; TE = 40 ms; 3.75 × 3.75 in-plane resolution). Stimuli were projected onto a screen at the end of the magnet bore that participants viewed by way of a mirror mounted on the head coil. A pillow and foam cushions were placed inside the head coil to minimize head movements.

fMRI data were preprocessed and analyzed using SPM99 (Wellcome Department of Cognitive Neurology, London, UK). First, functional data were time-corrected for differences in acquisition time between slices for each whole-brain volume and realigned to correct for head movement. Functional data were then transformed into a standard anatomical space (3-mm isotropic voxels) based on the ICBM 152 brain template (Montreal Neurological Institute). Normalized data were then spatially smoothed (8 mm full-width-at-half-maximum [FWHM]) using a Gaussian kernel.

Data were conditionalized as a function of target (person, object) and orienting task (impression formation, sequencing), resulting in four trial types: *person-impression*, *person-sequencing*, *object-impression*, and *object-sequencing*. Statistical analyses were performed using the general linear model in which the event-related design was modeled using a canonical hemodynamic response function, its temporal derivative, and additional covariates of no interest (a session mean and a linear trend). Comparisons of interest were implemented as linear contrasts using a random-effects model. A voxel-based statistical threshold of $P < 0.001$ was used for all comparisons; regions-of-interest were required to exceed 10 contiguous voxels in extent. Peri-stimulus hemodynamic time courses for each region were extracted on a subject-by-subject basis using a selective averaging procedure (Poldrack, University of California Los Angeles). Statistical comparisons between conditions were conducted using analysis of variance (ANOVA) procedures on the parameter estimates associated with each trial type.

Results

We adopted several complementary analytic strategies to examine differences in neural activation among conditions. To identify regions that were selective for social-cognitive processing per se, we first examined regions in which activity on person-impression trials was greater than the other types of trial. The contrast of *person-impression* > *other trial types* yielded an extensive region of dorsal mPFC (362 voxels) that was distributed as an arc along the medial banks of the superior frontal gyrus. As displayed in Fig. 1A, this region extended dorsally in more posterior regions, such that the most dorsal peak was also the most posterior (MNI coordinates = −6, 18, 60) and the most ventral peak was also the most anterior (−15, 60, 18). Interrogating this region for differences among trial types, we observed significant main effects of both target and orienting task (both P values < 0.01). No significant two-way interaction was observed ($P > 0.75$). However, person-impression trials were associated with significantly greater activation than the other three types of trial (all P values < 0.02), and only person-impression trials were associated with a statistically reliable difference in activity from resting baseline ($P < 0.0001$ for person-impression trials; $P > 0.05$ for other trial types). Additional regions observed from this contrast included bilateral inferior frontal gyrus (IFG), bilateral superior temporal sulcus, orbitofrontal cortex, and precuneus. Table 1a lists coordinates for these regions as well as the pattern of differences observed in each.

Overlapping dorsal mPFC regions were also observed in a number of other direct contrasts. First, to examine the results of the same comparison used in earlier work (Mitchell et al., 2004), we contrasted *impression formation* > *sequencing* for person trials only (i.e., *person-impression* > *person-sequencing*). This contrast yielded a region of dorsal mPFC as well as left IFG (Table 1b). In both regions, we observed main effects of target type and orienting task and greater activation for person-impression trials than any of the other three trial types. Second, to avoid any a priori bias toward identifying regions in which activation was greater for person trials, we also examined the results of the direct contrast of *impression* > *sequencing* regardless of target type (which was

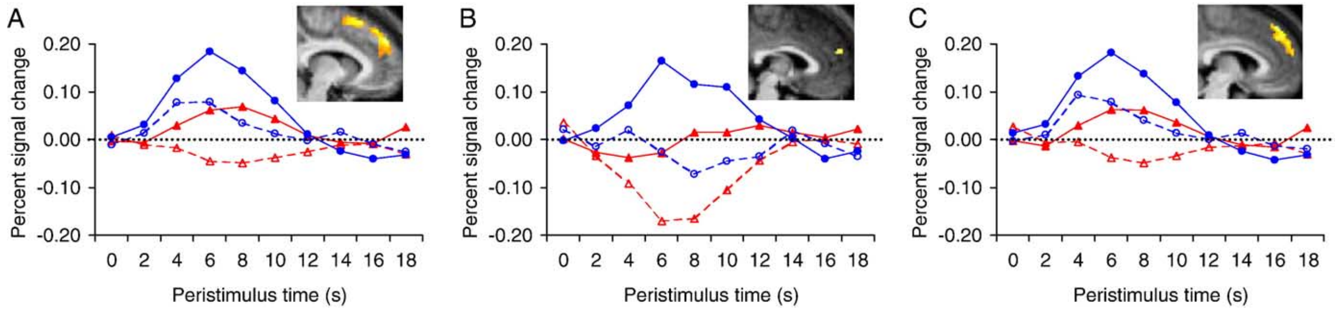

Fig. 1. Dorsal regions of mPFC were interrogated for differences among trial types: (A) an extensive region obtained from the contrast of *person-impression* > *other trial types*; (B) a more focused region obtained from contrasts of *impression formation* > *sequencing* for person trials only as well as for all trials; and (C) a similar dorsal mPFC region originally reported by Mitchell et al. (2004). Each panel displays hemodynamic timecourses averaged across all voxels in a region for each trial type: person-impression (solid blue circles), person-sequencing (dashed blue circles), object-impression (solid red triangles), object-sequencing (dashed red triangles). Within each panel, the voxels comprising each region-of-interest are overlaid on the anterior portion of a sagittal slice of subjects' mean normalized brain. In all dorsal mPFC regions, person-impression trials were associated with significantly greater activation than each of the other three trial types.

unbiased toward finding differences between person and object trials). This contrast yielded several loci in dorsal mPFC (including a region with the same peak activation as the one identified for person trials only), as well as left IFG, and orbitofrontal cortex (Table 1c). In all three mPFC regions and the left IFG region, we observed the same pattern of activation as above, that is, main effects of both target type and orienting task and greater activation for person-impression trials than any of the other three trial types. Fig. 1B displays hemodynamic timecourses for the dorsal mPFC region identified by both of these contrasts.

To confirm that differences among trial types were obtained in the exact region previously associated with impression formation, we interrogated the same dorsal mPFC region reported by Mitchell et al. (2004). This earlier study linked impression formation to an extensive area of dorsal mPFC that was highly similar to the one obtained here for *person-impression* > *other trial types*. Analyzing the differences among trial types in the current experiment for dorsal mPFC region-of-interest reported by Mitchell et al. – that is, precisely the same voxels – revealed the same pattern of results as above: main effects of both target type and orienting task and greater activation for person-impression trials than any other trial types. Fig. 1C displays hemodynamic timecourses for this dorsal mPFC region.

Finally, we examined regions that were more active during sequencing than impression formation. The contrast of *sequencing* > *impression formation* for person trials only, (i.e., *person-sequencing* > *person-impression*) yielded all the regions previously reported in earlier work (Mitchell et al., 2004) that has examined these conditions – superior parietal gyrus, postcentral gyrus, and superior frontal gyrus – as well as additional loci in anterior and

Table 1
Regions-of-interest associated with the impression formation task

Anatomical label	*X*	*Y*	*Z*	Cluster size	Target type	Orienting task	Person-impression > others
(a) Person-impression > other trial types							
Dorsomedial PFC	−9	54	36	362	**	**	*
Inferior frontal gyrus	−54	21	9	116	**	***	***
	51	27	−9	44	*	***	*
Superior temporal sulcus	−57	−12	−18	50	**	$P > 0.18$	$P > 0.31$
	63	−6	−18	27	*	$P > 0.22$	$P > 0.18$
Orbitofrontal cortex	0	42	−18	31	**	*	$P > 0.10$
Precuneus	−3	−54	30	25	*	**	*
(b) Impression formation > Sequencing (person trials only)							
Dorsomedial PFC	3	57	24	10	*	***	*
Inferior frontal gyrus	−54	24	6	15	**	***	**
(c) Impression formation > Sequencing (all trials)							
Dorsomedial PFC	−9	18	63	24	**	***	**
	3	57	24	28	*	***	*
	−9	51	36	15	*	***	*
Inferior frontal gyrus	−57	21	6	12	**	***	**
Orbitofrontal cortex	3	33	−12	29	$P > 0.45$	***	$P > 0.09$

Note. *t* tests were conducted on the parameter estimates associated with each trial type for regions-of-interest defined by the direct contrast indicated. The target type and orienting task columns indicate the statistical reliability of the main effects of target type and orienting task, respectively. The rightmost column indicates the least statistically reliable *P* value associated with pairwise *t* tests of person-impression trials vs. each other trial type (i.e., person-sequencing, object-impression, object-sequencing). Coordinates refer to the MNI stereotaxic space.
* $P < 0.05$; ** $P < 0.005$; *** $P < 0.001$.

posterior cingulate, cerebellum, frontal pole, fusiform gyrus, and middle frontal gyrus (Table 2). The comparable analysis including both person and object trials (i.e., *sequencing* > *impression* formation, regardless of target type) yielded activations in the same set of regions with only slight shifts in the peak activations associated with each (exact coordinates available upon request).

Discussion

Extending earlier work that has suggested a distinct neural basis for impression formation (Mitchell et al., 2004), participants in the current study were asked either to form an impression about or remember the order of information presented alongside two types of target, people and inanimate objects. This design allowed a direct test of the hypothesis that dorsal mPFC activity observed in earlier research specifically indexed the *social-cognitive* aspects of impression formation; that is, that dorsal mPFC activity does not generally accompany attempts to form an impression but is instead selectively engaged for tasks requiring reference to the psychological states of another mental agent.

To examine this issue, we began by identifying regions in which activation was greater for trials on which participants attempted to form an impression of a person rather than any other type of object. A direct contrast of *person-impression* > *other trial types* demonstrated activity in an extensive region of dorsal mPFC. Dorsal mPFC loci that were contained within this extended region were also observed from direct contrasts between *impression* > *sequencing* for all trials, as well as for person trials only. A single pattern of results was observed in all dorsal mPFC regions. First, we observed main effects of target type and orienting task, indicating that dorsal mPFC activation was significantly greater both for the impression formation task than the sequencing task as well as for person trials compared to object trials. More importantly, however, significantly greater activation was observed for person-impression trials than for each of the three other trial types. That is, dorsal mPFC was differentially activated by forming impressions of other people compared to forming impressions of inanimate objects or to intentionally encoding the order of information associated with targets of either type. Finally, person-impression trials were the only ones associated with significantly greater activation than baseline. This pattern was also observed in the very same dorsal mPFC voxels reported earlier by Mitchell et al. (2004).

Table 2
Regions-of-interest associated with the sequencing task for person trials only (*person-sequencing* > *person-impression*)

Anatomical label	*X*	*Y*	*Z*	Cluster size
Anterior cingulate cortex	9	24	42	73
Cerebellum	−36	−60	−33	141
	36	−57	−51	20
	39	−60	−36	18
Frontal pole	−36	54	12	29
	36	60	6	77
Fusiform gyrus	−33	−69	−15	27
Middle frontal gyrus	−36	33	30	36
	42	42	30	141
Posterior cingulate	12	−42	27	118
Postcentral gyrus[a]	42	−48	54	382
	−51	−42	54	281
Superior frontal gyrus[a]	27	9	66	162
	−27	6	54	23
	24	36	42	10
Superior parietal gyrus[a]	6	−66	45	250

[a] Regions that were also reported by Mitchell et al. (2004) for the same contrast.

This result provides support in favor of the thesis that activity in dorsal mPFC is specifically sensitive to the social-cognitive demands of impression formation. Although Mitchell et al. (2004) demonstrated that mPFC activity differentiates between impression formation and a comparable nonsocial task (i.e., sequencing), the current results more definitively suggest that mPFC contributions are uniquely engaged in tasks that involve a meaningful social object, such as other humans. Forming impressions of inanimate objects was not sufficient to engage mPFC activity as robustly as forming impressions of other people, strongly suggesting that the *social-cognitive* aspects of integrating information into a coherent impression of another person – and not simply forming impressions more generally – appears to be subserved by dorsal mPFC.

In addition to its role in impression formation, dorsal mPFC has been linked to a range of other tasks that require reference to the mental states of other people. For example, in some of the earliest work that examined the neural basis of social cognition, Goel et al. (1995) reported greater dorsal mPFC activity when perceivers judged whether an historical figure (Christopher Columbus) would recognize the function of various objects (e.g., a compact disc) than when they reported on semantic or visual aspects of those objects. Around the same time, Fletcher et al. (1995) observed greater dorsal mPFC activity when participants read stories that required an understanding of the mental states of their characters compared to control stories that required an understanding of physical causality. In a follow-up to this study, Gallagher et al. (2000) reported a similar dorsal mPFC region for comparisons involving these same mental-state stories as well as cartoons that also required understanding the minds of their characters. More recent work has observed dorsal mPFC activity in conjunction with playing interactive computer games that require second-guessing an opponent (Gallagher et al., 2002) or cooperating with one's partner (McCabe et al., 2001). Finally, regions of mPFC have also been associated with making semantic judgments about words that could potentially describe another person's psychological states (Mitchell et al., 2002).

In addition to dorsal mPFC, impression formation was also associated with two additional regions that have been linked to various aspects of social processing: superior temporal sulcus (STS) and orbitofrontal cortex (OFC). Neurophysiological studies of nonhuman primates have suggested that neurons in the STS region may be selective for the perception of meaningful biological motion, especially socially relevant head and eye movements (Perrett et al., 1985a,b). Later neuroimaging research has confirmed that the STS contributes similarly to social perception in humans by demonstrating that, as in the monkey, regions of human STS respond preferentially to the perception of biological motion (Allison et al., 2000), as well as direction of eye gaze (Hoffman and Haxby, 2000; Hooker et al., 2003; Puce et al., 1998) and some forms of emotional expression (Narumoto et al., 2001). Consistent with the role of this region in the perception of socially relevant stimuli, STS activation observed in the current study was significantly greater during person than object trials but did not differentiate between trials as a function of orienting task. That is, although STS activation was modulated by whether or not participants saw the face of another person, it was not sensitive to the way in which participants were oriented towards that other person. Although some other researchers have observed STS activation during social-cognitive tasks in which no direct perception of other people took place (e.g., Saxe and Kanwisher, 2003), the current results suggest that the STS responded preferentially to the *perception* of another person, but did not contribute significantly to the *social-cognitive* aspects of considering another's psychological characteristics.

In contrast, activation in OFC consistently differentiated between trials as a function of orienting task, but not as a function of target type (although OFC activity in one cluster was greater for person than object trials, activity in a slightly more posterior and dorsal cluster failed to differentiate between target types). That is, the OFC appeared to index differences between the demands of the two orienting tasks, but did not consistently distinguish the targets of processing. The sensitivity of the OFC to the difference between impression formation and sequencing may be consistent with suggestions that this structure contributes importantly to the processing of affective or evaluative information (Adolphs, 2002; Damasio, 1994; O'Doherty et al., 2001; Rolls, 2004). Because the act of forming an impression inherently involves evaluation of the relative positive and negative aspects of a target, we suggest that OFC activity in the current context may have indexed the requirement to process affective information during impression formation. This hypothesized role of the OFC in impression formation dovetails with earlier studies, which have suggested that OFC contributions to the understanding of mental states are most pronounced within highly affective social situations, such as ones involving deception (Stuss et al., 2001) or embarrassing social behavior (Berthoz et al., 2002; Stone et al., 1998).

Interestingly, differences between impression formation and sequencing were obtained despite earlier observations that perceivers spontaneously form impressions even when engaged in ostensibly nonsocial tasks (Uleman and Moskowitz, 1994; Whitney et al., 1992) or during concurrent secondary tasks (Todorov and Uleman, 2003; Winter et al., 1985). On the other hand, research has also suggested that such spontaneous inferences require some cognitive capacity and attention to the social relevance of stimuli (Uleman et al., 1992, 1996). Because little is known about which nonsocial tasks leave sufficient cognitive resources for making such spontaneous trait inferences, it remains possible that the distinction drawn in the current study between social and nonsocial cognitive tasks may actually reflect the difference between intentional and spontaneous impression formation. However, in light of the fact that sequencing trials were associated with none of the brain regions previously implicated in social-cognitive processing (with the exception of the fusiform gyrus, which has been linked to the perception of faces), we believe this alternative interpretation of the current results is unlikely.

Although the particular choice of impression formation as the task used to operationalize social-cognitive processing was motivated by its adoption in earlier, behavioral work on social cognition, we note that this task is relatively underspecified. That is, the exact nature of the processes that perceivers engaged during their attempts to form an impression are not fully characterized (of course, the same criticism applies to much neuroimaging work on higher cognitive processes, e.g., research on "controlled semantic retrieval" (Wagner et al., 2001) or higher-order reasoning tasks (e.g., Christoff et al., 2001)). One question that research has not yet begun to address is to what extent regions implicated in social cognition may be differentially engaged by any domain for which perceivers have deep expertise. A parallel issue has developed in response to neuroimaging work on face perception, with some researchers arguing that distinct, domain-specific activity subserves the perception of faces (Kanwisher, 2000; Kanwisher et al., 1997), whereas others have argued that this brain activity actually represents the processing of any stimulus for which a participant has extensive visual expertise (Gauthier et al., 1999; Tarr and Gauthier, 2000). A similar ambiguity emerges in the current study: namely, does mPFC activity during impression formation of other people indicate distinct processes for social cognition, or just more extensive processing in a domain about which participants have a great deal of knowledge (i.e., other people)? Although the current data cannot address this issue directly, our earlier work with the same behavioral paradigms (Mitchell et al., 2004) obtained a double dissociation between mPFC and medial temporal cortex which suggests that mPFC activity during impression formation cannot simply index "deeper" or more elaborate processing. Specifically, in that study, subsequent memory effects (brain regions in which activity during initial encoding correlates with whether an item goes on to be remembered or forgotten) were observed in mPFC for items initially encountered as part of impression formation but in medial temporal regions for items initially encountered as part of sequencing, suggesting that the differences between social and nonsocial orienting tasks observed cannot be attributable to a single metric (such as task difficulty or conceptual expertise). Nevertheless, the issue of how to isolate social-cognitive processing per se from conceptual expertise more generally remains a fundamental challenge to researchers in this area.

As outlined in the current introduction, a central question posed by the study of social cognition has been the extent to which human social abilities rely on a distinct set of cognitive processes that distinguish thinking about the psychological characteristics of other people from other forms of thought. By demonstrating that dorsal mPFC was differentially engaged during consideration of the psychological aspects of another person, the current study supports a social-cognition-as-distinct view and, as such, complements a growing neuroscience literature that has consistently linked mental state attribution to a discrete set of brain regions. In addressing one central question regarding social cognition, however, this body of research has exposed a second issue that awaits empirical resolution: namely, specification of the precise nature of such putative social-cognitive processes. As a result of the sizeable number of studies supporting the notion that apprehending the psychological characteristics of others relies on mental processes dedicated to social cognition, a new challenge is to describe exactly what such processes might entail (Mitchell et al., in press). Such a detailed characterization of the complex and multifaceted operations that give rise to human social cognition will undoubtedly provide a fertile domain of future inquiries at the intersection of mind, brain, and social behavior.

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