SOCIAL NEUROSCIENCE, 2011, 6 (3), 211–218

Medial prefrontal cortex subserves diverse forms of self-reflection

Adrianna C. Jenkins and Jason P. Mitchell
Harvard University, Cambridge, MA, USA

The ability to think about oneself—to self-reflect—is one of the defining features of the human mind. Recent research has suggested that this ability may be subserved by a particular brain region: the medial prefrontal cortex (MPFC). However, although humans can contemplate a variety of different aspects of themselves, including their stable personality traits, current feelings, and physical attributes, no research has directly examined the extent to which these different forms of self-reflection are subserved by common mechanisms. To address this question, participants were scanned using functional magnetic resonance imaging (fMRI) while making judgments about their own personality traits, current mental states, and physical attributes as well as those of another person. Whereas some brain regions responded preferentially during only one form of self-reflection, a robust region of MPFC was engaged preferentially during self-reflection across all three types of judgment. These results suggest that—although dissociable—diverse forms of self-referential thought draw on a shared cognitive process subserved by MPFC.

INTRODUCTION

Throughout our lives, each of us effortlessly distinguishes our own "self" from those around us. Although we may fumble the identities of other people ("Was it Bill or Jim whose daughter took those singing lessons?"), we rarely mistake ourselves for someone else. Indeed, so pervasive is the distinction between ourselves and other individuals that it often gives rise to systematic differences in the ways in which we reason about ourselves vs. others. When we think about ourselves—i.e., when we self-reflect—we tend to think of ourselves as having a more complex personality (Sande, Goethals, & Radloff, 1988) and a richer emotional life (Leyens et al., 2000) than others do, and we tend to believe that our behavior is more adaptable to different situations (Jones & Nisbett, 1971) than that of other people.

Over the past decade, a particular brain region has repeatedly been linked to the distinction between thinking about the self and thinking about others. Specifically, the medial prefrontal cortex (MPFC) is consistently recruited by tasks that require participants to introspect about their own personality traits (e.g., "how adventurous am I?") compared to tasks that require judging the traits of others (Craik et al., 1999; Jenkins, Macrae, & Mitchell, 2008; Kelley et al., 2002; Macrae, Moran, Heatherton, Banfield, & Kelley, 2004; Mitchell, Macrae, & Banaji, 2006); see Mitchell (2009b) for review. Such findings have prompted a number of researchers to posit a general role for the MPFC and related cortical midline regions in self-reflection (Northoff & Bermpohl, 2004; Schneider et al., 2008; Uddin, Iacoboni, Lange, & Keenan, 2007; cf. Gillihan & Farah, 2005).

Correspondence should be addressed to: Adrianna C.Jenkins, Department of Psychology, Harvard University, William James Hall, 33 Kirkland Street, Cambridge, MA 02138, USA. E-mail: ajenkins@wjh.harvard.edu

The authors thank Daniel L. Ames, Josh Greene, Andrea Heberlein, Dave Johnson, Matt Killingsworth, Lindsey Powell, Rebecca Saxe, and Diana Tamir for advice and assistance. This work was supported by the National Science Foundation (BCS 0642448). Data were collected at the Athinoula A. Martinos Center for Biomedical Imaging, which is supported by the National Center for Research Resources (P41 RR14075) and the MIND Institute.

www.psypress.com/socialneuroscience DOI: 10.1080/17470919.2010.507948

However, there are reasons to question the extent to which self-reflection is generally subserved by cognitive processes carried out by MPFC. First, the distinction between self and others appears not to be exclusive to MPFC. Recent functional magnetic resonance imaging (fMRI) research has revealed that other brain regions, such as the temporoparietal junction (TPJ) and precuneus, also sometimes respond preferentially to self (see Legrand & Ruby, 2009 for review). Second, studies identifying a distinction between self and others in MPFC have almost uniformly used comparisons of a single type of judgment—personality traits—raising the possibility that a specific difference between the two particular tasks may account for their differential activation. For example, thinking about one's own personality and that of another person may differ in the extent to which they elicit semantic or episodic memory, in the extent to which they require effort, or in the extent to which they elicit visual imagery. As such, the preferential MPFC response during self-reflection about traits may result from an incidental difference between considering one's own traits vs. the traits of another person, rather than a more pervasive difference between the processes typically engaged when individuals think about themselves vs. others.

Although the bulk of research on the role of MPFC in self-reflection has focused exclusively on a single type of introspection, one can reflect about the self in multiple ways. Just as we can consider the relatively stable aspects of our minds in the form of our *personality traits* (e.g., "Am I really as neurotic as everyone says?"), most of us are also keenly aware that the particular sensation of "what it feels like to be me" changes dynamically from moment to moment, allowing us to reflect on our transient *mental states* (e.g., "Right now, am I feeling confident?"). Furthermore, we also possess an ability to consider ourselves in the form of our *physical attributes* (e.g., "Have I become a bit pudgy?"). Although some research has suggested that reflecting on one's current emotional state may also recruit MPFC compared to similar judgments about others (Gusnard, Akbudak, Shulman, & Raichle, 2001; Ochsner et al., 2004), introspecting about one's own personality traits and mental states have not been compared directly, thus leaving open the possibility that these different forms of self-reflection may recruit nearby but distinct regions of cortex.

Indeed, there are reasons to suspect that distinct processes may be engaged during self-reflection of different types. Recent studies have observed neural differences in the processes engaged by "narrative" vs. "experiential" self-focus during meditation (Farb et al., 2007); and in the processes associated with some forms of 'implicit' vs. 'explicit' processing of self-related information (Moran, Heatherton, & Kelley, 2009; but see Rameson, Satpute, & Lieberman, 2010), suggesting that not all self-related thought is subserved by the same neural substrates. Moreover, research focusing on how individuals make attributions to *others* has observed dissociations along lines similar to those examined here; for example, differences have been observed in the brain regions associated with judgments about others' emotional states vs. their personality traits (Heberlein & Saxe, 2005); others' beliefs vs. their personality and physical characteristics (Saxe & Powell, 2006); and, more generally, others' affective states vs. their cognitive states (Hynes, Baird, & Grafton, 2006; Vollm et al., 2006). These findings suggest that different processes subserve attributions to others depending on the particular type of judgment, hinting at the possibility that such divergences among the processes subserving judgments about personality traits, mental states, and physical attributes may also be observed when such judgments concern the self.

To date, no cognitive neuroscience research has directly examined the extent of convergence among different forms of explicit reflection on the self. In the current experiment, we sought to address this question by investigating the extent to which reflecting on one's *personality traits*, transient *mental states,* and *physical attributes* is associated with activation in common brain regions. Participants were scanned using fMRI while they made judgments about their own personality traits, current mental states, and physical attributes as well as those of another person. To the extent that any process consistently differentiates thinking about oneself from thinking about other people, that process should be preferentially engaged during a variety of forms of self-reflection compared to similar kinds of thought about others. On the other hand, to the extent that distinct processes subserve different kinds of self-reflection, introspecting about one's stable personality traits, reporting one's transient mental states, and judging one's physical characteristic should recruit mostly non-overlapping brain regions. To examine commonalities among these three different forms of self-reflection, we isolated regions characterized by greater response during judgments about the self than judgments about others across assessment of personality traits, transient mental states, and physical characteristics. In light of previous demonstrations that MPFC is consistently recruited during introspection about one's own personality traits, we were particularly interested in the extent to which multiple forms of self-reflection would be associated with activation in this region.

METHOD

Participants

Fifteen right-handed, native English speakers (10 female; age range 19–32, mean age 21.2 years) with no history of neurological problems participated for payment or course credit. Written informed consent was obtained from all participants in a manner approved by the Human Studies Committee of the Massachusetts General Hospital.

Stimuli and behavioral procedure

During fMRI scanning, participants evaluated adjectives for how well they described either themselves or then-current US President, George W. Bush. Three different sets of adjectives referred to (i) stable personality traits (e.g., *In general, how brave?*); (ii) current mental states (e.g., *In the moment, how bored?*); and (iii) stable physical attributes (e.g., *Physically, how tall?*); see Table 1 for additional examples. Each list of adjectives comprised 40 items, and lists were matched for average word length, affective valence, and intensity. The choice of the other target (George W. Bush) was guided by earlier studies, which have typically used the current head of state (a familiar, but not personally known, other) as a comparison to self-judgments (Kelley et al., 2002; Rogers, Kuiper, & Kirker, 1977). For *self* trials, the question was presented alongside a chalk outline of a person's head (representing the participant), whereas *other* trials were accompanied by a photograph of Bush (randomly selected from among four possible photographs). Participants judged how well each word described self or Bush on a 4-point scale (anchored by 1 = not at all and 4 = very). For current mental state judgments of Bush, participants were instructed to rate Bush's state as it appeared "at the time when the photo was taken." Six trial types were defined from the 3 types of judgment (personality traits, mental states, and physical attributes) × 2 targets (self, other). Participants judged each adjective once in the *self* condition and once in the *other* condition (240 trials total) in random order. The duration of each trial was 3600 ms.

TABLE 1
Stimulus examples for personality traits (left), mental states (center), and physical attributes (right)

"In general, how . . .?"	*"In the moment, how . . .?"*	*"Physically, how . . .?"*
ambitious	confused	overweight
idealistic	annoyed	blemished
open-minded	thirsty	pale
patient	excited	flexible
careless	embarrassed	muscular
arrogant	amused	freckled

Imaging procedure

FMRI data were collected using a 3 T Siemens Trio scanner. The task comprised 2 functional runs of 320 volume acquisitions (26 axial slices, 5 mm thick; 1 mm skip). Functional imaging used a gradient-echo echo-planar pulse sequence (TR = 2 s; TE = 35 ms; 3.75 × 3.75 in-plane resolution). PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993) for Mac OS X was used to project stimuli onto a screen at the end of the magnet bore, which participants viewed via a mirror mounted on the head coil. Following the functional scans, we collected a high-resolution T1-weighted structural scan (MP-RAGE). A pillow and foam cushions were placed inside the coil to minimize head movement.

Functional data were preprocessed and analyzed using SPM2 (Wellcome Department of Cognitive Neurology, London, UK). Images were time-corrected for differences in acquisition time between slices for each whole-brain volume, realigned to correct for head movement, and 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.

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). This analysis was performed individually for each participant, and contrast images for each participant were then entered into a second-level analysis treating participants as a random effect. Peak coordinates were identified using a statistical criterion of 25 or more contiguous voxels at a voxel-wise threshold of $p < .001$. This cluster size was selected on the basis of a Monte Carlo simulation of our brain volume (S. Slotnick, Boston College), which indicated that this cluster extent cutoff provided an experiment-wise threshold of $p < .05$, corrected for multiple comparisons.

Conjunction analysis was performed following the procedure described by Cabeza, Dolcos, Graham, &

Nyberg (2002). Whole-brain statistical maps were created from the *self* > *other* contrast for each of the three judgment types separately to identify voxels activated by each kind of self-reflection (thresholded at $p < .01$). These maps were then multiplied together using the ImCalc function in SPM2, which yielded a composite map that identified voxels that significantly differentiated between *self* > *other* for each and all forms of self-reflection at a probability of $p < .000001$.

RESULTS

Behavioral data

On average, participants responded in 2209 ms. A two-way ANOVA of judgment type (personality trait, mental state, physical attribute) × target (self, other) on response times revealed only a main effect of target, such that participants responded more quickly to questions about self ($M = 2177$ ms, $SD = 219$ ms) than to questions about another person ($M = 2241$ ms, $SD = 212$ ms), $F(1, 14) = 14.97$, $p < .002$, $d = 1.03$. Importantly, no differences were observed among judgment types (all pairwise comparisons, $p > .30$), suggesting that judgment types did not significantly differ in difficulty.

FMRI data

Analysis of fMRI data revealed that a sizeable region of MPFC differentiated *self* > *other* regardless of judgment type. First, to identify brain regions that responded preferentially during self-reflection for each judgment type separately, we conducted whole-brain, random-effects analyses of each of the *self* > *other* comparisons for trials of each judgment type. Consistent with previous research, thinking about one's own personality traits was associated with greater response in MPFC than judging the personality traits of another person (Figure 1A). Interestingly, thinking about one's own current mental states (Figure 1B) and thinking about one's own physical attributes (Figure 1C) were also associated with a preferential response in MPFC. The (reverse) contrasts of *other* >*self* consistently yielded activation in occipital cortex and fusiform gyrus, most likely resulting from the greater visual information presented during *other* trials (i.e., a photograph of another person); see Tables 2–4.

To determine the extent to which these three self-referential tasks genuinely recruited a common MPFC region, we next conducted a conjunction analysis on the three independent *self* > *other* contrasts (Cabeza et al., 2002). Critically, this analysis revealed a single region of MPFC that responded robustly to self trials across all three judgment types (Figure 2A). Finally,

TABLE 2
Peak voxel and number of voxels for brain regions other than MPFC differentiating self from another person during judgments about *personality traits*

Region	*x*	*y*	*z*	*Voxels*
Self > other				
Insula	36	20	–6	840
Insula	–36	14	–6	314
Central sulcus	62	6	6	39
Intraparietal sulcus	34	–64	56	386
Intraparietal sulcus	–22	–64	58	278
Caudate nucleus	14	18	4	84
Caudate nucleus	–12	14	6	496
Middle frontal gyrus	–32	48	16	31
Sup frontal sulcus	–22	56	32	54
Inf frontal sulcus	48	2	38	76
Sup temporal gyrus	–58	–36	16	26
Occipital cortex	48	–68	–8	49
Occipital cortex	–44	–66	–4	211
Other > self				
Fusiform gyrus	28	–54	–4	109
Occipital cortex	10	–92	28	1083

Notes: $p < .05$ corrected. Coordinates refer to the Montreal Neurological Institute stereotaxic space. Inf = inferior; Sup = superior.

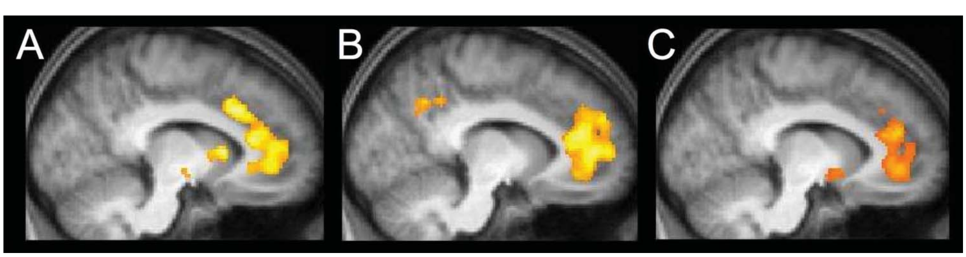

Figure 1. Brain regions identified from the contrast of *self* > *other* for each type of judgment. Whole-brain, random-effects analyses ($p < .05$, corrected) revealed regions of MPFC in which the BOLD response was greater for *self* > other during judgments about personality traits (A), mental states (B), and physical attributes (C). Regions are displayed on sagittal images ($x = –10$) of participants' mean normalized brain.

TABLE 3
Peak voxel and number of voxels for brain regions other than MPFC differentiating self from another person during judgments about *mental states*

Region	*x*	*y*	*z*	*voxels*
Self > Other				
Temporo-parietal junction	56	–44	30	119
Temporo-parietal junction	58	–50	20	27
Temporo-parietal junction	–52	–58	32	188
Medial parietal cortex	–8	–60	38	184
Inf frontal gyrus	–30	16	–20	51
Other > Self				
Fusiform gyrus	26	–48	–14	259
Fusiform gyrus	–28	–54	–14	187

Notes: $p < .05$ corrected. Coordinates refer to the Montreal Neurological Institute stereotaxic space. Inf = inferior.

TABLE 4
Peak voxel and number of voxels for brain regions other than MPFC differentiating self from another person during judgments about *physical attributes*

Region	*x*	*y*	*z*	*voxels*
Self > other				
Superior temporal sulcus	–50	–42	8	37
Cerebellum	8	–54	–40	41
Cerebellum	24	–68	–50	45
Cerebellum	18	–88	–24	34
Cerebellum	20	–42	–44	41
Other > self				
Fusiform gyrus	24	–46	–6	164
Fusiform gyrus	–22	–50	–6	94
Occipital cortex	14	–68	–4	601
Occipital cortex	16	–68	14	65
Occipital cortex	–20	–78	–2	26

Notes: $p < .05$ corrected. Coordinates refer to the Montreal Neurological Institute stereotaxic space.

we confirmed these findings in an independent, *a priori* region of interest by defining a sphere around coordinates (10, 52, 2; 8 mm radius) from a paradigmatic study of self-referential processing of trait information (Kelley et al., 2002). Analysis of the parameter estimates of the blood-oxygen-level-dependent (BOLD) signal in this region of interest confirmed that, compared to judgments of another person, MPFC showed greater response during consideration of participants' own personality traits, $t(14) = 4.38$, $p < .001$, $d = 1.17$; transient mental states, $t(14) = 6.03$, $p < .0001$, $d = 1.71$; and physical attributes, $t(14) = 4.00$, $p < .002$, $d = 1.07$ (Figure 2B).

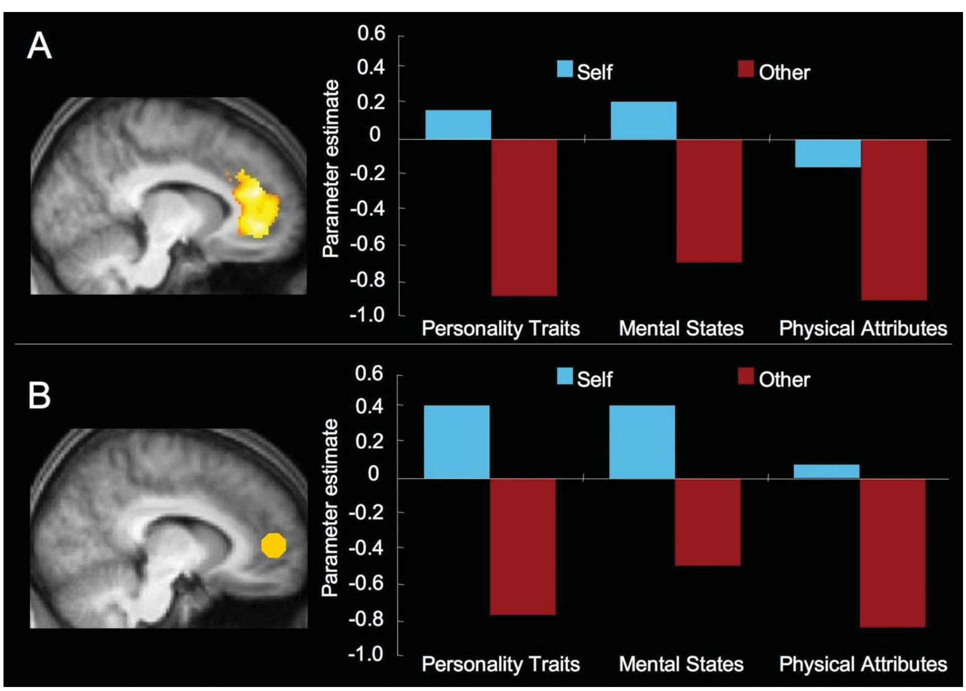

Figure 2. Preferential neural response to *self > other* across judgment types. A: A conjunction analysis revealed an extensive region of MPFC (2564 voxels) in which BOLD response differentiated self from other for personality traits, mental states, and physical attributes. This region is displayed on a sagittal image ($x = -10$) of participants' mean normalized brain. B: Preferential BOLD response during self-reflection on personality traits, mental states, and physical attributes in an a priori region of interest defined from Kelley et al. (2002). This region is displayed on a sagittal image ($x = 10$) of participants' mean normalized brain.

Although only MPFC responded preferentially during self-reflection across all types of judgment, other brain regions responded preferentially to self trials specifically during judgments of one particular type. For example, reflecting on one's own personality was specifically associated with activation in the intraparietal sulcus (IPS) and the caudate bilaterally (Table 2). Post-hoc comparisons confirmed that activation in these regions failed to distinguish between self and another person during judgments about mental states (IPS, $p > .46$; caudate, $p > .41$) or physical attributes (IPS, $p > .63$; caudate, $p > .36$). In contrast, reflecting on one's own current mental states was specifically associated with activation in regions previously linked to inferences about the mental states of others, including medial parietal cortex and bilateral temporoparietal junction (TPJ; Table 3). Again, activation in these regions failed to distinguish between self and another person during judgments about personality traits (medial parietal cortex, $p > .95$; TPJ, $p > .58$) or physical attributes (medial parietal cortex, $p > .57$; TPJ, $p > .89$). Finally, reflecting on one's own physical attributes was specifically associated with activation in the cerebellum (Table 4). This region failed to distinguish between self and another person during judgments about personality traits ($p > .48$) or mental states ($p > .18$).

DISCUSSION

Regardless of whether participants were considering personality traits, mental states, or physical attributes, a robust region of MPFC was more engaged when participants thought about themselves than when they made judgments about another person. That these disparate tasks genuinely activated a common region of MPFC was supported by a conjunction analysis, which revealed a large set of voxels in MPFC that responded preferentially during self-reflection across all three types of judgment. Accordingly, these findings suggest that a common, MPFC-based process subserves multiple forms of self-reflection.

At the same time, several other regions responded preferentially to self-reflection during only a single kind of judgment, suggesting that these regions are sensitive to the different demands of various kinds of contemplation. For example, previous research has demonstrated that the TPJ plays a specific role in representing transient mental contents, such as a belief about the location of a hidden object (Saxe & Kanwisher, 2003; Saxe & Powell, 2006). Consistent with this work, the current study found that TPJ responded preferentially during self-reflection only during the consideration of transient states of mind (such as confusion, anger, or excitement). The selectivity of TPJ response to reflection on one's mental states suggests that this region may sometimes differentiate thought about the self from thought about others, but does not play a more pervasive role in self-reflection. Because this region does not respond preferentially to self during other types of judgment, the TPJ cannot be responsible for processes that distinguish self-reflection in general. Thus, whereas some brain regions appear to differentiate thought about oneself from thought about others only under certain circumstances (e.g., when thinking about mental states), MPFC appears to subserve processes that differentiate self-reflection from thought about others more broadly.

Overall, these findings are consistent with two main interpretations regarding the specificity of the MPFC response to self. One interpretation is that MPFC could be understood as a "self region" that necessarily responds during reflection on the self *per se*. In contrast, an alternative possibility is that MPFC subserves processes typically associated with, but not necessarily specific to, self-reflection. Both the current data and other recent fMRI research are most consistent with the latter interpretation. First, if MPFC simply supported processes necessarily engaged whenever a person thinks about himself or herself, the region should respond robustly, and to a roughly equal degree, whenever a person self-reflects. However, although conjunction analysis revealed a single region of MPFC that distinguished between s*elf* and *other* across all three judgment types, the response of this region during consideration of physical questions (for both targets) was significantly lower than during the consideration of mental questions (states and traits), $F(1, 14) = 4.72$, $p < .05$, $d = 0.58$ (Figure 1). Accordingly, MPFC activation appeared not to be determined solely by the presence vs. absence of self-reflection. Instead, the region also distinguished mentalistic judgments (states and traits) from nonmentalistic judgments (physical attributes). This pattern is consistent with observations that MPFC is particularly sensitive to mental content (Mitchell, Heatherton, & Macrae, 2002) and suggests that MPFC subserves processes typically more engaged both during reflection on the self (vs. others) and reflection on mental (vs. physical) aspects of people (Jenkins & Mitchell, 2010; Mitchell, 2009b).

Second, if MPFC activation supports processes that are not limited to self-reflection, then other tasks that draw on those processes should also be associated with greater MPFC response. Consistent with this possibility, researchers have observed that MPFC contributes importantly to a variety of cognitive tasks other than self-reflection, including thinking about the past, thinking about the future, engaging in spatial navigation, and thinking about the minds of other people (Addis, Wong, & Schacter, 2007; Buckner & Carroll, 2007; Spreng, Mar, & Kim, 2009). One potential point of convergence among all of these tasks is that they all require individuals to attend to internally generated representations that are independent of the immediate perceptual environment. This observation is consistent with recent suggestions that MPFC may participate in a "default network" of brain regions that support the ability to attend to one's own simulated thoughts and feelings (Buckner & Carroll, 2007; Jenkins & Mitchell, 2010; Mitchell, 2009a). As such, we suspect that MPFC activation during self-reflection comprises another form of such internally generated, nonperceptual processes and will not be limited to self-reflection *per se*. Consistent with this possibility, recent research suggests that reflecting on the traits of individuals who are similar to oneself recruits MPFC to a greater degree than reflecting on the traits of individuals who are dissimilar from oneself (Jenkins et al., 2008; Mitchell, Macrae, & Banaji, 2006). It remains an open and interesting question whether reflecting on the current mental states or physical attributes of similar vs. dissimilar individuals would also recruit MPFC to different degrees; however, because the "other" target in the current study (i.e., George W. Bush) was presumably fairly dissimilar from most participants, the present results do not address this question. We look forward to future research that determines the processes that unify self-reflection, reflection on others, and other tasks in the MPFC.

The current study investigated the processes engaged when individuals think explicitly about various aspects of themselves—i.e., when they self-reflect. However, self-reflection is just one of many different kinds of thought that may be associated with the self in some way. Indeed, throughout the history of psychology, researchers have attempted to deconstruct the self into its constituent parts, starting with William James's (1890) initial bifurcation of the self into the 'I' and the 'me' (also see Boyer, Robbins, & Jack, 2005; Neisser, 1998; Tajfel & Turner, 1986). Specifically, recent research suggests that explicit self-reflection, which we have investigated in this study, may be supported by processes distinct from those supporting other kinds of self-related tasks. For example, a recent fMRI experiment observed that distinct brain regions were associated with a preferential response to self depending on whether participants activated "agentic" vs. "conceptual" representations of self (e.g., completing an action vs. contemplating one's personality; Powell, Macrae, Cloutier, Metcalfe, & Mitchell, 2010), a distinction that could map on to a difference between implicit and explicit forms of self-involvement. In this way, research has begun to characterize both the unified and the divided nature of the self. Although certain aspects of self-related processing may be dissociable, the current study demonstrates that explicit self-reflection, despite the variety of forms in which it may take place, may indeed draw on a common cognitive process, subserved by MPFC.

Manuscript received 29 March 2010
Manuscript accepted 2 July 2010
First published online 12 August 2010

REFERENCES

Addis, D. R., Wong, A., & Schacter, D. L. (2007). Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia*, *45*, 1363–1377.

Boyer, P., Robbins, P., & Jack, A. I. (2005). Varieties of self-systems worth having. *Consciousness and Cognition*, *14*, 647–660.

Buckner, R. L., & Carroll, D. C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences*, *11*(7), 280–289.

Cabeza, R., Dolcos, F., Graham, R., & Nyberg, L. (2002). Similarities and differences in the neural correlates of episodic memory retrieval and working memory. *NeuroImage*, *16*, 317–330.

Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavioral Research Methods, Instruments, and Computers*, *25*, 257–271.

Craik, F. I. M., Moroz, T. M., Moscovitch, M., Stuss, D. T., Winocur, G., Tulving, E., et al. (1999). In search of the self: A positron emission tomography study. *Psychological Science*, *10*, 26–34.

Farb, N. A. S., Segal, Z. V., Mayberg, H., Bean, J., McKeon, D., Fatima, Z., et al. (2007). Attending to the present: Mindfulness meditation reveals distinct neural modes of self-reference. *Social Cognitive and Affective Neuroscience*, *2*(4), 313–322.

Gillihan, S. J., & Farah, M. J. (2005). Is self special? A critical review of evidence from experimental psychology and cognitive neuroscience. *Psychological Bulletin*, *131*(1), 76–97.

Gusnard, D. A., Akbudak, E., Shulman, G. L., & Raichle, M. E. (2001). Medial prefrontal cortex and self-referential mental activity: Relation to a default mode of brain function. *Proceedings of the National Academy of Sciences USA*, *98*(7), 4259–4264.

Heberlein, A. S., & Saxe, R. R. (2005). Dissociation between emotion and personality judgments: Convergent evidence from functional neuroimaging. *NeuroImage*, *28*(4), 770–777.

Hynes, C. A., Baird, A. A., & Grafton, S. T. (2006). Differential role of the orbital frontal lobe in emotional versus cognitive perspective-taking. *Neuropsychologia*, *44*(3), 374–383.

James, W. (1890). *Principles of psychology*. New York: Holt, Rinehart, & Wilson.

Jenkins, A. C., Macrae, C. N., & Mitchell, J. P. (2008). Repetition suppression of ventromedial prefrontal activity during judgments of self and others. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(11), 4507–4512.

Jenkins, A. C., & Mitchell, J. P. (2010). Mentalizing under uncertainty: Dissociated neural responses to ambiguous and unambiguous mental inferences. *Cerebral Cortex*, *20*(2), 404–410.

Jones, E. E., & Nisbett, R. E. (1971). *The actor and the observer: Divergent perceptions of the causes of behavior*. New York: General Learning Press.

Kelley, W. M., Macrae, C. N., Wyland, C. L., Caglar, S., Inati, S., & Heatherton, T. F. (2002). Finding the self? An event-related fMRI study. *Journal of Cognitive Neuroscience*, *14*, 785–794.

Legrand, D., & Ruby, P. (2009). What is self-specific? Theoretical investigation and critical review of neuroimaging results. *Psychological Review*, *116*(1), 252–282.

Leyens, J.-P., Paladino, P. M., Rodriguez-Torres, R., Vaes, J., Demoulin, S., Rodriguez-Perez, A., et al. (2000). The emotional side of prejudice: The attribution of secondary emotions to ingroups and outgroups. *Personality & Social Psychology Review*, *4*(2), 186–197.

Macrae, C. N., Moran, J. M., Heatherton, T. F., Banfield, J. F., & Kelley, W. M. (2004). Medial prefrontal activity predicts memory for self. *Cerebral Cortex*, *14*(6), 647–654.

Mitchell, J. P. (2009a). Inferences about other minds. *Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences*, *364*, 1309–1316.

Mitchell, J. P. (2009b). Social psychology as a natural kind. *Trends in Cognitive Sciences*, *13*(6), 246–251.

Mitchell, J. P., Heatherton, T. F., & Macrae, C. N. (2002). Distinct neural systems subserve person and object knowledge. *Proceedings of the National Academy of Sciences of the United States of America*, *99*, 15238–15243.

Mitchell, J. P., Macrae, C. N., & Banaji, M. R. (2006). Dissociable medial prefrontal contributions to judgments of similar and dissimilar others. *Neuron*, *50*(4), 655–663.

Moran, J. M., Heatherton, T. F., & Kelley, W. M. (2009). Modulation of cortical midline structures by implicit and explicit self-reference evaluation. *Social Neuroscience*, *4*(3), 197–211.

Neisser, U. (1998). Five kinds of self-knowledge. *Philosophical Psychology*, *1*, 35–39.

Northoff, G., & Bermpohl, F. (2004). Cortical midline structures and the self. *Trends in Cognitive Sciences*, *8*(3), 102–107.

Ochsner, K. N., Knierim, K., Ludlow, D. H., Hanelin, J., Ramachandran, T., Glover, G., et al. (2004). Reflecting upon feelings: An fMRI study of neural systems supporting the attribution of emotion to self and other. *Journal of Cognitive Neuroscience*, *16*(10), 1746–1772.

Powell, L. J., Macrae, C. N., Cloutier, J., Metcalfe, J., & Mitchell, J. P. (2010). Dissociable neural substrates for agentic versus conceptual representations of self. *Journal of Cognitive Neuroscience*, *22*(10), 2186–2197.

Rameson, L. T., Satpute, A. B., & Lieberman, M. D. (2010). The neural correlates of implicit and explicit self-relevant processing. *NeuroImage*, *50*(2), 701–708.

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality & Social Psychology*, *35*(9), 677–688.

Sande, G. N., Goethals, G. R., & Radloff, C. E. (1988). Perceiving one's own traits and others': The multifaceted self. *Journal of Personality and Social Psychology*, *54*(1), 13–20.

Saxe, R., & Kanwisher, N. (2003). People thinking about thinking people: fMRI investigations of theory of mind. *NeuroImage*, *19*, 1835–1842.

Saxe, R., & Powell, L. J. (2006). It's the thought that counts: Specific brain regions for one component of theory of mind. *Psychological Science*, *17*(8), 692–699.

Schneider, F., Bermpohl, F., Heinzel, A., Rotte, M., Walter, M., Tempelmann, C., et al. (2008). The resting brain and our self: Self-relatedness modulates resting state neural activity in cortical midline structures. *Neuroscience*, *157*(1), 120–131.

Spreng, N. R., Mar, R. A., & Kim, A. S. N. (2009). The common neural basis of autobiographical memory, prospection, navigation, theory of mind, and the default mode: A quantitative meta-analysis. *Journal of Cognitive Neuroscience*, *21*(3), 489–510.

Tajfel, Y., & Turner, J. C. (1986). The social identity theory of intergroup behavior. In S. Worchel & W. G. Austin (Eds.), *Psychology of intergroup relations* (pp. 7–24). Chicago: Nelson-Hall.

Uddin, L. Q., Iacoboni, M., Lange, C., & Keenan, J. P. (2007). The self and social cognition: The role of cortical midline structures and mirror neurons. *Trends in Cognitive Sciences*, *11*, 153–157.

Vollm, B. A., Taylor, A. N., Richardson, P., Corcoran, R., Stirling, J., McKie, S., et al. (2006). Neuronal correlates of theory of mind and empathy: A functional magnetic resonance imaging study in a nonverbal task. *Neuroimage*, *29*(1), 90–98.