Cell PRESS

Social psychology as a natural kind

Jason P. Mitchell

Department of Psychology, Harvard University, William James Hall, 33 Kirkland Street, Cambridge, MA 02138, USA

Although typically defined as the study of how people and groups interact, the field of social psychology comprises several disparate domains that make only indirect contributions to understanding interpersonal interaction, such as emotion, attitudes and the self. Although these various phenomena seem to have little in common, recent evidence indicates that the topics at the core of social psychology form a natural group of domains with a common functional neuroanatomy, centered on the medial prefrontal cortex. That self-referential, attitudinal, affective and other social phenomena converge on this region might reflect their shared reliance on inexact and internally generated estimates that differ from the more precise representations underlying other psychological phenomena.

What is social psychology?

A common definition of social psychology suggests that the field represents 'an attempt to understand and explain how the thought, feeling, and behavior of individuals are influenced by the actual, imagined, or implied presence of others' [1]. However, as practiced today, social psychology focuses as often on the cognitive workings of an individual in isolation as is does on those specific to interpersonal interaction. Beginning with the social cognition movement in the 1970s, social psychology has emerged as the primary headwater for the study of three intrapersonal phenomena that rely little on the 'presence of others': (i) the structure of knowledge about the self; (ii) attitudes and their influence on one's choices and (iii) the subjective experience of emotion. Indeed, the 4th edition of *The Handbook of Social Psychology* – widely considered the definitive encyclopedia of the field – devotes its first two topical sections to such intrapersonal domains, postponing its review of phenomena that occur in social contexts until the second of its two volumes.

How have these intrapersonal topics emerged as the central province of social psychology, ostensibly the science of understanding humans in interpersonal contexts? Why instead have these topics not formed a core part of cognitive psychology, which explicitly attempts to model the mental operations that support other such within-person abilities such as perception, attention and memory? Moreover, why have several phenomena with clear implications for interpersonal behavior, such as face identification and language, become central pursuits within cognitive science while remaining comparatively peripheral to social psychology? Although a coherent sense of self, stable attitudes and a rich repertoire of emotional experience doubtlessly have vital roles in interpersonal interaction, it is unclear how they bear more directly on social behavior than some of the abilities that have been relatively neglected by social psychology.

Over the past decade and a half, studies using neuroimaging and neuropsychological patients have provided a surprising but consistent answer to the question of what, if anything, binds these disparate topics within social psychology: a common neural basis. This work has demonstrated that four seemingly distinct cognitive phenomena – thinking about oneself, accessing one's attitudes, the experience of emotion and inferring the contents of another person's mind – all converge on a single brain region, the medial prefrontal cortex (MPFC). Such observations suggest that contemporary social psychology, far from being a patchwork of unrelated research questions, is the science of a set of closely related phenomena with a common functional neuroanatomy. Indeed, the neural confluence of self, attitudes, emotional experience and mental state inference implies that these phenomena pose a common cognitive challenge to the human mind, met by a common processing solution [2]. Rather than being the result of historical accident, social psychology seems to be a 'natural kind' – a genuine set defined by deep and nonarbitrary characteristics.

MPFC contributions to 'social' phenomena

Here, I review findings that suggest the ubiquity of MPFC involvement in four topics of central interest to social psychologists: the self-concept, attitudes and evaluation, emotional experience and understanding the minds of others. The goal is to provide an impressionistic – rather than exhaustive – overview of the surprising convergence of such 'social' abilities in the MPFC. Accordingly, discussion of other brain regions known to contribute to these phenomena is deferred (Box 1).

Self-concept

More than a dozen neuroimaging studies have examined the neural basis of the self-concept, as traditionally operationalized by social psychologists (Box 2), and these studies have ubiquitously linked self-referential processing to activity in MPFC (Figure 1a). In the preponderance of such studies, participants have been asked to introspect about their own personality characteristics, either by reporting how well they are described by a trait adjective (e.g. curious, intelligent, impatient) or by responding to questions about their dispositions (e.g. I have a quick temper). Reflecting on one's own dispositions in this manner consistently prompts greater MPFC activity than a variety of control conditions, including judging the personality traits of another person [3–10]; judging the social desirability of

Corresponding author: Mitchell, J.P. (jason_mitchell@harvard.edu)

1364-6613/$ – see front matter doi:10.1016/j.tics.2009.03.008 Available online 6 May 2009

Box 1. Interactions between the MPFC and other brain regions

Although the MPFC has a crucial role in subserving several phenomena of interest to social psychologists, several other brain regions also contribute importantly to the self-concept (e.g. medial parietal cortex), evaluation (the orbitofrontal cortex and ventral striatum), mentalizing (the medial parietal cortex and bilateral temporo-parietal junction), and emotional experience (e.g. the amygdala and anterior insula). In many cases, little is known about the independent contributions made by these other brain regions to such phenomena; for example, although the medial parietal cortex is frequently observed in conjunction with MPFC during self-referential processing and mentalizing, little is known about how the processes subserved by this region specifically contribute to such phenomena. At the same time, an important but unresolved issue in cognitive neuroscience is how the particular computations performed by a brain region might vary as a function of the other regions active during a particular cognitive task. For example, in what way might the particular computations performed by the MPFC differ when interacting more prominently with medial parietal cortex in contrast to the anterior insula? An important direction for future research will be to understand how networks of interacting brain regions together subserve our cognitive abilities, rather than focusing on single brain regions in isolation.

a personality trait (is being 'curious' generally considered positive or negative?) [9,11–14]; answering questions based on semantic knowledge (is 10 s longer than a minute?) [15] and judging lexical or orthographic features of words [16,17]. Moreover, MPFC activity correlates with successful memory for information processed in a self-referential manner [18], suggesting that this region supports the well-documented mnemonic benefits of linking information to the self-concept [19]. Consistent with these neuroimaging observations, patients with frontotemporal dementia – a progressive disorder associated with disproportionately high atrophy in MPFC – demonstrate profound changes in the self-concept, including an impaired ability to judge their own personality traits [20].

Attitudes and evaluation

A central concept in social psychology has been that of attitude, defined as 'a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor' [21] (Box 3). As for the self-concept, a series of recent neuroimaging studies has suggested that the MPFC has a crucial role in the ability to access and explicitly report one's attitudes (Figure 1b). A fairly circumscribed region of ventral MPFC is preferentially engaged when individuals respond to questions about their own preferences (e.g. 'I enjoy doing laundry over going grocery shopping') than about those of another person [6,10,22,23]. Likewise, explicitly evaluating a stimulus as positive or negative produces greater response in this region than judging semantic [24,25], perceptual [26,27] or other nonevaluative [28] aspects of a stimulus. Consistent with these neuroimaging observations, patients with damage to the ventral MPFC show impairments in reporting their preferences in a consistent manner. For example, such an individual might evaluate one person as more positive than a second and that second person as more positive than a third, but then also judge, incompatibly, the third to be more positive than the first [29].

Whereas social psychologists have often relied on what respondents explicitly articulate about an attitude object – that is their 'reported' preferences – several other research traditions have studied preferences as they are 'revealed' by an individual's observable choices. These literatures confirm the functional importance of ventral aspects of the MPFC for evaluating the desirability of a stimulus. Activity in this region has been observed to correlate with participants' preference for one taste over another as revealed in a blind 'taste test' [30] and with their relative preference for immediate over delayed monetary rewards in an intertemporal choice paradigm (e.g. opting to receive $20 now versus a larger amount in a week) [31]. Moreover, beginning with the well-known case of Phineas Gage, neuropsychological research has repeatedly demonstrated that damage to ventral MPFC impairs one's abilities both to evaluate competing courses of action [32] and to revise earlier evaluations of a stimulus [33].

Emotional experience

Both social and clinical psychology have been centrally concerned with understanding the nature of emotional

Box 2. The self in social psychology

Research on the self encompasses a variety of phenomena, from self-referential thought and self-initiated behavior to self-regulation and self-esteem. Although there is no single definition of the self, social psychology has paid special attention to one particular aspect of selfhood: one's concept of self [82]. The self-concept refers to a person's understanding of what she 'is like' as a person, that is, what personality characteristics she manifests, what idiosyncratic abilities and proclivities define her as an individual, and to what extent she regards herself positively (i.e. has high or low self-esteem). Social psychological research on the self-concept has included (i) determining what information people use as a primary basis for judging what they are like; (ii) documenting the consequences of processing events in a self-referential manner; (iii) demonstrating the extent to which people distort information to maintain a consistent self-concept and (iv) detailing individuals' attempts to maintain high regard for the self.

A rough sense of the importance of this topic to social psychology can be estimated from the prevalence of the word 'self' in titles of articles published in the field's journals. Between 1965 and 2008, 'self' appeared in the title of roughly every eighth article published in the *Journal of Personality and Social Psychology* (1,056 of 8,539 total) and the *Journal of Experimental Social Psychology* (255 of 2,235 total). By contrast, over the same span of time, all subtitles of the *Journal of Experimental Psychology* have included a mere 82 articles with 'self' in the title (of more than 16 000 articles published; ~0.5%), and *Cognition* has published only 15 such articles (~0.7%).

One important line of research on the self has focused on the demonstration of enhanced processing for information encoded self-referentially. This 'self-reference effect' [19] has typically been observed as better memory for stimuli that participants initially judge in relation to the self (e.g. 'how well does the word *curious* describe you?') than those they initially judge in relation to another person ('how well does the word *honest* describe Bill Clinton?') or about which they make semantic judgments ('was Bill Clinton the 40th president of the United States?'). Tellingly, although by definition this work focuses on an inherently intrapersonal phenomenon (the self) and examines a phenomenon of central interest to cognitive psychologists (memory), it has overwhelmingly appeared in social psychology (and, to some extent, clinical psychology) journals, rather than in mainstream cognitive psychology outlets.

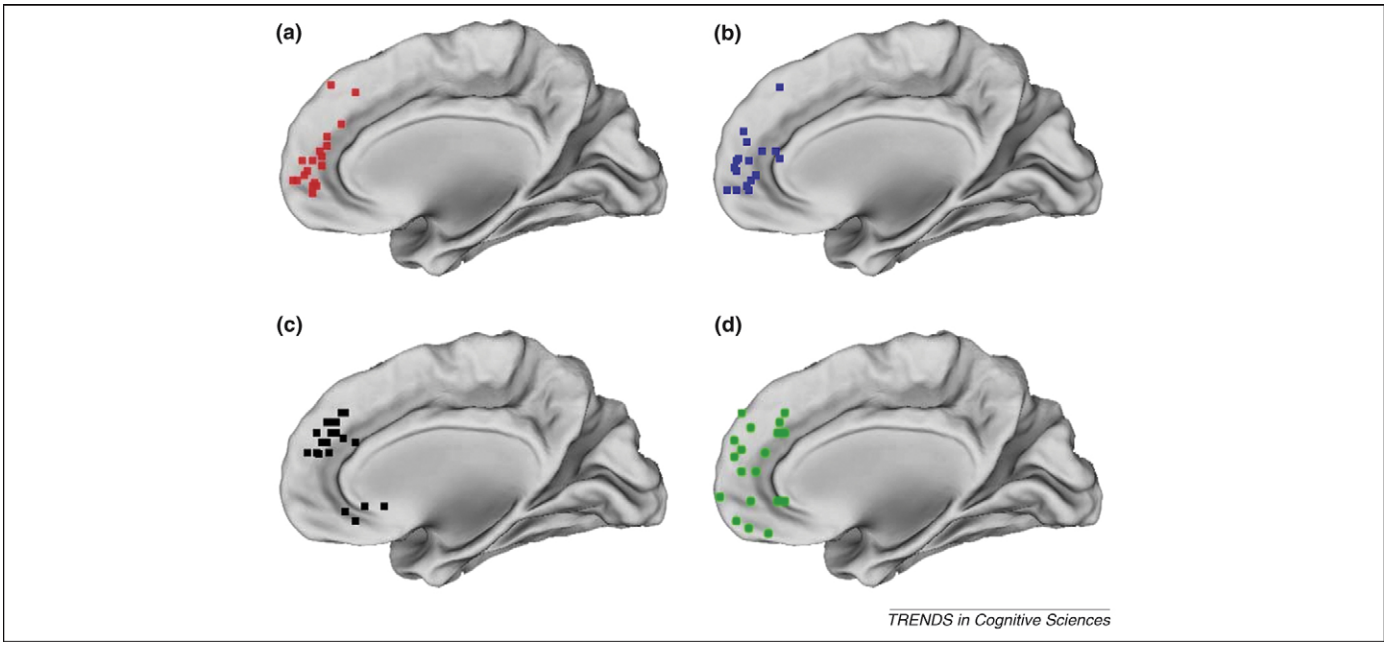

Figure 1. Location of peak MPFC activations associated with 'social' phenomena. Each of the four images displays the midline of a canonical right hemisphere with the peak MPFC coordinates observed by studies of different classes of psychological phenomena primarily studied by social psychologists. **(a)** The self-concept refers to a person's introspective awareness of her own personality traits and idiosyncratic dispositions [3–18]. **(b)** Attitudes entail positive or negative evaluations of an object, idea, other person or group, and can be reported explicitly through language or revealed through actual behavior [6,10,22–28,30,31] (for attitudes, only studies identifying MPFC, rather than OFC, were plotted). **(c)** The subjective experience of emotion refers to the subjective awareness of one's affective states, such as the degree to which one is experiencing happiness, sadness, disgust or fear [37–48]. **(d)** Theory-of-mind or mentalizing refers to the ability to infer the thoughts, feelings and desires of other people [53–68]. Although each of these phenomena differs superficially from the others, all ultimately rely on the internal generation of probabilistic and malleable estimates – rather than exact representations that correspond veridically and stably to external reality – a set of functions linked to MPFC.

Box 3. Attitudes, evaluation and preferences

How do humans form opinions about unfamiliar novel objects and people? How do we store and access such evaluations? And how do we update our attitudes in response to new or contradictory information? The origins of social psychology are so closely linked to these questions that some early commentators equated the entire field with the study of attitudes and evaluation [83]. By 1935, the concept of an attitude had been proclaimed the principal foundation on which social psychology rests, and throughout the 1960s and 70s, the study of attitudes and attitude change dominated research in social psychology. Even today, the lead section of the *Journal of Personality and Social Psychology* is devoted to 'attitudes and social cognition.' Consistent with their position at the center of the field, a wide-ranging array of evaluative responses have been studied by social psychologists. Although much of this work has focused on respondents' attitudes towards social groups, individuals and social policies (e.g. Communism, the right-to-life or affirmative action), researchers have also commonly examined less overtly interpersonal attitudinal responses, such as those regarding personal behavior or idiosyncratic preferences (e.g. the value of tooth-brushing, the taste of anchovies, etc.).

Although social psychologists have traditionally relied on what respondents explicitly report about an attitude object, more recent work has focused on unconscious or 'implicit' forms of evaluation that unfold automatically and without subjective awareness. Whether or not such implicit evaluations arise from the same processes as one's conscious opinions and preferences continues to be a matter of some debate within the social psychological literature, although recent neuroimaging findings have suggested that implicit forms of evaluation might be distinct from explicitly reported attitudes in relying on a neural system centered around the amygdala [84]. Such dissociations are reminiscent of the distinctions between explicit and implicit memory, which likewise seem to be two different systems of memory that rely on distinct neural systems.

experience, that is, one's subjective awareness of affective states and the consequences of such experience on behavior. The topics addressed by such researchers have ranged from the source of subjective emotional experience to the maladaptive effects of emotion that define many clinical disorders to the relationship between emotion and 'colder', less affectively based, mental operations. In addition, a sizeable literature has examined emotional expression, cataloguing the discrete types of facial expressions that accompany different emotions and examining how perceivers recognize the emotions of others [34].

Although several brain regions make well-characterized contributions to the experience and recognition of particular emotions (such as the anterior insula to disgust and the amygdala to fear and anxiety) [35], a somewhat underappreciated finding has been the generality of the response in MPFC during emotional experience. In a review of 55 neuroimaging experiments up to 2002 [36], the MPFC was the brain region most commonly associated with affective processing, regardless of the specific emotion being targeted (disgust, fear, sadness, anger, happiness). Interestingly, manipulations that induce particularly rich emotional experience were those most likely to engage MPFC [37–48] (Figure 1c). MPFC modulation is particularly likely when a person engages in extended affective processing that allows for genuine, subjective experience of emotion, such as by recalling an evocative autobiographical memory or viewing emotionally charged films (in contrast to passively viewing affective words or still photographs). This observation suggests that the MPFC might specifically contribute to emotion by

subserving the subjective experience of one's affective state. More recently, neuropsychological research has confirmed the important role of MPFC in emotion, demonstrating that lesions to this region impair both emotional experience and the recognition of emotional expressions [49]. Together, these results indicate that, although specific brain regions like the amygdala and insula might have crucial roles in specific emotions, the MPFC has a broad – albeit incompletely specified – role in emotional experience more widely.

Understanding the minds of others

Notwithstanding frequent forays into purely intrapersonal phenomena, social psychologists have long examined the question of how perceivers make sense of the behavior of others. For more than three decades starting in the 1960s, a sizeable literature developed around questions of attribution, such as how one determines whether an individual's behavior (Mary is biting her finger nails) is better ascribed to her internal mental states and dispositions (she must be a nervous person) or to situational influences and constraints (she is waiting for the results of an important exam). (For a comprehensive review of social psychological research on attribution, see Ref. [50].) More recently, researchers have begun to concentrate on one aspect of attribution, examining how perceivers generate their initial inferences about others' mental states in the first place (e.g. how does one infer that Mary is feeling nervous to start with?), an ability referred to as 'mentalizing' or 'theory-of-mind'.

For all intents and purposes, neuroimaging studies have unanimously implicated MPFC in tasks that require perceivers to mentalize about the thoughts or feelings of others (Figure 1d). Recent reviews of the functional neuroanatomy underlying social cognition [51,52] have catalogued the wide range of contexts in which MPFC activity accompanies mentalizing. Greater response in this region has been observed when perceivers (i) regard stories or cartoons whose comprehension requires inferring the mental states of their protagonists (compared to understanding physical causality) [53–55]; (ii) answer questions about another person's knowledge [56–59]; (iii) watch abstract cartoons that imply the presence of a mental agent [60–62] or (iv) play a competitive game against a human (compared to a computer) opponent [63,64]. Moreover, similar MPFC modulation has been associated with tasks originally developed within the social psychological literature on attribution, such as those designed to favor dispositional over situational attributions [65] or during explicit attempts to form an impression of another person's personality [66–68]. Neuropsychological results also confirm that, at least for nontrivial theory-of-mind tasks, damage to the MPFC impairs the ability to apprehend others' mental states [69,70]. And autism, which is marked by severe impairments in understanding others' mental states, has been linked by at least two studies to abnormal activity in MPFC [71,72] (although the functional neuroanatomy underlying this disorder is far from completely understood).

Social psychology as the study of 'fuzzy' cognition

To the extent that shared functional neuroanatomy implies shared cognitive processing [2], the overlapping MPFC basis for the self-concept, attitudes, emotional experience and mentalizing indicates that these seemingly diverse phenomena all draw on a common set of underlying mental operations. But what does the fact that the MPFC in particular subserves these social phenomena – and not some other brain region – imply about the nature of the processes underlying them? Interestingly, the MPFC has been implicated in several additional abilities that call for nonliteral, counterfactual or probabilistic processing, such as understanding figurative linguistic constructions like metaphor and analogy [73,74], simulating hypothetical future events [75] and reasoning about ambiguous moral conflicts [76,77]. In sharp contrast, the MPFC has not only been only rarely implicated in most other cognitive activities but routinely demonstrates reduced response (i.e. 'deactivation') when participants engage in tasks involving semantic memory, executive function, perception and many of the other types of processes studied by cognitive psychology [78]. Such deactivations have been argued to mark the suspension of an internally focused mode of processing that would otherwise interfere with attention to the external environment [75,78].

Together, these neural observations support the view that 'social' phenomena can be distinguished from other kinds of cognitive processing by their dependence on a qualitatively distinct class of mental representation. Most cognitive abilities require exact representations that correspond veridically to the external world: people are typically surprised and consternated when they generate inexact or fallacious representations of the outside world; for example, misreaching for a wine glass and knocking it over, intending one word but blurting out another, or feeling confident in memories that prove to be false or distorted. By contrast, when it comes to our self-concept, attitudes, emotional experience and understanding of others minds, we readily handle – indeed, often insist upon – considerably less exactitude and accuracy. Although we know roughly what defines us as a person, how much we like or dislike something, the strength of our current emotional experience or what is going on inside the head of another person, the functional utility of these social processes does not rely on the ability to pinpoint an exact representation that corresponds precisely to an actual 'fact of the matter' in the external world. Instead, social phenomena demand an ability to operate over 'fuzzy' mental estimates that are inexact, probabilistic, internally generated and subject to revision. Whereas abilities like motor control, language and perception require the generation of discrete, specific representations, we typically experience our selves, our attitudes, our emotions and the minds of others more like continuously shifting and indefinite approximations. Reifying these fuzzy experiences by assigning them specific labels (e.g. through language, Likert scales, and so on) either acutely disrupts normal functioning, as in the case of affective processing [79], or else provides flawed or inadequate insights into their workings, as for our self-concept, attitudes and social inferences [80].

A possible exception might be our inferences about mental states, which can sometimes pertain to specific information that another person may or may not know.

Box 4. Questions and future directions

- Although research has established that many concepts of interest to social psychologists rely on the MPFC, little is known about the neural basis of many other important social psychological phenomena, such as self-esteem, motivation, persuasion and stereotyping. An open question remains whether the MPFC also subserves these other lines of social psychological inquiry, or if such phenomena rely on distinct forms of cognitive processing.
- Most neuroimaging and neuropsychological research on revealed preferences has implicated particularly inferior regions of MPFC that extend into the orbitofrontal cortex (OFC) [85]. The distinction between the evaluative processing subserved by ventral MPFC and OFC is not yet fully understood.
- Somewhat ironically, the concept of 'fuzzy' cognition is itself vague and imprecise. Although likely to be somewhat controversial, the use of the term reflects the current lack of a more appropriate one with which to describe the putative distinction between the 'social' processing subserved by the MPFC and other forms of processing that have been of primary interest to cognitive psychologists. An important direction for future research will be to illuminate the exact contours of the attributes that underlie social psychological phenomena and their difference from other branches of cognitive science.

Indeed, a good deal of research in social cognition has examined tasks that imply 'correct' answers about another person's knowledge (such as the 'Sally-Anne' false belief task). Interestingly, these tasks are most closely associated with activity in a region outside the MPFC, the temporo-parietal junction [81]. By contrast, many of our mental state inferences center around fuzzier, more probabilistic estimates of others' experience. For example, we might infer that someone is sad, but rarely need to estimate exactly how dysphoric. Or we might consider someone to possess a certain personality trait (intelligence), but rarely consider exactly to what extent.

Conclusion

By increasingly adopting the methods of cognitive neuroscience, social psychologists have discovered a previously unsuspected correspondence among many of the important phenomena at the core of the field. Such observations underscore the unique power of functional localization methods, such as neuroimaging, to uncover links among researchers who once believed themselves to be studying disparate empirical issues, but who we now understand to have been probing different manifestations of a common underlying system. This neurally inspired 'lumping' of seemingly disparate phenomena promises not only to help underscore what makes social psychology distinctive but also suggests the need to rethink the assumption that the field studies phenomena at a 'higher' or more 'macro' level than cognitive psychology. Rather than equating the study of social phenomena with a particular level of analysis, these findings suggest a view of social psychology as a unique branch of cognitive science, specialized for examining a distinct and natural kind of approximate, shifting and internally generated – in other words, 'fuzzy' – cognitive operations (Box 4).

Acknowledgements

The preparation of this article was supported by NSF and NIA grants to J.P.M. Thanks to Mahzarin Banaji, Wendy Berry Mendes, Randy Buckner, Dan Gilbert, Abby Klima, Neil Macrae, Lindsey Powell, Rebecca Saxe, Diana Tamir, Dan Wegner and Jamil Zaki for helpful comments and discussion and Dave Johnson and Jessica Schirmer for their assistance in preparing the manuscript.

References

1 Allport, G.W. (1968) The historical background of modern social psychology. In *Handbook of Social Psychology* (Lindzey, G. and Aronson, E., eds), pp. 1–80, Addison-Wesley Publishing Company
2 Henson, R. (2006) Forward inference using functional neuroimaging: dissociations versus associations. *Trends Cogn. Sci.* 10, 64–69
3 D'Argembeau, A. *et al.* (2005) Self-referential reflective activity and its relationship with rest: a PET study. *Neuroimage* 25, 616–624
4 D'Argembeau, A. *et al.* (2007) Distinct regions of the medial prefrontal cortex are associated with self-referential processing and perspective taking. *J. Cogn. Neurosci.* 19, 935–944
5 Kelley, W.M. *et al.* (2002) Finding the self? An event-related fMRI study. *J. Cogn. Neurosci.* 14, 785–794
6 Pfeifer, J.H. *et al.* (2007) "I know you are but what am I?!": neural bases of self- and social knowledge retrieval in children and adults. *J. Cogn. Neurosci.* 19, 1323–1337
7 Zhu, Y. *et al.* (2007) Neural basis of cultural influence on self-representation. *Neuroimage* 34, 1310–1316
8 Gutchess, A.H. *et al.* (2007) Aging, self-referencing, and medial prefrontal cortex. *Soc. Neurosci.* 2, 117–133
9 Zhang, L. *et al.* (2006) In search of the Chinese self: an fMRI study. *Sci. China C Life Sci.* 49, 89–96
10 Jenkins, A.C. *et al.* (2008) Repetition suppression of ventromedial prefrontal activity during judgments of self and others. *Proc. Natl. Acad. Sci. U. S. A.* 105, 4507–4512
11 Fossati, P. *et al.* (2003) In search of the emotional self: An fMRI study using positive and negative emotional words. *Am. J. Psychiatry* 160, 1938–1945
12 Saxe, R. *et al.* (2006) Overlapping and non-overlapping brain regions for theory of mind and self reflection in individual subjects. *Soc. Cogn. Affect. Neurosci.* 1, 229–234
13 Schmitz, T.W. *et al.* (2004) Metacognitive evaluation, self-relevance, and the right prefrontal cortex. *Neuroimage* 22, 941–947
14 Schmitz, T.W. *et al.* (2006) Neural correlates of self-evaluative accuracy after traumatic brain injury. *Neuropsychologia* 44, 762–773
15 Johnson, S.C. *et al.* (2002) Neural correlates of self-reflection. *Brain* 125, 1808–1814
16 Ochsner, K.N. *et al.* (2005) The neural correlates of direct and reflected self-knowledge. *Neuroimage* 28, 797–814
17 Vanderwal, T. *et al.* (2008) Self, mother and abstract other: an fMRI study of reflective social processing. *Neuroimage* 41, 1437–1446
18 Macrae, C.N. *et al.* (2004) Medial prefrontal activity predicts memory for self. *Cereb. Cortex* 14, 647–654
19 Symons, C.S. and Johnson, B.T. (1997) The self-reference effect in memory: a meta-analysis. *Psychol. Bull.* 121, 371–394
20 Miller, B.L. *et al.* (2001) Neuroanatomy of the self: evidence from patients with frontotemporal dementia. *Neurology* 57, 817–821
21 Eagly, A.H. and Chaiken, S. (1998) Attitude structure and function. In *Handbook of Social Psychology* (4th edn) (Gilbert, D.T. *et al.*, eds), pp. 269–322, McGraw Hill
22 Ames, D.L. *et al.* (2008) Taking another person's perspective increases self-referential neural processing. *Psychol. Sci.* 19, 642–644
23 Mitchell, J.P. *et al.* (2006) Dissociable medial prefrontal contributions to judgments of similar and dissimilar others. *Neuron* 50, 655–663
24 Cunningham, W.A. *et al.* (2004) Implicit and explicit evaluation: FMRI correlates of valence, emotional intensity, and control in the processing of attitudes. *J. Cogn. Neurosci.* 16, 1717–1729
25 Zysset, S. *et al.* (2002) The anterior frontomedian cortex and evaluative judgment: an fMRI study. *Neuroimage* 15, 983–991
26 Gusnard, D.A. *et al.* (2001) Medial prefrontal cortex and self-referential mental activity: Relation to a default mode of brain function. *Proc. Natl. Acad. Sci. U. S. A.* 98, 4259–4264
27 Paulus, M.P. and Frank, L.R. (2003) Ventromedial prefrontal cortex activation is critical for preference judgments. *Neuroreport* 14, 1311–1315
28 Turk, D.J. *et al.* (2004) From facial cue to dinner for two: the neural substrates of personal choice. *Neuroimage* 22, 1281–1290

29 Fellows, L.K. and Farah, M.J. (2007) The role of ventromedial prefrontal cortex in decision making: judgment under uncertainty or judgment *per se? Cereb. Cortex* 17, 2669–2674
30 McClure, S.M. *et al.* (2004) Neural correlates of behavioral preference for culturally familiar drinks. *Neuron* 44, 379–387
31 Kable, J.W. and Glimcher, P.W. (2007) The neural correlates of subjective value during intertemporal choice. *Nat. Neurosci.* 10, 1625–1633
32 Damasio, A.R. (1994) *Descartes' Error.* Grosset/Putnam
33 Fellows, L.K. and Farah, M.J. (2005) Different underlying impairments in decision-making following ventromedial and dorsolateral frontal lobe damage in humans. *Cereb. Cortex* 15, 58–63
34 Hall, J.A. and Bernieri, F.J. (2001) *Interpersonal Sensitivity: Theory and Measurement.* Lawrence Erlbaum Associates
35 Adolphs, R. (2002) Neural systems for recognizing emotion. *Curr. Opin. Neurobiol.* 12, 169–177
36 Phan, K.L. *et al.* (2002) Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. *Neuroimage* 16, 331–348
37 Baker, S.C. *et al.* (1997) The interaction between mood and cognitive function studied with PET. *Psychol. Med.* 27, 565–578
38 Beauregard, M. *et al.* (1998) The functional neuroanatomy of major depression: an fMRI study using an emotional activation paradigm. *Neuroreport* 9, 3253–3258
39 Dougherty, D.D. *et al.* (1999) Anger in healthy men: a PET study using script-driven imagery. *Biol. Psychiatry* 46, 466–472
40 Kimbrell, T.A. *et al.* (1999) Regional brain activity during transient self-induced anxiety and anger in healthy adults. *Biol. Psychiatry* 46, 454–465
41 Reiman, E.M. *et al.* (1997) Neuroanatomical correlates of externally and internally generated human emotion. *Am. J. Psychiatry* 154, 918–925
42 Lane, R.D. *et al.* (1997) Neuroanatomical correlates of happiness, sadness, and disgust. *Am. J. Psychiatry* 154, 926–933
43 Liotti, M. *et al.* (2000) Differential limbic–cortical correlates of sadness and anxiety in healthy subjects: implications for affective disorders. *Biol. Psychiatry* 48, 30–42
44 Mayberg, H.S. *et al.* (1999) Reciprocal limbic-cortical function and negative mood: converging PET findings in depression and normal sadness. *Am. J. Psychiatry* 156, 675–682
45 Pardo, J.V. *et al.* (1993) Neural correlates of self-induced dysphoria. *Am. J. Psychiatry* 150, 713–719
46 Partiot, A. *et al.* (1995) Brain activation during the generation of non-emotional and emotional plans. *Neuroreport* 6, 1397–1400
47 Shin, L.M. *et al.* (2000) Activation of anterior paralimbic structures during guilt-related script-driven imagery. *Biol. Psychiatry* 48, 43–50
48 Teasdale, J.D. *et al.* (1999) Functional MRI study of the cognitive generation of affect. *Am. J. Psychiatry* 156, 209–215
49 Heberlein, A.S. *et al.* (2008) Ventromedial frontal lobe plays a critical role in facial emotion recognition. *J. Cogn. Neurosci.* 20, 721–733
50 Gilbert, D.T. (1998) Ordinary personology. In *Handbook of Social Psychology* (4th edn) (Gilbert, D.T. *et al.*, eds), pp. 89–150, McGraw Hill
51 Amodio, D.M. and Frith, C.D. (2006) Meeting of minds: The medial frontal cortex and social cognition. *Nat. Rev. Neurosci.* 7, 268–277
52 Blakemore, S.J. *et al.* (2004) Social cognitive neuroscience: where are we heading? *Trends Cogn. Sci.* 8, 216–222
53 Fletcher, P.C. *et al.* (1995) Other minds in the brain: a functional imaging study of "theory of mind" in story comprehension. *Cognition* 57, 109–128
54 Gallagher, H.L. *et al.* (2000) Reading the mind in cartoons and stories: An fMRI study of 'theory of mind' in verbal and nonverbal tasks. *Neuropsychologia* 38, 11–21
55 Brunet, E. *et al.* (2000) A PET investigation of the attribution of intentions with a nonverbal task. *Neuroimage* 11, 157–166
56 Goel, V. *et al.* (1995) Modeling other minds. *Neuroreport* 6, 1741–1746
57 Ruby, P. and Decety, J. (2003) What you believe versus what you think they believe: a neuroimaging study of conceptual perspective-taking. *Eur. J. Neurosci.* 17, 2475–2480
58 Saxe, R. and Powell, L.J. (2006) It's the thought that counts: specific brain regions for one component of theory of mind. *Psychol. Sci.* 17, 692–699
59 Saxe, R. and Wexler, A. (2005) Making sense of another mind: the role of the right temporo-parietal junction. *Neuropsychologia* 43, 1391–1399
60 Castelli, F. *et al.* (2000) Movement and mind: a functional imaging study of perception and interpretation of complex intential movement patterns. *Neuroimage* 12, 314–325
61 Martin, A. and Weisberg, J. (2003) Neural foundations for understanding social and mechanical concepts. *Cogn. Neuropsychol.* 20, 575–587
62 Wheatley, T. *et al.* (2007) Understanding animate agents: Distinct roles for the social network and mirror system. *Psychol. Sci.* 18, 469–474
63 Rilling, J.K. *et al.* (2004) The neural correlates of theory of mind within interpersonal interactions. *Neuroimage* 22, 1694–1703
64 Gallagher, H.L. *et al.* (2002) Imaging the intentional stance in a competitive game. *Neuroimage* 16, 814–821
65 Harris, L.T. *et al.* (2005) Attributions on the brain: neuro-imaging dispositional inferences, beyond theory of mind. *Neuroimage* 28, 763–769
66 Mitchell, J.P. *et al.* (2006) Medial prefrontal dissociations during processing of trait diagnostic and nondiagnostic person information. *Soc. Cogn. Affect. Neurosci.* 1, 49–55
67 Mitchell, J.P. *et al.* (2004) Encoding specific effects of social cognition on the neural correlates of subsequent memory. *J. Neurosci.* 24, 4912–4917
68 Mitchell, J.P. *et al.* (2005) Forming impressions of people versus inanimate objects: Social-cognitive processing in the medial prefrontal cortex. *Neuroimage* 26, 251–257
69 Stone, V.E. *et al.* (1998) Frontal lobe contributions to theory of mind. *J. Cogn. Neurosci.* 10, 640–656
70 Stone, V.E. *et al.* (2002) Selective impairment of reasoning about social exchange in a patient with bilateral limbic system damage. *Proc. Natl. Acad. Sci. U. S. A.* 99, 11531–11536
71 Kennedy, D.P. *et al.* (2006) Failing to deactivate: resting functional abnormalities in autism. *Proc. Natl. Acad. Sci. U. S. A.* 103, 8275–8280
72 Gilbert, S.J. *et al.* (2009) Abnormal functional specialization within medial prefrontal cortex in high-functioning autism: a multi-voxel similarity analysis. *Brain* DOI:10.1093/brain/awn365
73 Bottini, G. *et al.* (1994) The role of the right hemisphere in the interpretation of figurative aspects of language. A positron emission tomography activation study. *Brain* 117, 1241–1253
74 Green, A.E. *et al.* (2006) Frontopolar cortex mediates abstract integration in analogy. *Brain Res.* 1096, 125–137
75 Buckner, R.L. and Carroll, D.C. (2007) Self-projection and the brain. *Trends Cogn. Sci.* 11, 49–57
76 Greene, J.D. *et al.* (2001) An fMRI investigation of emotional engagement in moral judgment. *Science* 293, 2105–2108
77 Koenigs, M. *et al.* (2007) Damage to the prefrontal cortex increases utilitarian moral judgements. *Nature* 446, 908–911
78 Gusnard, D.A. and Raichle, M.E. (2001) Searching for a baseline: functional imaging and the resting human brain. *Nat. Rev. Neurosci.* 2, 685–694
79 Wilson, T.D. and Schooler, J.W. (1991) Thinking too much: introspection can reduce the quality of preferences and decisions. *J. Pers. Soc. Psychol.* 60, 181–192
80 Nisbett, R.E. and Wilson, T.D. (1977) Telling more than we can know: verbal reports on mental processes. *Psychol. Rev.* 84, 231–259
81 Saxe, R. (2006) Uniquely human social cognition. *Curr. Opin. Neurobiol.* 16, 235–239
82 Baumeister, R.F. (1998) The self. In *Handbook of Social Psychology* (4th edn) (Gilbert, D.T. *et al.*, eds), pp. 680–740, McGraw Hill
83 Allport, G.W. (1935) Attitudes. In *Handbook of Social Psychology* (Murchison, C., ed.), pp. 798–844, Clark University Press
84 Cunningham, W.A. and Zelazo, P.D. (2007) Attitudes and evaluations: a social cognitive neuroscience perspective. *Trends Cogn. Sci.* 11, 97–104
85 Montague, P.R. and Berns, G.S. (2002) Neural economics and the biological substrates of valuation. *Neuron* 36, 265–284