Social Cognitive Neuroscience: A Review of Core Processes

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theory of mind, empathy, emotion regulation, self-control, mirror neurons, social cognition, social neuroscience, automaticity, neuroeconomics

Abstract

Social cognitive neuroscience examines social phenomena and processes using cognitive neuroscience research tools such as neuroimaging and neuropsychology. This review examines four broad areas of research within social cognitive neuroscience: (*a*) understanding others, (*b*) understanding oneself, (*c*) controlling oneself, and (*d*) the processes that occur at the interface of self and others. In addition, this review highlights two core-processing distinctions that can be neurocognitively identified across all of these domains. The distinction between automatic versus controlled processes has long been important to social psychological theory and can be dissociated in the neural regions contributing to social cognition. Alternatively, the differentiation between internally-focused processes that focus on one's own or another's mental interior and externally-focused processes that focus on one's own or another's visible features and actions is a new distinction. This latter distinction emerges from social cognitive neuroscience investigations rather than from existing psychological theories demonstrating that social cognitive neuroscience can both draw on and contribute to social psychological theory.

Contents

INTRODUCTION

Social cognitive neuroscience is a burgeoning interdisciplinary field combining the tools of cognitive neuroscience with questions and theories from various social sciences including social psychology, economics, and political science. Although research on the biological correlates of social processes has been ongoing for decades (Cacioppo & Bernston 1992), this approach has gone through a period of rapid expansion with the advent of functional neuroimaging (Adolphs 2003, Ochsner & Lieberman 2001). Since the time of the first conference on social cognitive neuroscience (the UCLA Conference on Social Cognitive Neuroscience, April 2001) until the present, there has been an enormous growth in the field as evidenced by increasing numbers of research articles, edited volumes, and academic meetings devoted to social cognitive neuroscience. An Internet search using the words "social cognitive neuroscience" yielded 53 hits in early 2001, whereas today the same search yields more than 30,000 hits. Moreover, in the past year, two new journals have been created (*Social Cognitive and Affective Neuroscience* and *Social Neuroscience)* to provide outlets for this work.

Although selective reviews of social cognitive neuroscience have been written in the past few years (Blakemore et al. 2004, Ochsner 2004), no comprehensive review has captured the breadth of the area. Thus, first and foremost, this review covers the broad themes and main findings across numerous areas of social cognitive neuroscience research. The review is divided into four subsections focusing on (*a*) understanding others, (*b*) understanding oneself, (*c*) controlling oneself, and (*d*) the processes that occur at the interface of self and others. Unfortunately, space constraints prevent this review from covering some topics relevant to social cognitive neuroscience, such as emotion recognition and face processing (see Adolphs 2002, Haxby et al. 2002).

The second goal of this review is to identify core-processing distinctions that may cut across the different domains of social cognition and provide a framework for organizing general principles of social cognitive neuroscience. Two core-processing distinctions are examined throughout this review: (*a*) automatic versus controlled processes and (*b*) internally-focused versus externally-focused processes.

Dual-process models of automatic and controlled social cognition have been proposed in nearly every domain of social psychology (Chaiken & Trope 1999). Controlled processes (e.g., rehearsing a nine-digit number) are associated with awareness, intention, effort, and the capacity for interruption (Wegner & Bargh 1998). In contrast, automatic processes (e.g., "Juliet" spontaneously

Table 1 Features associated with X- and C-systems posited to support reflexive (analogous to automatic) and reflective (analogous to controlled) processes. Adapted from Satpute & Lieberman (2006)

X-System	C-System
Parallel processing	Serial processing
Fast operating	Slow operating
Slow learning	Fast learning
Nonreflective consciousness	Reflective consciousness
Sensitive to subliminal presentations	Insensitive to subliminal presentations
Spontaneous processes	Intentional processes
Prepotent responses	Regulation of prepotent responses
Typically sensory	Typically linguistic
Outputs experienced as reality	Outputs experienced as self-generated
Relation to behavior unaffected by cognitive load	Relation to behavior altered by cognitive load
Facilitated by high arousal	Impaired by high arousal
Phylogenetically older	Phylogenetically newer
Representation of symmetric relations	Representation of asymmetric relations
Representation of common cases	Representation of special cases (e.g., exceptions)
	Representation of abstract concepts (e.g., negation, time)

coming to mind upon hearing “Romeo”) lack one or more of these qualities. Consistent with the notion that automatic and controlled processes are supported by distinct systems (Smith & DeCoster 1999), distinct neurocognitive systems have been hypothesized to support these two forms of social cognition.

The X-system, named for the “x” in reflexive (Lieberman et al. 2002, Satpute & Lieberman 2006), corresponds roughly to an automatic social cognition system (see **Table 1**). The neural regions associated with the X-system (see **Figure 1**) are the amygdala, basal ganglia, ventromedial prefrontal cortex (VMPFC), lateral temporal cortex (LTC), and dorsal anterior cingulate cortex (dACC).

The C-system, named for the “c” in reflective, corresponds roughly to a controlled social cognition system. The neural regions associated with the C-system are lateral prefrontal cortex (LPFC), medial prefrontal cortex (MPFC), lateral parietal cortex (LPAC), medial parietal cortex (MPAC), medial temporal lobe (MTL), and rostral anterior cingulate cortex (rACC). For a rationale of each nomination to the two systems, see Satpute & Lieberman (2006). The automatic and control distinctions are addressed in each section of this review for which relevant data are available.

This review also highlights a second core-processing distinction between internally-focused and externally-focused forms of social cognition. This is not a distinction between self- and other-focused cognition. Rather, internally-focused cognition refers to mental processes that focus on one’s own or another’s mental interior (e.g., thoughts, feelings, experience), whereas externally-focused cognition refers to mental processes that focus on one’s own or another’s physical and visible features and actions that are perceived through sensory modalities and are experienced as part of the material world. This distinction emerges as a data-driven finding across numerous domains of social cognitive neuroscience rather than from any existing theories of social cognition. As such, this review hopefully reveals how social cognitive neuroscience can inform social psychological theory, in addition to being informed by it.

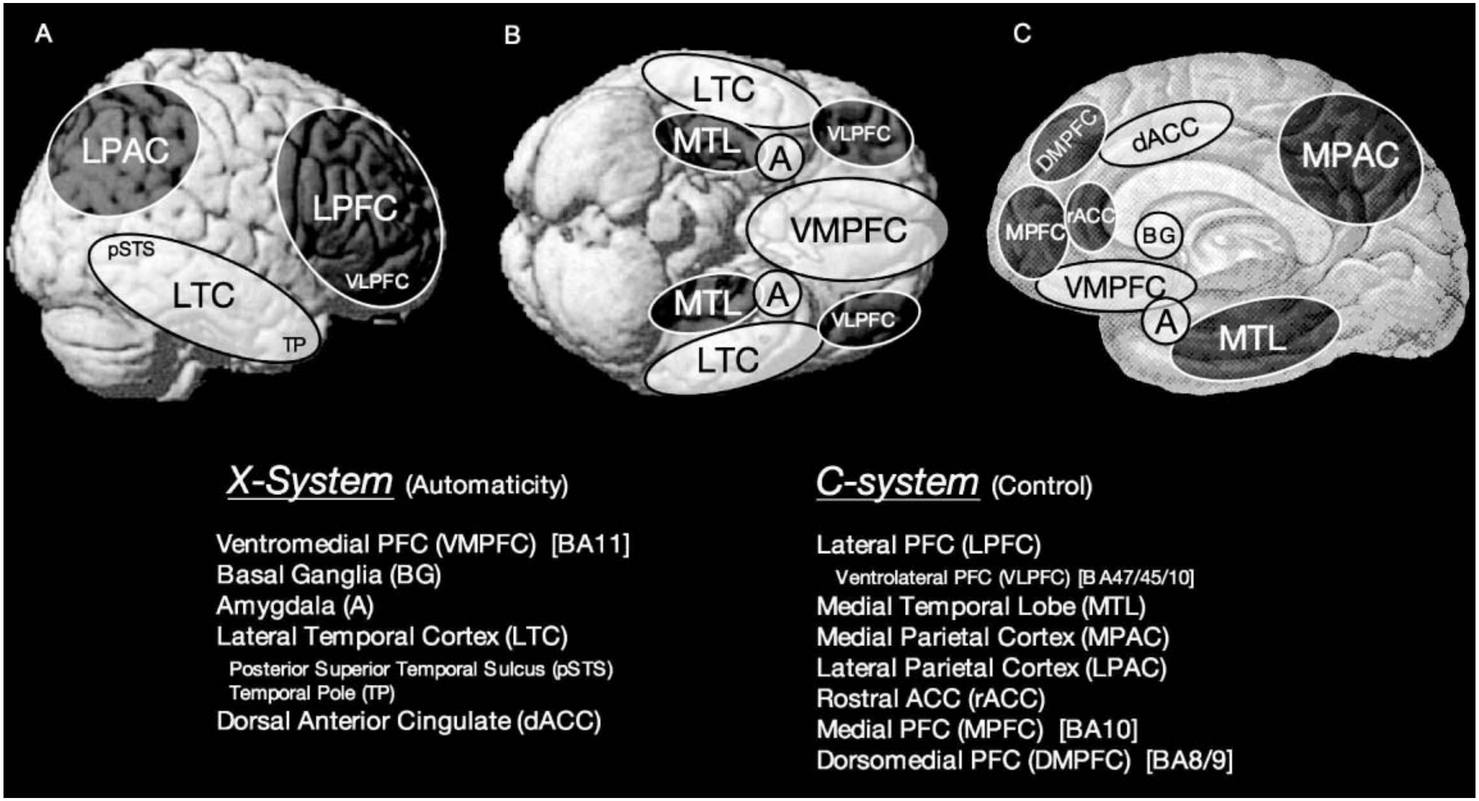

Figure 1

Hypothesized neural correlates of the C-system supporting reflective social cognition (analogous to controlled processing) and the X-system supporting reflexive social cognition (analogous to automatic processing) displayed on a canonical brain rendering from (*A*) lateral, (*B*) ventral, and (*C*) medial views. Note: the basal ganglia and amygdala are subcortical structures that are displayed here on the cortical surface for ease of presentation.

UNDERSTANDING OTHERS

Although social cognition has come to encompass a broad range of mental processes, in the strictest sense, social cognition is about understanding other people. In some ways, other people are like objects that have various physical characteristics, but unlike objects, other people have minds and experiences that are not directly open to inspection. There are at least two ways to try to understand the experience and the mind of another. One of these ways is addressed by work on "theory of mind" (Perner & Wimmer 1985). Theory of mind research examines the ability to propositionally reason from one's theory of how minds operate and how social situations affect mental states in general, in order to represent the mental state of a particular individual given a particular situation. Thus, our knowledge of social rules and norms mediates these insights (Gilbert & Malone 1995). However, there are also times when our insight feels unmediated, when it feels like we are seeing the world directly through another person's eyes and feeling the world through their visceral reactions. In this case, we feel like we have an insider's perspective on what it is like to be that person. The following sections review the neural bases of these two ways of knowing others.

Representing the Minds of Others

Representing psychological states of others. The ability to represent the contents of another's mind consists of two components: (*a*) the recognition that, unlike other objects in the world, people have minds with thoughts and feelings, and (*b*) the development of a theory regarding how other people's minds operate and respond to events in their environment. Research on theory of mind (Perner & Wimmer 1985) has found that by age four nearly all children develop the ability to assess the mental states of others. This process may build upon the capacity to recognize biological motion and goal-directed action that emerges by around six months of age (Woodward 1998). From childhood through adulthood, increasingly complex and domain-specific theories form (Reeder 1993), although this increasing sophistication does not always yield greater accuracy (Gilbert & Malone 1995).

Neuroimaging studies of theory of mind have typically shown activations in DMPFC (BA 8/9), posterior superior temporal sulcus (pSTS) in LTC, and the temporal poles in LTC (for review, see Frith & Frith 2003). Research suggests that pSTS is particularly sensitive to biological motion (Allison et al. 2000) and that the temporal poles may be associated with perception of familiar individuals (Sugiura et al. 2001). Frith & Frith (2003) suggest that unlike LTC, which is sensitive to external visual cues, DMPFC is specifically associated with mentalizing, which is overt thought about the internal mental states of others. Additionally, Saxe et al. (2004) have suggested that the temporoparietal junction in LPAC is distinct from nearby pSTS and is also involved in theory of mind processes. Finally, both neuroimaging and neuropsychological investigations have suggested that right ventrolateral prefrontal cortex (VLPFC), a subregion within LPFC, helps to inhibit one's own experience during the consideration of another's state of mind (Samson et al. 2005, Vogeley et al. 2001). These findings are consistent with developmental research indicating that theory of mind development is linked to advances in general inhibitory control (Carlson & Moses 2001). It is plausible that a failure of this process in adults may play a central role in naïve realism (Griffin & Ross 1991, Pronin et al. 2004), whereby individuals assume that others see the world the same way that they do and have difficulty acknowledging alternative viewpoints (see Lieberman 2005).

Given the early development of sensitivity to biological motion and the fact that adults perceive biological motion without effort, one would expect this to be a relatively automatic process. Alternatively, explicit propositional thought about the content of another's mind would seem to fall squarely within the domain of controlled processes. One study using functional magnetic resonance imaging (fMRI) confirms these intuitions, as cognitive load was found to diminish DMPFC responses, but not pSTS or temporal pole responses, during a mentalizing task (den Ouden et al. 2005). Another study suggests that DMPFC is active during covert mentalizing processes (German et al. 2004); however, the covert condition in this study appears to require more overt mentalizing than does the control condition.

It is also interesting to note that the only medial activation (DMPFC) associated with theory of mind processes is associated with the internally-focused process of considering the contents of another person's mind. Sensitivity to biological motion and person familiarity in lateral regions (pSTS and temporal poles, respectively) are both externally-focused processes that do not require consideration of a target's internal states.

Representing psychological traits of others. Beyond knowing how the typical person would respond psychologically to particular events, individuals are also interested in identifying the enduring psychological traits of others. Individuals use their theories of how people with different kinds of dispositions behave in order to infer targets' dispositions from their behavior (Gilbert 1989). A recent fMRI study of dispositional attribution (Harris et al. 2005) found that when individuals read behavioral descriptions diagnostic for drawing dispositional inferences about a target (Kelley 1967), both DMPFC and pSTS were more active.

Another study (Mitchell et al. 2004) found that trait-relevant action descriptions (e.g., "he refused to loan his extra blanket to the other campers") shown with a target face led to DMPFC activity only when subjects had an explicit goal to form an impression of the target. This is the first study to hold constant the relevance of stimulus information for understanding the mental states or traits of another and instead manipulate whether or not the subject has the goal of understanding another mind.

Given that controlled processes that support trait attribution should only occur when the intention to make sense of another person is present, the study by Mitchell et al. (2004) suggests that DMPFC contributes to controlled processing aspects of trait attribution. Alternatively, pSTS was active in response to the action descriptions regardless of the subject's encoding goal (J.P. Mitchell, personal communication), a finding that suggests that this response reflects automatic social cognition. A similar dissociation has also been observed between DMPFC and the temporal poles (Mason et al. 2004; M.F. Mason, personal communication). Both of these results are consistent with the previously described study by den Ouden et al. (2005) that examined the automatic and controlled components of theory of mind processes. Additionally, these findings are consistent with the internal/external distinction observed in theory of mind research, as DMPFC was associated with encoding the psychological traits of a target (internal), whereas pSTS and the temporal poles were activated in response to descriptions of observable behavior (external).

Experiencing the Mental States of Others

Empathy. This second way of knowing others is far more embodied than logical (Merleau-Ponty 1962) and is more appropriately referred to as empathy than as theory of mind. Empathy has been associated with increased helping and social support (Batson 1991); however, this consequence of empathy requires the individual to maintain an awareness that the emotional response is an embodied simulation of another person's experience, not to be confused with one's own experience. Thus, the two criteria for empathic responses are (*a*) an emotional and experiential response that approximates that of the target and (*b*) an awareness and identification of this emotion as referring to the target's experience.

A number of studies have now addressed the first of these criteria. Wicker et al. (2003) found that two regions associated with affective processing, the anterior insula and dACC, were activated both when individuals smelled disgusting odors themselves and when they watched videoclips of others smelling these odors. Similarly, a number of studies have observed activation in these two regions when individuals either felt physical pain or observed another feeling physical pain (Botvinick et al. 2005, Jackson et al. 2005, Morrison et al. 2004, Singer et al. 2004), and the strength of these responses correlated with self-reported trait empathy (Singer et al. 2004). Alternatively, Farrow et al. (2001) observed greater activity in VMPFC, MPFC, DMPFC, and MPAC when individuals were asked to make empathic judgments relative to other forms of social reasoning. Similarly, Botvinick et al. (2005) found greater VMPFC activity when observing another's pain but not when feeling pain oneself, which suggests that this region might contribute to the additional processes invoked by empathy over direct feeling. Finally, in two neuropsychological investigations of patients with different cortical lesions (Shamay-Tsoory et al. 2003, 2005), VMPFC damage was found to be the strongest predictor of empathic deficits.

Interestingly, unlike theory of mind processes that logically proceed from externally-focused processing of situational information and observed behaviors to internally-focused processing of another's mental state, empathy is focused primarily on the experience of another and is thus internally-focused. Consistent with this distinction, the empathy research reviewed here has typically found medial, rather than lateral, activations. It is also worth noting that in comparison with representing other minds, the sense of experiencing other minds appears to recruit brain regions more closely tied with automatic affective processes, including the dACC and VMPFC.

Issues for empathy research. One open issue for empathy research is whether the pain distress felt while watching another's pain is personal distress or empathic distress. In Batson's (1991) examination of empathy as it relates to altruism, he cites Adam Smith, who wrote about the distinction clearly: "In order to enter into your grief, I do not consider what I, a person of such a character and profession, should suffer if I had a son and if that son was unfortunately to die . . . . I not only change circumstances with you, but I change persons and characters" (1853/1759, p. VII).

In each of the neuroimaging studies of empathy, it is unclear whether subjects are imagining their own experience of pain or truly empathizing (for the study that is most successful at addressing this, see Singer et al. 2006). In the same way that false-belief paradigms were critical in establishing theory of mind because accuracy required children to indicate that a target person had different beliefs from their own, here the study of empathy would seem to require situations in which the subject and the target have different experiential responses. For instance, empathy while watching a masochist receive painful stimulation might be expected to activate reward rather than pain regions.

UNDERSTANDING ONESELF

Given that the self feels hermetically sealed off from others, containing private thoughts and feelings, one might wonder why the self is so heavily researched by social psychologists whose main focus is on social interactions and situational pressures. The playwright Oscar Wilde captured the social psychologist's answer when he wrote, "Most people are other people. Their thoughts are someone else's opinions, their lives a mimicry, their passions a quotation" (Wilde 1905). Social psychologists from Wilde's era (Cooley 1902, Mead 1934) predicated their theories of the self on the notion that the self is formed through social feedback from other people. They believed that what people experience as introspective self-talk is actually a conversation with a simulated other who is an internalized amalgam of our early social learning that comes to serve as a guide for appropriate social behavior. Thus, research on the self is integral to social psychology (Baumeister 1998) and now to social cognitive neuroscience. Here and in the next section, the four topics that have dominated social cognitive neuroscience research on the self (self-recognition, self-reflection, self-knowledge, and self-control) are reviewed.

Recognizing Oneself

Visual self-recognition. The ability for infants to visually recognize themselves in a mirror comes online in the second year of life, with most infants achieving this skill by 21 months of age (Lewis & Ramsay 2004). This contrasts with the ability to recognize one's mother in a mirror by nine months of age (Dixon 1957), suggesting that either more time is needed for the neural machinery supporting self-recognition to mature or more socialization is needed in which parents can teach infants to identify themselves as a self.

Perhaps because self-recognition is one of the few self-processes that can be examined in preverbal humans and animals it has received a great amount of attention. In what is perhaps the first social cognitive neuroscience experiment, self-recognition processes examined in a split-brain patient (Sperry et al. 1979) suggested that each hemisphere of the human brain was independently capable of recognizing the self. One study has replicated this finding (Uddin et al. 2005b), whereas the data in two others have each favored one hemisphere or the other (Keenan et al. 2003, Turk et al. 2002). Other research using different techniques to isolate the processing of each hemisphere has also yielded mixed results (Brady et al. 2004, Keenan et al. 2001).

A half-dozen fMRI studies clarify the neural basis of self-recognition to some extent. Although there is also variability in the fMRI studies examining self-recognition, most have observed greater right LPFC and LPAC activity (Platek et al. 2006; Sugiura 2000, 2005; Uddin et al. 2005a) when individuals identify pictures as themselves compared with when they identify pictures of familiar others. Given the symbolic nature of the self, it is not surprising that the regions involved in self-recognition have been linked with controlled processing.

Agency. In addition to visual recognition of one's face, there is also the recognition of one's body parts and movements as one's own, a process that involves the combined inputs from the visual system and internal proprioception from the muscles. Neuroimaging (Farrer et al. 2003, Farrer & Frith 2002, Leube et al. 2003, Shimada et al. 2005), transcranial magnetic stimulation (MacDonald & Paus 2003), and neuropsychological studies (Sirigu et al. 1999) all suggest that LPAC regions bilaterally, but particularly on the right side, are involved in detecting mismatches between visual and proprioceptive feedback. In these studies, video displays of the subject's own hand movements are shown to the subject either in real time or at short delays such that the visual feedback and proprioceptive feedback are asynchronous. Results indicate that greater LPAC activity is present during mismatches than during matches. In related work, schizophrenics experiencing passivity, a state characterized by a feeling of not owning one's own actions, showed greater activation of right LPAC (Franck et al. 2002, Ganesan et al. 2005, Spence et al. 1997). Similarly, Blanke and colleagues have shown, with a variety of methods, that out-of-body experiences are also associated with right LPAC activity (Blanke et al. 2002). One caveat to these findings is that the LPAC is typically activated when the external visual representation of one's body conflicts with one's internal experience of oneself. Thus, it may be more appropriate to suggest that an absence of LPAC activation is associated with the feeling that one's actions are one's own.

Reflecting on the Self

Reflecting on one's current experience. Although other animals presumably have experiences, humans may be the only living creatures who can reflect upon and explicitly represent the character of those experiences. Having explicit insight into the situations that make one feel good or bad allows an individual to much more efficiently seek out or avoid similar situations in the future. This insight also allows individuals to communicate their preferences and dislikes to others.

Reflecting on one's current experience leads to remarkably consistent activation of MPFC (BA10) across a variety of different tasks. BA10 is the only region of prefrontal cortex that has thus far been found to be disproportionally larger in humans than in other primates (Semendeferi et al. 2001). The studies that most directly isolate the act of self-reflection have examined neural responses occurring when participants indicate their current emotional response to a picture (e.g., "How pleasant do you feel in response to this picture?") compared with when making a non-self-relevant judgment (e.g., "Is the picture of an indoor or outdoor scene?"). In each of these studies (Gusnard et al. 2001, Johnson et al. 2005, Lane et al. 1997, Ochsner et al. 2004), MPFC was more active during self-reflection than during the control task. Two of these studies (Johnson & Schmitz 2005, Ochsner et al. 2004) found additional activation in MPAC. Similarly, Eisenberger et al. (2005) found that greater dispositional self-consciousness was associated with greater MPFC and MPAC activation during a conflict detection task.

Given that cognitive tasks tend to decrease the activity in MPFC (McKiernan et al. 2003), it is possible that results of self-reflection studies are being driven by MPFC changes associated with the control condition rather than by self-reflection per se. However, a neuropsychological study by Beer et al. (2003), which is not susceptible to this alternate explanation, suggests that this is not the case. In their study, patients with extensive damage to MPFC, as well as VMPFC, experienced less self-conscious emotion after engaging in inappropriate behavior compared with controls, suggesting that MPFC is associated with initiating or carrying out self-reflective processes. Surprisingly, patients with MPFC lesions are capable of self-conscious emotions if shown their embarrassing behavior on a video recording (Beer et al. 2006), a process that may rely on externally-focused visual self-recognition mechanisms rather than internally-focused self-reflection. Taylor et al. (2003) also observed increases in MPFC activity, relative to a resting baseline, when participants rated their own emotional reaction to emotional stimuli, also suggesting that the MPFC findings in other studies are not artifacts of the control conditions.

Interestingly, Taylor et al. (2003) found that self-reflection on emotional stimuli was also associated with reduced activity in the amygdala, a region implicated in automatic affective processes (Pasley et al. 2004). Although it seems paradoxical that self-reflection on one's feelings could lead to a reduction in those feelings, this result is consistent with other behavioral research (Silvia 2002, Wilson et al. 2005, Wilson & Schooler 1991) and highlights the fact that feelings themselves and thoughts about feelings are not necessarily isomorphic (Lieberman 2006).

Given that self-reflection feels effortful and resource consuming, it is not surprising that this process relies on neural structures that have undergone recent evolutionary development (Semendeferi et al. 2001) and whose activity is interrupted by cognitive load manipulations (Greicius et al. 2003, McKiernan et al. 2003). Perhaps somewhat more surprising is that the neural correlates of self-reflection are quite distinct from those involved in self-recognition and agency judgments. Self-reflection, an internally-focused process, is strongly associated with activity in a medial frontoparietal network, whereas self-recognition and agency judgments invoke externally-focused processes and are strongly associated with activity in a lateral frontoparietal network. Such a dramatic dissociation between self-reflection and self-recognition processes is not easily accounted for in existing social psychological theories.

Reflecting on past experiences. In addition to being able to reflect upon our current experience, we are also capable of reflecting on our autobiographical past, the events of personal importance that have made up our lives. People do not recall all events from their past equally well. Remembering one's wedding is presumably easier than remembering what one had for breakfast August 21, 2001. Our autobiographical memory tends to be filled with events of personal significance, rather than a linear record of events over time (Lieberman & Eisenberger 2005). Thus, although autobiographical memory and episodic memory bear more than a passing resemblance, their neural correlates are only partially overlapping.

Gilboa (2004) reviewed the prefrontal activations in 14 neuroimaging studies that contained both autobiographical and episodic memory conditions. Gilboa reported that although VLPFC activations are common to retrieving both forms of memory, MPFC (BA10) and VMPFC (BA11) are present only in autobiographical memory retrieval, whereas right DLPFC is present primarily in episodic memory retrieval. The medial activations associated with autobiographical memories may result from these memories being linked to one's internal sense of self and the feelings one had during the events. Multiple studies have also observed MTL activity during both kinds of memory retrieval, but more so during autobiographical retrieval than episodic retrieval (Cabeza et al. 2004, Gilboa et al. 2004).

Reflecting on one's self-concept. Within the study of self-focused processing, reflection upon one's own self-concept in trait terms (e.g., "kind," "smart") has received a great deal of attention (for review, see Lieberman & Pfeifer 2005). Several studies have examined the neural activity involved in determining whether trait words and sentences are self-descriptive. Most of these studies have included a nonsocial control task, such as determining the number of vowels in the trait words (Johnson et al. 2002). The studies often included a social control task, such as determining whether the trait term describes a close friend (Ochsner et al. 2005, Schmitz et al. 2004), casual acquaintance (Seger et al. 2004), famous politician (Craik et al. 1999, Kelley et al. 2002, Kjaer et al. 2002), or whether the trait is socially desirable (Fossati et al. 2003). Virtually all of these studies report greater MPFC during the self-judgments task than during the nonsocial control task, and several also report greater MPFC during self-judgments than during other social judgments (Craik et al. 1999, Fossati et al. 2003, Kelley et al. 2002, Schmitz et al. 2004). Additionally, a number of these studies also report greater activity in MPAC during self-judgments (Fossati et al. 2003, Johnson et al. 2002, Kelley et al. 2002, Seger et al. 2004). In two other studies, individuals were prompted to think about their own personality characteristics over a period of minutes; greater MPFC and MPAC were observed in this condition than when participants thought about someone else's personality characteristics (D'Argembeau et al. 2005, Kjaer et al. 2002). In addition, in two studies (Fossati et al. 2004, Macrae et al. 2004) that examined the effects of self-referential encoding on memory, it was observed that greater MPFC activity during self-referential encoding is associated with better memory performance for this information (for an analogous study linking DMPFC with memory for social information, see Mitchell et al. 2004). These studies are remarkably consistent in identifying activity in a medial frontoparietal network when individuals reflect on their own psychological make-up, an internally-focused process.

These studies, however, have not disentangled the act of self-reflection (i.e., effortfully trying to think about oneself) from self-knowledge activation (i.e., the knowledge that is reflected upon and retrieved). Although the act of self-reflection is a canonical form of controlled processing, self-knowledge consists of both automatically accessible and effortfully retrieved representations (Klein et al. 1992, 1996; Markus 1977). Lieberman et al. (2004) examined the neural responses of individuals who possessed strong self-schemas (i.e., automatically accessible self-knowledge) for either acting or athletics while they judged the trait descriptiveness of trait words related to acting or athletics. Retrieval of nonschematic self-knowledge was relatively slow and was associated with activity in DMPFC and MTL, whereas automatically accessible schematic self-knowledge was associated with activity in VMPFC, amygdala, ventral striatum in the basal ganglia, LTC, and MPAC. The absence of MPFC in this comparison suggests that the primary role of MPFC is in self-reflection rather than self-knowledge representation (see also J.H. Pfeifer, M.D. Lieberman, & M. Dapretto, under review).

SELF-REGULATION

The capacity for self-regulation is critical to the achievement of both personal and social goals. Self-regulatory skills allow us to act in accordance with long-term goals (e.g., getting a promotion) rather than being slaves to our emotional impulses (e.g., wanting to yell at one's boss). Indeed, individual differences in the ability to delay gratification as a child are highly predictive of achievement decades later (Metcalfe & Mischel 1999). Self-regulation has received a great deal of attention within the social cognitive neuroscience and broader cognitive neuroscience literature. Although the neural regions associated with self-regulation are quite similar across the different forms of self-regulation, there is also a major conceptual distinction between those forms of self-regulation in which the individual has the intention to regulate a response and other forms of self-regulation in which the regulatory effects occur, but only as an unintended by-product of other processes.

Intentional Self-Regulation

Impulse control. A number of neuroimaging studies have examined the process whereby individuals intentionally override a prepotent response or impulse. The two brain regions that have consistently been associated with this process are dACC and LPFC (MacDonald et al. 2000). A number of studies have implicated the dACC in detecting the conflict between a current goal and the prepotent response rather than in the process of exerting top-down control to facilitate the appropriate response or inhibit the inappropriate response (Botvinick et al. 2004). Alternatively, LPFC has been more closely tied to maintaining the current goal in working memory and to implementing the top-down control needed to produce appropriate responses (Aron et al. 2004). Similar LPFC activations are present when individuals must inhibit beliefs in order to reason correctly (Goel & Dolan 2003).

Reappraising emotional events. Recent studies have built on the impulse control findings by examining self-control of emotional responses and emotional experience (Ochsner & Gross 2005). These studies have examined reappraisal as a strategy for emotional self-control. Reappraisal typically involves reframing a negative emotional event such that the new understanding renders the event less aversive. Reappraisal efforts commonly activate regions of LPFC, most often VLPFC, regardless of whether the reappraisal focuses on trying to reduce the emotional significance of highly aversive images (Ochsner et al. 2002, 2004; Phan et al. 2005), physical pain anticipation (Kalisch et al. 2005), sad films (Levesque et al. 2003), or erotic films (Beauregard et al. 2001). This manipulation also tends to produce decreased activity in the amygdala, with some studies also showing decreased activity in either temporal pole or VMPFC. In one study, Ochsner et al. (2004) manipulated whether individuals reappraised in order to feel more or less negative affect and manipulated whether individuals reappraised in ways that focused on changes in the target's physical situation or in ways that focused on the subject's personal relationship to the target. Reappraising to increase negative affect was associated with activity in DMPFC, MPFC, and posterior cingulate near MPAC, whereas reappraising to decrease negative affect was associated with right lateral orbitofrontal cortex in the vicinity of VLPFC. One can imagine that instructions to increase their negative emotional responses may have led participants to spontaneously engage in internally-focused empathy for the target (resulting in more medial activity), whereas instructions to decrease negative affect may have led participants to engage in externally-focused detachment from the target (resulting in more lateral activity). Similarly, reappraisals focused on one's personal relation to the target activated rACC, whereas situation-focused reappraisal activated left LPFC. Here again, the split between medial and lateral prefrontal activations maps onto internally- versus externally-focused processes, respectively.

Unintentional Self-Regulation

Putting feelings into words. It has long been known that putting feelings into words is an effective strategy for regulating negative emotional responses. Although expressing these feelings is known to have benefits for both mental and physical health (Hemenover 2003, Pennebaker 1997), the benefits seem to occur whether one is intentionally trying to regulate one's emotions or not, and even occur if one writes about an imaginary trauma rather an actual one (Greenberg et al. 1996). A number of neuroimaging studies have shown that merely labeling emotionally evocative visual images with emotional labels (i.e., affect labeling) leads to a reduction in the amygdala activity that would otherwise occur in the presence of these images (Hariri et al. 2000, Lieberman et al. 2006). These studies also show increased activity in right VLPFC during affect labeling and an inverse relationship between this prefrontal activity and the activity in the amygdala. Thus, the pattern of activity is very similar to the pattern observed during reappraisal processes, suggesting that self-regulation is occurring despite the absence of any intention to self-regulate.

Placebo effects. Expectancy-based placebo effects typically involve a consciously held belief about the effectiveness of a treatment or medication that leads to a reduction in aversive symptoms. Although only a handful of neuroimaging studies have examined placebo effects, the results have been remarkably consistent. Investigations of placebo effects on momentary pain stimulation (Kong et al. 2006, Petrovic et al. 2002, Wager et al. 2004), chronic pain (Lieberman et al. 2004), and the distress associated with aversive images (Petrovic et al. 2005) have almost all observed greater activity in right VLPFC and rACC during placebo compared with control conditions. Placebo effects were also associated with reductions in subjective distress, dACC activity, or amygdala activity, with rACC and LPFC activations predicting the magnitude of these reductions. Interestingly, both rACC and right VLPFC overlap with the opioid network evoked during opioid analgesia (Petrovic et al. 2002). As with putting feelings into words, placebo effects invoke a network similar to that observed during reappraisal, a finding that suggests common processes are at work despite different phenomenologies accompanying reappraisal, placebo, and putting feelings into words.

BEING IN A SOCIAL WORLD

A great deal of our waking lives is spent navigating the social world with others, and many of the processes already reviewed presumably evolved, in part, to facilitate social living (Dunbar 1998). The topics reviewed in this section all link the self and social world together within a single mental act. We coordinate our activity with those around us, use feedback from others to understand ourselves, make sense of others based on our self-theories, and develop personal attitudes about social groups. We also care deeply about being connected to loved ones, not being rejected, and being treated in a fair and trustworthy manner in our interactions with strangers. Together, these processes contribute to a coherent social world in which individuals continuously make adjustments to conform to the norms of other individuals and society more generally.

Mirror Neurons and Imitation

In the early 1990s, di Pellegrino and colleagues discovered a class of neurons in primates that were activated both when primates performed a goal-directed action (e.g., grasping an object) and when they observed the experimenter perform the same action (e.g., grasp the same object). Dubbed mirror neurons, the presence of these neurons suggests that the same motor action representations are activated when performing and observing goal-directed actions (di Pellegrino et al. 1992). This is analogous to Kosslyn's earlier finding that visual perception and visual imagery both rely on the same visual code in visual cortex (for review, see Kosslyn et al. 2001). In humans, activation in regions homologous to those found in primates has also been reported both when participants observe intentional action and when they imitate intentional action (Iacoboni et al. 1999). In particular, regions of LPFC (pars opercularis in BA44) and LPAC have been found to follow this pattern.

It has been widely speculated that mirror neurons represent a basis for understanding the behavior, intentions, and experience of others, but this has not yet been demonstrated empirically. One can imitate without understanding, and to date, no mirror neuron study has assessed whether activity in the mirror neuron system is associated with the experience of understanding the perspective or experience of another. Based on the earlier section that focused on understanding others, one would expect that if imitation promoted or served as a form of embodied understanding of another's mental states, it would lead to increased activity in the medial frontoparietal network. Instead, imitation is associated with a lateral frontoparietal network consistent with externally-focused understanding of physical action but not with internally-focused processes such as mental state representation or empathy. Indeed, research examining the imitation of emotional facial expressions observed less activity in DMPFC during imitation than observation (Carr et al. 2003), a finding that suggests that imitation may demand externally-focused attention to the actions as actions, rather than as indicators of another's internal states.

It is possible, however, that mirror neurons play an important role in nonverbal communication (i.e., gestures, facial expressions, and posture; see DePaulo 1992). There is evidence for a complex reciprocal nonverbal "dance" that occurs between interaction partners (Word et al. 1974) that can provide the basis for our judgments about an interaction (Chartrand & Bargh 1999). The difficulty in making this link is that whereas a great deal of nonverbal communication occurs without conscious effort (Ambady et al. 2000, Lieberman 2000), the human imaging research on mirror neurons has examined explicit intentions to observe and imitate a single behavior that is presented focally. The connection between mirror neuron work and nonverbal communication could be strengthened if the mirror neuron system were found to be similarly activated by behaviors that are embedded in a larger scene unfolding over time, while participants are not attending to the behavior focally or under cognitive load.

Interactions of Self and Social Understanding

Reflected appraisals (i.e., "what I think you think of me") are thought to be a critical source of self-knowledge throughout development (Cooley 1902, Mead 1934). A single neuroimaging study has examined the neural bases of reflected appraisals. Ochsner et al. (2005) observed that reflected appraisal processes were associated with greater activity in the orbital extension of right VLPFC, MTL, and MPAC, compared with direct appraisals of the self. This pattern of activation is consistent with the notion that overt generation of reflected appraisals is an effortful controlled process.

In contrast to reflected appraisals, which involve consulting one's theory of another person's mind in order to understand oneself, under some conditions, individuals may consult their theories of themselves in order to understand other individuals. The existing evidence suggests that this occurs when the target is a close associate of or is seen as similar to the participant. When individuals judge the psychological traits and states of their mother (Ruby & Decety 2004), close friend (Ochsner et al. 2005), or someone rated as similar to themselves (Mitchell et al. 2005), significant activations are produced in MPFC, the region most typically found in self-reflective processes. Mitchell et al. (2005) also reported an interaction between DMPFC and MPFC activity as a function of similarity between the participant and target, such that DMPFC activity decreased and MPFC activity increased with increasing similarity. This suggests that similarity is promoting understanding the minds of others in terms of one's theory of oneself.

Attitudes and Prejudice

Implicit and explicit attitudes. Attitudes serve a critical function in our social lives as they support and define our social identities. When we share our attitudes with others, we are providing a roadmap to our behavioral proclivities and a promissory note regarding our reactions to different attitude-relevant situations. Neuroimaging work on attitudes has primarily focused on identifying the neural correlates of implicit and explicit attitudes. When individuals express explicit attitudes toward concepts (Cunningham et al. 2004b, Zysset et al. 2002), famous names (Cunningham et al. 2003), geometrical shapes (Jacobson et al. 2006), or paintings (Vartanian & Goel 2004), activation tends to increase in both medial and lateral frontoparietal networks, compared with when nonevaluative judgments are made about the same stimuli. This network includes MPFC, MPAC, VLPFC, and LPAC. These regions have all been associated with controlled processes and are consistent with the notion that the expression of explicit attitudes depends on controlled processing. Additionally, an event-related potential study (Cunningham et al. 2005; see also Cela-Conde et al. 2004) observed that the LPFC activations associated with explicit attitudes appear at least 400 ms after the presentation of the attitude object, also implicating LPFC in controlled processing of attitudes (Neely 1977).

Other studies have identified brain regions associated with implicit attitudes. In these studies, negative- and positive-attitude objects, such as African American and Caucasian American faces, are shown to individuals as they perform a nonevaluative task (e.g., gender judgments). Typically, the amygdala has been found to be more active to negative-attitude objects than to positive-attitude objects (Cunningham et al. 2003, Hart et al. 2000, Wheeler & Fiske 2005; for review of race-related neuroimaging, see Eberhardt 2005; for race-related electroencephalogram research, see Ito et al. 2006). Phelps et al. (2000) observed that the amygdala response of Caucasian Americans to African American faces was correlated with an implicit measure of racial attitudes but not with an explicit attitude measure (cf. Phelps et al. 2003). Lieberman et al. (2005) found that African American subjects also showed greater amygdala activity to African American faces than to Caucasian American faces, consistent with past findings that African Americans have negative implicit attitudes toward African

Americans, in contrast to their positive explicit attitudes toward African Americans (Nosek et al. 2002). Cunningham et al. (2004b) found that the amygdala response to African American faces was stronger when target faces were presented subliminally rather than supraliminally and that the amygdala was the only brain region that showed this pattern of activity. Apart from the amygdala, the only other brain region that has been associated with implicit attitudes is VMPFC. Milne & Grafman (2001) conducted a study of patients with VMPFC damage and observed no implicit gender bias. Similarly, Knutson et al. (2006) found VMPFC activity associated with the automatic activation of political attitudes. These results are consistent with findings from McClure et al. (2004) demonstrating that VMPFC activity was associated with behavioral preferences between Coke and Pepsi when individuals were unaware of the brand they were drinking. Alternatively, when individuals were informed of the brand they were drinking, behavioral preferences were associated with activity in controlled processing regions, DLPFC and MTL.

Regulating prejudicial responses. A number of neuroimaging studies have combined the study of intentional self-regulation with the study of race-related attitudes in order to understand the mechanisms by which people control their prejudicial responses. As with self-control more generally, it appears that the dACC may be involved in detecting that an undesirable attitude is prepotent and about to be revealed (Amodio et al. 2004), whereas LPFC regions tend to be implicated in exerting control and diminishing the activity of the amygdala. Multiple studies have shown that a desire to regulate the expression of a particular attitude is associated with greater activity of right LPFC in the presence of the attitude object (Cunningham et al. 2004a,b; Richeson et al. 2003). Additionally, the magnitude of right LPFC under conditions promoting prejudice regulation is associated with the extent to which amygdala responses are diminished (Cunningham et al. 2004a).

Unintentional self-regulation of prejudicial attitudes has also been demonstrated in fMRI studies. Simply categorizing African American targets in terms of their personal food preferences rather than their group membership was sufficient to reverse the amygdala's response to African American and Caucasian American targets (Wheeler & Fiske 2005). In another study, similar to the affect-labeling studies described above, processing the race of targets verbally rather than perceptually was sufficient to eliminate the amygdala's sensitivity to race, and this reduction was related to increases in right VLPFC activity (Lieberman et al. 2005).

Attitude change. Cognitive dissonance research has established that when individuals perform a behavior or make a choice that conflicts with a previously established attitude, the attitude tends to change in the direction that resolves the conflict with the behavior. From the outside, this process appears to involve rationalization, whereby individuals strategically change their attitudes in order to avoid appearing inconsistent. However, neuropsychological work by Lieberman et al. (2001) demonstrated that this might not always be a conscious strategic process. In one study, anterograde amnesia patients, who had neurological damage affecting the functioning of MTL and were incapable of forming new memories, were compared with healthy controls on a dissonance task. The amnesics had no memory of having performed a behavior that conflicted with their previously established attitudes and thus were not likely to have engaged in conscious strategic attitude change. Nonetheless, the amnesics changed their attitudes to the same extent as controls. These results suggest that, rather than conscious rationalization, cognitive dissonance reduction may sometimes depend on implicit constraint satisfaction processes (Read et al. 1997).

Social Connection and Social Rejection

Social connection. The need for social connection and acceptance are powerful motivators (Baumeister & Leary 1995) that guide human interactions with peers, romantic partners, and family. Although behavioral work in social psychology has emphasized the power of unfamiliar individuals to influence our own behavior (Asch 1956, Sherif 1937), few neuroimaging studies have examined this form of social pressure (Amodio et al. 2006, Berns et al. 2005). Instead, neuroimaging studies have focused primarily on neural responses associated with responses to close others. In these studies, individuals are shown pictures of either their romantic partner or their own infant along with relevant control images. Most often, when individuals see someone they love, they show greater activity in the basal ganglia (Aron et al. 2005; Bartels & Zeki 2000, 2004; Leibenluft et al. 2004; cf. Nitschke et al. 2004). Two of these studies also found a broad network of theory of mind areas to be less active during the presentation of a loved one than a control (Bartels & Zeki 2000, 2004); however, another study found the opposite pattern of activity (Leibenluft et al. 2004). These differences may be attributed to the fact that in the studies showing a decrease in these regions, the images were presented for ∼15 seconds, whereas in the study showing an increase in these regions, the images were presented for 1.5 seconds. Thus, there may be differences in the immediate and long-term responses to the presentation of images of loved ones.

Social rejection. Mammals, unlike their reptilian ancestors, form long-term parental bonds with their young. Separation from caregivers typically results in death for young mammals. dACC activity has been associated with the distress of losing social connections. Primates with lesions to this region display a reduced frequency of distress vocalizations (MacLean & Newman 1988), whereas stimulation of this region spontaneously induces distress vocalizations (Robinson 1967, Smith 1945). Additionally, cingulate-lesioned female rodents do not provide effective maternal care, resulting in a 12% survival rate for their offspring compared with 95% for offspring from sham-lesioned rodents (Stamm 1955).

In humans, neuroimaging studies of social exclusion (Eisenberger 2006, Eisenberger et al. 2003) have found that self-reports of social distress are strongly related to dACC activity during exclusion, whereas right VLPFC was associated with downregulating both dACC activity and self-reported social distress. Attachment anxiety is also related to dACC activity when thinking about negative relationship scenarios (Gillath et al. 2005). In related work, the sound of infant cries activated dACC (Lorberbaum et al. 2002) and did so more for parents than nonparents (Seifritz et al. 2003). Finally, a recent study of grief found that activity in dACC, along with a number of theory of mind regions, was greater when bereaved individuals looked at pictures of the recently deceased individual compared with control images (Gundel et al. 2003; cf. Najib et al. 2004).

It has been hypothesized that mammalian social pain may have evolved out of the existing system for physical pain (Eisenberger & Lieberman 2004, MacDonald & Leary 2005, Panksepp 1998), with dACC playing a key role in the emotional distress of physical pain (Rainville et al. 1997). Evidence comes for this, in part, from laboratory findings that feeling socially rejected heightens sensitivity to physical pain (Eisenberger et al. 2006a), whereas social support reduces sensitivity to physical pain (Brown et al. 2003).

Heightened activity in the dACC, amygdala, and periaqueductal gray (another component of the pain matrix; Peyron et al. 2000) during a social rejection episode in the fMRI scanner has also been linked to greater reports of social disconnection in day-to-day life using an experience-sampling methodology (Eisenberger 2006). Finally, dACC reactivity during social rejection has been found to mediate the relationship between a polymorphism in the monoamine oxidase A gene and aggression in males (Eisenberger et al. 2006b), such that this gene may render individuals more sensitive to social threats and lead to greater defensive aggression as a result (Twenge et al. 2001).

Social Decision-Making

Social and moral reasoning. Behavioral research has shown that performance on conditional reasoning tasks is substantially improved if the conditional rules are formulated from real social norms rather than from abstract content (Cheng & Holyoak 1985). Neuroimaging studies investigating domain-specific reasoning effects have found a lateral frontoparietal network that is more active during conditional social reasoning than during conditional abstract reasoning (Canessa et al. 2005, Fiddick et al. 2005), with one group also observing greater activity in DMPFC during social reasoning (Fiddick et al. 2005). It is important to note that the social rules used in these tasks did not require representing mental states (e.g., if a man is drinking beer, he must be over 21), and thus the predominance of lateral frontoparietal activity is consistent with other domains covered in this review.

More attention has been given to the study of moral reasoning. The most common finding across these studies is that moral reasoning activates MPFC to a greater extent than do relevant control tasks (Heekeren et al. 2003; Moll et al. 2002a,b, 2005), with some of these studies also finding greater activation in pSTS and the temporal poles. In the first neuroimaging study of moral reasoning, Greene et al. (2001) compared personal and impersonal moral reasoning. In the personal condition, individuals were induced to focus on their own personal involvement in bringing about a distasteful but utilitarian outcome; in the impersonal condition, individuals were induced to focus primarily on the utilitarian outcome. The personal condition activated a medial frontoparietal network along with LPAC to a greater degree than did the impersonal condition, consistent with the notion that the personal condition promotes self-reflection on the implications of one's contribution to the outcome. The impersonal condition, in contrast, led to greater activity in lateral frontoparietal regions than did the personal condition, consistent with an external focus on events in the world. A recent study (Mendez et al. 2005) with patients with MPFC damage confirmed these results: The patients were impaired in making personal moral judgments but not impersonal moral judgments.

Fairness and trust in interactions. A new area of research, neuroeconomics (Camerer et al. 2005, Trepel et al. 2005), has combined the study of behavioral economics and cognitive neuroscience. Studies that involve economic exchange with social dynamics are particularly relevant to social cognitive neuroscience. These studies use paradigms such as the ultimatum game (Sanfey et al. 2003), the prisoner's dilemma (Rilling et al. 2002), and the trust game (de Quervain et al. 2004) in order to examine the neural responses associated with cooperation, competition, fairness, and trust. Across these studies, cooperation, trust, and fair play typically activate VMPFC, MPFC, and MPAC (Decety et al. 2004, McCabe et al. 2001, Rilling et al. 2002), whereas unfair and untrustworthy responses activate insula (Sanfey et al. 2003), caudate in the basal ganglia (de Quervain et al. 2004), or DMPFC (Decety et al. 2004). The finding that cooperation, relative to competition, promotes MPFC rather than DMPFC activity is consistent with previously described work by Mitchell et al. (2005), such that cooperation may be associated with seeing the other players as more similar to oneself (see Decety et al. 2004). Cooperation has long been studied as a technique for overcoming intergroup differences and promoting a sense of shared identity (Sherif et al. 1961).

Across these studies of fairness and trust, the fairness of the decision-making process has often been confounded with the material value of the outcome. That is, fair responses from a partner are typically associated with better financial outcomes for the subject. G. Tabibnia, A.B. Satpute, & M.D. Lieberman (under review) recently manipulated the material payoffs and the fairness of the partner's behavior independently. After controlling for material payoffs, fairness still activated an array of motivation- and reward-related regions, including VMPFC, ventral striatum in the basal ganglia, and amygdala, which suggests that fairness is hedonically valued in social interactions.

CORE PROCESSES

Automatic Versus Controlled Processes

Across the different domains of social cognitive neuroscience that allow for an assessment of their automatic and controlled components, a clear pattern of neural activation emerges (see **Figure 2**). Some social psychological processes, by their very nature, appear to consist exclusively of either automatic or controlled processes (e.g., self-reflection, moral decision-making, feeling rejected). Other processes involve task conditions and baseline conditions that intuitively seem to compare controlled processes with spontaneous processes that may be more automatic (e.g., reappraisal, affect labeling). Finally, some processes have been examined with tasks that manipulate whether particular controlled processes of interest are likely to operate or not (e.g., theory of mind, dispositional attribution, self-knowledge, and attitude processes), providing the clearest examination of automaticity and control.

The picture that emerges is consistent with previous work on the neural systems supporting reflective and reflexive social cognition (Lieberman et al. 2002, Satpute & Lieberman 2006). Here, controlled forms of social cognition were consistently associated with activations in LPFC, LPAC, MPFC, MPAC, and MTL. Alternatively, automatic forms of social cognition were consistently associated with activations in amygdala, VMPFC, and LTC. Not enough studies of automatic and controlled social cognition have implicated the basal ganglia or rACC one way or another to allow an assessment. Also, the studies were mixed regarding the contribution of dACC. Based on the existing results, dACC could either be (*a*) engaged in active controlled processing or (*b*) responding to goal-related conflict automatically (Bargh 1989) and then triggering other controlled processes as a result. Either alternative would produce dACC activity during tasks that recruit controlled processes in response to conflict.

Although these results must be considered preliminary, they do suggest that differences between automatic and controlled processes may constitute a core-processing distinction in the study of social cognitive neuroscience. Given the importance that this distinction has had over the past 20 years within the field of social cognition (Chaiken & Trope 1999, Wegner & Bargh 1998), it is valuable to identify the neural regions that support this distinction. In the long run, it may be possible to conduct studies in which the extent of automatic and controlled processing can be identified from neuroimaging alone, without the need for cognitive load or subliminal presentations, which would allow for more naturalistic investigations of automatic and controlled social cognition (cf. Poldrack 2006).

Internally-Versus Externally-Focused Processes

Across a number of social psychological domains, a clear division is present between the neural correlates of tasks that focus attention on interior psychological worlds and tasks that focus attention on the exterior social world and the physical social agents in it (see **Figure 3**). Externally-focused processes are

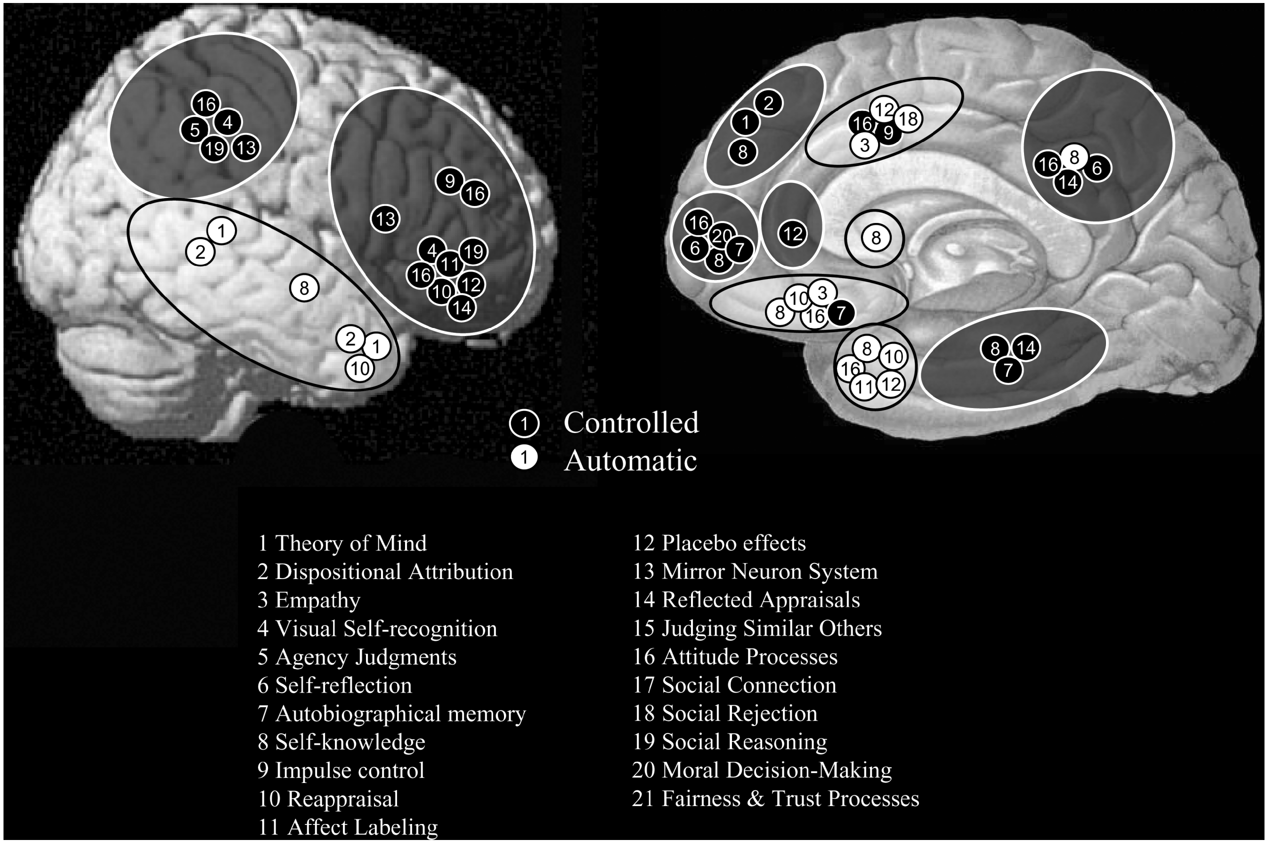

Figure 2

Neural correlates of automatic and controlled processes from multiple domains of social cognition overlaid on to the X-system and C-system regions displayed in **Figure 1**. Controlled/reflective processes are represented by small circles with white text on a black background. Automatic/reflexive processes are represented by small circles with black text on a white background. Small circles are placed schematically within a region and are not meant to indicate a precise location within a region.

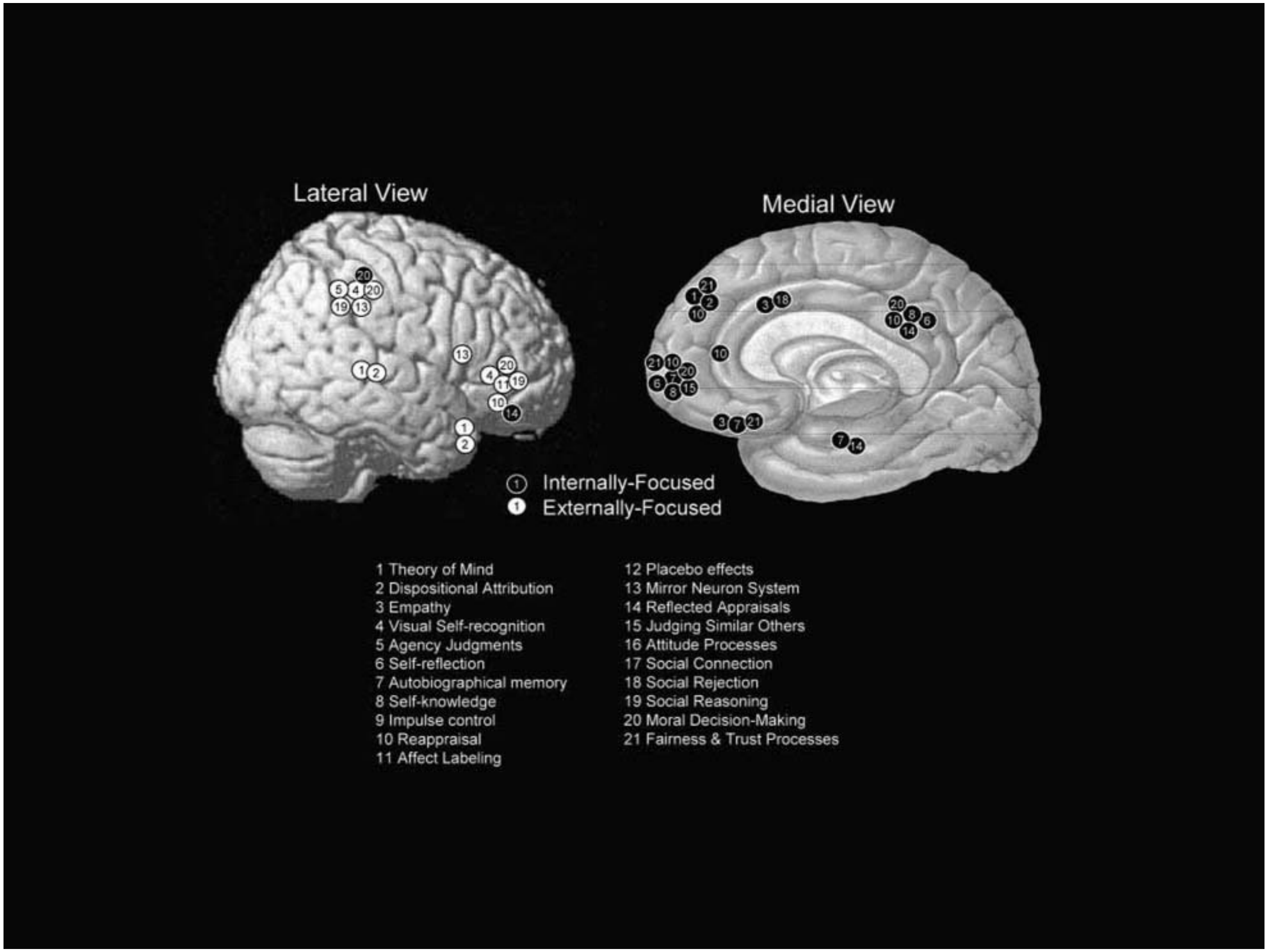

Figure 3

Neural correlates of internally-focused and externally-focused processes from multiple domains of social cognition. Internally-focused processes are represented by small circles with white text on a black background. Externally-focused processes are represented by small circles with black text on a white background. Small circles are placed schematically within a region and are not meant to indicate a precise location within a region.

associated with a lateral frontotemporoparietal network, whereas internally-focused processes are associated with a medial frontoparietal network.

A lateral frontotemporoparietal network is more activated by social-cognitive tasks that focus attention on the external, physical, and most often visual characteristics of other individuals, oneself, or the interaction of the two. This lateral frontotemporoparietal network is activated in tasks involving the nonmentalizing aspects of theory of mind and dispositional attribution tasks, action observation and imitation, visual self-recognition, impersonal moral and social reasoning, reappraisal by focusing on physical events, and labeling the visual displays of affect in the facial expressions of others.

In contrast, a medial frontoparietal network is more activated by social-cognitive tasks that focus attention on the internal, mental, emotional, and experiential characteristics of other individuals or oneself. This medial frontoparietal network is activated by tasks involving the mentalizing aspects of theory of mind and dispositional attribution tasks, empathy, self-reflection on current experiences, autobiographical memory, self-reflection on one's traits, personalized moral reasoning, and reappraisal by focusing on one's personal relation to a target.

It is important to note that this distinction is orthogonal to and cuts across self and other processing. Consequently, this distinction refers to two ways that self and other can each be processed. In the absence of existing neurocognitive data, it is hard to imagine making a case for self-reflection having such a distinct representational basis from self-recognition. However, in the context of the distinction between internally- and externally-focused processes that emerged from this review, these results are entirely sensible.

CONCLUSION

Social cognitive neuroscience is a vibrant young area of research. The amount of research and the number of scientists conducting research at the interface of the social sciences and neuroscience have increased by an order of magnitude since the first review of social cognitive neuroscience (Ochsner & Lieberman 2001). Several exciting lines of social cognitive neuroscience research are providing new discoveries, generating original ideas, and challenging longstanding conceptions of existing social science perspectives. This is exactly what interdisciplinary cross-fertilization should do. Here, I have provided evidence for two broad organizing principles of social cognition within the human brain, one quite old and one that is new. The distinction between automatic and controlled social cognition has long been a contributor to social psychological research. Identifying the neural bases of this distinction will help social cognitive neuroscience research to carve social processes at their joints, just as it has helped social psychologists in the past. In contrast to automaticity and control, the distinction between internally-focused and externally-focused social cognition has no clear theoretical precursor in social psychology, but emerges unmistakably from social cognitive neuroscience research (see also Eisenberger et al. 2005, Ochsner et al. 2004). Hopefully, the identification of this core-processing distinction can contribute to the development of new theories and the enrichment of existing theories within the social sciences, demonstrating that social cognitive neuroscience can be both a science of new techniques and a science of new ideas.

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