

# SOCIAL COGNITIVE NEUROSCIENCE: A REVIEW OF CORE SYSTEMS

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Descartes famously argued that the mind is both everlasting and indivisible (Descartes, 1988). If he was right about the first part, he is probably pretty impressed with the advance of human knowledge on the second. Although Descartes' position on the indivisibility of the mind has been echoed at times in the history of psychology and neuroscience (Flourens & Meigs, 1846; Lashley, 1929; Uttal, 2003), the modern field has made steady progress in demonstrating that subjective mental life can be understood as the product of distinct functional systems. Today, largely because of the success of cognitive neuroscience models, researchers understand that people's intellectual faculties emerge from the operation of core systems that are instantiated by particular brain networks (Gazzaniga, 2009; Shallice, 1988). From this perspective, the brain consists of a set of distinct but interacting information processing systems that carry out cognitive functions of perception, attention, decision making, memory, executive control, and so forth. Without a doubt, the breadth of these models is impressive, but until relatively recently they have been incomplete in an important way. Namely, researchers in this tradition had placed scant emphasis on the social and emotional abilities that account for much of what makes human experience such a complex and fascinating target of scientific explanation.

## SOCIAL COGNITIVE NEUROSCIENCE APPROACH

In the past decade, the field of social cognitive neuroscience (SCN) has attempted to fill this gap, integrating the theories and methods of two parent disciplines: social psychology and cognitive neuroscience. Stressing the interdependence of brain, mind, and social context, SCN seeks to explain psychological phenomena at three levels of analysis: the neural level of brain systems, the cognitive level of information processing mechanisms, and the social level of the experiences and actions of social agents (Ochsner & Lieberman, 2001). In contrast to scientific approaches that grant near exclusive focus to a single level of analysis (e.g., behaviorism, artificial intelligence, eliminative materialism), SCN researchers develop theories that leverage data from each of these three levels, regarding them as complementary sources of information that enrich and mutually constrain the understanding of mental function (Cacioppo & Berntson, 1992; Ochsner, 2007). Accordingly, SCN experiments typically involve manipulating and measuring variables at the social and neural levels and attempting to draw inferences about intervening psychological processes. In service of this goal, SCN research makes use of a wide array of tools, including complex social paradigms meant to model aspects of everyday social phenomena, tightly controlled cognitive tasks, and neuroimaging as well as other biological measures.

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Integrating and categorizing data collected across these levels of analysis is inherently challenging, especially when the theories and methods traditionally applied to different levels have tended to develop in relative isolation. Although it is clear that different regions of the brain are associated with different psychological functions, finding psychological categories that “carve nature at its joints” is difficult because the natural ways of segmenting concepts in psychology (or, for that matter, in human language) may not map cleanly onto the brain (Barrett, 2009). Consequently, early attempters of this kind of categorization are like vegetarians supplied with a turkey and an electric carving knife in that their naiveté ran them the risk of misspecifying the boundaries of the natural world and passing on a legacy of dyspepsia rather than enlightenment. That said, without clear guiding principles it can be difficult to figure out how the myriad and diverse pieces of data collected under the SCN umbrella fit together, or how to prevent Thanksgiving from devolving into a slapdash free-for-all. Some happy medium must be reached in which the processing language researchers use to make sense of brain systems is useful both for that purpose and for connecting to higher level descriptions of behavior and experience.

Keeping these precautions in mind, our overarching goal in this chapter is to illustrate the SCN approach at work in the context of key topics in social psychology and social cognition research. Rather than simply cataloguing the manifold brain regions implicated in social processing, we distill findings from the SCN literature into a set of basic functional brain systems that together support a wide range of social cognitive abilities. Toward these ends, this chapter has three parts. The first proposes a social cognitive processing stream consisting of six basic systems—three of which perform evaluative, regulatory, and self-representational functions we have cast as intrapersonal and three of which perform perceptual and cognitive functions that support the ability to understand other people, cast here as interpersonal. In the second part of this chapter, we attempt to explain how high-level social psychological phenomena—from morality and altruism to persuasion and romantic love—can be

understood as emerging from interactions of these core systems. Finally, we consider the near future of SCN in general and our processing stream model in particular, with an eye toward identifying exciting new questions about the basic nature and translational potential of these core systems.

Across topic areas and processing systems, we illustrate two types of goals that motivate SCN research (Ochsner, 2007). The first goal is exemplified in experiments designed to ask the question “Where is psychological process X located in the brain?” By carefully manipulating the psychological state of research participants and observing resulting activity in particular brain regions or networks of regions, such research allows for functional inferences about what particular parts of the brain do (this process is sometimes referred to as *forward inference*, or a brain mapping approach). Although clearly illuminating to a brain researcher, knowing the location of processes in the brain may not seem particularly informative to a social psychological theorist. Critical consumers of this literature sometimes ask whether there are instances in which social psychological theories developed from behavioral observation have needed to be updated in light of SCN data (Kihlstrom, 2010). As it turns out, there are already several such instances (which we outline here), and, moreover, there is reason to be optimistic that they will occur with greater frequency and have more profound impact in the not-too-distant future.

As our repository of functional inference findings grows, so too does researchers’ ability to use the tools of neuroscience to ask social psychological questions. The results of repeated imaging investigations of a given task or psychological process give researchers an idea of how reliably a given psychological function is associated with activity in a certain brain region. With quantitative or qualitative review of the broader imaging literature, researchers can also make an estimate of the specificity with which activity in the region corresponds to that function (Poldrack, 2006; Yarkoni, Poldrack, Van Essen, & Wager, 2010). Together, this information can be used to estimate the validity of a particular brain region as a marker of a specific psychological process, thereby laying the groundwork for the second goal of SCN research: using observed brain

activity to draw psychological inferences (sometimes called *reverse inferences*) about the processes underlying a given behavior or experience. Although functional inferences are more prevalent in the literature and necessarily come first, every SCN experiment in a sense serves both functional and psychological inferential goals by (1) providing additional information about brain regions activated by particular psychological manipulations and (2) requiring that these results be placed in the context of previous research to draw inferences about the psychological processes that observed activations represent (Ochsner, 2007). In sum, by approaching neuroimaging with these two inferential goals in mind, SCN researchers can observe multiple psychological processes operating in concert and link theory developed in social psychology to an extensive neuroscience literature.

## SOCIAL COGNITIVE PROCESSING STREAM

### Core Systems of Intrapersonal Social Cognition

**System 1: Evaluation.** Among the most fundamental of human activities is the process of assigning a valenced evaluation (good or bad) to objects, people, and other aspects of the surrounding environment (Figure 22.1; Osgood, Suci, & Tannenbaum, 1957). The process of evaluating something can involve integrating sensory information about that

thing with interoceptive information from the body (Schachter & Singer, 1962), with resulting evaluations playing central roles in approach and avoidance behavior (Chen & Bargh, 1999), emotional experience (Russell, 2003), attitude formation (Eagly & Chaiken, 2007), decision making (Montague & Berns, 2002), and many other phenomena in psychology. It is hardly surprising then that the evaluation system has long been of interest in social psychology (Hovland, Janis, & Kelley, 1953; Thurstone, 1928). However, many questions about the nature of evaluation and the mechanisms underlying it have been difficult to address through behavioral studies alone, prompting much recent neuroscientific interest in this topic.

At the social level, evaluations exist as subjective experiences of valence and arousal, meaning an evaluation is felt or behaviorally expressed as a positive or negative reaction to a stimulus that carries some degree of arousal or intensity, from low to high (Russell, Lewicka, & Niit, 1989). Across stimulus domains, evaluations operate on stimuli with intrinsic, learned, or cognitively generated affective properties (see Ochsner et al., 2009). Two neural structures strongly implicated in the evaluative process—the amygdala and ventral portions of the striatum—are evolutionarily old areas of subcortex that receive multimodal perceptual inputs and are interconnected with autonomic control areas and neuromodulatory systems (Pitkänen, Kelly, & Amaral, 2002; Schultz, 2004). Other brain regions critical to evaluation include the ventromedial prefrontal



FIGURE 22.1. Evaluation.

cortex (vmPFC) and nearby orbitofrontal cortex (OFC), the insula, the dorsal anterior cingulate cortex (dACC), and the periaqueductal gray (PAG). Together, these structures work to integrate sensory and visceral information to form aspects of an experience-dependent value representation (see Kober et al., 2008; Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012). Much recent work has illuminated the precise components of the evaluation process performed by each of these regions.

*Amygdala.* One of the most replicated findings in this domain is that the amygdala is critical for the recognition of stimuli that directly or indirectly signal the presence of a potential threat, such as pictures of untrustworthy faces (Mende-Siedlecki, Said, & Todorov, 2013) or fearful faces (Whalen, 1998), findings clearly consistent with a wealth of research demonstrating the importance of this brain structure in the acquisition, storage, and expression of conditioned fear (LeDoux, 1996). However, it is becoming increasingly clear that although the amygdala is crucial to negative evaluations, it also responds to a wide variety of stimulus dimensions, including novelty, positivity, and ambiguity, leading to a broader conceptualization of the amygdala as a surveillance system that continuously monitors the environment for affectively relevant stimuli and modulates activity in perceptual and memory systems to detect and encode them (Whalen, 1998).

*Ventral striatum and ventromedial prefrontal cortex.* Similarly, the ventral striatum and the vmPFC have been implicated in both encoding and constructing evaluations of stimulus value. These structures receive dopaminergic input from the ventral tegmental area in the midbrain and represent key parts of the mesolimbic dopamine reward pathway. The animal literature investigating this pathway has suggested that the function of mesolimbic dopamine is to gate attention to novel, salient, or rewarding events that require an effortful response (Berridge & Robinson, 1998; Schultz, Apicella, & Ljungberg, 1993). Imaging studies have shown that these structures respond to a wide range of rewarding stimuli including sweet liquids, money, attractive faces, political figures, and desirable consumer goods (reviewed in Haber & Knutson, 2010). One functional distinction between regions seems

to be that the ventral striatum responds to differences between the outcomes predicted and those actually received and uses these prediction errors to guide learning (Delgado, Li, Schiller, & Phelps, 2008; Knutson & Cooper, 2005; Schultz, Dayan, & Montague, 1997), whereas areas of the vmPFC more directly track reward outcome magnitude in a variety of contexts, and thus activity in this region is thought to represent an integrative value signal (Fehr & Rangel, 2011; Schoenbaum, Saddoris, & Stalnaker, 2007).

*Insula, dorsal anterior cingulate cortex, and periaqueductal gray.* Initially, on the basis of patterns of anatomical connectivity (Augustine, 1996; Craig, 2009) and bolstered by meta-analyses of neuroimaging studies (e.g., Chang, Yarkoni, Khaw, & Sanfey, 2012), it has been proposed that the insula supports the integration of visceral and somatic information involved in interoceptive states, including the experience of disgust and pain. In contrast with amygdala lesions, which disproportionately decrease arousal ratings to negative stimuli, lesions to the insula result in attenuated valence and arousal ratings to both positive and negative stimuli (Berntson et al., 2011). Together with the dACC, PAG, and other cortical and brain stem structures, the insula is also recognized as a crucial region of the pain matrix, the set of brain structures that underlie the sensory and affective components of the experience of pain. In addition to responding during physical pain, the PAG has recently been shown to be involved in negative affect more generally (Buhle et al., 2013; Mobbs et al., 2010).

*On the automaticity of evaluation.* When people report or otherwise express their evaluations, it is difficult to know what underlying processes have generated these evaluations. For instance, although people sometimes express their attitudes reflexively, at other times they deliberately shape these attitudes before expressing them. Interestingly, regions of the evaluation network may in some cases respond regardless of the deliberate intention to evaluate, although the precise conditions under which this happens remain a subject of debate. On one hand, many early observations showed that the amygdala responds to threatening stimuli that are subliminally presented (Anderson, Christoff, Panitz,

De Rosa, & Gabrieli, 2003; Whalen et al., 2004). On the other hand, there are reports that amygdala responses are sensitive to the amount of attention paid to stimuli (Hsu & Pessoa, 2007; Pessoa, Japee, Sturman, & Ungerleider, 2006), which suggests that top-down, controlled processes exert modulatory influences over evaluative processes. Indeed, when participants are asked to explicitly evaluate a concept on a good–bad dimension, to the extent that they try to control their evaluation of the topic, increased activity is observed in the dACC and ventrolateral prefrontal cortex (vlPFC; Cunningham, Raye, & Johnson, 2004), two regions that make up part of a regulatory processing system, which we turn to next.

**System 2: Regulation.** Within both social psychology and cognitive psychology, *regulation* refers to the process of overriding prepotent responses to respond in a context-sensitive and deliberate manner (Figure 22.2). Cognitive neuroscience research has suggested important distinctions among sub-components of regulation, including the detection of response conflicts and the implementation of controlled processing (e.g., Miller & Cohen, 2001). Recent SCN research has demonstrated that similar systems are drawn on when people regulate their feelings, overcome stereotypes, and enact other

forms of self-control (Cunningham & Zelazo, 2007; Ochsner & Gross, 2005).

*Explicit regulation.* Perhaps the most commonly studied means of regulating behavior involves asking participants to keep in mind explicit regulatory goals that they use to guide and shape their behavior. Such explicit forms of regulation have been shown to depend on two kinds of processes. The first involves detecting a conflict between two or more alternative responses—for example, reaching for versus not reaching for a piece of chocolate cake. Botvinick, Braver, Barch, Carter, and Cohen (2001) proposed that the dACC and adjacent medial prefrontal cortex (mPFC) support this conflict monitoring function and, when conflict arises, a signal is sent to regions of the prefrontal cortex involved in implementing the intended response. Activation of dACC has been shown in imaging studies of stereotyping (Amodio, Master, Yee, & Taylor, 2008; Kubota, Banaji, & Phelps, 2012) and social exclusion (Eisenberger, Lieberman, & Williams, 2003), providing converging neural evidence that these phenomena entail conflict processing.

Once the need for control is detected and signaled by the dACC, the second type of cognitive control process kicks in. This type is associated with activity in the lateral regions of the prefrontal cortex that implement deliberate and controlled forms of

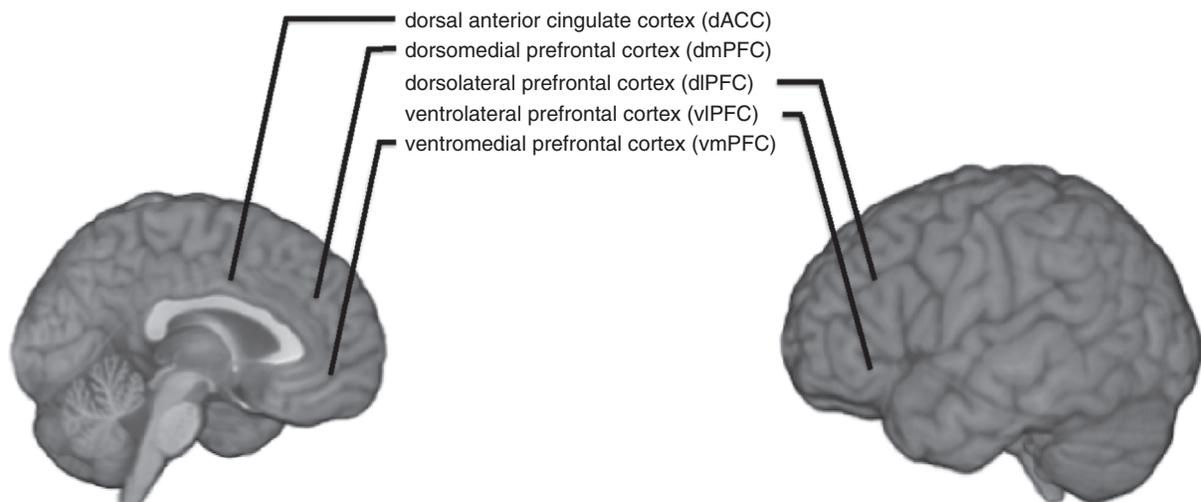


FIGURE 22.2. Regulation.

regulation. Anatomically, both dorsolateral prefrontal cortex and vlPFC have extensive connections with a wide range of other cortical and subcortical brain structures (Passingham, 1993; Petrides, 2005). Neuroimaging studies of cognitive tasks have shown that these regions support language, attention, and working memory functions (Badre, 2008). SCN studies have shown that cognitive reappraisal, which entails reinterpreting the meaning of a stimulus to diminish or enhance an affective response, also depends on regions of the regulation system, including the vlPFC and dorsolateral prefrontal cortex, as well as posterior portions of the dorsomedial prefrontal cortex similarly implicated in cognitive control. Together, these regions act to modulate activity in regions of the evaluation system that support emotional experience, including the amygdala, insula, and ventral striatum (Ochsner & Gross, 2005; Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008).

*Implicit regulation.* In contrast to forms of regulation that are driven by explicit regulatory goals, SCN studies have also looked at forms of learning-based regulation in which stimulus values are updated implicitly according to principles of associative learning. One example of this form of learning is extinction of the conditioned fear response. Fear conditioning involves learning that an initially neutral stimulus (the conditioned stimulus) predicts the occurrence of an intrinsically unpleasant outcome (the unconditioned stimulus). During extinction, the conditioned stimulus is repeatedly presented without the unconditioned stimulus. Over time, conditioned responses to the conditioned stimulus diminish as the organism learns to no longer fear that the unpleasant unconditioned stimulus will soon follow. Recording and lesion studies in animals as well as functional imaging studies in humans have implicated a region of the vmPFC in this ability (Delgado, Nearing, LeDoux, & Phelps, 2008; Phelps, Delgado, Nearing, & LeDoux, 2004). Overlapping regions of vmPFC have been shown to support performance in reversal learning tasks, in which participants are trained to respond differentially to two stimuli through reward and punishment conditions and then tested under reversed reward and punishment

mappings (Schiller & Delgado, 2010; Schiller, Levy, Niv, LeDoux, & Phelps, 2008). Interestingly, regions of the vmPFC also underlie effective placebo analgesia—the modification of pain by belief in a treatment (Diekhof, Geier, Falkai, & Gruber, 2011). Taken together, these findings suggest that activity in the vmPFC supports regulatory processes that are not driven by explicit regulatory goals but nonetheless have a powerful impact on affective experience.

**System 3: Self-representation.** The self is one of psychology's richest constructs (see Baumeister, 1998) and may prove to be among the most complex to map comprehensively onto underlying brain processes. Nevertheless, imaging studies have already identified a number of cognitive and neural mechanisms underlying self-representation, which we consider here as a single system performing the conceptually related functions of recognizing, reflecting on, and maintaining knowledge of the self (Figure 22.3).

*Agency.* One key component of the self is the experience that one was causally responsible for generating a particular behavior. This process, often referred to as *agency*, has been studied in a number of ways. In an early study of this process, participants were asked to watch a clock and remember the precise time when they formed the intention to respond (Libet, Gleason, Wright, & Pearl, 1983). Intriguingly, this study revealed a neural response that preceded participants' reports of the time they consciously decided to act by a few hundred milliseconds. Subsequent neuroimaging studies of this task have observed similar responses in supplementary motor areas, along with the dACC, dorsolateral prefrontal cortex, mPFC, and precuneus (Babiloni et al., 2008; Lau, Rogers, Haggard, & Passingham, 2004). Although one interpretation of this work is that neural responses are causally antecedent to both intentions and behavior, whether neural events causally precede all intentions or just reflective reports of intention recognition is unclear at this point (Wegner, 2003).

Another approach to the study of agency investigates action monitoring, which involves the detection of the divergence (or lack of divergence) between observed behaviors and expected behaviors,

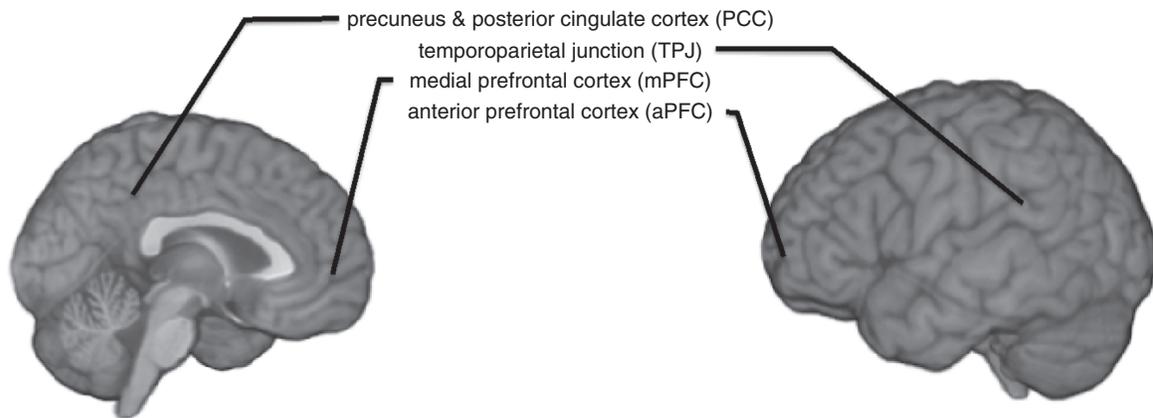


FIGURE 22.3. Self-representation.

as well as the metacognitive assessment of agency, which occurs when participants reflect on the output of the action monitoring process and then consciously infer the extent to which they caused the behavior in question (Miele, Wager, Mitchell, & Metcalfe, 2011). Across several studies, the most common correlate of action monitoring is activity in the temporoparietal junction (TPJ) that tracks the mismatch between observed and predicted behavior (Blakemore, Oakley, & Frith, 2003; Miele et al., 2011; C. Preston & Newport, 2008). Metacognitive assessments of agency, however, seem to rely not on TPJ but on the anterior prefrontal cortex, a region implicated in metacognition more generally (Miele et al., 2011).

*Self-knowledge.* Beyond just recognizing authorship of their actions, humans have the remarkable ability to reflect on and maintain knowledge about themselves. A fundamental question in social psychology is the degree to which the self is a unique knowledge structure, qualitatively different from other kinds of mental representations (Higgins & Bargh, 1987; Klein, Loftus, & Kihlstrom, 2002). This line of investigation has played out in SCN research as a search for neural regions specific to self-knowledge processing. An early study found that, relative to judgments about other people, self-judgments of trait words more strongly engage a region of mPFC (Kelley et al., 2002). Activity of mPFC has since been seen in several studies of self-judgment, often observed in concert with activity in the posterior cingulate cortex and precuneus

(reviewed in Legrand & Ruby, 2009). Interestingly, activity in the mPFC, posterior cingulate cortex, and precuneus is also observed during retrieval of autobiographical memory episodes (Cabeza & St. Jacques, 2007), imagination of potential future events (Szpunar, Watson, & McDermott, 2007), and during periods of rest in the functional MRI (fMRI) scanner, when participants are free to engage in spontaneous thought (Gusnard & Raichle, 2001). These regions are also commonly recruited when people think about other people, particularly those who are emotionally close to them (Krienen, Tu, & Buckner, 2010; van Overwalle, 2009). Thus, rather than being “self regions” per se, it is possible that activity in mPFC, posterior cingulate cortex, and precuneus supports more general processes that are recruited across these contexts—for example, inferential or associative processing that operates on information recalled from memory (see Bar, 2009; Legrand & Ruby, 2009; Lieberman, 2012).

Shedding light on this issue, a recent meta-analysis has shown that the mPFC regions most strongly engaged for judgments about the self are relatively ventral, whereas more dorsal regions of mPFC are more strongly engaged when making judgments about others (Denny, Kober, Wager, & Ochsner, 2012). This finding suggests that ventral and dorsal mPFC regions are topographically mapped with respect to processes engaged more strongly for self as opposed to other judgments, perhaps relating to the differential connectivity these regions have with other parts of the brain (Ongür, Ferry, & Price, 2003). As noted

earlier, vmPFC enjoys strong interconnections with regions implicated in evaluation and is involved in implicit forms of learning-based regulation. By contrast, dorsal portions of mPFC are relatively more interconnected with lateral PFC regions implicated in cognitive control and memory retrieval, although they too have connections with subcortical regions implicated in evaluation. This pattern suggests that self-focused judgments depend more on systems involved in evaluation, perhaps because the expression of self-knowledge inherently involves a constant tracking of the value of things with respect to the self.

### Core Systems of Interpersonal Social Cognition

**System 4: Nonverbal social perception.** To understand and interact with other people, one must first perceive them as social entities, distinct from other objects in the environment. The system underlying this ability is made up of several distinct brain regions that are specialized for detecting particular features of other people (Figure 22.4). All of these regions are part of the ventral visual stream that is the primary processing pathway for visual inputs.

Studies have found that the fusiform face area and the occipital face area are uniquely sensitive to static face stimuli (Hoffman & Haxby, 2000; Kanwisher, McDermott, & Chun, 1997; McCarthy, Puce, Gore, & Allison, 1997). Another region of the brain, the extrastriate body area, selectively responds to visual presentation of bodies (Downing, Jiang, Shuman, & Kanwisher, 2001). Consistent

with its other-detection function, extrastriate body area activation is greater when viewing bodies from a third-person perspective (i.e., externally, at a distance) than from a first-person perspective (i.e., the viewpoint from which one views one's own body; Chan, Peelen, & Downing, 2004; Saxe, Jamal, & Powell, 2006). The posterior superior temporal sulcus (pSTS) responds to various dynamic social cues such as moving eyes, lips, fingers, and hands (Allison, Puce, & McCarthy, 2000; Pelphrey, Morris, & McCarthy, 2005; Pelphrey, Singerman, Allison, & McCarthy, 2003), as well as point-light videos depicting only the articulated motion of joints during human action (e.g., Grèzes et al., 2001; Grossman & Blake, 2002; Puce & Perrett, 2003; Vaina, Solomon, Chowdhury, Sinha, & Belliveau, 2001). Neurophysiological research in monkeys has revealed that neurons in the pSTS activate in response to biological motion cues from multiple perceptual modalities (Barraclough, Xiao, Baker, Oram, & Perrett, 2005), and human neuroimaging studies have confirmed that the human pSTS responds to the sound of people walking (Bidet-Caulet, Voisin, Bertrand, & Fonlupt, 2005; Saarela & Hari, 2008). This body of research has demonstrated the existence of a core social perception system that receives dedicated support from brain regions sensitive to particular static and dynamic social cues.

**System 5: Experience sharing.** The simple act of observing another person's behavior has been shown to rapidly (i.e., without reflection or extensive inferential processing) activate representations of

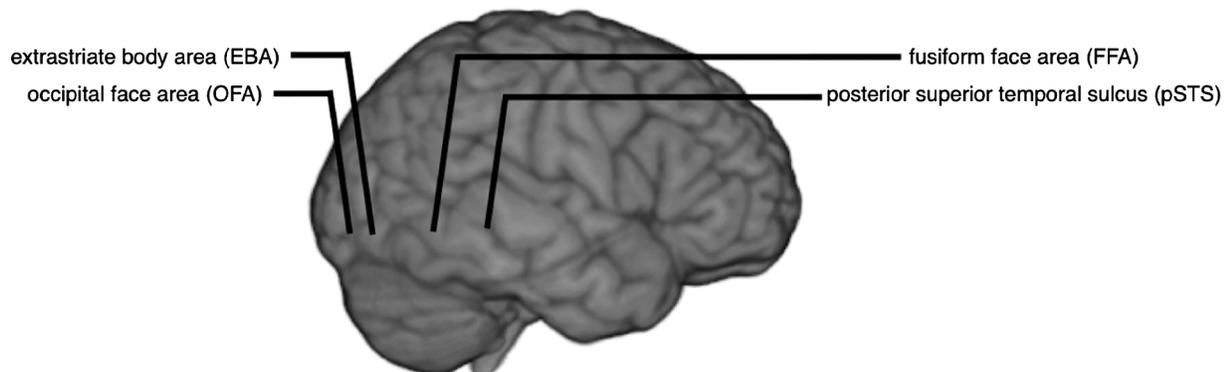


FIGURE 22.4. Nonverbal social perception.

certain kinds of internal mental states associated with the behavior (Figure 22.5). This process is thought to support vicarious social inference by matching a target's behaviors to stored representations in the perceiver's own repertoire—including, crucially, the motor intentions and affective states associated with the behaviors. In so doing, the experience-sharing system is thought to provide people with direct experiential understanding of other people's internal states.

Neuroscience research on experience sharing began with electrophysiological recordings of individual neurons in the macaque ventral premotor cortex that fired when the monkey either executed or observed a manual grasping action (di Pellegrino et al., 1992). Deemed *mirror neurons*, these cells seemed to encode representations of an action's intended goal whether performed by the self or by others. The discovery of such low-level self–other linkage prompted hypotheses positioning mirror neurons as the foundation of human social cognition (e.g., Gallese, Keysers, & Rizzolatti, 2004). Although this view has some problems (see Gallese, Gernsbacher, Heyes, Hickok, & Iacoboni, 2011; Glenberg, 2011), these ideas inspired a productive body of research asking how human perceivers use shared self–other representations to understand other people.

*Action understanding.* According to the direct-matching hypothesis, perceivers comprehend an observed goal-directed action by mapping its perceptual representation onto a corresponding motor representation of the same action (Rizzolatti,

Fogassi, & Gallese, 2001). Converging neuroscience research on action understanding implicates a network of several interconnected brain regions: the anterior intraparietal sulcus, premotor cortex, and inferior frontal gyrus (Rizzolatti, Fabbri-Destro, & Cattaneo, 2009). This network receives input from the pSTS, which integrates visual and auditory sensory information about biological motion (for reviews, see Barraclough et al., 2005; Pulvermüller, 2005). Dovetailing research in monkeys and humans has found that signals from the pSTS propagate to the anterior intraparietal sulcus (Keysers & Perrett, 2004; Nishitani & Hari, 2002), which specifies the action's context and associated objects (Tunik, Rice, Hamilton, & Grafton, 2007), and to the premotor cortex, where input is compared with stored motor representations for actions (Rizzolatti et al., 2001). Compellingly, the premotor cortex contains neurons that activate with sensitivity to the particular goal of an action, for example, grasping an object to eat it versus place it in a container (Fogassi et al., 2005). The inferior frontal gyrus is also thought to facilitate identification of motor intentions by comparing resemblance of input to stored representations in the perceiver's repertoire (Rizzolatti et al., 2009). By representing simple motor intentions, these systems enable a social perceiver to identify what a social target is doing as well as how she or he is accomplishing this act (see Spunt & Lieberman, 2012a).

*Affect sharing.* Extending the shared representation logic beyond the scope of affectively neutral actions, it has been suggested that perceivers also

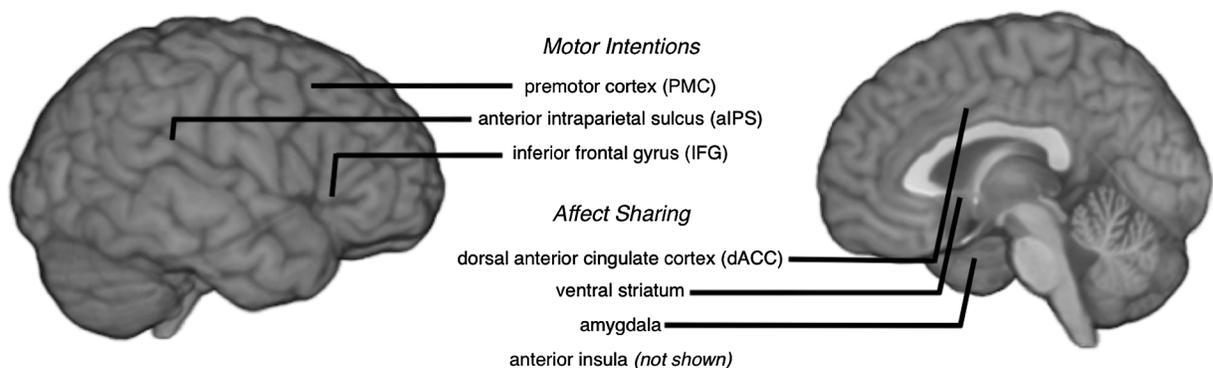


FIGURE 22.5. Experience sharing.

simulate affective states (Bastiaansen, Thioux, & Keysers, 2009; Decety & Jackson, 2004; Keysers & Gazzola, 2006; Niedenthal, 2007; S. D. Preston & de Waal, 2002), resulting in what has been called both *emotional contagion* and *affect sharing* between perceiver and target. Consistent with this hypothesis, studies have shown overlapping patterns of brain activity during execution and observation of emotional facial expressions (e.g., Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003; Hennenlotter et al., 2005; Jabbi, Swart, & Keysers, 2007; Lee, Josephs, Dolan, & Critchley, 2006; Leslie, Johnson-Frey, & Grafton, 2004; Pfeifer, Iacoboni, Mazziotta, & Dapretto, 2008). Botox injections that paralyze facial muscles involved in frowning present a natural experiment for testing the link between execution and observation of emotional displays: A recent study found that these injections cause proportional decreases in the responsiveness of frown muscles and the amygdala when viewing angry faces (Hennenlotter et al., 2009).

Further support for affect sharing comes from findings that sniffing disgusting odors and observing others doing so recruits overlapping portions of the anterior insula (Jabbi et al., 2007; Wicker et al., 2003) and, similarly, observing people receive monetary rewards activates regions of the ventral striatum also engaged by reward receipt (Mobbs et al., 2009). Other studies have focused on sharing of pain-related negative affect, showing activation of

dACC and anterior insula during both the observation and the personal experience of pain (Bernhardt & Singer, 2012; Zaki & Ochsner, 2012). Indeed, observation of various pain-related social stimuli has been found to engage these regions, including watching video clips of targets hearing painfully aversive sounds (Lamm, Batson, & Decety, 2007), seeing hands being pricked by needles (Morrison, Lloyd, Di Pellegrino, & Roberts, 2004), and viewing other body parts in painful circumstances (Jackson, Meltzoff, & Decety, 2005).

**System 6: Mentalizing.** Whereas research on experience sharing focuses on shared self–other representations that enable vicarious understanding of others’ intentions and experiences, work on the mentalizing system instead emphasizes abstract semantic representations that support symbolic, descriptive, and propositional understanding of these mental states (Figure 22.6; Ochsner, 2008). This line of research follows from seminal work on theory of mind: the capacity to attribute mental states on the basis of an understanding that others have beliefs, intentions, and feelings that are different from one’s own (Premack & Woodruff, 1978). Consistent with the methodological tradition of theory-of-mind work, SCN studies of mentalizing have typically involved explicit judgments about the mental states of human targets. Collectively, they have implicated a mentalizing network made

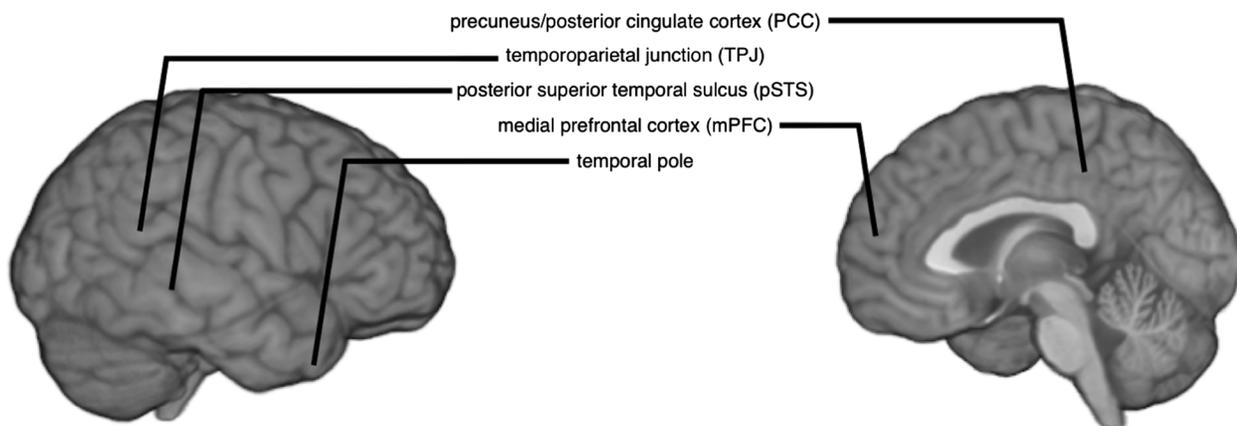


FIGURE 22.6. Mentalizing.

up of the mPFC, pCC, precuneus, TPJ, pSTS, and temporal poles (see Van Overwalle, 2009).

One striking finding is the extent to which this mentalizing system overlaps with the network for self-representation, which suggests that some of the processes perceivers recruit to understand others are also engaged to understand themselves. In particular, the mPFC is activated in virtually all studies that require making judgments about transient or enduring psychological characteristics of oneself or other people (see Mitchell, 2009). Yet studies that include judgments about self and others have generally shown both shared and distinct patterns of activation within the mPFC (Jenkins, Macrae, & Mitchell, 2008; Mitchell, Macrae, & Banaji, 2006; Ochsner et al., 2004, 2005; Saxe, Moran, Scholz, & Gabrieli, 2006). As discussed earlier, a recent meta-analysis revealed that judgments about self versus other within the mPFC are functionally organized along a ventral to dorsal gradient (Denny et al., 2012), a pattern that can be observed in single studies as well (e.g., Mitchell et al., 2006). Interestingly, mentalizing about similar or close others also recruits the regions of the vmPFC that support mentalizing about the self (Krienen et al., 2010; Mitchell et al., 2006; Mitchell, Banaji, & Macrae, 2005), thus suggesting that making inferences about people who are similar or close to one is psychologically and neurally akin to introspecting about one's own mind.

Aside from the mPFC, additional components of the mentalizing system are activated in some, but not all, studies in this research domain. The heterogeneity of results across studies of mentalizing is not altogether surprising given the variety of tasks used by different researchers. It suggests that reasoning about others is not a monolithic process; rather, perceivers recruit different constellations of mentalizing system components depending on the particulars of their task. For instance, increased activation of pSTS (implicated in nonverbal social perception) is consistently observed in mentalizing studies that use nonverbal stimuli such as eye-gaze cues (e.g., Baron-Cohen et al., 1999; Platek, Keenan, Gallup, & Mohamed, 2004) and animations of anthropomorphized geometric shapes (e.g., Castelli, Frith, Happé, & Frith, 2002; Gobbini, Koralek, Bryan, Montgomery, & Haxby, 2007). It seems that

perceivers recruit pSTS for tasks in which nonverbal social cues contain information relevant to mental state attribution. By contrast, TPJ activation is more typically observed in studies that use exclusively verbal variants of Wimmer and Perner's (1983) false-belief paradigm to test children's theory-of-mind competence (e.g., Gobbini et al., 2007; Saxe & Kanwisher, 2003). These studies have led to proposals that TPJ specifically underlies attributions of belief (e.g., Saxe & Kanwisher, 2003). An alternative explanation of TPJ activation is that false-belief paradigms require participants to recruit this region simply to reorient attention to task-relevant stimuli (Decety & Lamm, 2007; Mitchell, 2008). To establish a comprehensive model of the mentalizing system, future SCN research must continue to clarify the independent and interactive contributions of its individual components.

#### COMPLEX SOCIAL PHENOMENA EMERGE FROM INTERACTIONS AMONG CORE SYSTEMS

Just as a cognitive neuroscience approach can explain high-level cognitive abilities, such as working through a difficult math problem, in terms of interacting brain systems enabling, for example, selective attention, cognitive control, and long-term memory, the SCN approach considers complex social phenomena such as empathy and social rejection as emerging from the interaction of more basic component processes, including the six core systems we have outlined. Because neuroscience tools allow researchers access not only to stimulus inputs and behavioral outputs but to the brain mechanisms underlying phenomena of interest, these tools are uniquely capable of revealing interactions of these core systems. In this section, we summarize SCN research aimed at delineating the roles of core processes in the construction of a wide range of social psychological phenomena.

#### Empathy

Despite its prominence in social psychological theory and research, empathy is a notoriously ill-defined construct made up of multiple component processes (Wispe, 1986; Zaki & Ochsner, 2012).

Some studies of empathy have focused on neural responses when observing pain, demonstrating that the magnitude of participants' dACC and anterior insula response is correlated with their self-reported tendency to share others' affective states (Lamm et al., 2007; Lamm, Nusbaum, Meltzoff, & Decety, 2007). Other studies have shown measures of trait empathy to correspond with activation of mPFC (Rankin et al., 2006; Shamay-Tsoory, Tomer, Berger, & Aharon-Peretz, 2003; Shamay-Tsoory et al., 2005; Singer et al., 2004), as well as dorsomedial prefrontal cortex, vLPFC, and ventral striatum (Chakrabarti, Bullmore, & Baron-Cohen, 2006; Kaplan & Iacoboni, 2006; Pfeifer et al., 2008; Rankin et al., 2006; Schulte-Rüther, Markowitsch, Fink, & Piefke, 2007; Shamay-Tsoory et al., 2005; Singer et al., 2004). This diverse array of findings links individual differences in dispositional empathy to activity in the brain's evaluation, experience-sharing, mentalizing, and regulation systems. It may also reflect the heterogeneous conceptualizations of empathy probed by different trait measures. Inspired by social psychological theories that dissect the traditionally unitary construct of empathy into functionally distinct component processes, some researchers have also developed fMRI paradigms aiming to probe particular subcomponents of empathy.

Although early accounts of the brain basis of empathy tended to place sole emphasis on either experience-sharing or mentalizing functions as instantiated by distinct brain systems (see Shamay-Tsoory, Aharon-Peretz, & Perry, 2009), a growing trend in the field advances an integrative model of empathy, using tasks that examine the way in which these two systems may interact to produce empathic outcomes (Keysers & Gazzola, 2007; Spunt & Lieberman, 2012b; Zaki & Ochsner, 2012). Although earlier studies used relatively artificial stimuli that elicited increased activation of either experience-sharing or mentalizing systems (but not both), results from more naturalistic paradigms, such as live joint-attention tasks (Redcay et al., 2010) and video accounts of autobiographical events (Wolf, Dziobek, & Heekeren, 2010; Zaki, Hennigan, Weber, & Ochsner, 2010; Zaki, Weber, Bolger, & Ochsner, 2009), have revealed coactivation of the two systems. Moreover, activity in both

experience-sharing and mentalizing systems predicts the accuracy of perceivers' judgments concerning the target's emotional state (Zaki et al., 2009), as well as feelings of empathy and resultant helping behavior (Rameson, Morelli, & Lieberman, 2012; Waytz, Zaki, & Mitchell, 2012).

Much recent research has conceptualized empathy as a flexible phenomenon and aims to specify when and how particular situational, motivational, and dispositional factors influence the component systems that perceivers recruit (e.g., Decety & Lamm, 2006; Downey, Zaki, & Berenson, 2008; Hein & Singer, 2008; Hodges & Wegner, 1997; Spunt & Lieberman, 2012b; Zaki & Ochsner, 2012). One situational factor affecting empathic responding that is emphasized in social psychological theory is the goal of the perceiver. In the context of empathy for others' emotional experiences, the action identification model would distinguish between identifying the behavioral actions involved in an expression of emotion and then inferring the cause of these actions (Vallacher & Wegner, 1987). Intriguingly, Spunt and Lieberman (2012b) found that participants watching videos of people displaying emotional behavior show neural evidence of experience sharing (but not mentalizing) when simply identifying the emotion displayed and, interestingly, functional coupling of experience-sharing and mentalizing systems when attributing a cause to the emotional behavior.

The relationship between the perceiver and target also influences empathic responding. Converging evidence has indicated that the target's closeness or similarity to a perceiver modulates activity of brain regions supporting experience sharing. For example, when participants are close to or perceive themselves to be similar to a target, they show greater ventral striatum activity when that target wins money (Mobbs et al., 2009) and greater dACC and anterior insula response when that target is in pain (Beeney, Franklin, Levy, & Adams, 2011; Hein, Silani, Preuschoff, Batson, & Singer, 2010; Meyer et al., 2013; Xu, Zuo, Wang, & Han, 2009). Interestingly, people who endorse a preference for social dominance hierarchy over egalitarianism (Chiao, Mathur, Harada, & Lipke, 2009) show lesser dACC and anterior insula responses when

observing others in pain, and men watching competitors experience pain actually show activation of the ventral striatum (Singer et al., 2006), thought to reflect an instance of *schadenfreude*, or joy derived from the misfortune of others (see also Takahashi et al., 2009). Another study (Masten, Morelli, & Eisenberger, 2011) suggested that people observing social pain tend to show more mentalizing activity when targets are unfamiliar and more experience-sharing activity when targets are familiar. Intriguingly, this pattern did not hold for highly empathic perceivers, who showed affect-sharing responses to both familiar and unfamiliar targets. Thus, there is still much to understand about patterns of empathic responding that differ between people and the extent to which these differences are stable versus malleable.

### Prosocial Motivation

A defining feature of human beings is their profoundly social nature. The motivation to affiliate with and care for other people has surely been a big factor in the success of the species. Yet many economic and evolutionary models of human nature have proposed that prosociality and altruism are merely cleverly disguised self-interest—sham displays deployed in the service of protecting a reputation and avoiding social punishment (e.g., Dovidio, 1984). Evidence in support of such a view certainly exists. For example, emphasizing the importance of reputation leads people to distribute resources more equitably (Milinski, Semmann, & Krambeck, 2002), and threatening to punish participants who do not act fairly leads to increased giving that is strongly correlated with activity in the dorsolateral prefrontal cortex (Spitzer, Fischbacher, Herrnberger, Gron, & Gehr, 2007), suggesting active regulation of prepotent responses driven by self-interest.

However, numerous experimental demonstrations have suggested against self-interest as a primary motivator for prosocial behavior (Batson, 1991). For example, even in the complete absence of threats of punishment, most people opt to share money with each other in economic games (Andreoni & Miller, 2002). These findings, together with the results of several recent fMRI experiments, have suggested an alternative model of prosocial acts: Perhaps these acts are motivated by their own

intrinsic value (see Fletcher & Doebeli, 2009). An early imaging study on this topic asked participants to donate money to charities at their own personal expense. Relative to baseline, both receiving money and donating money to charity engaged regions of the brain's mesolimbic dopamine system, including the ventral tegmental area and ventral striatum (Moll et al., 2006). Subsequent studies have shown that the vmPFC also responds during charitable decision making (Hare, Camerer, Knoepfle, O'Doherty, & Rangel, 2010; Zaki & Mitchell, 2011) and that the magnitude of this vmPFC response correlates with the subjective value of the donation (Hare et al., 2010). Moreover, inequitable decisions are associated with activity in the anterior insula, a region associated with negative affect (Zaki & Mitchell, 2011). A parallel line of research has shown that individual differences in pSTS and mPFC activity predict self-reports of altruistic motivation (Mathur, Harada, Lipke, & Chiao, 2010; Tankersley, Stowe, & Huettel, 2007) and that individual differences in mPFC response during a social judgment task predict the later amount of money given and amount of time spent helping another person (Waytz et al., 2012).

Taken together, these findings support the notion that fairness can act as its own reward and show that people who tend to strongly engage the brain's mentalizing system also tend to be generous with their time and money. These studies have drawn strong connections between social understanding, evaluative processing, and altruistic behavior and in doing so provide a preliminary sketch of the mechanisms enabling the sociality that characterizes the human species.

### Social Exclusion

To the extent that social disconnection can be a fundamental threat to survival, socially painful experiences should engage basic neural circuitry involved in processing physical pain (Baumeister & Leary, 1995; Bowlby, 1969; Eisenberger & Lieberman, 2004; Macdonald & Leary, 2005; Panksepp, 1998). Pain researchers have determined that this circuitry includes at least two distinct components: (a) Somatosensory cortex and posterior insula map the sensory pain signal to a particular location on the

body, whereas (b) dACC and anterior insula generate pain's subjectively felt unpleasantness (Price, 2000; Treede, Kenshalo, Gracely, & Jones, 1999).

If processing social pain engages the basic neural systems for processing the affective component of pain, then socially painful experiences should evoke activation in the dACC and anterior insula (Eisenberger, 2012; Eisenberger, Lieberman, & Williams, 2003). To investigate this hypothesis, many fMRI studies have used the Cyberball task to induce social exclusion. In this task, participants believe they are playing a virtual game of catch over the Internet with other study participants (actually computer-programmed players) who, after initially including the participant, stop throwing the ball to the participant entirely. Being excluded from the ball-tossing game in fact reliably evokes increased activation of the dACC and anterior insula (see Eisenberger, 2012). Moreover, just as activity in the dACC and anterior insula correlates with self-reports of the unpleasantness of physical pain (Craig, 2002; Craig, Reiman, Evans, & Bushnell, 1996; Kulkarni et al., 2005; Schreckenberger et al., 2005), activity in these regions also tracks feelings of distress evoked by social exclusion in Cyberball (see Eisenberger, 2012) and by negative feedback about a personal interview (Eisenberger et al., 2011). Converging with findings from research on emotion regulation processes, activation of right vIPFC during social exclusion relates to downregulation of self-reported distress and affective pain regions (Eisenberger, Gable, & Lieberman, 2007; Eisenberger et al., 2003).

Individual differences in activity of affective pain regions also correlates positively with daily life experiences of social disconnection (Eisenberger et al., 2007), as well as with low self-esteem (Onoda et al., 2010), rejection sensitivity (Burklund, Eisenberger, & Lieberman, 2007), and anxious attachment style (DeWall, Masten, Powell, Schurtz, & Eisenberger, 2012; Gillath, Bunge, Shaver, Wendelken, & Mikulincer, 2005; Lemche et al., 2006). However, some factors correlate negatively with this activity, including social support (Eisenberger et al., 2007; Masten, Telzer, Fuligni, Lieberman, & Eisenberger, 2012) and avoidant attachment style (DeWall et al., 2012). Collectively, these studies have provided mounting

evidence that individual differences in sensitivity to social disconnection relate to responsiveness of brain regions that signal affective pain.

### **Grief and Romantic Rejection**

Although most studies have investigated social pain in the context of interacting with strangers, a few have examined the brain systems that respond to the loss of a significant other because of death or the end of a relationship. Two studies have documented activation of dACC and anterior insula when bereaved participants view photographs of deceased loved ones (Gündel, O'Connor, Littrell, Fort, & Lane, 2003; O'Connor et al., 2008), supporting the social pain account of grief. Several studies have also investigated brain processes implicated in romantic rejection, another source of painful loss. In one such study, viewing photographs of a recent ex-partner and thinking about the unwanted break-up elicited increased activation of dACC and anterior insula (Fisher, Brown, Aron, Strong, & Mashek, 2010; Kross, Berman, Mischel, Smith, & Wager, 2011).

Another interesting parallel between studies of grief and romantic rejection concerns the role of the reward system. In participants suffering from complicated grief (i.e., prolonged, unabated grief), this task additionally engaged the ventral striatum, and the magnitude of this response correlated with self-reported yearning for the deceased (O'Connor et al., 2008). This pattern of results corroborates the role of reward circuitry in attachment and suggests that enduring reward responses to reminders of the deceased may interfere with adaptively letting go of this attachment. In a study of people who were still intensely in love with an ex-partner, activity while viewing images of the ex was observed in the ventral striatum, vmPFC, and ventral tegmental area, regions implicated in reward, craving, and addiction (Fisher et al., 2010). Together, these findings suggest that engagement of reward circuitry, which likely serves a function in sustaining the bonds of a close relationship, may become maladaptive when it endures after a relationship terminates. These studies have laid the groundwork for a functional neuroanatomy of grief and romantic rejection. It would be fruitful for future studies to examine how

trajectories after a loss can be shaped by various individual- and relationship-level factors.

Comparing neuroimaging findings from studies on grief and romantic rejection has also yielded several divergent results that have not yet been adequately explained. First, studies of grief have yielded activation of the PAG (Gündel et al., 2003; O'Connor et al., 2008), but studies of romantic rejection have not. Second, although studies of both types of social loss implicate dACC and anterior insula, reminders of romantic rejection additionally elicit responses in neural substrates underlying the sensory components of pain: posterior insula (Fisher et al., 2010; Kross et al., 2011) and secondary somatosensory cortex (Kross et al., 2011). Explicating the functional roles of these threat- and somatosensory-related components in processing grief and romantic rejection, respectively, remains a goal of future SCN research on social loss.

### Romantic Love and Attachment

Love is a complex and elusive object of scientific inquiry, varying significantly across cultures and individuals, as well as within a given relationship over time. Neuroimaging methods allow researchers to unravel some of the component psychological processes underlying the construct of romantic love, including caregiving, attachment, and sexual attraction (Acevedo, Aron, Fisher, & Brown, 2012; Fisher, Aron, & Brown, 2005, 2006). Many fMRI studies of love and attachment have shown participants in the scanner images of a loved one. These studies have typically implicated regions involved in basic reward and motivation systems in responding to romantic targets (Acevedo et al., 2012; Aron et al., 2005; Bartels & Zeki, 2000, 2004; Fisher et al., 2005, 2006, 2010; Leibenluft, Gobbini, Harrison, & Haxby, 2004; Ortigue, Bianchi-Demicheli, Hamilton, & Grafton, 2007; Ortigue, Bianchi-Demicheli, Patel, Frum, & Lewis, 2010). Some studies have also reported increased activation of the mentalizing system (Leibenluft et al., 2004; Seifritz et al., 2003), whereas others have reported the opposite (Bartels & Zeki, 2000, 2004). Such conflicting results are perhaps not surprising given the complexity and heterogeneity of love as a psychological construct.

Paradigms that involve active tasks—rather than passive viewing of stimuli—have gained more traction, particularly in elucidating the brain systems underlying attachment in close relationships. Some social psychologists have suggested that secure attachment figures provide a critical analgesic safety signal, particularly during threatening or painful situations (Ainsworth, 1979; Bowlby, 1988; Feeney & Kirkpatrick, 1996; Hazan & Shaver, 1987). Consistent with this account, exposure to an attachment figure during physically painful circumstances reduces both self-reported physical pain (Eisenberger et al., 2011; Master et al., 2009; Younger, Aron, Parke, Chatterjee, & Mackey, 2010) and associated neural responses in affective pain regions such as the dACC and anterior insula (Eisenberger et al., 2011; Younger et al., 2010). Moreover, the pain relief associated with the presence of a romantic partner is directly linked to recruitment of systems that inhibit threat-related responding, including vmPFC (Eisenberger et al., 2011) and the ventral striatum (Younger et al., 2010), which may support implicit emotion regulation and retrieval of rewarding associations. In addition to inhibiting recruitment of affective pain regions and decreasing self-reported pain ratings, vmPFC activity also tracks relationship length and perceived social support provided by the romantic partner (Eisenberger, Master, et al., 2011). Exposure to images of a supportive attachment figure also reduces neural responses underlying distress induced by social exclusion (Karremans, Heslenfeld, van Dillen, & Van Lange, 2011). Turning to attachment processes more broadly construed, it has been shown that, although positive social feedback has been associated with increased activation of reward-related regions such as ventral striatum (e.g., Izuma, Saito, & Sadato, 2008), this activity is less apparent for those with an avoidant attachment style (Vrtička, Andersson, Grandjean, Sander, & Vuilleumier, 2008).

### Moral Judgment

Philosophers and psychologists have long asked how it is that people come to know what is right and wrong and on what factors this knowledge is based. Recent work in the neuroscience of moral judgment has begun to contribute to this line of inquiry in

several intriguing ways. As is the case with most social and cognitive neuroscience research, early studies of this topic focused on the functional inferential goal of mapping moral cognition to putative brain substrates. These studies often proceed by constructing controlled contrasts between types of stimuli that ostensibly differ only in terms of their moral content. For example, participants may be scanned while reading sentences describing moral violations (e.g., “He shot the victim to death”) versus social violations (e.g., “He licked the dirty toilet”)—these types of studies have revealed greater vmPFC response to moral versus nonmoral stimuli (Harenski & Hamann, 2006; Heekeren, Wartenburger, Schmidt, Schwintowski, & Villringer, 2003; Moll, de Oliveira-Souza, Eslinger, et al., 2002), supporting the notion that basic affective evaluation processes subserved by the vmPFC contribute to moral judgment (reviewed in Young & Dungan, 2011).

Other studies have opted to contrast one or more different types of moral cognition with each other. An early investigation into this topic contrasted “personal,” or highly emotionally salient, moral decisions, such as physically shoving a man off a bridge to save five other people from being killed, with “impersonal” moral decisions, such as rerouting a trolley so it hits one man instead of five others (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). This study found that the personal scenarios were associated with vmPFC activity and that the magnitude of this activity predicts participants’ tendency to condemn the emotionally salient act of shoving one man to save five others. The same personal scenarios were also associated with increased activity in lateral PFC and parietal cortex, which Greene et al. (2001) interpreted as reflecting processing of the cognitive and emotional conflict involved in such trials, an inference bolstered by behavioral data showing that response times for personal dilemmas were longer when the participants responded that the act was morally appropriate versus morally inappropriate.

In addition to vmPFC, several studies of moral judgment have generally implicated TPJ and posterior STS, regions crucial to mentalizing and self-representation (Berthoz, Grèzes, Armony, Passingham, & Dolan, 2006; Moll, de Oliveira-Souza,

Bramati, & Grafman, 2002; Moll, de Oliveira-Souza, Eslinger, et al., 2002). Subsequent research has shown modulation of activity in these regions by particular aspects of the moral scenario, including the actor’s intentions (Schaich Borg, Hynes, Van Horn, Grafton, & Sinnott-Armstrong, 2006) and the consequences of the actor’s actions (Young, Cushman, Hauser, & Saxe, 2007).

Thus, what has largely emerged from these studies aimed at uncovering the moral brain is that the brain substrates of moral judgment largely overlap with areas of the brain crucial in evaluative, regulatory, and social processing (Young & Dungan, 2011). As such, the weight of the neural evidence suggests that the evaluation, regulation, and mentalizing systems act as key inputs to moral judgment, a conceptualization complementary to current social psychological theories of morality (e.g., Haidt, 2007) and encouraging for future investigators interested in the interaction of these component processes.

### Conformity

Why do individuals conform to the judgments and behavior of others? This question has always been central to social psychology, inspiring a research agenda spanning several decades (Asch, 1956; Sherif, 1936; Turner, 1991). Most of the findings in this area are broadly consistent with two potential accounts of conformity. The first, private acceptance, proposes that individuals might be drawing on the behavior of others to inform and truly modify their own judgments. The second, public compliance, holds that individuals could merely be professing agreement with norms they do not accept to obey perceived requests and avoid social sanctions. These two sources of conformity, conflated in many behavioral studies of this phenomenon, have proved exceedingly difficult to disentangle empirically.

Aiming to isolate the effects of private acceptance, many studies have asked participants to provide their responses anonymously and in private. Yet even these requirements cannot rule out the possibility of participants conforming because of the influence of implied or imagined others (Allport, 1954). Indeed, a meta-analysis of nearly 100 studies of conformity indicated that responding publicly

versus privately has no effect on participants' responses (Bond & Smith, 1996). In its attempt to measure the isolated effects of private acceptance uncontaminated by public compliance effects, empirical research on conformity has been mired by this quandary: Measuring social modulation of privately held beliefs requires that participants explicitly report their judgments, but this necessarily introduces the possibility of public compliance, if even to the experimenters themselves.

Recently, several studies have used neuroimaging to distinguish public and private sources of conformity effects by using both explicit (self-report) and implicit (neural) measures of evaluations of the objects of social influence. One study examined the reevaluation of facial attractiveness owing to exposure to peer ratings (Zaki, Schirmer, & Mitchell, 2011). Participants provided attractiveness ratings for a series of faces before and then again after learning how their peers had rated each face; consistent with extant behavioral findings, participants' second attractiveness ratings conformed to peer norms. Neural responses collected during the second rating period revealed that changes in participants' ratings tracked with activity in brain regions of the evaluation system that code subjective value (vmPFC and ventral striatum). Thus, exposure to peer norms changed explicit attractiveness ratings of faces as well as evaluative neural responses (Zaki et al., 2011).

Neuroimaging paradigms have also shed light on the conflict processes evoked when participants find out that other people disagree with their judgment and how these processes predict later conformity with these other people. Several studies have shown that conflict with social norms results in deactivation of ventral striatum and activation of dACC and anterior insula, whereas agreement with norms produces an inverse pattern of activation (Berns, Capra, Moore, & Noussair, 2010; Campbell-Meiklejohn, Bach, Roepstorff, Dolan, & Frith, 2010; Klucharev, Hytonen, Rijpkema, Smidts, & Fernandez, 2009). On a trial-by-trial basis, stronger conflict-related signals in dACC and striatum predict subsequent behavioral judgment adjustments in line with group norms (Klucharev et al., 2009). Moreover, activation of dACC and anterior insula during conflict with social norms predicts individ-

ual differences in behavioral conformity effects (Berns et al., 2010; Campbell-Meiklejohn et al., 2010; Klucharev et al., 2009).

Collectively, these studies have charted a course that enables conformity research to circumvent long-standing obstacles of the field, distinguishing private and public sources of conformity as well as clarifying their particular antecedents and consequences. By drawing on these findings, researchers can better understand specific stages of conformity processes and the psychological operations they engage. Revealing how the processes underlying particular conformity effects are modulated by situational (e.g., exposure to peer vs. expert attitudes), developmental (e.g., adolescent vs. adult populations), and dispositional (e.g., individual differences in rejection sensitivity) factors remains an important goal for future SCN research.

## CONCLUSIONS AND THE NEAR FUTURE OF SOCIAL COGNITIVE NEUROSCIENCE

In this chapter, we have sketched out a précis of the guiding principles of the SCN approach, nominated a short list of brain systems core to social cognitive functioning, and illustrated efforts to explain complex social phenomena in terms of interactions among these core systems. Along the way, we have tried to emphasize the value of neuroimaging research in teaching researchers more about what particular parts of the brain do and how this information can then be used to discover how the social mind works.

For the behavioral psychologist considering engaging with the SCN approach, there are, at present, reasons for both caution and enthusiasm. On the cautionary side, there is little doubt that studies using artificial and highly simplified tasks run the risk of generating patterns of social cognitive brain activity that differ systematically from brain activity underlying everyday social experience. In addition, studies that apply a subtractive logic to isolate the neural correlates of high-level psychological phenomena such as romantic love risk obscuring the possibility that such phenomena actually reflect the emergent properties of more basic brain systems. Fortunately, however, there are reasons for

enthusiasm as well. Studies along all points of this spectrum have expanded with amazing speed in the past decade: The broad view of this work provides an increasingly refined model of how the fundamental building blocks of the mind give rise to the most complex human experiences. Recent years have seen social scientists applying brain imaging tools to address some of social psychology's oldest questions, revealing, as a few examples, that conformity and altruism modulate basic neural computations of value, that judging an act as moral entails interplay of evaluation, regulation, and mentalizing processes, and that social rejection activates systems for processing conflict and registering affective pain. These early successes suggest that SCN will fulfill its promise in continuing to contribute to advancements in social psychological theory. We hope that this constructionist approach will also be profitably extended toward identifying the core systems underlying social cognitive psychiatric impairments (see Insel, 2010), life span changes (see Mather, 2012), cultural influences (see Chiao & Cheon, 2011), and untold other phenomena, shedding light on questions both long enduring and previously unasked.

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