

Contributions of Functional Neuroimaging to the Study of Social Cognition

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ABSTRACT—*Increasingly, researchers have been applying the methods of cognitive neuroscience—especially functional neuroimaging—to address questions about how humans make inferences about the mental states of others. At the same time, a number of critics have warned against the use of these new techniques by suggesting that functional neuroimaging has been unable to provide novel insights into the nature of social cognition. Addressing these critiques, this article briefly describes some of the ways in which functional neuroimaging has indeed redirected the study of the social mind, reviewing not only the novel data these techniques have provided but also the ways in which cognitive neuroscience has prompted researchers to consider entirely new questions about the organization of human social cognition. Such questions include whether or not there are cognitive processes dedicated for social thought; what the constituent parts of our social-cognitive system might be; how social cognition overlaps with other mental processes in previously unanticipated ways; and whether social cognition might play a privileged role in the human cognitive repertoire.*

KEYWORDS—*social cognition; social neuroscience; theory of mind; mentalizing; self*

Throughout its history, social psychology has been deeply concerned with the mental states, representations, and mechanisms that underlie social behavior (e.g., Heider, 1958). Starting in the late 1970s, the term *social cognition* was introduced to explicitly identify a new interest in understanding how the mind operates in social contexts (Fiske & Taylor, 1984; Wegner & Vallacher, 1977). This research has addressed basic questions about the

mechanisms that support the complex ability of one human to understand another in terms of that person's internal mental states such as beliefs, feelings, goals, and attitudes. Accordingly, a central goal of the study of social cognition has been to understand the cognitive processes that permit one human to make accurate and rapid inferences about the internal states of another—that is, to mentalize about other people.

Researchers are increasingly adapting the methods of cognitive neuroscience to address such questions about the social mind. Beginning in the mid-1990s, an expanding number of studies have used functional neuroimaging techniques, such as positron emission tomography and functional magnetic resonance imaging (fMRI), to examine the processes that subserve inferences about the mental states of others. This research has provided one of the most consistent observations in cognitive neuroscience—namely, that the processes that occur during mentalizing are associated with a small number of brain regions, including the medial prefrontal cortex (MPFC), temporo-parietal junction, precuneus/posterior cingulate, amygdala, superior temporal sulcus, and temporal poles (Fig 1).

However, at the same time that social cognition has busily expanded its neuroimaging portfolio, a fairly regular chorus of critics has questioned the potential value of these new techniques, suggesting that functional neuroimaging may be fundamentally unable to provide novel insights into the nature of cognitive processes (or, at the very least, that it has yet to do so in actual practice; Coltheart, 2006; Willingham & Dunn, 2003). What, these commentators have asked, has neuroscience told psychology that we could not otherwise have figured out using other, more established measures such as accuracy and response latency? Have the expense and effort of neuroimaging studies been justified by novel observations about social cognition that could not have been obtained using the (cheaper and less technically demanding) methods that psychologists have come to know and love? Of course, scientists evaluate the validity of newly introduced methods against existing measures, so the

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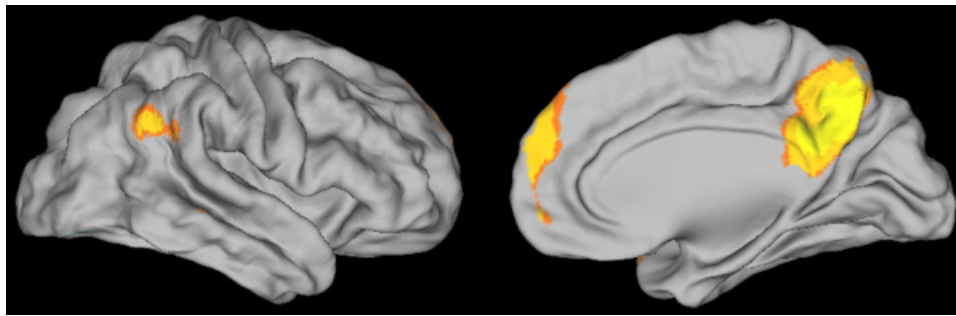


Fig. 1. Three brain regions commonly modulated by tasks that require inferences about the mental states of other people. The image isolates the right hemisphere, showing the outer (lateral) view on the left, and the inner (medial) view on the right. Highlighted in the left panel is a region of the temporo-parietal junction, toward the back of the right hemisphere. Highlighted on the left side of the right panel is the medial prefrontal cortex—situated at the front of the brain’s medial surface—and, toward the right (posterior) portion, the precuneus/posterior cingulate.

requirement that neuroimaging studies yield observations that could not, in principle, be made via other methods is fatuous. To have any value to psychology, functional neuroimaging—like any other empirical method—must produce results not only that converge with extant findings in the field but that can be verified with other methods. As one method among many for studying human cognition, functional neuroimaging should be held to standards commensurate with those used to evaluate other measures used by psychologists.

Yet, regardless of whether neuroimaging has produced unique insights into cognition that would have been impossible without it, the field of social cognition, like psychological science in general, is currently awash in empirical observations and theoretical concepts that nevertheless were not (and probably would not have been) developed without neuroimaging. The incorporation of functional neuroimaging by social cognition has resulted in an irreversible shift within the field, not only producing data of a new kind but, more importantly, prompting researchers to consider novel questions about the organization of human social behavior. That is, functional neuroimaging has suggested where psychologists might profitably address their empirical efforts as often as it has provided the appropriate methodology for doing so. As such, the main contribution of neuroimaging to social cognition has primarily been to bring into focus a series of questions about the social mind that might have been—but were not—asked by researchers using other empirical methods.

DO SOCIAL AND NONSOCIAL COGNITION DRAW ON DISTINCT OR OVERLAPPING PROCESSES?

Among the first contributions made by functional neuroimaging to the study of social cognition has been to demarcate a potential border between social and nonsocial cognition. As Blakemore, Winston, and Frith (2004) have noted, “one key question is whether general cognitive processes involved in perception, language, memory, and attention are sufficient to explain social competence, or whether over and above these general processes,

there are specific processes that are special to social interaction” (p. 216). In other words, is social cognition continuous with other kinds of mentation or do the inferences we make about other minds rely on a set of cognitive processes that are simply not required by other kinds of thought (i.e., about nonsocial entities)?

Functional neuroimaging is particularly well suited to address this question. To the extent that different brain regions generally subservise different cognitive processes (Henson, 2005), one can interpret differences in the brain regions associated with two different tasks as evidence that they recruit cognitive processes that are distinct from one another. Consistent with a view that social cognition may rely on a set of unique cognitive processes, a small number of brain regions has consistently distinguished social-cognitive from nonsocial tasks. In particular, activation in the MPFC has nearly ubiquitously been observed in experiments that oblige participants to consider the psychological characteristics of another person, relative to when participants engage in tasks that do not require such mentalizing. For example, in one of the earliest functional neuroimaging studies of social cognition, Fletcher et al. (1995) observed differential MPFC activation when participants read stories that required mental attribution, relative to those that required an understanding of physical causality. Since then, MPFC activation during social cognition has been observed dozens of times, across tasks that vary in the particular stimuli used to invoke mental-state inferences (e.g., cartoons, stories, photographs of faces); the kinds of mental states perceivers were required to consider (e.g., beliefs, feelings, physical sensations); and the kinds of behavioral tasks that participants performed while being scanned (e.g., passive reading vs. explicit mentalizing; for a review, see Blakemore, Winston, & Frith, 2004).

This putative “signature” of social cognition has, in turn, allowed researchers to revise earlier interpretations of a number of empirical phenomena within social psychology. For example, in the late 1970s, researchers began to report differences in memory depending on whether participants considered another

person's mind by forming an impression of the person based on brief description of his or her behaviors (e.g., "Stepped on his girlfriend's feet while dancing") or simply memorized the descriptions (Hamilton, Katz, & Leirer, 1980; Hastie & Kumar, 1979). Specifically, memory was not only better for information encoded as part of the social-cognitive task (i.e., a quantitative difference) but overall patterns of memory often differed as a function of the two tasks (i.e., a qualitative difference). At the time, researchers interpreted these qualitative differences in patterns of memory as resulting from greater recruitment of the same stock of general-purpose cognitive processes; for example, impression formation was considered to be a "deeper," more elaborative encoding task than nonsocial control tasks.

However, Mitchell, Macrae, and Banaji (2004) recently used functional neuroimaging to suggest a different interpretation of these findings—namely, that social-cognitive tasks produce different patterns of memory performance because they engage qualitatively distinct forms of cognitive processing. Participants in this study underwent fMRI scanning while reading short, descriptive phrases about people's behavior and either forming impressions of those people or intentionally memorizing the sequence of presented material. Consistent with the possibility that social cognition may recruit unique types of cognitive processing, a distinct pattern of brain activity emerged for comparisons of the social vs. nonsocial tasks: Impression formation preferentially engaged regions of the MPFC, whereas the intentional-encoding task did not. Moreover, activity in this MPFC region correlated with the likelihood that a particular piece of information would later be remembered, but only for those items encountered as part of the impression-formation task. The qualitative nature of this dissociation is the nontrivial aspect of these findings: It might just as well have been the case that social cognition engaged a different level of activation in the same set of brain regions associated with other kinds of higher-order cognition. That it instead was found to recruit activity in a distinct set of brain regions suggests that earlier researchers of social cognition may have been fairly conservative in discussing social-cognitive computations as extensions of general-purpose processes rather than as a discrete set of mental operations.

Interestingly, functional neuroimaging has also recently been used to demonstrate situations in which the inverse may be true—that social cognition may at times recruit processes that overlap unexpectedly with nonsocial tasks. Besides linking to the MPFC, social-cognitive tasks have frequently been linked to activation of the right temporoparietal junction (RTPJ). Work by Saxe and colleagues (e.g., Saxe & Kanwisher, 2003) has repeatedly demonstrated that this region is differentially activated by stories that refer to the content of another person's erroneous beliefs (e.g., someone mistakenly thinking that a piece of red glass is a precious gem) compared to stories that refer to erroneous physical representations (e.g., a photograph that becomes outdated after the scene it depicts undergoes change). At the same time, a very similar region of RTPJ has been consistently

implicated in tasks that require attentional reorienting—for example, when one's visual attention is directed away from a task-relevant location and has to be redirected appropriately. In recent work, these two RTPJ regions have been shown to be one and the same—that is, the region of RTPJ preferentially activated by some mentalizing tasks also responds during attentional miscuing by decidedly nonsocial targets (Mitchell, 2008). This finding adds an unexpected twist to the literature on social cognition, suggesting that drawing inferences about another's beliefs may recruit some cognitive process that is likewise deployed for particular kinds of endogenous control of attention. Although an exact description of what this process entails has yet to be outlined, the use of functional neuroimaging in this context has produced an unanticipated bridge between two research enterprises that in all likelihood would have otherwise continued to proceed in isolation from one another. It is unclear how more traditional research, using strictly behavioral methods, would have as readily demonstrated that social cognition and attentional reorienting apparently face a shared cognitive challenge, addressed by an overlapping set of mental processes.

IDENTIFYING THE PROCESSES UTILIZED DURING SOCIAL COGNITION

The foregoing discussion suggests both that some behavioral observations result from the distinctiveness of social cognition and that some aspects of social cognition may draw in unexpected ways on shared cognitive processes. However, researchers strive not only to delineate situations in which social and nonsocial tasks recruit divergent or overlapping cognitive processes but also to reveal the identity of those processes. How exactly do perceivers gain access to what others are thinking and feeling? Can neuroimaging contribute to attempts to describe the processes that are brought to bear during social cognition by proactively "ruling in" which mental operations might subserve inferences about others' minds?

Recently, a number of studies have used functional neuroimaging to address a long-standing theoretical dispute about how exactly mentalizing takes place. One side in this debate has noted that, although we never directly perceive others' mental states (which are inherently unobservable constructs), perceivers do enjoy direct access to what may be a reasonable model of other minds—namely, their own mental states. Such self-referential accounts of social cognition suggest that when inferring the thoughts and feelings of another person, perceivers might profitably simulate what they would think or feel in the same situation, almost as if they were "in the shoes" of the target person. One can then project the output of this simulation (consciously or unconsciously) onto the experience of the target by assuming that the other person thinks or feels something akin to one's own simulated experience. In contrast, a second view has suggested that perceivers may instead reason about social cognition in a rule-based manner. In this theory, social cognition

comprises a basic body of knowledge about how other minds work (e.g., people will feel hunger after fasting for 24 hours) and a set of rules for combining these building blocks into complex inferences about another's mental experience (perhaps akin to a "social grammar").

Using functional neuroimaging, a sizeable number of recent studies have demonstrated support for the former, self-referential theories of social cognition. Specifically, researchers have consistently found that the same brain regions are activated both by the experience of an affective state—such as fear, disgust, or pain—and the observation of another person experiencing that same state. For example, regions of the anterior cingulate cortex that are thought to be involved in the subjective experience of pain are also modulated by watching videos of someone else about to undergo bodily harm (such as a person cutting her finger with a kitchen knife; Singer et al., 2004). Likewise, smelling a foul odor engages the same subregions of the anterior insula as does watching another person express smell-induced disgust (Wicker et al., 2003). Extending these observations beyond affective experience, researchers have also observed such overlap between the neural substrates involved in goal-directed action and observing the same action in others (Rizzolatti & Craighero, 2004) and, recently, between regions engaged when reporting one's own preferences and opinions and those activated when inferring the preferences and opinions of others (Mitchell, Macrae, & Banaji, 2006). The neural overlap between one's own experience and the observation of similar experiences in others weighs heavily in favor of self-referential, simulationist views of social cognition that have posited exactly such a link between self and other. Of course, this is not to say that social cognition proceeds exclusively via simulation; indeed, an active area of current investigation seeks to delineate the specific contexts in which mentalizing may or may not include self-referencing (e.g., do we mentalize self-referentially for all targets, including those dissimilar from us?). Although evidence for self-referential mentalizing has also come from earlier research using traditional behavioral measures, functional neuroimaging has provided a renewed emphasis on thinking about social cognition as relying on the "co-registration" of mental states among people.

THE PRIMACY OF SOCIAL COGNITION

The final consideration in this brief sketch of social-cognitive neuroscience derives uniquely from examination of the brain-based implementation of social cognition. As discussed above, social-cognitive tasks have consistently been linked to a few brain regions, the most common being the MPFC, temporo-parietal junction, and precuneus/posterior cingulate cortex. Interestingly, each of these brain regions is distinguished by a distinctive physiological property: an unusually high rate of metabolic activity. Specifically, researchers have recently observed that different brain areas have overall higher or lower

rates of metabolism when individuals rest passively without performing a specified task (Gusnard & Raichle, 2001), suggesting that regions may differ in the baseline level with which they carry out cognitive processing. This observation suggests that, when allowed to relax to baseline, the human brain seems to persist in some kinds of cognitive processing, which are subserved by regions with high resting metabolic rates. Of interest to researchers of social cognition is the fact that the regions with the highest resting metabolic rates are also those implicated in social cognition, implying that the human mind has a particular propensity for social thought.

Even more suggestively, these same brain regions demonstrate a tendency to "deactivate" when individuals engage in nonsocial tasks. That is, when asked to perform a task that highlights something other than the mind of another person, the human brain seems to suppress the high resting activity in regions that subserve social cognition. The tendency to deactivate during nonpreferred tasks distinguishes mentalizing-sensitive regions from most others in the brain; for example, when we engage in nonlinguistic tasks, language-sensitive regions of the human brain do not proactively "switch off" but simply remain at baseline. That activity in the regions subserving social cognition appears to be actively dampened during nonmentalizing tasks implies that the processing in these regions may be fundamentally incompatible with nonsocial cognition. Together, these observations suggest, albeit speculatively, that the human cognitive system may be in a state of continuous readiness to encounter other minds (hence the high resting metabolic rate evinced by these regions) and that this social default must be actively suspended to engage appropriately with nonsocial entities such as inanimate objects.

CONCLUSION

Like most areas of psychology—from research on perception, attention, and memory to the study of consciousness and executive control—social cognition has been heavily influenced by a recent influx of methods from cognitive neuroscience. This integration has resulted in several kinds of contributions to the study of the social mind. First, the use of functional neuroimaging has steered researchers toward a set of questions that they were not yet pursuing actively. Unsurprisingly, these questions naturally tend to be those that functional neuroimaging is especially adept at addressing, such as how social cognition may alternately diverge from and overlap with other, nonsocial forms of mentation. Second, researchers have used functional neuroimaging to augment their search for the processes of which social cognition consists. In particular, these techniques have provided data that affirm a long-standing notion that thinking about the minds of others may draw—at least at times—on the same processes used for thinking about one's own mental states. Finally, research on the neural basis of mentalizing has unexpectedly suggested that social cognition may enjoy a particular kind of

privileged status in the brain, being subserved by regions that appear continuously active. Considered together, these observations belie arguments that cognitive neuroscience has contributed weakly (or not at all) to the psychology of social thought. Like its sibling areas of cognitive study, social cognition highlights the potential for functional neuroimaging to illuminate new avenues of inquiry, to provide novel empirical observations, and to bridge seemingly disparate areas of psychological research.

Recommended Reading

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- Frith, C.D., & Frith, U. (1999). Interacting minds – A biological basis. *Science*, *286*, 1692–1695. One of the first—and still most influential—reviews of the brain basis of human social cognition.
- Mitchell, J.P. (2006). Mentalizing and Marr: An information processing approach to the study of social cognition. *Brain Research*, *1079*, 66–75. Outlines an approach to studying social cognition using the information processing metaphor that has been instrumental in other areas of cognitive neuroscience.
- Saxe, R., Carey, S., & Kanwisher, N. (2003). Understanding other minds: Linking developmental psychology and functional neuroimaging. *Annual Review of Psychology*, *55*, 1–38. Combines insights from both developmental and neuroscientific work on mentalizing to suggest the “specialness” of social cognition.
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