

# The Social Cognitive Brain

## *A Review of Key Individual Difference Parameters with Relevance to Schizophrenia*

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Individuals with schizophrenia exhibit poor general information processing ability, which is thought to reflect a generalized disruption of neuronal connectivity in the brain (e.g., Heinrichs & Zakzanis, 1998; Hoff et al., 1999; Karlsgodt et al., 2008; Taylor & Abrams, 1984). These impairments have been shown to adversely affect functional outcomes, including social problem-solving ability and social skill acquisition (e.g., Green, 1996; Liddle, 2000). However, a critical question is whether anything particular is disrupted in how such individuals process social information. Before that question can be answered, one would need to answer the question of whether there is something special about social information processing per se. Some have argued that social intelligence is just "general intelligence applied to social situations" (Wechsler, 1958, p. 75). This chapter will review the literature illustrating a different view, that social and emotional information processing is indeed distinct from nonsocial information processing.

The chapter will primarily focus on the state of the field of basic social cognitive neuroscience to set the stage for a focus on clinical populations; namely, social cognitive neuroscience in schizophrenia. To that end, we will focus on domains that may be particularly disrupted in individuals with schizophrenia, either based on typical clinical presentation (i.e., symptomatology) or reliance of processing on distributed neural networks, which are evidently disrupted in schizophrenia (e.g., Bullmore, Frangou, & Murray, 1997; Friston & Frith, 1995). Specifically, the focus will be on self- versus other-oriented information, emotion perception, intentional and incidental emotion regulation processes, and the tendency versus capacity to engage in such processes.

## THE SELF

Social cognitive neuroscience is increasingly revealing distinct networks for social types of information, differentiating between nonemotional ("cold") cognition and social-emotional ("hot") cognition. A basic premise assumed by the existence of a cohesive social cognition network is the ability to distinguish between *self* and *other*. This would include existence of an intact sense of self to allow for self-referential knowledge, as well as the ability to understand others' mental states as necessary for psychological states such as empathy, which is important for normative subsequent social interactions. Researchers have sought to reach a workable definition of *self*, operationalizing both physical aspects of the self, including a sense of ownership and agency over one's body, and psychological aspects of the self, including self-relevance of stimuli and "metarepresentation" of one's own mental states (Gillihan & Farah, 2005; Vogeley et al., 2001). Such operational definitions allow for an empirical approach to the study of self-consciousness, a burgeoning area of inquiry within the field of social cognitive neuroscience.

Sense of ownership involves recognition of being the one who is undergoing an experience, whose body is moving or responding, whether or not the movement or response is voluntary (Gallagher, 2000). On the other hand, a sense of agency has been defined as the recognition of being the cause of an action, the sense of initiating and executing one's own actions as opposed to another's actions (Blakemore & Frith, 2003; Gallagher, 2000). To illustrate the difference between the two, a sense of ownership would be intact during passive or involuntary movements (such as when one's arm is moved by someone else), whereas a sense of agency would, in this case, be violated (David, Newen, & Vogeley, 2008). Both ownership and agency contribute to the self-other distinction in the physical domain critical to the experience of self-consciousness. However, sense of agency may be of particular relevance to patient experiences in schizophrenia, especially in regards to delusions of thought, mind, and/or action control (Gillihan & Farah, 2005). In a study by Spence and colleagues (1997), patients with delusions of control or loss of agency who erroneously attributed their actions to another showed abnormally high activation in right inferior parietal cortex (Spence et al., 1997).

According to a substantive review by Gillihan and Farah (2005), some physical aspects of the sense of self fail to show conclusive evidence of specialization, according to criteria of anatomical specificity, functional uniqueness, and functional independence. Specifically, they conclude that there does not appear to be a coherent or cohesive neural network for the holistic representation of the physical self. In addition, awareness and tracking of movement and position of the spatial layout of one's body seems to be represented in common with the layout and tracking of other people's bodies. On the other hand, body part ownership shows evidence of functional independence and anatomical specificity to the right supra-marginal gyrus, as demonstrated by lesion studies (Gillihan & Farah, 2005).

Imaging studies have implicated several brain areas specifically in action ownership, or the sense of agency, beyond those regions of the motor system

(i.e., premotor cortex [PMC], supplementary motor area [SMA] and pre-SMA, and the cerebellum) commonly activated by planned, imagined, or actual motor activity. As demonstrated in studies utilizing imagined and actual self-action compared to imagined or actual experimenter or other action, these regions include anterior and posterior insula, posterior inferior parietal cortex, dorsolateral prefrontal cortex (dlPFC), and the posterior segment of the superior temporal sulcus (pSTS; David et al., 2008; Farrer & Frith, 2002; Jeannerod, 2004; Leube et al., 2003; Powell, Macrae, Cloutier, Metcalfe, & Mitchell, 2009; Ruby & Decety, 2001). In particular, Farrer and Frith (2002) suggest that the anterior insula plays a role in the elaboration of an image of the body in space and in time. In addition, the insula may be a site for the integration of multimodal sensory signals associated with voluntary movements, which are attended to during self-attribution. The inferior parietal cortex, in contrast, may be a site for the elaboration of internal representations of the external world and one's interactions with it, to then represent movements in an allocentric (as opposed to egocentric) coding system that can be applied to the actions of others, as well as to the self (Farrer & Frith, 2002).

More recent studies have begun to engage multiple elements thought to be involved in the construction of self-consciousness to begin to deconstruct how such elements are organized and interact in the brain. For example, David and colleagues utilized a virtual ball-tossing game to simulate agency versus observing another person as agent of action from both a first- and third-person perspective (David et al., 2006). No significant neural interactions between agency and perspective taking were observed, although there was an overlap of activity in medial prefrontal regions associated with representations of one's own perspective and actions. Finally, few studies to date have investigated the functional relationship between regions during sense of agency to identify neural networks in support of the creation of self. In one recent study, David and colleagues (2007), utilizing a psychophysiological interaction (PPI) method, found enhanced functional connectivity between posterior inferior parietal cortex and a region of occipitotemporal cortex (also known as the extrastriate body area) during judgments of agency. Both regions were more active when visual feedback was incongruent to the subjects' own executed movements, indicating involvement in distinguishing whether actions are caused by oneself or by another person (David et al., 2007).

In terms of the psychological aspects of *self*, it is easy to intuit that the manner in which individuals process self-relevant information and self-knowledge may be distinct from that of other types of information, including information about other people and their mental states. However, capturing the nature of that distinctive processing within an experimental setting has proved to be a challenge, as evidenced by the wide range of task paradigms utilized and their somewhat disparate findings (e.g., Gillihan & Farah, 2005; Lombardo et al., 2009). However, a growing body of literature continues to investigate whether a specialized neural system in the brain may support self-referential information processing. This type of information might include self-face identification, conceptual representations of self, self-evaluation, and self-referential

emotions (Kircher et al., 2000; Morita et al., 2008; Platek, Keenan, Gallup, & Mohamed, 2004; Platek, Thomson, & Gallup, 2004; Powell et al., 2009; Zinck, 2008). Although overlapping in many ways with studies of the physical self, self-identification has generally been viewed as a psychological self-oriented process and has been investigated in a variety of ways. For example, studies using morphed facial images require self-other discrimination from pictures of the self morphed to varying degrees with famous, familiar, or unfamiliar faces. Neuropsychological case studies using these task paradigms have found evidence for right hemisphere specialization for self-identification (reviewed in Gillihan & Farah, 2005). A left-hand advantage in reaction time (implicating right hemisphere dominance) for self-face recognition has also been demonstrated, with the speed of recognition further facilitated by multimodal sensory self-priming (i.e., exposure to one's own body odor and seeing and hearing one's own name; Platek, Thomson, et al., 2004).

Imaging studies have sought to further localize self-identification processing. A common finding has been involvement of frontal regions, especially right inferior frontal gyrus (IFG), using morphed (e.g., Kircher et al., 2000) and passive (e.g., Kaplan, Aziz-Zadeh, Uddin, & Iacoboni, 2008; Platek, Keenan, et al., 2004) self-face identification, self-face evaluation (Morita et al., 2008), and self-voice recognition (Kaplan et al., 2008).

Conceptual knowledge of one's own personality and traits has been studied extensively, often via semantic self-labeling tasks contrasting judgments of self with judgments of famous or unknown others, and has been shown to be subserved primarily by medial PFC (mPFC; e.g., Fossati et al., 2003; Kelley et al., 2002; Powell et al., 2009). In a recent review, Lieberman (2010) noted that mPFC activity was observed in 94% of studies on self-knowledge. A comprehensive meta-analysis by Van Overwalle (2009) revealed that, more specifically, the ventral portion of mPFC (vmPFC) was engaged in 85% of studies exploring the representation, evaluation, or description of the self. The Lieberman (2010) review further revealed that the contiguous regions of the posterior cingulate cortex/precuneus (PCC/PC) were also represented in 63% of such studies on self-knowledge, and dorsal medial PFC (dmPFC) appeared in 53% of the studies.

Taken together, neuroimaging research suggests that the construction of the "self" is based on a collection of functionally independent, physically and psychologically based constituents involving distinct mental operations distributed throughout the brain, rather than on a unitary cognitive system (see Figure 4.1). Although the anterior insula seems to play a critical role in the sense of agency (e.g., Farrer & Frith, 2002), a number of other aspects of self seem to implicate mPFC, including conceptual judgments about one's personality (Lieberman, 2010), autobiographical memory (Calarge, Andreasen, & O'Leary, 2003; Maguire, 2001), and self-thought monitoring (Mason et al., 2007). Such findings may indicate a general role for mPFC (and related midline cortical regions) as subserving a unique set of cognitive operations engaged by "the self," broadly construed.

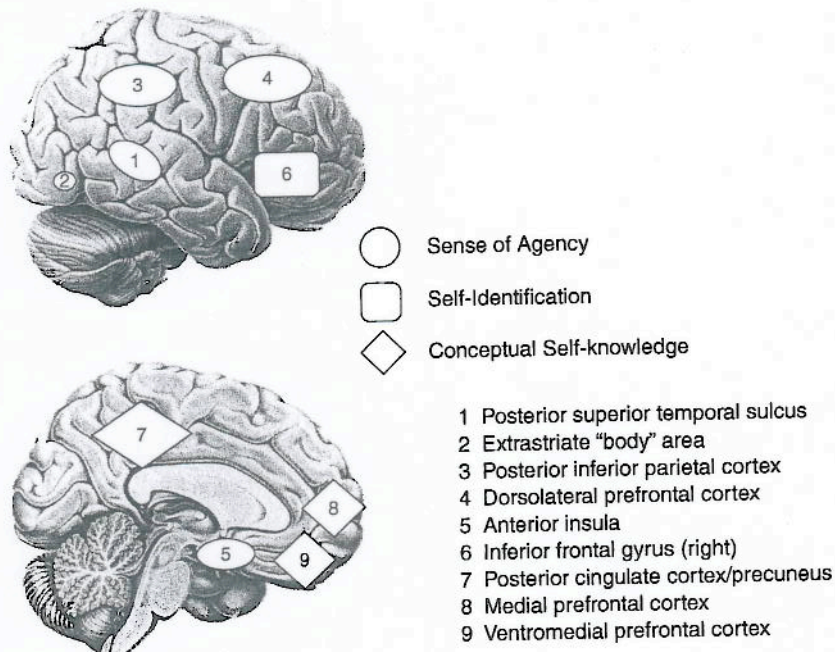


Figure 4.1 The self.

## UNDERSTANDING OTHERS

Many experimental investigations of the *self* rely on contrasts to conditions that reference the *other* (e.g., imagining another's actions, third-person perspective taking, and other-oriented information processing). Both self- and other processing requires the metacognitive ability to think about mental states, such as thoughts, beliefs, desires, and intentions, and make inferences about them in oneself and others. Such inferences can then be used to make predictions about the behavior of others. This is generally referred to as *theory of mind* (ToM; Premack & Woodruff, 1978) or *mentalizing*. Closely following the ability to understand other minds is the ability to relate to the mental states of others with some personal relevance or *empathy* (e.g., Derntl et al., 2010; Gallup & Platek, 2002; Keenan & Wheeler, 2002; Preston & de Waal, 2002). Clearly, these are highly intertwined abilities: By rendering the behavior of others comprehensible and predictable, both are critical for effective interpersonal relationships and normative social behavior (although see also Zahavi, 2008).

Researchers have utilized a variety of experimental paradigms to establish the neurobiological basis of ToM, largely driven by investigations of autism. Early behavioral work with children utilized false-belief tasks in which the observer knows more than the characters in a play and must model the character's perspective, which is different from their own, to answer questions about the story correctly (e.g., Baron-Cohen, Frith, & Leslie, 1985). Such a task requires awareness

that different people can have different beliefs about the same situation, and this awareness can guide predictions of their subsequent behavior. Developmental psychologists have shown that children begin to successfully complete simple or "first-order" ToM tasks around age 2, and most do so reliably by age 4 (e.g., Bretherton & Beeghly, 1982; Wimmer & Perner, 1983; and see Lyons & Koenig, 2013, Chapter 1, this volume).

More developmentally advanced or "higher-order" mentalizing has also been explored behaviorally, via tasks that require attribution of more complex mental states (e.g., recursive thinking, double bluff, white lie), subtle social reasoning (e.g., recognition of irony, sarcasm, humor, or faux pas), and nuanced understanding of motivation and intention (e.g., use of pretend play, deception, and persuasion). Such studies have utilized live action plays (Baron-Cohen, 1989) and short stories or vignettes (e.g., Happé, 1994) to directly compare among different levels and types of "mind-reading" or social reasoning ability. Autistic children who successfully complete simpler ToM tasks are often severely impaired at these higher level tasks. Similar studies have been conducted with patients with damage to the orbital frontal cortex (OFC; in contrast to patients with dlPFC damage), with similar results (e.g., Stone, Baron-Cohen, & Knight, 1998).

Following this line of work, social cognitive neuroscientists have investigated the neural basis for simple and more complex ToM abilities in tasks utilizing vignettes (e.g., Fletcher et al., 1995; Saxe & Powell, 2006), cartoons (Gallagher et al., 2000), geometric shape animations depicting social interactions (e.g., Gobbini et al., 2007), and more active engagement in third-person perspective taking and mental state attribution via creation of stories about strangers (e.g., Calarge et al., 2003). Such studies have demonstrated activity in several different brain regions, including dmPFC, vmPFC, PCC/PC, temporo-parietal junction (TPJ), pSTS, and the anterior temporal cortex (aTC; see Figure 4.2) (see also Farrer & Frith, 2002; Morita et al., 2008; Platek, Keenan, et al., 2004).

In a substantive review, Carrington and Bailey (2009) considered whether task design and presentation modality (e.g., verbal vs. nonverbal; explicit vs. implicit instructions) explain the somewhat heterogeneous and widely distributed anatomical regions implicated in ToM. However, they concluded that methodological variability does not entirely account for the variation in findings. Rather, they suggest that ToM activates an integrated functional network involving several distinct core (consistently activated) and peripheral (activated depending on specifics of the task) brain regions contributing to ToM. Core regions were identified as mPFC/OFC, STS, TPJ, and PCC/PC (see also Frith & Frith, 2006; Gallagher & Frith, 2003; Siegal & Varley, 2002). Recruitment of neural systems subserving other elements of cognition, such as autobiographical memory (e.g., Calarge et al., 2003) or executive control (e.g., Saxe, Schulz, & Jiang, 2006), may also come on line as contributing but dissociable peripheral processes, depending on the specific ToM task.

Based on a meta-analysis of over 200 functional magnetic resonance imaging (fMRI) studies of social cognition, Van Overwalle (2009) further narrowed the

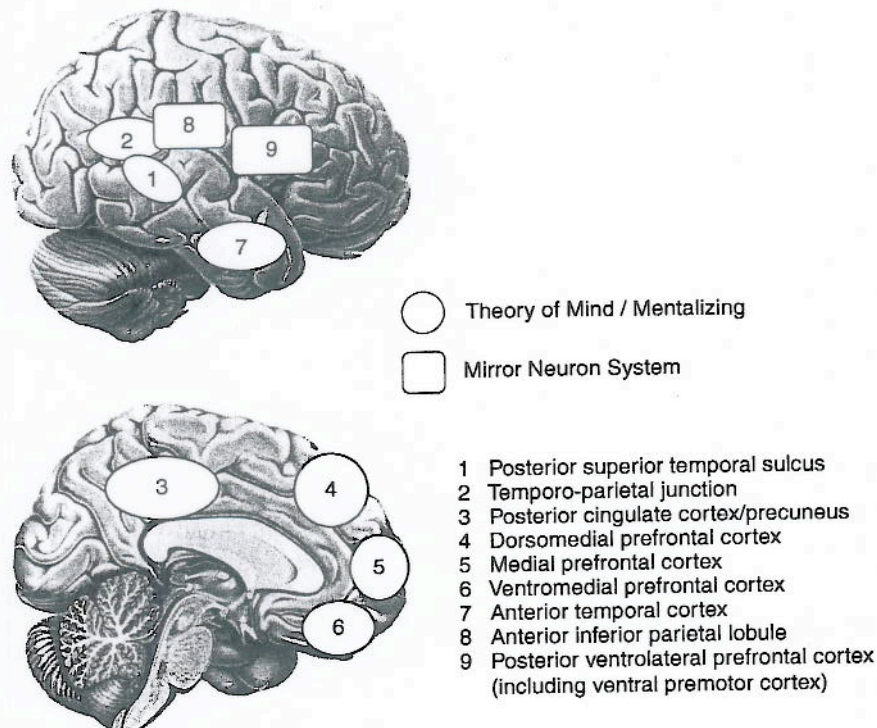


Figure 4.2 Understanding others.

core system for ToM processing to two primary regions: TPJ and mPFC. That analysis found that the primary distinction between mPFC and TPJ activation was that identification and representation of temporary mental states, such as goals, intentions, and desires of other people, engages the TPJ, especially for nonverbal material, whereas inferences about more enduring dispositions or traits of others and the self engage the mPFC. Temporary states can also activate mPFC, and this is perhaps driven by the presence of a verbal component or the necessity of spontaneous judgments of enduring states (spontaneous trait inferences).

Indeed, although the majority of studies have implicated mPFC in self-knowledge (see Lieberman, 2010; Van Overwalle, 2009), this region has also been shown to be involved in semantic judgments about personally close others (e.g., Krienen, Tu, & Buckner, 2010) and similar others (e.g., Mitchell, Banaji, & Macrae, 2005), perhaps indicating a broader role for this region in representing socially or emotionally relevant information about another person (Gallagher & Frith, 2003; Saxe & Powell, 2006). However, Mitchell and colleagues (2006) further dissociated mPFC functioning in regard to similar others with the finding that vmPFC responds to mentalizing about a similar other, whereas dmPFC was differentially involved in mentalizing about a dissimilar other (Mitchell, Macrae, & Banaji, 2006). In fact, dmPFC, in particular, is most often associated with thinking about the mental states of others (e.g., Lieberman, 2010).

Nevertheless, there is evidence of both overlapping and nonoverlapping regions of activation associated with *self* and *other* (especially similar other) processing (e.g., Frith & Frith, 2006; Rabin, Gilboa, Stuss, Mar, & Rosenbaum, 2009; Saxe, Moran, Scholz, & Gabrieli, 2006; Vogeley et al., 2001). These findings suggest that *other*-oriented processing integrally involves *self*-processing, such that neural architecture implicated in processing knowledge about the self is likewise called upon when processing knowledge about others (e.g., Platek, Keenan et al., 2004). These findings are in line with a *simulation theory* of ToM (e.g., Gallese & Goldman, 1998), which posits that perceivers use knowledge about themselves and refer to their own past experiences to infer the mental states of others (see also Apperly, 2008).

This line of thinking may implicate the putative "mirror neuron system," which is thought by some investigators to be a distributed neural system in humans for action understanding. *Mirror neurons* were so named due to findings from research in nonhuman primates that individual neurons in PMC fire not only during performance of coordinated, goal-oriented action, but also during observation of another performing these actions, suggestive of an overlap between perception and execution of action (Iacoboni, 2009). In humans, a frontal-parietal network including posterior ventrolateral PFC (comprising posterior IFG and ventral PMC) and anterior inferior parietal lobule (IPL) has been suggested as the site for a mirror neuron system (see Figure 4.2; Iacoboni et al., 1999; Lieberman, 2010; see also Jeannerod, 2004). To be sure, the research on mirror neurons is extensive, and this complex phenomenon is only briefly described here. However, the key question raised by the possibility of a mirror neuron system in humans is whether automatic imitative processes underlie biological motion detection, which may in turn underlie, at least in part, ToM processing. That is, ToM abilities may build on the capacity to recognize biological motion and goal-directed action, which appears much earlier developmentally and has been shown to be associated with pSTS activity (Lieberman, 2007). pSTS activity may thus support ToM processing via perception and representation of the intentions and goals of others implied by perceived action cues (e.g., Allison, Puce, & McCarthy, 2000; Gobbini et al., 2007).

By most accounts then, the mentalizing and mirror neuron systems are largely anatomically distinct and functionally dissociable, although they may interact in some way to aid collectively in social cognitive processes (Van Overwalle & Baetens, 2009). The precise nature of this interaction is not yet clear. Van Overwalle (2009) posits that a key component of early social information processing is the perception of goal-directed behavior, which is supported by two interactive processes. First is the perception of biological information (e.g., human faces, bodies, and movements) via specialized face (i.e., fusiform face area; FFA), body (extrastriate body area; EBA), and biological motion (pSTS) regions, followed by engagement of the mirror system, which identifies the goals behind these behaviors. A transition from the mirror to the mentalizing system may occur when mental state attributions from observation of body part and whole body motion are consciously deliberated (e.g., when participants are explicitly instructed to deliberate



on the intentions of actors) and when such a focus is triggered by motions that are contextually inconsistent, implausible, or pretended. The latter may require more elaborative inferencing, perhaps beyond the purview of the mirror system (Van Overwalle & Baetens, 2009).

Spunt and Lieberman (2012) sought to directly test how these distinct systems interact in the brain during social cognition, specifically in regards to emotion recognition. They developed a paradigm requiring, in one condition, participants to identify facial expressions, hypothesized to engage the human mirror neuron system via automatic facial mimicry (Niedenthal, Mermillod, Maringer, & Hess, 2010). Another condition required mental state attributions to be made via causal emotion judgments, hypothesized to activate the mentalizing system. As predicted, explicit emotion recognition was associated with core regions of the mirror neuron system, whereas explicit mental state attribution activated areas of the mentalizing system. Furthermore, frontal mirror system regions (i.e., bilateral posterior IFG) demonstrated functional connectivity with mentalizing regions (i.e., dm/vmPFC, PCC/PC, bilateral TPJ, and left aTC), with mirror region activity preceding mentalizing region activity temporally. These findings suggest that the two systems may work in concert, with mirror activity informing mentalizing activity, to enable efficient and comprehensive emotional (and, by extension, social cognitive) processing.

The reference to emotion recognition in the preceding study highlights the fact that emotion understanding is an integral component of normal social cognition. Although effective emotional appraisals occur automatically for most of us, such judgments first require that multiple stages of complex information processing occur, several of which show evidence of disruption in individuals with schizophrenia (e.g., Karlsgodt et al., 2008) and warrant further discussion in terms of contributions from social cognitive neuroscience.

## EMOTION

In a discussion of emotion within a social cognitive neuroscience framework, it is helpful to conceptualize emotion processing as occurring in a hierarchical stream, beginning with emotion perception—including perception of one's own emotions and that of others—and ending with regulation of one's emotions, which may occur intentionally with awareness or incidentally without awareness. Although a universally accepted definition of emotion may be difficult to find (e.g., Ekman, 1992; Panksepp, 2007; Russel, 2003), most researchers agree that for a stimulus to be appraised as having emotional or affective content, it must be salient and self-significant (e.g., Campos, Frankel, & Camras, 2004; LeDoux, 2000). Emotion perception cues us in to dangers and threats from our environment and those around us and facilitates the maintenance and enhancement of pleasurable or otherwise favorable experiences and relationships. Identification of emotion from facial expressions is a primary example of perception of emotion in others, which itself requires many levels of visual perceptual ability that occur on both conscious

and unconscious levels, including the basic ability to process faces. Once an emotion is generated, it can be regulated through various distinct mechanisms that occur at different times in the emotion-generative process. Emotion regulation can serve many aims, including the down-regulation or up-regulation of an emotion. For example, during an altercation involving intense anger, effective emotion regulation allows one to down-regulate feelings of anger and express it in a more socially appropriate manner. In this way, such a process is adaptive and facilitates mood regulation and social interaction.

### Face Perception

Human faces are essential for social interaction and communication and uniquely equipped to convey an abundance of information from person to person. As such, face perception is one of the most highly developed of human visual perceptual skills. Extensive research has been dedicated to understanding how the brain processes faces, with a focus on facial representations as distinct from other object representations, and distinct neuronal pathways involved in the perception and appraisal of various types of information conveyed by faces.

That faces are processed differently than other types of stimuli and that such processing is supported by a specialized neural system in the brain is well established. In human imaging studies, the perception of faces has been reliably associated with activity in a region of the lateral fusiform gyrus, so much so that many have come to refer to this region as the fusiform "face" area (FFA; Halgren et al., 1999; Kanwisher, McDermott, & Chun, 1997; McCarthy, Puce, Belger, & Allison, 1999). Other regions of visual extrastriate cortex that appear to be selective for faces include the inferior occipital gyrus, also known as the occipital face area (OFA; Gauthier, Skudlarski, Gore, & Anderson, 2000; Halgren et al., 1999; Rossion et al., 2003; Sergent, Ohta, & MacDonald, 1992), as well as pSTS (Engell & Haxby, 2007; Haxby, Hoffman, & Gobbini, 2000; Hooker et al., 2003). These regions of activation are usually bilateral with right hemispheric dominance (see Figure 4.3).

These three bilateral regions of occipitotemporal cortex (OFA, FFA, pSTS) may participate differentially in the different aspects of face perception (Haxby et al., 2000). Specifically, invariant aspects of faces (i.e., for identity recognition) may be processed via FFA, whereas changeable aspects (e.g., in support of expression and eye gaze detection) may be processed via pSTS, and early perception of facial features output to both of these regions occurs via OFA. Accordingly, FFA activation seems to be most prominent when comparing response to visual perception of faces to nonsense stimuli, scrambled faces, or other nonface objects utilizing passive viewing tasks or tasks in which attention is focused on the nonvariant aspects of the facial configuration (e.g., Kanwisher et al., 1997; McCarthy, Puce, Gore, & Allison, 1997; Sergent et al., 1992). Conversely, greater pSTS is elicited during tasks designed to direct attention to dynamic aspects of faces, such as direction of eye gaze or facial expression, rather than identity (Cloutier, Turk, & Macrae, 2008; Engell & Haxby, 2007; Hoffman & Haxby, 2000; Winston, Henson,

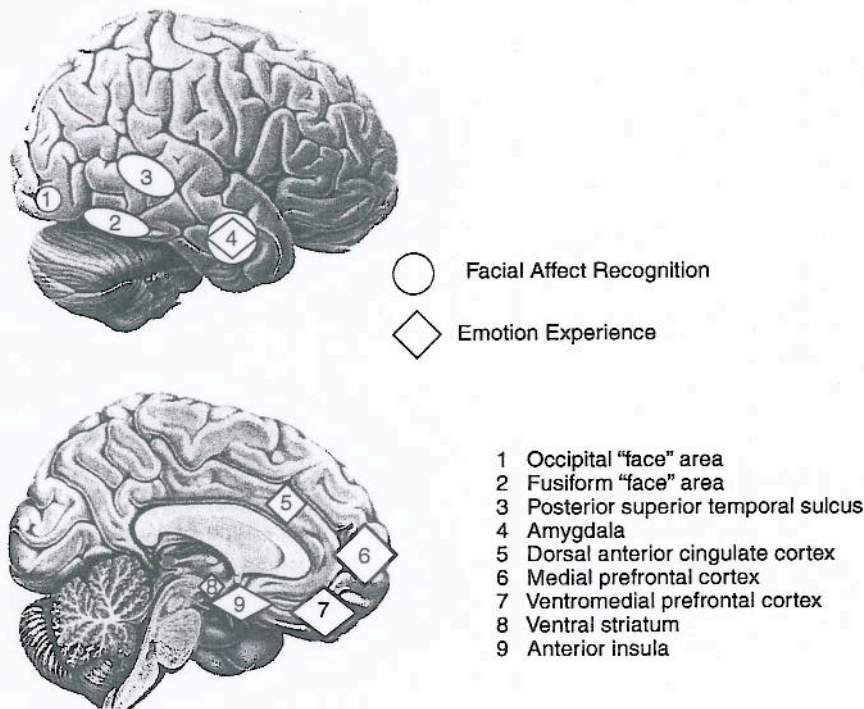


Figure 4.3 Emotion perception.

Fine-Goulden, & Dolan, 2004). Hooker et al. (2003) further demonstrated increased STS activation specifically for analysis of gaze cues that provide socially meaningful spatial information (in contrast with arrows that provide spatial information and with eye motion without spatial information; Hooker et al., 2003; see also Puce et al., 1998). Finally, support for the role of OFA as a visual processing "entry point" for face information has been supported by fMRI adaptation studies (e.g., Fox, Moon, Iara, & Barton, 2009).

Although these areas are clearly involved in face processing, not all findings suggest the same degree of functional specificity. For example, Ganel and colleagues (2005) found significant FFA activity when subjects made judgments of facial expressions, and FFA was sensitive to variations in expression even when attention was directed to identity (Ganel, Valyear, Goshen-Gottstein, & Goodale, 2005; see also Fox et al., 2009). Other researchers have suggested that, rather than specialization only for face recognition, these face-responsive regions may be specialized for visual expertise, responding to objects perceived as unique individuals rather than category exemplars (e.g., Gauthier et al., 2000; Rhodes & McLean, 1990; Tarr & Gauthier, 2000; see also Chao, Martin, & Haxby, 1999; Spangler, Schwarzer, Korell, & Maier-Karius, 2010). In addition, as highlighted previously, right STS is usually associated with the perception of any biological movement or human action, and whether these are distinguishable to include specialty to faces is not clear (e.g., Bonda, Petrides, Ostry, & Evans, 1996). In fact, Saxe and

colleagues (2004) found that right pSTS activity served a more generalized representation of observed intentional actions, not face action per se (Saxe, et al., 2004; see also Hein & Knight 2008). Finally, Rossion et al. (2003) found that, rather than receiving face-sensitive inputs from the OFA in a purely feed-forward hierarchical fashion, "feedback connections may facilitate re-entrant integration of FFA (and, presumably, STS) with OFA, allowing for normal face perception even in individuals with damages to right hemisphere inferior occipital cortex."

In summary, although advances have been made in our understanding of the neural underpinnings of face perception, more research is needed to elucidate the details of this complex system. What is clear, however, is that efficient processing of faces is reliant upon multiple interconnected brain regions acting in an orchestrated fashion. Highlighting the importance of connectivity between neuronal regions in face processing beyond a "core" system, predominantly active and perhaps selective for faces, an "extended" system may also contribute to face perception, although not exclusively involved in it (Haxby et al., 2000). These extended regions may be recruited, depending on the type of face perception, to extract meaning from faces and process the significance of the information gleaned. For example, perception of emotional facial expressions may activate the distributed neural system for emotion processing, including limbic regions such as the amygdala, dorsal anterior cingulate cortex (dACC), anterior insula, and ventral striatum (see Figure 4.3; Ishai, Schmidt, & Boesiger, 2005).

### Emotional Expressions

Similar to primary face processing, the ability to display, recognize, and respond to facial expressions is a fundamental aspect of sociality in humans, critical for social information exchange (e.g., Ekman, 1993; Darwin, 1872/1998). The neural network for emotional faces has generally been investigated in imaging studies that use comparisons of blank, expressionless, or neutral faces to faces displaying an expression of emotion. A recent meta-analysis of 100 neuroimaging studies utilizing emotional face stimuli found that several brain regions were consistently activated. In addition to face-responsive regions in extrastriate occipital cortex, the amygdala was the area of greatest overlap, followed by regions of inferior temporal cortex, mPFC, and OFC (Sabatinelli et al., 2011).

Amygdala activation has most often been associated with response to fearful but also neutral faces (e.g., Kesler-West et al., 2001; Whalen et al., 2001), regardless of spatial frequency of the facial stimuli or location in the visual field (Morawetz, Baudewig, Treue, & Dechent, 2011). More generally, an abundance of literature points to the amygdala as playing a critical role in the automatic evaluation of both salient and ambiguous sensory inputs and then coordinating subsequent neurophysiological responses to these (Holland & Gallagher, 1999; LeDoux, 2000; Posner, 2001), possibly by biasing cognition toward perceived stimuli with potential emotional and social significance (Adolphs, 2003; Vuilleumier & Pourtois, 2007). For example, Critchley and colleagues (2000) compared activation to

fearful and angry faces when explicitly (judging expression task) versus implicitly (judging facial gender task) attended to, and found that implicit processing involved greater amygdala activation. Similarly, Anderson and colleagues (2003) found that directing attention away from disgust and fear faces modulated regions involved in processing disgust (i.e., insula) but not amygdala; rather, amygdala activation increased. These findings suggest that when such stimuli are not attended to, amygdala processing becomes more diffuse to threat in general or attuned to the task of resolving ambiguity.

Selective involvement of other brain regions for experience of emotion in a category-specific manner has also been investigated with varying degrees of consistency. Generally, findings implicate a network of predominantly anterior limbic regions including the amygdala, ventral striatum, ACC, and anterior insula (see Figure 4.3; Kesler-West et al., 2001; Lane, Fink, Chau, & Dolan, 1997; Phillips, 2006; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998; Vytal & Hamann, 2010). In line with elements of the face processing model described above (e.g., Haxby et al., 2000; Hein & Knight, 2008), Peelen and colleagues (2010) found that mPFC and left STS activation was associated with presentation of five different emotions (fear, anger, disgust, happiness, sadness) in category-specific patterns of intensity but independent of modality of sensory input (i.e., facial expressions, body movements, or vocal intonations) or emotional intensity of the stimuli (see also Lane, Reiman, Ahern, Schwartz, & Davidson, 1997). They suggested that these "higher level" brain areas (also implicated in mental state attribution and ToM) represent emotions at an integrated, abstract, supramodal level and thus play a key role in understanding and categorizing others' emotional mental states.

### Intentional Emotion Regulation

Emotions play a powerful role in both facilitating and, in some cases, hindering, individuals' experiences and social interactions. Thus, the regulation of emotion is critical to functioning. For example, effective emotion regulation may decrease experiences of negative emotion during stressful times or help to control socially inappropriate expressions of emotion during experiences of anger. Gross (1998a) defined emotion regulation as "processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (p. 275). Emotion regulation can take a variety of forms, including both intentional and incidental processing. During intentional emotion regulation, individuals engage in effortful attempts to regulate their emotions. These attempts can impact experiences of emotion, expressive behavior, or physiological responding.

Emotions can be conceptualized as response tendencies that are generated after a stimulus is determined to be relevant and/or salient. Emotion regulation strategies can affect the course of the emotion-generative process at various time points. Gross (1998a) takes a process-oriented approach to describing five different types of emotion regulation: situation selection, situation modification, attention

deployment, cognitive change, and response modulation. More specifically, situation selection refers to the individual's choosing of the situation in which he or she finds him- or herself. Situation modification is the process of changing that situation such that its emotional impact is changed. Of note, different situations are characterized by differences in their complexity (e.g., how many aspects of the situation can be modified) and the extent to which they can be changed. Attention deployment signifies the individual's selection of which aspect of a given situation to focus on. For example, an individual might choose to focus on a more negative or a more positive aspect of a situation. Cognitive change is the selection of which meaning is assigned to a situation. In each situation, many different meanings could exist, with each potentially leading to different emotional responses. For example, an individual might reappraise the meaning of a situation or his or her own ability to deal with the situation. Finally, response modulation is the process of altering emotional response tendencies once they have been evoked. For example, these strategies might reduce or intensify an emotional experience or expression.

Emotion regulation processes can be separated into antecedent- and response-focused strategies (Gross 1998b). Situation selection, situation modification, attention deployment, and cognitive change comprise antecedent-focused strategies, which alter the input to the emotion-generative process at an early stage. Conversely, response modulation is a type of response-focused strategy that takes place at a later stage in the process to alter the emotional response. In order to examine differential impacts of antecedent- versus response-focused strategies, Gross (1998b) compared reappraisal (antecedent-focused) and suppression (response-focused). Specifically, the study examined the effects of these strategies on emotional experience, expressive behavior, and sympathetic activation during film clips intended to elicit disgust. Participants were instructed to reappraise, suppress, or watch during the film. Reappraisal resulted in decreased self-reported subjective experience of disgust, as well as reduced behavior expressing emotion. Reappraisal had no effect on sympathetic activation. Suppression was associated with decreased expressive behavior and increased sympathetic activation. However, participants did not report changes in experience of disgust while engaging in suppression. Although both groups exhibited smaller increases in expressive behavior (disgust, emotional intensity, and activity) compared to the group that simply watched the film, ratings of disgust and emotional intensity of expressive behavior were lower in the suppression group. Interestingly, suppression failed to alter the subjective experience of emotion, despite affecting both expression and sympathetic activation.

Numerous studies have now examined neural substrates of reappraisal using fMRI. Although results vary from study to study, the most common activations associated with reappraising are in dorsolateral, ventrolateral, and dorsomedial PFC (e.g., Goldin, McRae, Ramel, & Gross, 2008; Ochsner, Bunge, Gross, & Gabrieli, 2002). Reductions in activation are commonly seen in the amygdala and other limbic regions (see Figure 4.4). Moreover, lateral PFC activations have been

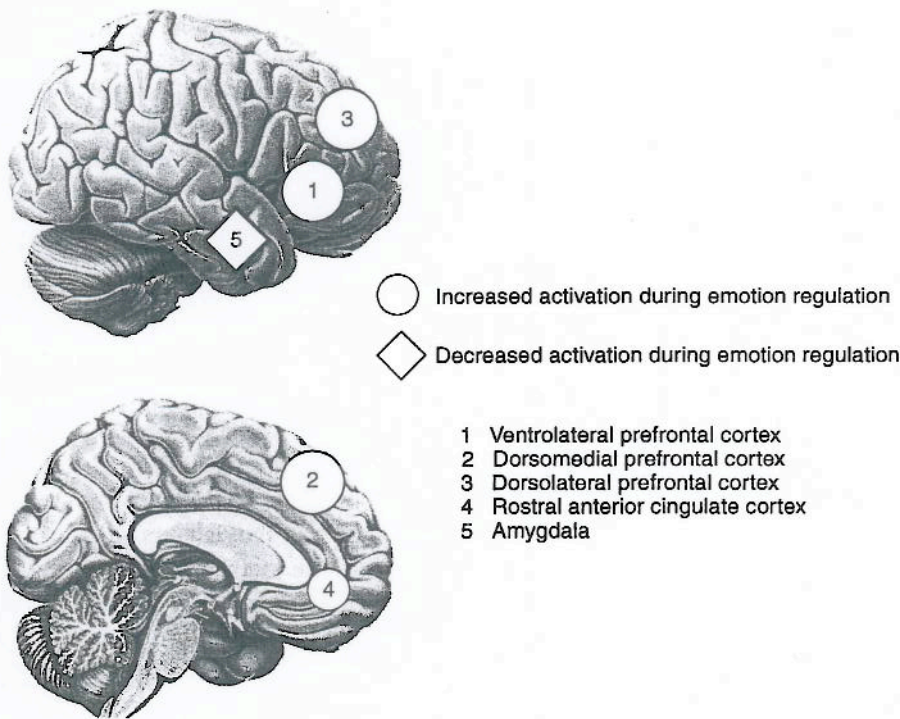


Figure 4.4 Emotion regulation.

seen in multiple studies to correlate inversely with both self-reported distress and with limbic activity.

One study compared the neural bases of strategies that differ in how and when they influence the emotion-generative process. Specifically, Goldin and colleagues (2008) examined activation among brain regions involved in cognitive reappraisal (early in the process) versus expressive-suppression (later in the process). In this study, participants viewed films designed to elicit negative emotion (negative) or no emotion (neutral) under the following four conditions: watch neutral, watch negative, reappraise negative, and suppress negative. Reappraisal, as compared with the watch-negative condition, was associated with early medial, dorsolateral, and ventrolateral PFC activation, along with decreased activation in amygdala and insula. However, suppression was associated with later dorsomedial, dorsolateral, and ventrolateral prefrontal responses and increased activation in the amygdala and insula. These results are consistent with the temporal dynamics evident in Gross's model (1998b) of emotion regulation strategies, as well as with the general conclusion that whereas suppression may reduce the expression of an emotion, it does little to diminish the experience.

More recently, Kanske and colleagues (2011) examined neural networks implicated in reappraisal versus distraction. Kanske et al. (2011) observed that OFC activation was uniquely activated for reappraisal. Conversely, their results demonstrated that distraction (a form of attention deployment) was associated with

activation in the dorsal anterior cingulate and parietal cortex. Both reappraisal and distraction resulted in increased activation in medial and dorsolateral prefrontal and inferior parietal cortex, as well as in decreased bilateral amygdala activation. Functional connectivity analyses, intended to examine regions that significantly covaried with the amygdala, demonstrated that the amygdala covaried with different prefrontal regions for reappraisal and distraction, consistent with the distinct prefrontal regions observed to be activated during reappraisal versus distraction. Of note, participants reported decreased subjective experience of negative emotion using both strategies.

Another cognitive strategy that has been examined using neuroimaging research is *distancing* (Beauregard, Levesque, & Bourgouin, 2001; Kalisch et al., 2005). Male participants viewed erotic film clips while either passively viewing or voluntarily trying to inhibit sexual arousal. During inhibition of emotional responding, participants were encouraged to distance themselves from stimuli (i.e., to observe the scene in a detached manner). Passive viewing, which was associated with increased arousal ratings, resulted in activation in the right amygdala, right anterior temporal pole, and hypothalamus. However, attempted inhibition was associated with increased activation in right superior frontal gyrus and right anterior cingulate gyrus and was not associated with limbic activation (Beauregard et al., 2001). These results suggest that a regulatory circuit including prefrontal cortex and the amygdala are also implicated in emotion regulation associated with cognitive distancing.

In summary, intentional emotion regulation processes appear to operate by way of lateral prefrontal activations. For reappraisal, distraction, and distancing, these prefrontal activations have been accompanied by reduced amygdala activity and diminished distress responses. Suppression, however, has not been associated with reductions in either amygdala activity or distress.

### Incidental Emotion Regulation and Contextual Modulation

Although often an intentional process, emotion regulation may also occur in the absence of awareness or explicit intent. Such regulation can be thought of as incidental in nature. Given that such effects have been observed in the context of processes that are effortful, but not aimed at regulation, we believe "incidental" is a more appropriate term than "automatic" or "implicit." Naturally, there is the question of whether it is appropriate to call something emotion regulation at all if it is not intentional, as emotion regulation does not seem to happen by accident.

There are several concomitants of emotion regulation, and it is reasonable to characterize a process as emotion regulation if it has all but one of these. Successful emotion regulation has been associated with changes in self-reported emotional experience, reduced physiological responses to threatening stimuli, increased lateral (usually ventrolateral) prefrontal activations, decreased limbic activity, negative correlations between prefrontal and limbic responses, and the awareness that one is trying to regulate one's emotions.



Labeling the affective component of something emotionally evocative (i.e., *affect labeling*) may be considered a form of incidental emotion regulation because all of the components of emotion regulation appear to be present, except for the awareness component. A number of studies have demonstrated the characteristic pattern of VLPFC increases, amygdala decreases, and inverse correlation between the two when people are shown an emotionally evocative image and asked to choose an affective word to characterize the picture, compared to when the same picture is shown but a nonaffect task is used (Hariri, Bookheimer, & Mazziotta, 2000; Lieberman et al., 2005, 2007; Payer, Lieberman, & London, 2011). Other studies have demonstrated physiological reductions in skin conductance associated with affect labeling (Kircanski, Lieberman, & Craske, in press; Tabibnia, Lieberman, & Craske, 2008). Finally, a recent dataset observed reliable reductions in self-reported distress associated with affect labeling (Lieberman, Inagaki, Tabibnia, & Crockett, 2011).

One recent paper (Payer, Baicy, Lieberman, & London, 2012) examined affect labeling and reappraisal within the same individuals, but on separate testing days. Using an anatomical region of interest (ROI) approach, Payer et al. found that the amygdala reductions due to affect labeling and reappraisal were highly correlated with one another ( $r = .77$ ). Additionally, functional connectivity analyses were performed to identify regions that were inversely correlated with amygdala activity from moment to moment. This analysis identified a substantial cluster in right VLPFC common to both affect labeling and reappraisal. These analyses suggest that, within the same individuals, affect labeling sets in motion a similar set of processes as reappraisal. With affect labeling showing so many of the characteristics of an emotion regulation process, without awareness that labeling produces these effects (Lieberman et al., 2011), it is best characterized as incidental emotion regulation.

Other tasks have produced some of the characteristics of emotion regulation as well. For example, in a revised version of the emotional Stroop task, participants were asked to identify an emotional expression on a target emotional face (Egner, Etkin, Gale, & Hirsch, 2008; Etkin, Egner, Peraza, Kandel, & Hirsch, 2006). The faces were superimposed with irrelevant information, which was not needed to respond correctly and had the potential to be distracting. The superimposed information was either emotional or nonemotional, and either congruent or incongruent with the target emotional face. For example, a nonemotional congruent distracter would be the word "FEMALE" over a female happy face, and an emotional incongruent distracter would be the word "HAPPY" over a female fear face. Key effects were observed during incongruent trials in which participants were required to regulate their attention to incongruent distracters in order to respond correctly. The authors found that regulation of attention to emotional (as compared with nonemotional) distracters was related to increased rostral anterior cingulate cortex (rACC) activation and corresponding decreases in amygdala activity. It is not yet clear whether this constitutes a form of emotion regulation, as there have been no measures of physiological or experiential changes.

Another set of tasks is more properly characterized as *contextual modulation of affect*. In these studies, the stand-alone emotional significance of a stimulus differs as a function of the context in which it is found. In these tasks, prefrontal mechanisms seem to play a role in understanding the context, which in turn may alter limbic responses. For example, one study used surprised facial stimuli that were immediately preceded by either a positive or negative sentence that provided a context for the face (Kim et al., 2004). As demonstrated in prior work (Kim, Somerville, Johnstone, Alexander, & Whalen, 2003), surprised faces are ambiguous in nature and elicit individual differences when participants are asked to make valence judgments of them. When presented in the context of positive and negative sentences, Kim and colleagues (2004) observed increased amygdala activation to surprised faces in the context of negative compared with positive sentences and increased rACC activation for the opposite contrast (i.e., surprised faces in the context of a positive compared with negative context).

Similarly, Hare and colleagues (2005) demonstrated contextual modulation of amygdala responsivity to facial expressions in differing contexts. Specifically, an emotional go/no-go paradigm was employed, in which participants were told to press a button every time they saw a fearful face. The fearful faces were interspersed with either neutral or happy faces. The authors reported decreased amygdala activation to fearful faces in the context of happy faces (compared with neutral faces), with a simultaneous increase in VLPFC activation during fearful faces in the context of happy faces. Moreover, subsequent research using a similar emotional go/no-go paradigm demonstrated that a failure of the amygdala to habituate to emotional stimuli was associated with weaker functional connectivity between the amygdala and ventral prefrontal cortex (Hare et al., 2008).

Thus, there are a variety of ways that affect can be altered by other ongoing processes that are not deployed for the sake of regulation per se. Some of these are clearly a form of emotion regulation, and others currently fall into the category of affect modulation, but could be considered forms of emotion regulation depending on the results of future research.

## CAPACITY VERSUS TENDENCY

Social cognitive neuroscience has identified the basic neural networks involved in a variety of socioemotional processes, including those reviewed here: the self, understanding others, emotion perception, emotional experience, and emotion regulation. As these are used increasingly in a translational context to probe schizophrenia and other psychopathologies, there is a critical distinction that is buried in all of this research.

All of the studies that have been conducted thus far have examined the *capacity* to perform a task and recruit particular neural regions when explicitly instructed to perform that task. In daily life, however, there are rarely experimenters inducing us to perform particular tasks, and thus our capacity, say, to engage in emotion regulation will only be useful to us to the extent that we have the *tendency* to use

that ability without prompting. More critically to the study of psychopathology, deficits can affect capacities, tendencies, or both. Thus, task paradigms that exclusively focus on capacity may be unable to detect key neurocognitive deficits.

To give one example, consider empathy. In a recent study, Rameson, Morelli, and Lieberman (2012) presented individuals who were high or low in self-reported trait empathy with pictures of people in empathy-inducing situations (e.g., someone finding out they have cancer). In one condition, the capacity to enter an empathic state was tested by explicitly instructing participants to try to empathize with the targets as much as possible. Here, self-reported levels of empathic experience were the same for high- and low-trait empathy individuals. Similarly, there were no differences in neural activity—both groups showed robust activity in medial frontal regions associated with empathic processing.

In the second condition, no empathy instruction was given. Instead, participants were given a distraction task in which they had to memorize an 8-digit number while viewing the pictures. Because empathy was not explicitly induced in this condition, differential evidence of empathic processing would indicate differential tendencies to be empathic. In this condition, significant differences in experience and neural activity were observed between high- and low-trait empathy participants. Despite the distracting task and the lack of empathy instructions, high-trait empathy individuals produced just as much medial frontal activity as when they were instructed to empathize, but low-trait empathy individuals showed a dramatic drop-off in response.

Thus, these data suggest that high-trait empathy has more to do with everyday tendencies than does the capacity to be empathic. More generally, these data suggest that if paradigms include only the instructed condition, without another condition in which the participants have more freedom to respond in natural ways, important sources of variance are likely to be lost. Moreover, neuroimaging procedures that could be used to test whether an intervention has produced results might overlook successes if neurocognitive tendencies are not measured along with neurocognitive capacities.

## CONCLUSION

This focused review has highlighted the distinctiveness of social and emotional information processing and demonstrated that a social cognitive neuroscience approach lends itself well to the study of key aspects of social cognition evidently disrupted in clinical populations. In particular, mapping of neural systems subserving complex social psychological phenomena, such as self-relevant and other-oriented information processing, emotion perception, and emotion regulation, reveals neural targets for investigation in schizophrenia. From basic brain mapping, the manner of inquiry in the field has begun to move forward, toward elucidating more precisely the nature of social cognition. This includes, for example, the differentiation between intentional and incidental processing and the tendency versus capacity to engage in such processes. Importantly, these more advanced

lines of research allow for more accurate interpretations to be made when neural differences are seen in clinical populations. Although the field of neuroscience is clearly in nascent stage relative to other more established fields of psychology, our understanding of the social brain is rapidly advancing with this methodology. The continuous emergence of studies pushing the boundaries of which research questions we may ask with this approach ensures that our knowledge of basic science, as well as of psychopathology, will continue to advance and be further refined in years to come.

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