# The Emergence of Social Cognitive Neuroscience

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*Social cognitive neuroscience is an emerging interdisciplinary field of research that seeks to understand phenomena in terms of interactions between 3 levels of analysis: the social level, which is concerned with the motivational and social factors that influence behavior and experience; the cognitive level, which is concerned with the information-processing mechanisms that give rise to social-level phenomena; and the neural level, which is concerned with the brain mechanisms that instantiate cognitive-level processes. The social cognitive neuroscience approach entails conducting studies and constructing theories that make reference to all 3 levels and contrasts with traditional social psychological and cognitive neuroscientific research that primarily makes reference to 2 levels. The authors present an introduction to and analysis of the field by reviewing current research and providing guidelines and suggested directions for future work.*

Two strangers pass each other on a deserted street, exchange glances, and hurry along their respective ways. All psychologists are interested in encounters such as this one. However, depending on their frame of reference, different psychologists will ask different questions about them. Cognitive neuroscientists, for example, might ask how specific brain systems allow each person to recognize a face as familiar or unfamiliar and know whether the other person is feeling happy, sad, or angry. Social psychologists, by contrast, take the ability to recognize faces and their expressions as a starting point and might ask how each stranger uses that ability to draw inferences about the enduring traits and dispositions of the other. In addition, a social psychologist might study how these inferences are biased by preexisting stereotypes, mood states, or any of a host of cultural, personal, and contextual factors that influence the way that each passer-by reacts to and construes the other. Where a cognitive neuroscientist might ask what neural systems enable one person to perceive the other as angry, a social psychologist might ask how both perception and behavior are altered when, for example, the angry person is White and the perceiver is Black.

At first blush, the approaches of social psychologists and cognitive neuroscientists may seem as foreign to one another as these two strangers passing on the street. There is, however, a long history of research that at least partially closes the gap between these disciplines. Examples of this work include the well-known case of Phineas Gage, whose turn-of-the-century railroad accident damaged the ventro-

medial aspects of his frontal lobe, causing emotional lability and socially inappropriate behavior despite preserved intellectual functioning (Harlow, 1868; Macmillan, 2000); work in primates demonstrating that damage to specific brain structures, such as the amygdala, affects various socioemotional behaviors (Bachevalier, 2000); studies of the link between social support, stress, and immune function (Cacioppo, 1994; Kiecolt-Glaser & Glaser, 1989; Kiecolt-Glaser, Glaser, Cacioppo, & Malarkey, 1998); and research showing that levels of the neurotransmitter serotonin and the neurohormone oxytocin may mediate social dominance and aggression or affiliation and social bonding, respectively (McGuire & Raleigh, 1985; Nelson & Panksepp, 1998; Raleigh, McGuire, Brammer, Pollack, & Yuwiler, 1991; Taylor et al., 2000; Uvnas-Moberg, 1998). Although it is beyond the scope and purpose of this article to review a century's worth of such work in detail, the present point is that research connecting social behavior to the brain and body has a rich history.
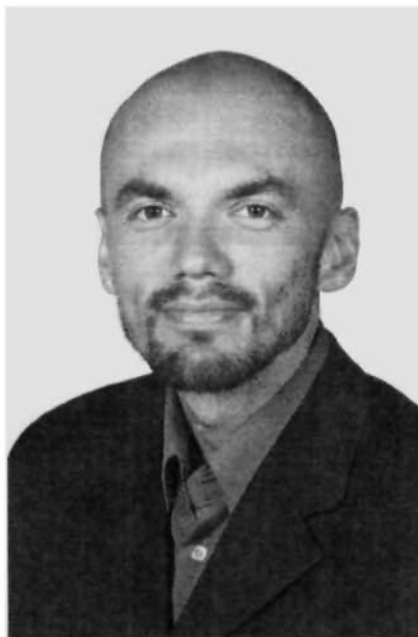
That being said, recent methodological developments in cognitive neuroscience have led to a new brand of exploration in the science of social cognition. Until relatively recently, many studies have used either pharmacological or psychophysiological techniques that correlate social cognitive variables with patterns of immune response, hormonal levels, heart rate, respiration, or some other peripheral physiological measure (see, e.g., Cacioppo et al., 1998; Cacioppo, Tassinary, & Berntson, 2000; Tomaka, Blascovich, Kelsey, & Leitten, 1993; Tomaka, Blascovich, Kibler, & Ernst, 1997; Uvnas-Moberg, Widstrom, Nissen, & Bjorvell, 1990). Because these measures only indirectly reflect the operation or modulation of brain sys-

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tems, researchers using these techniques could not draw direct inferences about the neurocognitive systems used to construe and respond to a socially or emotionally relevant stimulus. In the past few years, there has been an increase in the use of neuropsychological populations and functional neuroimaging techniques[1] to more directly connect social and emotional functions with neurocognitive systems and to test new and enduring hypotheses about the nature of social cognition (Adolphs, 1999; Cacioppo, Tassinary, & Berntson, 2000; Davidson, 1999; Klein & Kihlstrom, 1998). Arguably, the most important new research technology added to the study of socioemotional phenomena is functional magnetic resonance imaging (fMRI; Moonen & Bandettini, 1999; Sarter, Berntson, & Cacioppo, 1996),[2] which allows researchers to identify the location of task-related brain activity to within a few millimeters in both cortical and subcortical brain structures.

Fortunately, these new research endeavors have begun to involve collaborations between social psychologists and cognitive neuroscientists, thus integrating the best that both sides have to offer (Golby, Gabrieli, Chiao, & Eberhardt, 2001; Klein, Loftus, & Kihlstrom, 1996; Lieberman, Ochsner, Gilbert, & Schacter, 2001; Phelps et al., 2000). However, the amount of cross-disciplinary communication is still small and is hardly sufficient to ensure the health of this small but growing nexus of research. There is enormous promise in the integrative *social cognitive neuroscience* approach, described below in the first section of this article (see also Lieberman, 2000; Ochsner & Feldmann Barrett, 2001; Ochsner & Schacter, 2000, in press). However, there are equally large dangers if researchers do not pay attention to the obstacles and controversies as well as to the advances and insights that each parent discipline has encountered over the course of its

history. It is tempting, for example, to pick classic studies of social cognition and adapt them for use with patients or neuroimaging. Likewise, it is tempting to pick individuals with a classic neuropsychological deficit and examine their performance on emotional or social psychological tasks. Such work may be groundbreaking, but without a firm footing in both social psychology and cognitive neuroscience, it also can be methodologically and theoretically naive. With these concerns in mind, in the second section of this article, we review current research already using a social cognitive neuroscience approach with an eye toward the contributions these studies have made toward (a) using current knowledge of brain function to test hypotheses about the processes underlying social phenomena that would otherwise not be assessable and (b) more generally describing a functional neuroanatomy of social cognition and emotion that will form the foundation for future re-

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[1] Considering the ways in which various neuroscience methodologies can be used to address questions is essential for social cognitive neuroscience, but it is beyond the scope of this article to discuss in detail their relative advantages and disadvantages (for reviews, see Cacioppo, Tassinary, & Berntson, 2000; Caramazza, 1992; Churchland & Sejnowski, 1988; Frith & Friston, 1997; Kosslyn, 1999; Kosslyn & Intriligator, 1992; Kosslyn & Van Kleeck, 1990; Moonen & Bandettini, 1999). For present purposes, it is sufficient to make two points. First, no matter what technique one uses, even the most carefully designed study can be subject to multiple interpretations and can be understood only in the context of other related findings (Ochsner & Kosslyn, 1999). Second, most methodologies require that studies be designed to compare patterns of neural activity in two or more conditions that differ only in the extent to which they draw on the process(es) of interest (Cacioppo & Berntson, 1992; Kosslyn, 1994; Posner & DiGirolamo, 2000). Comparison of activity between two conditions allows inferences to be drawn about the relationship between brain activity and the psychological process(es) of interest (see also Footnote 2).

[2] Positron emission tomography (PET) and fMRI are the most common functional imaging techniques (for a review, see Moonen & Bandettini, 1999). They provide measures of activity in specific areas of the brain that are correlated with the performance of specific tasks, the experience of certain states, or membership in a particular group. PET involves inhalation of a radioactive gas or injection of a radioactive solution that is metabolized by brain areas. The more active a given brain region is during task performance, the more radioactive substance is present there and the greater the PET signal at that location. fMRI uses powerful magnetic fields to alter the orientation of atoms in the brain and measures signals given off by these atoms as they return to their normal orientation. Brain areas that are used for performance of a given task use more blood and therefore produce a stronger signal that is detected by the fMRI scanner. Experiments using PET or fMRI typically compare brain activation in two different psychological states (e.g., happy vs. sad), during the performance of two different kinds of tasks (e.g., remembering as opposed to passively viewing words) or for members of two different groups (e.g., depressed vs. nondepressed individuals). Whatever two tasks or conditions are being compared, it is important that they differ only in their reliance on the specific processes under investigation. When studies are designed in this way, one can infer that differences in brain activity between the two conditions reflect the operation of the processes of interest. The meaning of a given pattern of brain activity thus is always dependent on the other states with which it is being compared. For example, activation during perception of neutral faces may be compared with activation during perception of angry faces to determine which brain areas are associated with perception of anger per se. In both conditions, perception recruits mechanisms involved in perception of faces, but perception of angry faces presumably recruits additional mechanisms involved specifically in the perception of angry facial expressions.

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such terms can allow descriptions of cognitive processes to be the Rosetta stone of social cognitive neuroscience, translating terms that at first may seem like hieroglyphics into commonly understood information-processing terminology. Thus, the term social cognitive neuroscience not only reflects the interdisciplinary marriage that motivates the field but also conveys that the information-processing middle level is where, at least initially, research partners from different backgrounds can most readily communicate.
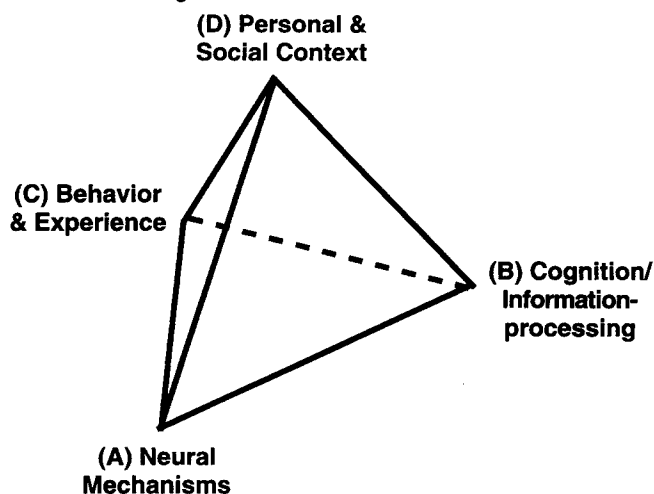
One premise of the social cognitive neuroscience approach is that the different questions asked by social psychologists and cognitive neuroscientists are not independent or mutually exclusive but can serve to enrich one another (Miller & Keller, 2000). On the one hand, social psychologists can use neuroscience data to disambiguate and test competing theories of psychological processes underlying various types of phenomena. In performing such tests, social psychologists can make use of the rich database of cognitive neuroscientific knowledge about the brain systems underlying memory, attention, language, emotion, and other processes to test hypotheses in ways not possible using behavioral means alone. On the other hand, the brain systems studied by cognitive neuroscientists may operate differently for social as opposed to nonsocial stimuli, when individuals are motivated to process information in biased ways (see, e.g., Forgas, 1995; Greenwald, 1980; Kunda, 1990), or when meaningful social contexts constrain the course of information processing (see, e.g., Wason & Johnson-Laird, 1972). In investigating social phenomena, cognitive neuroscientists can inform their studies with the rich social psychological database of knowledge about the factors that determine why and how human beings perceive themselves and others, emote, make decisions, and so on.

To give this approach a concrete guide, we represent the relationship between the different levels of analysis as a three-dimensional prism, shown in Figure 1. The prism is intended to capture the idea that social cognitive neuroscience is about studying phenomena at many levels of analysis to learn how and when brain systems are used to mediate motivated human behavior. Two of the prism's vertices correspond to the cognitive and neural levels of analysis. The third and fourth vertices correspond to two aspects of the social level: behavior or experience and the personal or social context in which it is situated. We represent these two aspects of the social level separately to highlight the importance of understanding the situations in which human beings act, think, and feel. Both kinds of variables importantly influence goals and determine the consequences of actions and, in so doing, thereby influence phenomena at every level of analysis.

search. In the third section of the article, we describe three broad ways in which social cognitive neuroscience can move beyond brain mapping and make new theoretical contributions to both parent disciplines.

## The Social Cognitive Neuroscience Approach

The name social cognitive neuroscience denotes both the interdisciplinary nature of the field and its emphasis on integrating data from multiple levels of analysis, ranging from the experience and behavior of motivated individuals in personally relevant contexts (the social level) to the information-processing mechanisms that give rise to these phenomena (the cognitive level) to the brain systems that instantiate these processes (the neural level).

In defining the field thusly, a distinct emphasis is placed on the cognitive level of analysis, in part because it is at this level that social psychologists and cognitive neuroscientists have the most in common and can most readily communicate. Although they tend to ask different types of research questions, practitioners of both disciplines share a concern with describing psychological processes in terms of information-processing mechanisms. Whereas social cognition research has uncovered a set of common information-processing mechanisms responsible for many of the most significant forms of social inference and behavior (Chaiken & Trope, 1999; Nisbett & Ross, 1980; Wegner & Bargh, 1998), cognitive neuroscientists have taken information-processing mechanisms as their point of departure and studied their basis in neuroanatomy, neurophysiology, and neurochemistry (see, e.g., Gazzaniga, 1994, 2000). Indeed, many concepts, such as schema, selective attention, inhibition, and implicit and explicit processing, are used in both fields. The common usage of

## Review of Current Research

Ideally, social cognitive neuroscience can serve the needs of social psychologists and cognitive neuroscientists simultaneously: Studies can inform theories of the psychological processes underlying a given kind of social cognition or behavior while at the same time providing information about the functions of brain systems. As the review in this section

Figure 1
The Social Cognitive Neuroscience Prism



Note. The prism graphically represents the relationships among the different levels of analysis in social cognitive neuroscience. An important feature of the prism is that it can be used to understand the relationship between social cognitive neuroscience and other related approaches. For example, the approaches taken by the parent disciplines of social psychology and cognitive neuroscience each can be represented by different faces of the prism that each lack one facet of the social cognitive neuroscience approach. Thus, the face defined by the vertices Behavior & Experience–Cognition/Information-processing–Neural Mechanisms describes the domain of inquiry for cognitive neuroscience (and is essentially identical to the cognitive neuroscience triangle described by Kosslyn & Koenig, 1992). Cognitive neuroscience tends to lack the emphasis on contextualized and motivated behavior important to social cognitive neuroscience. Similarly, social psychology can be represented by the vertices Personal & Social Context–Behavior & Experience–Cognition/Information-processing, to convey that social psychology typically is concerned with socially situated, individually motivated behavior and its information-processing underpinnings but not neural mechanisms.

illustrates, the field may still have a ways to go to attain this ideal, but it has taken some giant steps forward nonetheless.

Before beginning, it is important to note that this review is not intended to provide an exhaustive survey of all studies that could fit the social cognitive neuroscience mold or that relate the social and neural levels of analysis more generally. Reviews of work linking the social and neural levels using methods, populations, and approaches not discussed here can be found in Bachevalier (2000); Blascovich and Mendes (2000); Cacioppo et al. (1998); Cacioppo, Berntson, Sheridan, and McClintock (2000); Carter (1998); Depue and Collins (1999); Insel and Winslow (1998); Perrett, Oram, Wachsmuth, and Emery (1995); Taylor et al. (2000); Tomasello (2000); and Uvnas-Moberg (1998).

## Stereotyping

Stereotypes are cognitive structures that represent categorical information about a social group (S. T. Fiske, 1998). As such, they influence people's beliefs and expectations about group members, and this in turn biases person perception processes. For instance, if a White man possesses negative stereotypes toward Blacks, he will be likely to automatically perceive ambiguous signals from a Black

man as being more dangerous, less friendly, or less competent (Bargh, Chen, & Burrows, 1996; Dasgupta, McGhee, Greenwald, & Banaji, 2000; Greenwald & Banaji, 1995). Neuroimaging and neuropsychological methods can provide insight into the processes by which stereotyping occurs by revealing whether the same brain regions are involved in the affective, cognitive, and behavioral components of stereotyping (Breckler, 1984). Indeed, there may be as many kinds of stereotypes as there are kinds of knowledge systems in the brain (Schacter, Wagner, & Buckner, 2000), a point we return to in the section on future research directions.

Three recent studies have examined the processes underlying relatively automatic stereotyping by using functional neuroimaging to relate activation of the amygdala to perception of faces of a different race. The amygdala is a subcortical structure that plays a role in many socioemotional phenomena, including detecting gaze direction (Bachevalier, 2000; Baron-Cohen et al., 1999), consolidating explicit emotional memories (Cahill & McGaugh, 1998), learning affective associations (LeDoux, 2000), making affective judgments (Adolphs & Tranel, 1999), and perceiving novel, aversive, or potentially threatening stimuli (Isenberg et al., 1999; Whalen, 1998). The amygdala also is essential for learning fear responses and identifying fear-related stimuli, such as fearful facial expressions (Adolphs et al., 1999; Aggleton, 2000; LaBar, Gatenby, Gore, LeDoux, & Phelps, 1998; LaBar, LeDoux, Spencer, & Phelps, 1995; LeDoux, 2000). It is interesting to note that in humans, the amygdala may not play a direct role in either the experience or the expression (A. K. Anderson & Phelps, 2000, in press) of emotion, despite its important role in encoding emotional information.

The first study of stereotyping and the brain examined how perception of out-group members differs from perception of in-group members (Hart et al., 2000). It used fMRI to compare amygdala activation in both Black and White participants exposed to unfamiliar Black and White faces. For Blacks, White faces are representative of an out-group, and the reverse is true for Whites. In the first block of trials in which participants judged the gender of each face, Hart et al. found amygdala activation to both in-group and out-group faces in both Black and White participants. In contrast, in the second block of trials, the amygdala response to in-group faces habituated, whereas the response to out-group faces did not. Given the many functional roles for the amygdala listed above, the precise reason for these findings is not clear. They do, however, fit with Hart et al.'s suggestion that unfamiliar faces, whatever their group relation, are ambiguous and potentially threatening, which leads to activation of the amygdala when such faces first are seen. Presumably, the threat response to in-group faces habituates because of extensive prior experience with members of the in-group.

Extending the results of the previous study, Phelps et al. (2000) found a significant correlation between amygdala activity (in terms of both signal intensity and spatial extent of activation) in response to Black faces and amount of implicit anti-Black racial bias shown on a reaction time measure (known as the implicit attitude test, or IAT;

Greenwald, McGhee, & Schwartz, 1998) given a few days before. Interestingly, this correlation was not found for famous (and therefore familiar) Black faces (e.g., Michael Jordan). As was the case for the study of Hart et al. (2000), although there could be more than one functional basis for these correlations, the results fit with the Phelps et al.'s hypothesis that Whites automatically perceive unfamiliar Black faces as potentially threatening and fear relevant.[3] Consistent with this notion, amygdala activation to famous and familiar Black faces did not correlate with an explicit measure of racial prejudice (see also Cunningham, Johnson, Gatenby, Gore, & Banaji, 2001).

An important and contentious question about stereotypes concerns the ability of individuals to prevent stereotype activations or at least preclude those activations from biasing their judgments and behavior (Bargh, 1999; Devine & Monteith, 1999; Macrae, Bodenhausen, Milne, & Jetten, 1994). Lieberman, Hariri, and Bookheimer (2001) began tackling this issue with fMRI by having White and Black individuals view triangular displays of three faces in one of two conditions. In the race-matching condition, participants decided which of two faces presented at the bottom of the screen was of the same race as the target face presented at the top of the screen. In the race-labeling condition, participants decided which of two labels ("Caucasian," "African American") was appropriate for the target face. When the target face was from a racial out-group, amygdala activation was high in the matching task but low in the labeling task, whereas activation of an area of prefrontal cortex showed precisely the opposite pattern, low when matching and high when labeling. This pattern of results suggests the paradoxical conclusion that linguistic processing of a stereotype label actually reduces the sensitivity of the amygdala to the stereotype-relevant category membership of the perceived target.

## Attitudes and Attitude Change

Attitudes are tendencies to evaluate persons, places, and things favorably or unfavorably (Eagly & Chaiken, 1998). Understanding the nature, function, and malleability of attitudes has been a central concern of social psychology since the 1930s (LaPierre, 1934; Thurstone, 1928). Recently, social cognitive neuroscience methods have been used to elucidate the processes underlying the evaluative component of attitudes as well as the mechanisms that guide attitude change.

The former issue has been studied extensively by Cacioppo and colleagues, who examined the difference between evaluative (i.e., positive–negative) and nonevaluative (e.g., vegetable–nonvegetable) categorizations using scalp-electrode recording techniques to measure event-related brain potentials (ERPs; see, e.g., Cacioppo, Crites, Berntson, & Coles, 1993). ERPs are calculated by averaging responses to numerous events of a particular type, and components of ERP waveforms have been associated with specific cognitive processes. One ERP component, known as the P300 (so designated because it is a positive potential occurring 300 ms after stimulus onset), has been associated with preconscious registration of unusual or unexpected events (Polich, 1997). In a series of studies, Cacioppo and colleagues compared P300 responses to unexpected affective or neutral words that could be categorized evaluatively or nonevaluatively: They found that evaluative categorizations were associated with activity in the posterior right hemisphere, whereas nonevaluative categorizations were associated with activity in both hemispheres (Cacioppo, Crites, & Gardner, 1996; Crites & Cacioppo, 1996) that was not related to the execution of a motor response (Cacioppo et al., 1993; Crites, Cacioppo, Gardner, & Berntson, 1995). These studies suggest that evaluative and nonevaluative processes are functionally and neurally dissociable but not completely independent. Nonevaluative categorizations may be more complex and recruit the evaluative mechanisms of the right hemisphere as well as left hemisphere mechanisms that access semantic or associative meaning. Evaluative categorization may be so basic to survival that it plays a part in most judgments that humans make and thus has evolved to occur with greater efficiency than other forms of categorization (Zajonc, 1998).

Other studies have used neuropsychological populations to determine which processes are or are not necessary for the formation and expression of attitudes. In an early study, Johnson, Kim, and Risse (1985) demonstrated that amnesic patients could form attitudes despite a severe impairment in the ability to consciously or explicitly recollect which stimuli they had encountered (a condition termed *anterograde amnesia*; Milner, Corkin, & Teuber, 1968). In one experiment, amnesics showed greater liking for previously heard (as opposed to novel) melodies, and, in another, they showed a preference for photos of an individual previously paired with positive biographical information. This dissociation between attitude formation and memory for the formative experience suggests that attitudes can be formed implicitly, dovetailing nicely with behavioral and neuroimaging evidence from mere exposure and affective priming research (Elliott & Dolan, 1998; Murphy & Zajonc, 1993; Zajonc, 1968). A more recent study by Adolphs and Tranel (1999) suggests that the amygdala may play an important role in attitude expression. Adolphs and Tranel found that amygdala lesions influenced preference ratings for pictures and abstract designs, skewing them in the positive direction (Adolphs & Tranel, 1999). It is possible that objects elicit both positive and negative evaluations and that the amygdala contributes primarily to the latter.

The question of how and why attitudes change has been central to social psychology and has been the focus of some of its more enduring theories. Festinger's (1957) theory of cognitive dissonance, for example, posits that the discrepancy between existing attitudes and the behaviors that contradict them creates an aversive state of arousal called *cognitive dissonance*. Dissonance can be reduced

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[3] Showing a relationship between performance on a social cognitive task and activation of a theoretically relevant brain system (in this case, a system involved in detecting threats) can help validate the task as a measure of the process in question.

by changing one's preexisting attitudes so that they no longer conflict with one's actions. Most accounts of the dissonance-reduction process either explicitly state or indirectly imply (see, e.g., Brehm & Cohen, 1962; Elliot & Devine, 1994; Festinger, 1964) that conscious awareness of and thought about the attitude–behavior discrepancy is necessary to bring them into line. Lieberman, Ochsner, Gilbert, and Schacter (2001) tested the hypothesis that effortful mental work is always necessary for attitude change by working with amnesic patients who could not remember their counterattitudinal behavior. Lieberman, Ochsner, et al. reasoned that if dissonance reduction requires conscious reasoning about a past event, then the recollection of the discrepant cognitions must precede this reasoning, and that amnesic patients are unable to engage in this form of recollection. Consequently, any attitude change shown by amnesics could not be attributed to conscious post-choice rationalizing of the discrepant cognitions.

To test this hypothesis, Lieberman, Ochsner, et al. (2001) used a classic method from early dissonance research, the free choice paradigm (Brehm, 1956; Gerard & White, 1983), which arouses dissonance by asking participants to decide which of two sets of similarly liked stimuli is more desirable. After making this dissonance-arousing choice, amnesics came to like selected items more and to like rejected items less than they had liked them initially, just as nonamnesic participants did in this and many other studies. The amnesics' attitudes changed even though they were unable to recall ever making the dissonance-arousing choice. A second experiment with college undergraduates tested the notion that conscious reasoning during the choice process itself, but not after, is necessary to reduce dissonance. Participants who completed the task under cognitive load showed the same magnitude of attitude change as did those who completed the task with full attention. Together, these experiments suggest that attitude change can be automatic or implicit (Shultz & Lepper, 1995), and they challenge prevailing theories of attitude change that consider conscious evaluation and reevaluation of choices to be essential ingredients of the attitude change process.

## Person Perception

For more than half a century, one of the central concerns of social psychology has been the philosophically intractable but enormously adaptive human ability to assess the thoughts, beliefs, and desires of other people on the basis of behaviors and vocal utterances (Asch, 1946; Funder, 1987; Turing, 1950). Indeed, not only do humans have this capacity, but it is so automatic that people are more likely to spontaneously assess others in terms of intentional states than any other level of analysis (Dennett, 1989; Heider & Simmel, 1944; Moskowitz & Roman, 1992; Trope, 1986). Decades of research on attribution have addressed the question of how these inferences are in turn used to develop representations of the enduring dispositions of others and why these dispositional inferences are systematically biased (Gilbert, 1998; Ischeiser, 1949; Jones, 1979). The ability to draw accurate dispositional inferences is essential for predicting the future behavior of others and thus for the successful navigation of the social world.

A fundamental element of person perception is the ability to identify faces. Both neuroimaging (Haxby, Hoffman, & Gobbini, 2000; Kanwisher, McDermott, & Chun, 1997) and neuropsychological studies (Farah, 1990; Klein & Kihlstrom, 1998) indicate that face perception depends on regions of visual cortex including the lateral fusiform gyrus, which has been dubbed the *fusiform face area* (FFA), and inferior occiptal cortex (Kanwisher et al., 1997). Activations in the FFA are thought to reflect processing of invariant features of particular faces that do not change with different facial expressions, as evidenced by a reduction in FFA activation when attention is drawn to facial features that do change with facial expressions (Hoffman & Haxby, 2000). However, recent studies have cast doubt on whether this area is specialized for faces per se and instead suggest this area might respond to any stimuli for which the individual has visual expertise (Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999). Thus, bird and cat experts activate the FFA when looking at birds and cats, respectively (Gauther, Skudlarski, Gore, & Anderson, 2000). Faces are, nevertheless, likely to be the stimuli for which most individuals possess the greatest visual expertise, although this expertise may vary across social groups as a function of experience with them. Indeed, a recent study found that perception of faces from the same race as the participant led to greater activation of the fusiform gyrus than did perception of faces from another race (Golby et al., in press) and that this activation was the only neural predictor of the degree of memory advantage for same-race faces over other-race faces.

The superior temporal sulcus (STS) complements the FFA by responding to facial features that do change with different expressions, while remaining unresponsive to the invariant identity cues (Hoffman & Haxby, 2000). Perception of meaningful biological motion from the hands, eyes, mouth, and whole body have all activated the STS (Allison, Puce, & McCarthy, 2000; Bonda, Petrides, Ostry, & Evans, 1996; Decety & Grezes, 1999; Jellema, Baker, Wicker, & Perrett, 2000; Puce, Allison, Bentin, Gore, & McCarthy, 1998). Presumably, these gestural cues are associated with the experiential state of the target and can be meaningfully organized to draw inferences about the target's intentional state (Knapp & Hall, 1992).

The emotional meaning of at least some nonverbal cues may be processed separately from their perceptual features (Borod, Bloom, & Haywood, 1998; Bowers, Bauer, & Heilman, 1993; Perrett et al., 1995). Neuroimaging and neuropsychological findings suggest that the basal ganglia may play a special role in recognizing the facial expression of disgust (Lieberman, 2000; Philips et al., 1997; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998; Sprengelmeyer et al., 1996), whereas the amygdala plays a key role in identifying the expression of fear (see, e.g., Adolphs et al., 1999; Breiter et al., 1996; Hamann et al., 1996; Phillips et al., 2001). Consistent with the amygdala's role in fear recognition and the detection of threatening stimuli more generally, amygdala lesions make one more

likely to judge tough-looking individuals as being approachable and trustworthy (Adolphs, Tranel, & Damasio, 1998).

The consequences of an inability to make attributions about mental states based on nonverbal as well as more complex cues have been studied in the context of theory of mind (ToM). ToM is a term coined by developmental psychologists to describe the growing child's capacity to make attributions or predictions about behavior using mental-state concepts such as beliefs, desires, emotions, and intentions (Frith & Frith, 1999).[4] It has been hypothesized that autistic children and children with Asperger's syndrome (AS, a related disorder; Klin, Schultz, & Cohen, 1999) lack a ToM, which would explain why they treat other people as inanimate objects, failing to recognize their status as sentient, self-directed beings (Baron-Cohen, 1995; Klin, 2000).

Baron-Cohen (1995) suggested that ToM may depend on a network of brain systems important for social intelligence that functions abnormally in autism and AS. This network was first described by Brothers (1990). Primarily on the basis of work in primates, Brothers hypothesized that the amygdala, orbitofrontal cortex (or OFC, which is reciprocally connected with the amygdala and is important for emotion regulation; Rolls, 2000; Rolls, Hornak, Wade, & McGrath, 1994), and STS carry out functions necessary for navigating the social world. The results of some recent imaging studies are consistent with Baron-Cohen's hypothesis: Children with autism or AS show normal STS activation and abnormal amygdala activation when interpreting the social meaning of eye gaze (Baron-Cohen et al., 1999). In addition, patients with OFC damage show impairments on ToM tasks (Stone, Baron-Cohen, & Knight, 1998), and OFC activation may be important for drawing ToM inferences (Baron-Cohen et al., 1994). However, other studies suggest that other brain systems are important for ToM as well (cf. Brownell & Martino, 1998; A. Fiske, Iacoboni, Knowlton, & Lieberman, 2001): Children with AS fail to show normal activation in either the FFA when viewing faces (Schultz, Gauthier, et al., 2000) or in an area of medial prefrontal cortex activated when drawing ToM inferences (Fletcher et al., 1995; Gallagher et al., 2000; Happe et al., 1996). Taken together, these results suggest that children with autism can represent some social cues normally in the STS but that dysfunction in the FFA, OFC, and amygdala keep them from extracting the full social and emotional meaning of these cues (Baron-Cohen, 1995; Baron-Cohen et al., 2000; Schultz, Romanski, & Tsatdsanis, 2000; Stone et al., 1998).

Studies of another neuropsychological disorder known as Capgras syndrome suggest that another fundamental aspect of person perception—the ability to discriminate familiar from unfamiliar individuals—may similarly depend on interactions between brain systems that extract a person's appearance and brain systems that process how one feels about them. Capgras patients believe that their close friends and family have been replaced by exact replicas that look and act just like the real ones. One explanation for this disorder is that the ability to respond emotionally to or to extract the personal significance of faces has been disrupted. Ellis, Young, Quayle, and De Pauw (1997; Ellis & Lewis, 2001; see also Ramachandran, 1998) tested this idea by showing that Capgras patients failed to exhibit normal skin conductance responses (SCR, a measure of arousal) to familiar faces even though their SCRs were normal to other kinds of auditory stimuli. Ellis et al. reasoned that Capgras patients misattribute a lack of feeling in response to loved ones to their having been replaced with impostors who do not elicit the normal reactions. The recognition deficit of Capgras patients runs counter to prevailing notions that the ability to recognize another person depends on physical appearance and other external cues to personality and suggests instead that person perception depends critically on the automatic activation of an internal representation of a perceived person's emotional significance (Griffin & Ross, 1991).

As of now, the research reviewed above has yet to make substantial contact with social psychological approaches to attributional inference, which have been concerned less with the initial identification and labeling of a mental state and more with the relationship between that state and a person's enduring dispositions (for a review, see Gilbert, 1998). Many person perception models suggest that the process of making dispositional attributions is a multistep process, in which a behavior is first characterized ("That guy looks happy"), an inference is drawn about that person's disposition ("He's a happy person in general"), and that inference is corrected on the basis of situational constraints that could influence behavior ("Aha—he just won the lottery, so perhaps he isn't so dispositionally happy after all"). Social psychological research suggests that when one has the goal of understanding a person's disposition, one tends to automatically infer that behavior results from a corresponding disposition ("He's a happy guy in general"), whereas correcting that automatic attribution takes time and mental resources ("Hmmm. . . . Anyone would be happy after winning the lottery"; Gilbert, 1998).

The imaging and patient data reviewed above are broadly consistent with the idea that person perception is a multistep process, but it is apparent that they speak only to the initial stages of the person perception process posited by social psychologists. Research on ToM, facial identification and expression processing, and nonverbal decoding of the socioemotional meaning of facial and vocal cues has helped localize the brain systems supporting intentional state inferences. Using these findings as a springboard,

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[4] Before the age of two years, children learn that nonverbal cues such as pointing and eye gaze signal the intention to direct attention to particular locations or objects. By about age four, children then learn that their beliefs about the world may differ from those of other people and that the beliefs that anyone holds may in some cases be false. Finally, around age seven, children learn that other people also make use of mental state concepts to understand each other's behavior. Such second-order beliefs about beliefs allow children to make predictions about what another person believes a third person might know (Baron-Cohen, 1995; Perner, Stummer, & Lang, 1999).

future neuroimaging and patient research can begin to investigate the information-processing mechanisms involved in dispositional attribution. Such work could not only clarify the relationship between intentional and dispositional inference but, depending on which brain systems are involved, could also help to resolve debates over the degree to which attributions should be characterized as automatic (Gilbert, Pelham, & Krull, 1988; Kunda & Thagard, 1996; Lieberman, Gaunt, Gilbert, & Trope, in press; Read & Marcus-Newhall, 1993; Trope & Gaunt, 1999).

## Self-Knowledge

Knowing who one is, what one likes, and whether one is confident, curious, or anxious is essential to self-regulation as well as to navigating the social world. An enduring question about trait self-knowledge concerns its source: Some have argued that self-knowledge is episodic in nature and taps memory for specific experiences, whereas others have argued that self-knowledge is primarily abstract and schematic. Klein et al. (1996) hypothesized that access to trait self-knowledge does not require explicit access to recent personal experiences and tested this in a woman who had been rendered temporarily amnesic. The woman had suffered a severe head trauma that left her unable to explicitly remember experiences that occurred during the weeks preceding the injury (a condition termed *retrograde amnesia*). The injury impaired her episodic memory but left her ability to access semantic memory unaffected. Despite her episodic memory impairment, the woman's self-judgments made during the period of amnesia were essentially identical to those made after she recovered from the injury and regained memory for the previously lost weeks. This result therefore suggests that when making self-judgments, the knowledge people access is often schematic.

Converging support for this idea comes from a study by Craik et al. (1999), who used positron emission tomography to compare patterns of brain activation when participants made judgments of self-relevance, relevance to a public figure, social desirability, or number of syllables for a series of trait words. Compared with non-self-judgments, assessing the self-relevance of words activated regions of the left frontal lobe shown in previous work (e.g., Kapur et al., 1996) to be involved in accessing information in semantic memory. Although that result is compatible with the findings of Klein et al. (1996), Craik et al. also found that select areas of the right frontal lobe, which are known to be involved with retrieving memories for specific episodes, also were activated when making self-relevant judgments. This finding suggests that episodic as well as schematic representations may be activated when drawing inferences about one's traits. Although these findings do not indicate what role episodic information plays in trait inference, when taken together with the results of Klein et al., they suggest the possibility that autobiographical episodes are more important to naive theories of self-knowledge than they are to the actual bases of self-knowledge. That is, in many situations, one recollects episodes even though they do not increase the accuracy of one's schema-based self-

perceptions, perhaps in the mistaken belief that accurate self-knowledge is episodic.

In addition to helping in the judgment of one's stable personality traits, left hemisphere mechanisms may also be used for drawing inferences about the causes of one's recent or current actions. In a series of classic experiments, Gazzaniga (1985) studied patients who, for medical reasons, had undergone an operation that severed the connection between their cerebral hemispheres. This operation essentially isolated the processing capacities of each hemisphere so that the information received and the responses made by one hemisphere were not conveyed directly to the other. In a key study, a shovel was shown to the right hemisphere, and a chicken claw was shown to the left; then, the patient was asked select from a set of pictures the image just seen. The patient's right hand, which is controlled by the left hemisphere, pointed to the chicken claw, but the patient's left hand, which is controlled by the right hemisphere, pointed to the shovel. When asked to explain these discrepant responses, the patient explained that the shovel was needed to clean out the chicken coop. In this and other studies, even though the left hemisphere had no awareness of what the right hemisphere had seen, patients used the general personal and semantic knowledge accessible by the left hemisphere to construct plausible explanations for why they had made their responses. These findings also provide a neurological basis for a classic social psychological account of how people explain their behavior. According to Bem's (1972) self-perception theory, people do not have perfect self-knowledge about why they do what they do. As a result, people sometimes explain their own actions in the same way they explain the actions of others: by observing their behavior and drawing inferences about why they behaved as they did.

Although these findings are important and intriguing (see also Heilman, Barrett, & Adair, 1998), many of the basic building blocks of social psychological theories of the self have yet to be pursued. Little if anything is known about the neural correlates of self-esteem (Crocker & Wolfe, in press), self-schemata (Markus, 1977), self-serving biases (Drake & Seligman, 1989; Taylor & Brown, 1988), self-awareness (Heatherton, Polivy, Herman, & Baumeister, 1993; Wicklund, 1975), or cultural influences on the self-concept (Markus & Kitayama, 1991), all of which are ripe topics for social cognitive neuroscientific exploration (for a comprehensive review of research on the self, see Baumeister, 1998). To pick one example, debates over the putative motivational and cognitive aspects of self-serving biases (Tetlock & Levi, 1982) could be addressed in new ways by examining whether and how biased judgments recruit brain structures that have been associated with cognitive or affective processing, or both.

## Interaction of Emotion and Cognition

Although some areas of psychology have shied away from emotion for most of the past century, social psychologists have long considered emotion to be important and have studied a variety of ways in which emotions and cognition interact (Dewey, 1922; Mead, 1934). By and large, this

research has explored hypotheses about the ways in which emotion biases judgments in one manner or another (Forgas, 1995). However, until recently, no experiments had tested the more basic hypothesis that emotion is necessary for making certain kinds of decisions. The reasons for the failure to test this hypothesis are many and varied (Damasio, 1994), but one pragmatic reason stands out here: The only way to determine whether emotion plays a necessary role in reasoning would be to eliminate the capacity to generate emotional reactions and then determine whether the capacity to reason was adversely affected. Unfortunately for social psychologists, the elimination of emotion is plainly impossible for the average experimental participant. Yet, fortunately for social cognitive neuroscience, emotional impairments follow from damage to very specific parts of the brain, and study of such patients has revealed that emotion is essential for certain types of reasoning.

It has been known for almost a century that patients with damage to the ventral (lower) and medial (middle) regions of the prefrontal cortex may be inappropriately emotional, apathetic, or impulsive (Harlow, 1868; Hornak, Rolls, & Wade, 1996; Macmillan, 2000; Milner, 1964). The emotional responses that people ordinarily have learned to generate in response to social situations are often abnormal in these patients. Damasio and colleagues systematically studied the consequences of these deficits for decision making using a simple game in which participants try to win money by selecting cards from different decks. Whereas normal participants learn to sample from safe decks that result in the net gain of money and avoid risky decks that result in net losses, patients with ventromedial frontal lesions do not. Furthermore, when sampling from the risky decks, patients fail to show an "anxious" change in skin conductance that, in normal participants, signals anticipation of a possible loss (Bechara, Tranel, Damasio, & Damasio, 1996). More recent studies have extended this work to demonstrate that lesions to the amygdala also impair reasoning on this task because patients cannot register the significance of their choices (Bechara, Damasio, Damasio, & Lee, 1999), and neuroimaging studies using related paradigms have shown activation of areas of the ventromedial and orbital frontal cortices (O'Doherty, Kringelbach, Hornak, Andrews, & Rolls, 2001; Elliott, Friston, & Dolan, 2000; Rogers et al., 1999).

The above data have been used to explain cognition–emotion interactions underlying reasoning at the level of neural systems (see, e.g., Bechara et al., 1999; Damasio, 1994), and related analyses are available for research on memory (see, e.g., Gray, in press; LeDoux, 2000; but see Ochsner & Schacter, 2000, in press). Beyond this work, however, few hard data have addressed the neural systems that mediate cognition–emotion interactions for the majority of social psychological phenomena (cf. Cacioppo, 1994; Gray, 1999; Hariri, Bookheimer, & Mazziotta, 2000; Ochsner, Bunge, Gross, & Gabrieli, 2001; Panksepp, 1998). Social psychologists have documented myriad ways in which emotional states can bias reasoning, judgments of self and others, and the retrieval of memories (Forgas,

1995; Ochsner & Schacter, 2000, in press; Schwarz & Clore, 1988). They have also proposed models that explain why and how emotional and cognitive processes interact (see, e.g., Dalgleish & Power, 1999; Forgas, 1995; Kunda, 1990; Rusting, 1998). To date, however, comparatively little neuroscience research has contributed to progress on these issue (for a discussion, see Ochsner & Feldmann Barrett, 2001).

Equally important is studying the way in which cognition can be used to interpret and understand emotional experiences as well as regulate them. An initial step was taken in this direction by Ochsner, Bunge, Gross, and Gabrieli (2001), who studied the neural systems involved in cognitively reappraising an aversive image to diminish its emotional impact (Gross, 1998; Lazarus & Folkman, 1984; Richards & Gross, 2000). They found that areas of the ventrolateral frontal lobe, shown in cognitive studies to be important for interference control and response inhibition (see, e.g., Bunge, Ochsner, Desmond, Glover, & Gabrieli, in press; Jonides, Smith, Marshuetz, Koeppe, & Reuter-Lorenz, 1998), were activated when reappraising, whereas areas involved in generating an emotional response (including the amygdala and ventral medial frontal lobe) were not. In contrast, areas important for reappraising were inactive and areas important for emotion were active when individuals were aware of, but did not try to alter, their emotional reactions. This suggests that reappraisal is effective in neutralizing negative emotions at least in part because it influences multiple stages of the emotion generation process (Hariri et al., 2000; Lieberman, Hariri, & Bookheimer, 2001). Future work in social cognitive neuroscience should determine how emotions change the functioning of neural systems for other cognitive processes besides reasoning and memory and should study how cognitive systems can be used to generate and regulate emotional experiences (Clore & Ortony, 2000; Lane & Nadel, 2000; Lane et al., 1998; Ochsner & Feldman Barrett, 2001).

## Directions for Future Social Cognitive Neuroscience Research

The preceding review has illustrated some of the ways in which social cognitive neuroscience research can proceed. Although many topics already are being investigated, social cognitive neuroscience is in its infancy and will take time to mature and grow. As the field develops, one can expect a shift in the kinds of studies being conducted. When relatively little is known about the neural systems involved in a given form of behavior or cognition, initial studies may serve more to identify brain correlates for those phenomena than to test theories about how and why the phenomena occur. This has been the case for many areas of cognitive neuroscience research and for current social cognitive neuroscience research as well. Ultimately, it will be important to move beyond brain–behavior correlations, but that can only happen when researchers in the field have built a baseline of knowledge about the brain systems underlying specific types of social or emotional processing.

How is it possible to get there from here? Although it is surely impossible to predict the clever methods researchers will devise to address their particular theoretical questions and the impact their ingenuity will have, it is possible to talk in more general terms about what potential benefits may accrue and which pitfalls must be avoided by adopting a social cognitive neuroscience approach. In this regard, we believe that at least three important kinds of substantive progress can be made using a social cognitive neuroscience approach. Some types of progress may be of greater or lesser relevance to the traditional interests of both social psychologists and cognitive neuroscientists, but the important point is that as a whole, social cognitive neuroscience speaks to the interests of both parties.

## Unification

In the late 1970s and early 1980s, social psychology underwent a transformation when the adoption of the information-processing metaphor offered a set of conceptual tools that could explain the similarities and differences between a number of seemingly unconnected phenomena (S. T. Fiske, 1998; Gilbert, 1999). The field of social cognition was born, and today the lion's share of social psychological research bears the mark of the social cognition tradition (Gilbert, 1999). A little less than a decade later, cognitive psychology underwent an analogous transformation as data about the brain began to be used to constrain theories about the cognitive processes underlying memory (see, e.g., Schacter, 1990), attention (see, e.g., Posner & Petersen, 1990), and vision (see, e.g., Kosslyn, 1991), among other topics (Gazzaniga, 1994). The field of cognitive neuroscience was born, and today the cognitive neuroscience approach is used to study most every topic in cognitive psychology. In each case, by taking a step down from a higher (the social or cognitive) to a lower (the cognitive or neural) level of analysis, social psychology and cognitive neuroscience gained greater conceptual and explanatory power.

The emergence of social cognitive neuroscience indicates that social psychologists and cognitive neuroscientists once again are taking steps to broaden their theoretical and methodological horizons and stand to gain many of the same benefits that accrued from their earlier transformations. Starting at the social level, one important benefit of the social cognitive neuroscience approach can be increased precision in the characterization of socioemotional phenomena. By studying the underlying neurocognitive structures, researchers can capture commonalities across heterogeneous social phenomena in ways previously impossible.

For instance, over the past few years, the concepts of automaticity and control have brought tremendous order to areas of social psychological inquiry where previous understanding had primarily been descriptive rather than explanatory (Chaiken & Trope, 1999; Gilbert et al., 1988; Petty & Cacioppo, 1986; Wegner & Bargh, 1998). At present, however, different domains of social and self-inference research have developed their own formulations of automaticity and control in parallel, with little transfer of knowledge from one domain to another. There has been no way to determine whether the automatic components of persuasion were the same as the automatic components of attributional inference. Now, however, social cognitive neuroscience can shed new light on these relationships by mapping the neural bases of different forms of social cognition. If similar brain areas are activated by different forms of social cognition, and if manipulations of stimulus ambiguity or intensity, epistemic goals, and attentional resources lead to similar patterns of activational change for each kind of process, it would be reasonable to conclude that many of the same computations are being recruited by the different processes (Lieberman, 2000).

As an example, consider that the amygdala is a brain structure implicated in many different kinds of phenomena discussed above—in attitudes, stereotyping, person perception, and emotion, the amygdala seems to play an important functional role. This suggests that all of these phenomena, which typically are treated as distinct research topics, are fundamentally similar in terms of their reliance on at least one type of brain system important for processing affective stimuli.[5] There may be other brain systems, including those used to detect cognitive conflict (see, e.g., Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999; Carter et al., 1998), exert cognitive control (see, e.g., Miller & Cohen, in press), or encode memories (see, e.g., Brewer, Zhao, Glover, & Gabrieli, 1998; Schacter & Wagner, 1999), that are commonly recruited when stereotyping, drawing a dispositional inference, and so on. It is possible that qualitatively diverse social psychological processes use a small set of common mechanisms, with the different kinds of output resulting from different kinds of input, rather than from fundamentally different kinds of processing.[6] The benefits from such an understanding of diverse social psychological processes could be enormous. The sometimes blurry lines between related phenomena such as attitudes and stereotyping could be either sharpened or eliminated by understanding how they depend on the operation of the same or different brain systems. As a result, inquiries being made in different areas of social psychology could become more directly relevant to one another, leading to vertical rather than horizontal growth of the field.

[5] Neuroscience research suggests many additional functional roles for the amygdala (see Aggleton, 2000, for a review), and it is possible that the amygdala, which is composed of numerous subnuclei, carries out more than one type of computation. The problem then is to determine whether and how the subnuclei are involved in different socioemotional phenomena.

[6] Brain imaging and neuropsychological studies are showing that many brain systems carry out computations essential not just to different forms of social cognition but also to purportedly emotional as opposed to cognitive, or social as opposed to nonsocial, cognition. Although it may be true that the functions of some systems can best be described as social or emotional in nature (as may be the case for the amygdala but may not be the case for the FFA), these systems can be recruited for purportedly cognitive tasks, and, conversely, supposedly cognitive brain systems may be important for social and emotional abilities. This suggests that some of the distinctions currently made between domains of research, such as the distinctions between social and nonsocial perception, may break down at the level of the brain and its neural systems. It is not that such distinctions are unimportant. Rather, they may prove most useful at the social level of experience and behavior.

## Dissection

Information about brain function may be used not only to identify the commonalities between seemingly disparate phenomena but also to segregate seemingly similar phenomena into separate ones and to parse complex phenomena into their component processes. A good illustration of this comes from research on memory (Schacter, 1992; Squire, 1992). At one time, it was unclear whether different kinds of memory were the result of a single memory system operating in different ways or distinct memory systems operating in concert (Roediger, Rajaram, & Srinivas, 1990; Roediger, Weldon, & Challis, 1989). Although cognitive data alone were insufficient for discriminating between these alternative theories (J. R. Anderson, 1978), neuropsychological and neuroimaging data have clearly established that multiple memory systems do exist (Schacter & Tulving, 1994; Schacter et al., 2000; Squire, 1992). For example, amnesics with damage to the medial temporal lobe are impaired on tests requiring access to explicit or declarative memory but show normal performance on most implicit tests of memory (Schacter, Chiu, & Ochsner, 1993; Schacter et al., 2000; Squire, 1992). Different forms of implicit memory have in turn been shown to rely on different memory systems according to the kind of information being represented. Thus, implicit memory for object meaning depends on systems important for representing objects in the temporal lobe, whereas implicit memory of visual perceptual information relies on the occipital cortex (Schacter, 1990), and the procedural learning of skills and habits depends on the basal ganglia, which play a special role in representing sequences of actions or cognitions (Knowlton, Mangels, & Squire, 1996; Knowlton, Ramus, & Squire, 1992; Salmon & Butters, 1995).

One promise of social cognitive neuroscience is that the same kind of functional dissociation can aid understanding of social-level phenomena. For instance, research on stereotype representations could benefit from a research program similar to the one that has dissected memory representations. Although the past decade has seen increasing acceptance of the notion of implicit stereotypes (Banaji & Hardin, 1996; Lowery, Hardin, & Sinclair, in press), little has been done to make finer representational distinctions at both the explicit and the implicit levels. Presumably, there are episodic, semantic, perceptual, affective, and procedural stereotype representations. Each kind of stereotype representation could have different constraints in terms of initial formation, activation, application, controllability, and capacity for being extinguished. If these different types of representation do exist, then the current inability to make these distinctions must introduce noise and confounds into research methodologies.

Social cognitive neuroscience can also contribute to the decomposition of other processes that appear continuous but are in fact better understood as separate computational systems. Continua such a positive and negative affect (Cacioppo & Gardner, 1999; Carver & Scheier, 1990; Ochsner, 2000; Ochsner & Schacter, 2000), automaticity and control (Lieberman et al., in press; Ochsner et al.,

2001; Posner & Snyder, 1975; Seger, Prabhakaran, Poldrack, & Gabrieli, 2000; Shiffrin & Schneider, 1977; E. R. Smith & DeCoster, 1999), and high and low arousal (Lieberman & Rosenthal, 2001) are all successfully being dissociated. One upshot of these dissociations into separate neurocognitive systems is that each end of the continuum no longer needs to be tautologically described as the other end's opposite (Cacioppo & Gardner, 1999). For example, the neurocognitive system for positive affective associations (Berridge & Robinson, 1998; Lane, Reiman, et al., 1997; Lieberman, 2000) serves different functions and can be described without reference to neurocognitive systems for negative affect (LeDoux, 2000; Whalen et al., 1998).

Neuroimaging also allows the assessment of the independent contributions of simultaneously occurring processes from both ends of the supposed continua. As their knowledge base builds, researchers will be able to independently assess both the automatic and the controlled components of a given process, rather than assessing whether a process is more automatic or more controlled (Lieberman et al., in press). For instance, Humphreys and Revelle (1984) previously suggested that the quadratic relationship between arousal and performance would best be understood as a simple combination of two separate processes: an automatic process that monotonically improves with increasing arousal and a controlled one that is monotonically impaired with increasing arousal. Recent neuropharmacological and neuroimaging work has provided a neural basis for this claim (Arnsten, 1998; Aston-Jones, Rajkowski, & Cohen, 1999).

## Bottom-Up Versus Top-Down Science

During the early stages of social cognitive neuroscience research, investigators have tended to remain true to their roots in cognitive neuroscience or social psychology. For their part, cognitive neuroscientists have historically used minimalist methodologies to study a few basic abilities with little concern for the personal and situational conditions that elicit and influence them. From this perspective, understanding of real-world social phenomena is built from the bottom up, and researchers consequently have tried to identify the basic neural systems used to recognize, remember, and attend to socially (e.g., faces, facial expressions, biological motion) or emotionally (e.g., odors, films, photos, rewarding and risky choices) relevant stimuli, as reviewed above.

In contrast, social psychology has historically been interested in a broad range of complex and socially relevant phenomena that involve the self, how the self relates to others, and the impact of emotion and motivation on judgment, behavior, and experience (for a review, see Gilbert, Fiske, & Lindzey, 1998). From this perspective, understanding social phenomena is a top-down endeavor that begins with the real-world topic of interest. Taking this approach, social psychologists have begun studying brain systems underlying classic social psychological phenomena, including stereotyping, attitudes, attitude change, and self-knowledge, as reviewed above.

In recent years, there has been increased appreciation that the top-down and bottom-up approaches cannot be

researched independently because they are intimately linked to one another. Different neural circuitry is recruited by a given task depending on the overall psychological state of the individual. At the level of cognitive information processing mechanisms, mapping these changes has been one of the great achievements of social cognition research. A long list of research paradigms has revealed how the gestalt of cognition varies with mood (Forgas, 1995), emotion (Clore & Ortony, 1998; Rusting, 1998), motivation (Higgins, 1999), level of action identification (Baumeister, 1990; Vallacher & Wegner, 1987), self- versus other-focused attention (Carver & Scheier, 1981; Wicklund, 1975), temporal perspective (Gilbert et al., 1998; Liberman & Trope, 1998), culture (Lieberman, Gilbert, & Jarcho, 2001; Markus & Kitayama, 1991; Peng & Nisbett, 1999), personality (Humphreys & Revelle, 1984; Lieberman & Rosenthal, 2001), epistemic motivation (Kruglanski & Webster, 1996; Kunda, 1990; Tetlock, 1985), and analytic versus intuitive mental sets (Csikszentmihalyi, 1990; Epstein, Pacini, Denes-Raj, & Heier, 1996; Lieberman, 2000).

Much of the existing work in cognitive psychology and cognitive neuroscience has circumvented these distinctions by inducing a relatively constant mental state across most experimental situations (e.g., nonemotional, analytic, accuracy motivation). However, this does not mean that the results of studies conducted under these conditions reflect the basic building blocks of cognition. Rather, they reveal the operation of cognitive and neural processes under these particular conditions, but there are no a priori reasons to reify these conditions as basic. If anything, work from social cognition and evolutionary psychological theory suggests that cognition in most psychology experiments is quite removed from actual cognition embedded in the motivationally charged stream of everyday life. Furthermore, some have argued that many higher cognitive functions evolved in the service of social goals, such as the need to form, foster, and make use of social bonds (Baron-Cohen, 1995; Byrne & Whiten, 1988). Cognitive neuroscience has much to gain from incorporating social cognitive manipulations of psychological state into its basic research paradigms.

The importance of this point can be seen in recent neuroimaging research on emotion. From the view of social psychologists, emotions arise from appraisals of events and their relevance to goals, wants, and needs (see, e.g., Lazarus, 1991; Scherer, Schorr, & Johnstone, 2001). One's initial emotional responses may change if one tries to regulate them, which experimental participants may spontaneously elect to do when experiencing negative emotions (Erber & Erber, 2001; Singer & Salovey, 1996; S. M. Smith & Petty, 1995). By contrast, much cognitive neuroscience research has treated emotion as if it were a stimulus property such as color, shape, or size and not as a situation-dependent property of a person (Ochsner & Feldman Barrett, 2001). Uninformed by contemporary social psychological theories of emotion, imaging studies have typically studied only perception or memory of emotionally evocative photos, words, or films and have not instructed participants to process them in any particular way. Although putative emotion areas of the brain have been identified, the

resulting patterns of activation often are ambiguous with respect to the processes carried out in a given region. Is a given area activated because it is related to thoughts about a stimulus, regulation of a feeling, a representation of the affective properties of an event, an individual difference in emotional reactivity, or all of the above? It may be impossible to tell from research paradigms of this sort.

With these considerations in mind, a second generation of studies is beginning to manipulate the way in which participants attend to (Lane, Fink, Chau, & Dolan, 1997; Lane et al., 1998) or regulate (Beer et al., 2001; Ochsner et al., 2001) their feelings, to investigate the ways in which some aspects of emotion may be processed automatically and outside of awareness (see, e.g., A. K. Anderson & Phelps, 2001; Morris, Ohman, & Dolan, 1999; Whalen et al., 1998), and to explore the impact of personality on emotion processing (Canli et al., 2001). This analysis of emotion research could be extended to other topics in social cognitive neuroscience as well. The essential point is that building a theory of a social or emotional phenomenon from the bottom up, using perception and memory as one's primary methodological tools, can result in impoverished theories of the phenomenon in question. Looking across the fence at how one's neighbor studies the same topic may enrich both theory and methodology.

## Conclusions

The first meeting ever devoted to social cognitive neuroscience took place in April 2001 and was attended by social psychologists and cognitive neuroscientists, as well as by clinical psychologists, sociologists, anthropologists, economists, political scientists, and researchers in other related disciplines. The involvement of so many kinds of researchers suggests not only that the field has arrived but also that the social cognitive neuroscience approach has much to offer researchers in various domains interested in understanding the link between social-level phenomena and their underlying neurocognitive mechanisms.

Work in health psychology, for example, seeks to understand the consequences that particular psychological responses to illness, loss, pregnancy, and other stressors have for mental and physical health. Social cognitive neuroscience offers a natural framework for linking social factors to patterns of construal and brain mechanisms, and, in fact, much research in this area already has a social cognitive neuroscience flavor (see, e.g., Cole, Kemeny, & Taylor, 1997; Kiecolt-Glaser et al., 1998). Psychiatric and clinical psychological studies of mood, thought, and personality disorders also might profitably make use of the social cognitive neuroscience approach. Although research in this area already is concerned with multiple levels of analysis in understanding the pathophysiology of psychological disorders, it typically uses cognitive rather than social probes to understand the links between the brain and behavior. Researchers use participants' performance on neuropsychological tests of memory, attention, or language to draw inferences about the brain systems involved in schizophrenia, anxiety, phobias, and obsessive–compulsive disorder. In the future, they could more often use tests of nonverbal perception, attribution, emotion regulation,

and other processes to draw different inferences about the mechanisms underlying specifically social cognitive deficits in these disorders (see, e.g., Frith & Corcoran, 1996; Knutson et al., 1998). This type of analysis may be extended to the study of the deficits associated with aging or other neurodegenerative disorders (e.g., Alzheimer's, Parkinson's, and Huntington's disease) as well (cf. Benke, Bosch, & Andree, 1998; Speedie, Brake, Folstein, Bowers, & Heilman, 1990).

In closing, it may be useful to reiterate the goal of the social cognitive neuroscience approach in the form of an explicit warning against two potential misconstruals of it. The first misconstrual is perceiving the aim of social cognitive neuroscience to be the discovery of "social modules" in the brain. Although there may turn out to be brain systems whose function is best described as social or emotional in nature (as may be the case for the amygdala but may not be the case for the FFA; see the discussion above), imaging and neuropsychological studies are demonstrating that these systems can be recruited for cognitive tasks, and, conversely, purportedly cognitive brain systems may be important for social and emotional abilities. The goal of social cognitive neuroscience is to understand the links between the social, cognitive, and neural levels, whatever those links turn out to be. Its success does not turn on the discovery of brain systems specialized for processing social information per se. A second possible misconstrual is that social cognitive neuroscience is concerned only with mapping the brain correlates of social and emotional phenomena. As we have argued above, mapping is necessary to form the foundation on which hypothesis-driven studies are built, but mapping per se is not the only goal of social cognitive neuroscience. Once one has an idea of which processes a brain area carries out, one can make use of that knowledge to test hypotheses about the involvement of those processes in a given behavior. Some studies already have made use of the existing body of cognitive neuroscientific knowledge in this way, testing theories of the processes underlying self-knowledge (Klein et al., 1996), attitude change (Lieberman, Ochsner, et al., 2001), and stereotyping (Phelps et al., 2000). As the field develops, one can expect a change in the relative proportion of studies whose goal is brain mapping as opposed to theory testing.

A not-so-subtle message of this article is that for social cognitive neuroscience to be all it can be, social psychologists and cognitive neuroscientists must realize that they depend on one another. By remaining separate, each area has made advances that reflect its respective emphases on simple and universal, as opposed to complex and situation-dependent, phenomena. From the social cognitive neuroscience perspective, each approach provides a necessary but individually insufficient piece of a bigger psychological puzzle. By joining forces, social psychologists and cognitive neuroscientists will no longer be strangers passing on the street but colleagues walking together toward a brighter future.

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