Rilling, J., Gutman, D., Zeh, T., Pagnoni, G., Berns, G., & Kilts, C. (2002). A neural basis for social cooperation. *Neuron, 35*(2), 395–405.

Singer, T., Kiebel, S. J., Winston, J. S., Dolan, R. J., & Frith, C. D. (2004a). Brain responses to the acquired moral status of faces. *Neuron, 41*(4), 653–662.

Singer, T., Seymour, B., O'Doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004b). Empathy for pain involves the affective but not sensory components of pain. *Science, 303,* 1157–1162.

Wicker, B., Keysers, C., Plailly, J., Royet, J. P., Gallese, V., & Rizzolatti, G. (2003). Both of us disgusted in my insula: The common neural basis of seeing and feeling disgust. *Neuron, 40*(3), 655–664.

Social Neuroscience

The Neuroscience of Social Interaction: Decoding, Imitating, and Influencing the Actions of Others

Edited by Christopher D. Frith and Daniel M. Wolpert. New York: Oxford University Press, 2004. xxvii + 329 pp. Paper, $59.50.

Collaborations between cognitive scientists and neuroscientists in the twilight of the 20th century helped unravel puzzles of the mind, including aspects of object perception, imagery, attention, and memory. However, many aspects of the mind require a more comprehensive approach to reveal the mystery of mind–brain connections. Attraction, altruism, aggression, affiliation, attachment, attitudes, attribution, and autism are examples from the top of the alphabet alone. Humans are fundamentally social creatures whose mental and physical health depends on their social position and relationships. Accordingly, the human brain has evolved to promote social coordination, communication, interactions, relationships, and collective enterprises. *The Neuroscience of Social Interaction,* edited by Christopher Frith and Daniel Wolpert, therefore marks a step toward a more comprehensive understanding of the human mind and brain.

The Neuroscience of Social Interaction was originally published as an issue of the *Philosophical Transactions of the Royal Society, Series B* in 2003 (volume 358, pp. 429–602). As such, this volume is designed not to provide a comprehensive review of neuroscientific studies of social interaction but rather to provide a selective review of the neural and computational mechanisms underlying the human ability to mentalize, that is, the ability to perceive and communicate mental states, including the beliefs and desires of others. The book consists of an introduction, four chapters on biological motion, five chapters on mirror neurons, five chapters on mentalizing, and a subject index. The introduction by Tania Singer, Daniel Wolpert, and Christopher Frith reviews the need for research on the neurobiological mechanisms underlying social interaction, touches on related fields of study, and summarizes the major contributions of each of the chapters.

Our perceptual world is not constituted solely by stationary objects but is a continuous flow of movement and transitions. A fundamental perceptual quality of other animals (including humans) in our habitat is the distinctive fashion in which these animals move. People have no difficulty distinguishing between the movement of an automobile and a pedestrian, and there appears to be a greater

similarity in the movement of a walking person and a walking dog than there is between a walking person and a person in a moving automobile. The four chapters in the section on biological motion have in common the notion that specialized perceptual mechanisms have evolved for detecting biological movement. Aina Puce and David Perrett (chapter 1) review evidence from an array of studies, ranging from recordings of single-cell activity in the nonhuman primate brain to positron emission tomography and functional magnetic resonance imaging in humans, on the neural mechanisms underlying social perception. The superior temporal sulcus, an area adjacent to the area concerned with visual motion perception (V5), appears especially involved in the processing of moving faces and bodies. For instance, movements of the mouth indicative of speaking and movements of the eyes indicative of changes in gaze—both of which carry information about social attention and communication—produce especially strong brain activation in the superior temporal sulcus. Puce and Perrett conclude that the superior temporal sulcus is part of a more widely distributed system of neural processes that underlie social perception and cognition.

In chapter 2, Gergely Csibra reviews infant research on biological motion perception. As is typical in this field, infant mentation is gauged by changes in the time spent looking at an object (dishabituation). Based on behavioral studies, Csibra suggests that infants interpret the actions of others as either goal directed or referential. Attributions of actions as goal directed are promoted by motion cues (e.g., self-initiated movement) and result in inferences about the actor's intentions, desires, and beliefs. Referential attributions are promoted by motion cues that communicate spatial direction or communicative intent. Although some researchers treat both kinds of attributions similarly, Csibra argues that these attributions are triggered by different cues, apply to different representations and computations, serve different functions, and are likely to be implemented by different mechanisms.

In chapter 3, Uta Frith and Christopher Frith outline the development of the human ability to mentalize. The developmental steps described by Frith and Frith begin with biological motion perception, followed in turn by the abilities to infer agency and intentionality. Biological motion perception is evident in neonates, whereas the ability to mentalize, which depends not only on the superior temporal sulcus but also on regions in the medial prefrontal cortex and temporal poles, emerges as an implicit process by about 18 months of age and becomes an explicit capacity between the ages of 4 and 6. Frith and Frith suggest that the superior temporal sulcus probably underlies the detection of agency, the temporal poles the access to social knowledge in the form of scripts, and the medial prefrontal cortex the capacity to distinguish and manipulate mental and physical representations. The final chapter in the section on biological motion, by Jens Rittscher, Andrew Blake, Anthony Hoogs, and Gees Stein, describes computational approaches for the recognition and interpretation of human actions. Their computational analyses raise the interesting notion that the detection of biological motion is sufficient for the attribution of animacy, but contextual information is necessary for the attribution of goals and intentions.

The second section of the book consists of five chapters that share the perspective that the neural substrates of imitative acts and emotional contagion are made

possible by the operation of a mirror system, a system of neurons that subserve an individual's capacity to recognize actions made by others and in so doing to mirror the observed actions. Andrew Meltzoff and Jean Decety (chapter 5) emphasize the developmental and neural similarities between the perception and execution of actions and imitative acts. Meltzoff and Decety further detail how the neural mechanisms common to perception and action provide the foundation for understanding the similarity and differences between self and others, developing the ability to adopt the perspective of others, and enabling the capacity to empathize with others. Among the interesting neuroimaging evidence they review includes data indicating that the right inferior parietal lobe is critically involved in distinguishing self from others.

Observed behaviors sometimes lead to the same actions in the observer and at other times lead to complementary actions in the observer. Andreas Wohlschlager, Merideth Gattis, and Harold Bekkering (chapter 6) report a series of behavioral studies in which they investigated imitation errors. These studies suggest that the context of an observed action influences what actions are initiated in the observer and, more specifically, whether the actions in the observer are designed to support the main goal of the observed action rather than the observed action per se. One of the implications of this work, developed further by Vittorio Gallese in chapter 7, is that the mirror neuron system contributes to the establishment of a parity between actor and observer in a way that is rapid, automatic, and effortless, which serves as the basis for social cognition and social bonding.

The final two chapters in this section apply different methods in an attempt to further decompose imitative acts. In chapter 8, R. W. Byrne argues that mountain gorillas can show imitation learning by perceptually parsing the action into a correlated series of elementary acts that can be reproduced to achieve a reward rather than by understanding the intentions or cause–effect relationships of the observed behavior. This mechanistic account of imitation entails no special mentalizing ability and may suggest a rudimentary building block (behavioral parsing) out of which human imitation learning and mentalizing capabilities may grow. In chapter 9, Stefan Schaal, Auke Ijspeert, and Aude Billard adopt a strictly computational approach to decompose imitation into its functional subunits, with an emphasis on the motoric rather than perceptual side of the perception–action loop. Robots can be trained to mimic observed actions, but generalization to new contexts is severely limited. The computational analysis nevertheless reinforces the notion that imitation is achieved through a hierarchically organized set of functional subunits, a notion that should promote testable hypotheses about the brain–behavior relationships underlying social cognition and interactions.

The four chapters on mentalizing share the perspective that the response of the actor to the behavior of an observer is a function of inferences drawn about the mental contents of the observer. Such a perspective underscores the dyad (or group) as an important analytical unit because the reciprocal influences between two interactants have the potential to produce emergent effects not explicable from a focus on either alone.

Although the nature of these inferences becomes more sophisticated across development, evidence of rudimentary attributions has been documented in in-

fants. In chapter 10, Susan Johnson reviews evidence that both 12- to 15-month-old infants and children with autism respond to an amorphously shaped object whose movements are contingent on their own or another person's as if it were an agent with goals. Thus, it is the behavior of a stimulus, not the fact that the stimulus is human-like, that elicits imitation, goal reenactment, and communicative gestures in infants. The object used by Johnson, although amorphously shaped, is quite organic in appearance; whether this organic appearance is crucial for obtaining these effects is an interesting question.

Expressions of emotion have the power to convey valenced information and to influence social behavior, an effect addressed by Charles Darwin more than a century ago in the *Expression of Emotions in Man and Animals*. R. J. R. Blair (chapter 11) argues that the production and interpretation of emotional expressions are fundamental to effective social discourse, and he reviews evidence for the neurobiological substrates underlying the production and interpretation of emotional expressions. Interestingly, Blair then considers the possible role of aberrations in these substrates in the origin of psychiatric disorders. For instance, he suggests that psychopathy is associated with a blunting of the response to fearful or sad expressions of emotion and an impaired aversion to harming others, whereas autism is associated with an impaired ability to mentally represent the person expressing the emotion. These testable hypotheses have important implications for the understanding and treatment of these psychiatric disorders.

As noted earlier, the notion of mentalizing underscores the importance of examining an individual's behavior and brain function in the context of a social (e.g., dyadic) interaction. However, a striking feature of the statistical approaches typically found in this area is that the unit of analysis often is a single individual. Dale Griffin and Richard Gonzalez (chapter 12) caution about the limitations inherent in such a statistical approach, and they provide a tutorial on graphic procedures and statistical models that incorporate the dyad as a unit of analysis. Such statistical tools will be essential to advance the field if we are to fully appreciate the nonadditive effects of dyadic and group interactions on brain and behavior.

A second and quite different quantitative approach to the study of social behavior is game theory. Game theory suggests that people are characterized by an inherent sense of fairness that influences their behavior in social settings even when it is to their individual economic disadvantage to do so. In chapter 13, David Sally provides a lucid review of how game theory can be used to examine neural and behavioral mechanisms associated with specific intrapersonal and interpersonal processes including rationality, reciprocity, social preferences, coordination, cooperation, and punitive altruism. One gains an appreciation from this chapter for the incompleteness of selfish rationality as a model of human decision making and behavior.

The final chapter, by Daniel Wolpert, Kenji Doya, and Mitsuo Kawato, outlines a computational framework based on motor control that is extended to explain social interactions. Because the account is grounded in the motor control of an individual, Wolpert and colleagues reason that it should be applicable to robotic as well as human behavior, which they demonstrate nicely. The computational model they present is impressive, sophisticated, and efficient, but it may be worth

keeping in mind the work of Frith and Frith (chapter 3) and Schaal, Ijspeert, and Billard (chapter 9), which raises concerns about the generalization of efficient computational models of social interactions to novel contexts.

In sum, there have been tremendous advances in our understanding of the links between the mind, brain, and behavior over the past decade, but people generally have been considered as isolated units in these analyses. People are inherently social creatures, however, and the tools are now available to determine the biological mechanisms underlying social cognition, emotion, and interactions. As Frith and Wolpert note, uncovering the biological mechanisms underlying social interactions undoubtedly is one of the major problems for the neurosciences to address in the 21st century. For anyone interested in tackling this problem, *The Neuroscience of Social Interaction* is must reading.

John T. Cacioppo
Center for Cognitive and Social Neuroscience
University of Chicago
5848 S. University Avenue
Chicago, IL 60637
E-mail: Cacioppo@uchicago.edu

A Mechanistic View of the Expression and Experience of Emotion in the Arts

Deeper Than Reason: Emotion and Its Role in Literature, Music and Art

By Jenefer Robinson. Oxford: Oxford University Press, 2005. 516 pp. Cloth, $68.

It is a common belief that emotions are one of the special things that make us human. Yet centuries of philosophy, art, and sciences have revealed little about the true nature of emotions. Consider the very basic question of where emotions originate. Starting with ancient Greeks, they are in the liver, the heart, or the blood (Gardiner, Metcalf, & Beebe-Center, 1970), simply because this is where they are felt. It was not until the 19th century that the brain took its rightful place, with psychoanalysis and modern psychology. This new brain-centered approach has pointed to many areas (e.g., the amygdala, prefrontal cortex, hypothalamus) that are involved in the experience and expression of emotions. Though exciting and insightful, this approach is still not sufficient: None of these areas are exclusively in charge of emotions, and emotions are not exclusively confined to these areas. In an apparent reversal of focus, researchers now turn back to the body and look for the source of emotion in the interaction between body and brain (Damasio, 1996; Damasio, 1999), and we are back to square one: Where are emotions generated?

What if we were asking the wrong questions? What if emotions are better understood because of what they do rather than because of what they are or where they originate? What if emotions are in essence modes of operation rather than