

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

localizable entities? This has been my thesis for many years (Fellous, 1999; Arbib & Fellous, 2004; Fellous & Arbib, 2005) and one I share with Jenefer Robinson.

In *Deeper Than Reason*, Robinson makes a large sweep through the possible roles of emotions in literature, graphic art, and music, without ever (or rarely) losing the reader into definitions of emotions. The book is divided into four sections: "What Are Emotions and How Do They Operate?" "Emotion in Literature," "Expressing Emotion in the Arts," and "Music and the Emotions."

The book starts with a review of some of the existing theories of emotions. Robinson argues that emotions are not cognitive judgments but involve possibly unconscious appraisals that are specifically focused on our current actions, action tendencies, or goals. This appraisal is accompanied by physiological changes (e.g. heart rate, sweating) that are essential to making the event emotional but that are not sufficient to define a specific emotion. Psychophysical and neurophysiological studies (mainly those of Joseph LeDoux, LeDoux, 1996, 2002) indicate that emotions are prelinguistic and involve different processes occurring simultaneously. These processes achieve a trade-off between speed and information content. Fast, almost instinctive appraisals are made on the basis of rough, imprecise information ("Gun shots! Danger!"); slower evaluations (cognitive monitoring) involve richer information and modulate the fast appraisals ("But I am alone in the living room. This must be coming from the TV. No need to dive for cover."). This mechanistic view (process) is the main leitmotiv of the book. Robinson writes, "The emotional response is an automatic and immediate response that initiates motor and autonomic activity and prepares us for possible action. After the initial response cognition kicks in and corroborates or modifies our affective appraisal. And later still we may label our state with an emotion word from our folk psychology in an attempt to understand what has happened to us. The whole series of events is a *process* and each element in the process feeds back into and affects its development" (p. 310).

This view has at least two immediate consequences. First, because cognitive monitoring does not need to occur, emotions are not specifically human but can be found in animals from fruit flies to crayfish to monkeys. As I have argued elsewhere, these animal emotions are certainly not human emotions but may serve the same functions, given the animal bodies, goals, and behavioral constraints (Fellous, 2004).

Second, even though a given stimulus evokes the same kind of initial emotion in different individuals (i.e., the same appraisal), their overall reactions may be entirely different because their cognitive monitoring is strongly individualized. This individuality is related to memory (the synaptic self, as Joseph LeDoux, 2002, puts it). Robinson reviews the evidence for multiple emotional memory systems and the notion that part of the memory is a memory of physiological reaction patterns such as fast heart rate, high blood pressure, and high temperature. (This view was popularized by William James and Antonio Damasio.) What makes us experience emotions differently is how we relate a particular emotional percept or event (which may be identical for two individuals) to our multitude of past emotional experiences (which are likely to be significantly different for any two individuals). This notion is reminiscent of that of semantic nets in artificial intel-

ligence (Sowa, 1991). The basic idea is that *car* is not simply a word but a concept represented by a network of words bound together by links of various strengths. These words and the strength of their links depend on the individual past experiences. The *car* network of a child includes strong links to *toy*, *red*, and *fire truck*, whereas the *car* network of an everyday commuter includes *radio*, *boredom*, and *flat tire*. Both networks include *wheels*. Our concept of *car* depends on what nodes are currently activated. Similarly, an emotion is not a word but a network of associations. However, unlike generic knowledge such as that of a car, emotion networks also contain nodes that are physiological reaction patterns (physiological states such as tight stomach or short breath). Placed in this framework, Robinson's view is that emotions always involve physiological reaction nodes and that these nodes often are the first to be activated. In addition, the reason why my emotional experience is different from yours is that we simply have different emotional networks (nodes and links). Yet, interestingly, despite our many differences, many of us feel the same way about a specific painting (say the *Mona Lisa*) or about a particular musical score, suggesting that our emotional networks probably share some basic structure.

In sum, Robinson's view expressed in the first part of her book is that emotions are dynamic processes in constant motion that are steered by noncognitive appraisals, monitored by cognitive evaluations and constrained by previous experiences. Though not intended as a comprehensive review of the neuropsychology of emotion (which would take a book or two by itself), Robinson's focused review is insightful and convincing. The reader may want to complement it with some readings on the history of emotion theories (Gardiner et al., 1970), the developmental and evolutionary aspects of emotions and their relationship to reinforcement (Rolls, 1998), and their sociological underpinnings, beyond facial expressions (Brothers, 2001; Turner & Stets, 2005).

This theoretical foundation laid, the author turns to the arts. In part 2 the focus is on emotion in literature. Through specific examples, Robinson shows that emotions may be keys to understanding a literary work, especially when this work is based on the depiction of, and interactions between, realistic characters (in the sense that we can relate to them). Robinson argues that emotions have the powerful potential to drag the reader into different contextual settings by unconsciously activating the reader's noncognitive appraisal system.

To understand this, let us assume that a novel is constructed around a few crucial events or situations (which I will call juncture points) that together carry most of the meaning of the novel. Unless these junctures are reached and reasonably well understood, the reader will miss the point of the novel and the full effect intended. The goal of the writer, then, is to construct sequences of actions, people, and events that are designed to pull the reader into some desired state or context (with emotional content) in which a particular juncture must occur. A successful artist is one who is capable, using good techniques or good intuition, of designing such interjuncture sequences so as to pull the majority of the readers in, with minimal effort. How each reader experiences the interjuncture sequences is to some extent unimportant, and variable, as long as she eventually gets to the juncture point and grasps ("interprets," in Robinson's words) its significance.

In the language of semantic nets, the writer, not knowing the particulars of the knowledge networks of the readers, tries to activate crucial nodes that will eventually result, through their links, in the activation of a specific, intended blend of emotional networks.

Robinson takes us to Anna Karenina (Tolstoy), Macbeth (Shakespeare), and Lambert Strether (*The Ambassadors*, Henry James) to show how the reader is made to empathize with but not necessarily identify with these fictional characters, through affective appraisals and savvy cognitive manipulations. The author then takes us into an in-depth analysis of Edith Wharton's novel *The Reef*, where she shows how the main characters evolve in time, along the sequence of juncture points. She argues that readers learn from the characters' emotional journey and that the "sentimental education" readers undergo may be directed by a writer who controls the nature and timing of the complex blend of emotions that each character experiences. The emotional education and experience of the reader is her source of personal interpretation: Two readers interpret a novel differently largely because they have had different emotional experiences reading it. So how does the writer control the emotional experience of a reader?

Robinson argues that the form (e.g., irony, omission, moralizing) and structure (e.g., order of recounting of events) of a literary piece may give a unique set of tools to the writer to achieve this. The emotional experience of the reader is carefully manipulated and amplified and can be pushed beyond the kind of emotional experience she can encounter in real life. Form and structure control the initial noncognitive appraisals of a situation but also, to some extent, how the reader copes with the consequences of the affective appraisal. With the proper form and structure, a reader can feel good (or at least not bad) about a character being eaten alive by a tiger!

It is common knowledge among artists that a work of art is not simply about depicting but also about interpreting and projecting. In her classic textbook on drawing, Betty Edwards (1999, pp. 23–24) writes, "The object of drawing is not only to show what you are trying to portray, but also to show *you*. . . paradoxically, the more clearly you can perceive and draw what you see in the external world, the more the viewer can see you, and the more you can know about yourself. Drawing becomes a metaphor for the artist." How does such a symbiosis between the work of art and the artist come about? How can the viewers see the artist in the work of art?

In the third part of the book, Robinson partially addresses these questions and sets out to explain how works of art express emotions. Her focus is not so much on artistic techniques as on the cognitive processes that occur within the artist and within the audience. She puts forth a new romantic theory of expression that relies on the three-way interaction between an artist, an audience, and an intermediate embodiment of emotion that Robinson calls a persona. The expression of emotion as intended by the artist (consciously or not) and recreated (rather than passively perceived) by the audience is physically located in the persona. The relative distances between these three protagonists vary from art form to art form and, within an art form, from one work of art to another: The persona is the artist herself on stage in a play, an imaginary character in a novel, or an instrument

in a musical score. The audience may be close to the persona (as when reading a novel written in the first person) or further away from it (as in a complex ballet). This almost psychoanalytical view is interesting in itself because it provides a mechanistic framework in which to talk about the expression of emotions in art, which for too long relied on vague subjective notions of feelings and personal and cultural tastes. Of course, and as Robinson notes, not all aspects of artistic emotional expressions can be captured in such a framework, but she successfully argues that it is nonetheless useful. I would have liked to see some discussion of another potentially fruitful approach to understanding artistic emotional expression, alas not discussed in this book, based on the study of autistic artists. These people, for genetic or developmental reasons, are notoriously deficient in the expression and perception of emotion, but at least some of them manage to produce remarkably warm and, to the audience at least, emotionally charged artworks. Some of these people are beautifully described and analyzed in Oliver Sacks's work (Franco, Stephen, and especially Temple) (Sacks, 1995). These artists are not able to conceive of their own personas, let alone imagine or create one. So how do they express so much emotion? What do we learn about emotional artistic expression in normal individuals from that produced by emotionally flat autistic artists? Can one ask these questions at the level of the nervous system? I believe that such an approach would be important because it provides a framework (the autistic person) in which a theory can be tested and because it may even provide new insights into the nature of autism itself. Rather than focusing on such specific populations, but, I believe, in the same spirit of testing her theory, Robinson turns to a specific art form: music.

Many of us have been caught unconsciously foot or finger tapping to the beat of some songs, especially modern ones (rock, reggae), where rhythmic components are prominent. This unconscious response is channeled and expressed to various extents in dancing. The effect can be emotionally drastic, from a trancelike state in more primitive cultures to the (sometimes also trancelike) pleasure felt by teenagers in discotheques. In most cases, dancing to the music is accompanied by positive emotions. How does music elicit such powerful emotions?

The last part of *Deeper Than Reason* turns to musical expression and the arousal of emotions by music. However, the focus of Robinson's treatment is not on rhythm (which would have been interesting) but on melody. The mystery there is that music is, after all, just a production of sounds that have very little to do with our everyday experiences, emotional or not. To put it in the language of semantic nets, we probably have very few meaningful links or associations from the nodes we use every day (related to work, eating, sleeping) to music-related nodes. Those links, if any, would be explained by simple perceptual associations. Robinson refers to these as the doggy theory of musical emotional expression, whereby expressions often are erroneously associated with the emotion itself: The droopy face of a Saint Bernard dog is associated with sadness, even though the dog is perfectly happy. The sound of a tin whistle is associated with childish silliness, even though no such emotion is intended (as in, say, some sad pieces of Irish music). Of course, such associations often are used to purposefully elicit emotions (e.g., in Vivaldi's *Four Seasons*), but Robinson argues there is much more.

How, then, can particular sound combinations genuinely elicit emotions at all? Referring back to her discussion in the first part of the book, Robinson suggests that music has a strong potential for noncognitive physiological arousal and has fairly direct access to the body. It is after the physiological state is triggered (as in foot tapping, I would argue), that cognitive monitoring sets in, emotional labels are attributed, and the full-fledged emotion is elicited.

After a review of the main theories of musical expression, Robinson takes us through specific examples (e.g., Brahms's *Immer Leiser* and his *Intermezzo* Op. 117, no. 2) and defines her notion of musical persona. She argues that because emotions and music are both temporal processes, music is particularly well suited to eliciting emotions. Emotions can truly be experienced as a result of listening to music, and we understand music because of these emotions. In addition, and unlike other art forms, music is also able to elicit slower, more cognitively diffuse emotional states that Robinson relates to moods. Unfortunately, the difference between moods and emotions is not expanded on in relation to music or other art forms. In the mechanistic framework of fast appraisal and cognitive monitoring put forth in the first chapters, it would have been interesting to learn why depression, for example (if that is a mood), can be such a powerful drive for an artist.

Deeper Than Reason makes a daring attempt at a scientifically based theory of the expression and experience of emotion in art. It is clearly written, with many summaries and concrete examples, and adds to an increasing amount of work aimed at looking at art from a new, scientific perspective, notably through neuroscience (Goguen, 1999; Zaidel, 2005). It should be of great interest to both researchers and graduate students interested in cutting-edge thinking about art, cognition, and emotion.

Jean-Marc Fellous

Department of Psychology

University of Arizona

Department of Psychology

1503 E. University Boulevard

P.O. Box 210068

Tucson, AZ 85721

E-mail: fellous@nsma.arizona.edu

References

- Arbib, M. A., & Fellous, J. M. (2004). Emotions: From brain to robot. *Trends in Cognitive Sciences*, 8, 554–561.
- Brothers, L. (2001). *Friday's footprint: How society shapes the human mind*. London: Oxford University Press.
- Damasio, A. R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 351, 1413–1420.
- Damasio, A. (1999). *The feeling of what happens: Body and emotion in the making of consciousness*. San Diego, CA: Harcourt Brace.
- Edwards, B. (1999). *The new drawing on the right side of the brain*. New York: Tarcher, Penguin Putnam.

- Fellous, J.-M. (1999). The neuromodulatory basis of emotion. *The Neuroscientist*, 5, 283–294.
- Fellous, J.-M. (2004). From human emotions to robot emotions. In E. Hudlicka & L. Cañamero (Eds.), *Architectures for modeling emotion: Cross-disciplinary foundations* (pp. 37–47). Stanford, CA: American Association for Artificial Intelligence.
- Fellous, J.-M., & Arbib, M. A. (Eds.). (2005). *Who needs emotions? The brain meets the robot*. New York: Oxford University Press.
- Gardiner, H. M., Metcalf, R. C. M., & Beebe-Center, J. (1970). *Feeling and emotion: A history of theories*. Westport, CT: Greenwood.
- Goguen, J. A. (1999). Special issue on "Art and the Brain." *Journal of Consciousness Studies*, 6, 5–15.
- LeDoux, J. (1996). *The emotional brain*. New York: Simon & Schuster.
- LeDoux, J. E. (2002). *Synaptic self: How our brains become who we are*. Harmondsworth, Middlesex, England: Penguin.
- Rolls, E. T. (1998). *The brain and emotion*. Oxford University Press.
- Sacks, O. (1995). *An anthropologist on Mars*. New York: Random House.
- Sowa, J. (1991). *Principles of semantic networks: Explorations in the representation of knowledge*. San Francisco: Morgan Kaufmann.
- Turner, J. H., & Stets, J. E. (2005). *The sociology of emotions*. Cambridge, England: Cambridge University Press.
- Zaidel, D. (2005). *Neuropsychology of art: Neurological, cognitive and evolutionary perspectives*. Hove, UK: Psychology Press.

Context in Science Education

Internet Environments for Science Education

Edited by Marcia C. Linn, Elizabeth A. Davis, and Philip Bell. Mahwah, NJ: Erlbaum, 2004. 440 pp. Paper, \$39.95.

Although supporting the understanding of science content knowledge as traditionally conceptualized (i.e., specific facts, concepts, and ideas as articulated by many state standards) is important if we are to promote scientific literacy in youth, other goals consistent with contemporary notions of scientific literacy may be more educationally significant. The everyday world presents an array of decision-making opportunities wherein people must contemplate complex problems with ethical, economic, social, and scientific premises, issues, and implications. Scientific literacy involves using scientific concepts, methods, and tools to meaningfully interrogate these socioscientific issues. Although most of us would agree that being scientifically literate involves more than knowing facts, the current obsession with standard test performance, the challenges of teachers creating and supporting rich learning environments that support socioscientific inquiry, and the dominant cultural model of science as the exclusive domain of an elite group of individuals make it challenging to engage children in socioscientific investigations.

Students in well-resourced districts may conduct a number of actual experimental investigations, but these are usually focused on confirming known understandings or identifying existing phenomena that were long ago proven as fact by some adult scientist, usually a white man. Even in these classrooms, science education tends to consist of having students listen to lectures, complete worksheets, or