



John T. Cacioppo

Award for Distinguished Scientific Contributions

Citation

“For his pioneering research within social psychology and within psychophysiology, and especially for bringing these worlds together. John T. Cacioppo’s penetrating insights into the fundamental relations between psychological and physiological levels of analysis have provided a conceptual road map for the hybrid disciplines of social psychophysiology and social neuroscience. His methodological innovations in the use of psychophysiological measures to make inferences about the biological consequences of social processes have revolutionized thinking about mind–body interactions. He has made outstanding, programmatic, and integrative contributions to the understanding of evaluative processes, individual differences in cognitive engagement, loneliness, and the fundamental relation between the sympathetic and the parasympathetic nervous systems. All of his endeavors are characterized by conceptual and analytic precision and deep insights into the fundamental nature of relations between psychological and biological levels of analysis.”

Biography

John T. Cacioppo is the third of four children born to Cyrus and Mary K. Cacioppo and the first in the family to attend college. At the insistence of a math teacher, Cacioppo participated in a select summer mathematics program at the University of Missouri while in high school, leading him to complete his bachelor of science degree in economics at the University of Missouri in 1973.

Although the quantitative logic and formal proofs of economics were appealing, the emphasis on forecasting rather than on delineating underlying mechanisms was less so. A serendipitous meeting with Lee Becker, a social psychologist at the University of Missouri, led Cacioppo to the medical school, where he conducted his first study combining physiological and social measures in investigating a psychological question. Cacioppo abandoned his plans to pursue a career in law and instead went to graduate school in social psychology at Ohio State University.

Cacioppo’s mentors at Ohio State included Tony Greenwald, Tim Brock, Bob Cialdini, and John Harvey. Cacioppo also continued his studies of psychobiology and psychophysiology, working primarily with Curt Sandman with occasional but always memorable visits to John and Bea Lacey at the nearby Fels Research Institute in Yellow Springs, Ohio. Perhaps the most influential person he met at Ohio State, however, was another first-year graduate student, Richard Petty. By the end of their first week in graduate school, Cacioppo and Petty were arguing intensely about everything. To save money, they rented a dilapidated house and covered an entire wall with blackboard paint to work through their various arguments. These experiences drove home two points that have shaped Cacioppo’s thinking for the remainder of his career. First, complex social behaviors have multiple antecedents within and across levels of organization; as such, comprehensive accounts of social cognition, emotion, and behavior require the specification of both multiple causal mechanisms and moderator variables that govern the conditions under which they operate. Second, the identification of complex antecedents and mechanisms across levels of organization requires transdisciplinary research. Comprehensive accounts of social behavior, therefore, are more likely to come from collaborative, integrated programs of scientific research.

Cacioppo received his doctor of philosophy degree from Ohio State University in 1977 and joined the University of Notre Dame’s department of psychology as an assistant professor that year. He moved to the University of Iowa in 1979 and was promoted to associate professor in 1981 and to professor in 1985. The colleagues and students at Notre Dame and Iowa were stimulating and supportive, and both departments were sufficiently small that Cacioppo was exposed to yet a wider array of approaches, perspectives, and levels of analysis. Cacioppo’s collaboration with Petty also expanded during this period: They coauthored books and articles on, among other things, the elaboration likelihood model of attitudes and persuasion and individual differences in cognitive motivation (“need for cognition”) with an emphasis on the role of need for cognition in attitude formation and changes.

During this era, social and biological approaches to behavior were typically depicted as antagonistic or mutually exclusive. Cacioppo and Petty, therefore, also spent consid-

erable time in these early years debating the abyss between social and biological levels of analysis and how best to bridge it. By the mid-1980s, the impact of Cacioppo's psychophysiological analyses of social processes led Richard Louttit, the director of the Behavior and Neuroscience (BNS) Division of the National Science Foundation, to seek his help in fostering this type of research. The result was a pioneering five-year program developed and implemented by Cacioppo that, as Louttit noted when honored by the American Psychological Association for distinguished contributions to psychology, became one of the jewels of the BNS Division's funding history. More than 40 illustrious scholars (a number of whom became editors of leading journals in the field) completed the program between 1986 and 1991.

Preparation for and lectures to these scholars demanded the development of more sophisticated, comprehensive, and integrative formulations, and these demands resulted in several conceptual advances. Cacioppo and Louis Tassinari, an exceptional postdoctoral fellow from Dartmouth College working with Cacioppo during this period, pulled together the major components of the program in an edited volume; formalized the problem of mapping across social, cognitive, and biological levels of organization; and, together with Gary Berntson, developed a handbook whose coverage ranged from the physics of functional magnetic resonance imaging to social relationships and processes. With Elaine Hatfield and Richard Rapson, Cacioppo coauthored a book on emotional contagion; in collaboration with Richie Davidson, he organized a small focused scientific meeting for the James S. McDonnell Foundation on new approaches to the study of affect and emotion; and with Michael Coles, Berntson, and Steve Crites, he evolved an event-related brain potential procedure to investigate component processes underlying evaluative categorizations and affective processes.

Cacioppo returned to Ohio State University in 1989 to join the social psychology and psychobiology programs, the latter of which was directed by Berntson. Prior to meeting, Cacioppo and Berntson had each established programs entailing multiple levels of analysis. Over a series of early morning coffees, Cacioppo and Berntson discovered they shared a conviction regarding the importance of multiple levels of analysis, and the two began collaborative research integrating levels of organization from the social to the neural. They quickly developed a deep mutual intellectual respect and friendship, mirrored in the quality of the collaboration, which drove perspectives from different levels equally with none subservient to the others. Early in their collaboration, Cacioppo and Berntson articulated a logic and set of principles for a science concerned with the relationship between neural and social processes, including the intervening information-processing components and operations at both the neural and the computational levels

of analysis. Because this approach built on a long tradition of theoretical and empirical work in the neurosciences, cognitive sciences, and social sciences, Cacioppo and Berntson termed the field *social neuroscience*.

In the early 1990s, Cacioppo and Berntson also initiated studies on autonomic organization and function, emphasizing the implications of the heterarchical organization of the brain and central nervous system for understanding the autonomic substrates of stress and affect. Among the numerous findings from this work was that metabolic (e.g., orthostasis) and psychological (e.g., active coping) stress, although appearing comparable in nomothetic analyses, were organized quite differently. This led Cacioppo and Berntson to begin an innovative collaboration with Jan Kiecolt-Glaser, Ron Glaser, and Bill Malarkey to examine the role of social and autonomic factors in individuals' endocrine and cellular immune responses to stress and illness vulnerability. Cacioppo and Berntson also extended their work on the heterarchical organization of the central nervous system to develop a new theoretical perspective on attitudes, affect, and affective processing in their model of evaluative space. In 1995, Cacioppo joined the John D. and Catherine T. MacArthur Foundation Research Network on Mind-Body Interactions led by Bob Rose. This led to an expansion of his research examining how personal relationships get under the skin to affect social cognition and emotions, personality processes, biology, and health. As before, the students and postdoctoral fellows with whom Cacioppo worked made seminal contributions to each of these formulations.

In 1999, Cacioppo moved to the University of Chicago to build a social psychology program in the Department of Psychology. As the Tiffany and Margaret Blake Distinguished Service Professor at the University of Chicago, Cacioppo cofounded the Institute for Mind and Biology with Martha McClintock to support multilevel integrative analyses of social behavior. He has maintained extramural funding for his work throughout his career, and among his distinctions are the National Academy of Sciences Troland Research Award, the Society for Psychophysiological Research's Distinguished Scientific Award for an Early Career Contribution to Psychophysiology, the Society for Personality and Social Psychology's Donald Campbell Award for distinguished scientific contributions to personality and social psychology, and the Society for Psychophysiological Research's Award for Distinguished Scientific Contributions to Psychophysiology. He is a fellow in five different divisions in the American Psychological Association and in six other scientific societies, and he has served as the president of the Society for Personality and Social Psychology, the Society for Consumer Research, and the Society for Psychophysiological Research. He and his colleagues continue to forge new bridges across neural and social levels of organization and to examine the intervening information-processing components and operations at both the neu-

ral and the computational levels of analysis. He has worked with over a hundred students, postdoctoral fellows, and colleagues and still leaves research meetings amazed at his good fortune in having such wonderful and brilliant colleagues with whom to interact.

Selected Bibliography

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1991). Autonomic determinism: The modes of autonomic control, the doctrine of autonomic space, and the laws of autonomic constraint. *Psychological Review*, *98*, 459–487.

Cacioppo, J. T. (1994). Social neuroscience: Autonomic, neuroendocrine, and immune responses to stress. *Psychophysiology*, *31*, 113–128.

Cacioppo, J. T., & Berntson, G. G. (1992). Social psychological contributions to the Decade of the Brain: Doctrine of multilevel analysis. *American Psychologist*, *47*, 1019–1028.

Cacioppo, J. T., & Berntson, G. G. (1994). Relationship between attitudes and evaluative space: A critical review, with emphasis on the separability of positive and negative substrates. *Psychological Bulletin*, *115*, 401–423.

Cacioppo, J. T., Berntson, G. G., Adolphs, R., Carter, C. S., Davidson, R. J., McClintock, M. K., et al. (2002). *Foundations in social neuroscience*. Cambridge, MA: MIT Press.

Cacioppo, J. T., Berntson, G. G., Sheridan, J. F., & McClintock, M. K. (2000). Multilevel integrative analyses of human behavior: Social neuroscience and the complementing nature of social and biological approaches. *Psychological Bulletin*, *126*, 829–843.

Cacioppo, J. T., & Dorfman, D. D. (1987). Waveform moment analysis in psychophysiological research. *Psychological Bulletin*, *102*, 421–438.

Cacioppo, J. T., & Gardner, W. L. (1999). Emotion. *Annual Review of Psychology*, *50*, 191–214.

Cacioppo, J. T., & Petty, R. E. (1981). Electromyograms as measures of extent and affectivity of information processing. *American Psychologist*, *36*, 441–456.

Cacioppo, J. T., Petty, R. E., Feinstein, J., & Jarvis, W. B. G. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin*, *119*, 197–253.

Cacioppo, J. T., & Tassinary, L. G. (1990). Inferring psychological significance from physiological signals. *American Psychologist*, *45*, 16–28.

Cacioppo, J. T., Tassinary, L. G., & Berntson, G. G. (2000). *Handbook of psychophysiology* (2nd ed.). New York: Cambridge University Press.

Crawford, L. E., & Cacioppo, J. T. (2002). Learning where to look for danger: Integrating affective and spatial information. *Psychological Science*, *13*, 449–453.

Crites, S. L., Jr., & Cacioppo, J. T. (1996). Electrocardiac differentiation of evaluative and nonevaluative categorizations. *Psychological Science*, *7*, 318–321.

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1994). *Emotional contagion*. New York: Cambridge University Press.

Kosslyn, S. M., Cacioppo, J. T., Davidson, R. J., Hugdahl, K., Lovallo, W. R., Spiegel, D., & Rose, R. (2002). Bridging psychology and biology: The analysis of individuals in groups. *American Psychologist*, *57*, 341–351.

Petty, R. E., & Cacioppo, J. T. (1981). *Attitudes and persuasion: Classic and contemporary approaches*. Dubuque, IA: Brown.

Petty, R. E., & Cacioppo, J. T. (1986). *Communication and persuasion: Central and peripheral routes to attitude change*. New York: Springer-Verlag.

Sarter, M., Berntson, G. G., & Cacioppo, J. T. (1996). Brain imaging and cognitive neuroscience: Toward strong inference in attributing function to structure. *American Psychologist*, *51*, 13–21.

Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K. (1996). The relationship between social support and physiological processes: A review with emphasis on underlying mechanisms and implications for health. *Psychological Bulletin*, *119*, 488–531.

Social Neuroscience: Understanding the Pieces Fosters Understanding the Whole and Vice Versa

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Social science and neuroscience perspectives represent two ends of a continuum of levels of organization studied in psychology. Human behavior as a whole unfolds at social levels of organization, whereas much of the research in psychology has focused on cognitive and biological pieces

of this whole. Recent evidence underscores the complementary nature of social, cognitive, and biological levels of analysis and how research integrating these levels can foster more comprehensive theories of the mechanisms underlying complex behavior and the mind. This research underscores the unity of psychology and the importance of retaining multilevel integrative research that spans molar and molecular levels of analysis.

Neuroscientists and cognitive scientists have collaborated for more than a decade, with the common goal of understanding how the mind works. These collaborations have helped unravel puzzles of the mind including aspects of perception, imagery, attention, and memory (see, e.g., Kandel, 2001; Kosslyn & Andersen, 1992; LeDoux, 1995; Posner & Raichle, 1997). Many aspects of the mind, however, require a more comprehensive approach to elucidate the mystery of mind–brain connections. Attraction, altruism, speech recognition, affiliation, attachment, attitudes, identification, kin recognition, cooperation, competition, empathy, sexuality, communication, dominance, persuasion, obedience, morality, contagion, nurturance, violence, and person memory are just a few.

The notion that 100 billion neurons can give rise to the human mind can be daunting, especially when trying to say anything more specific about this feat. To simplify the study of the mind, many scientists have ignored the social aspects. The architects of development and behavior were initially conceived in molecular biology as the forces of evolution operating over millennia; the builders were cast as encapsulated within each living cell far from the reach of personal ties, social influences, or society; and the brain was treated simply as an information-processing machine (Crick, 1970). The additional information that might be attributable to the social world was conceived as best considered later, if the need arose (cf. Allport, 1947). Social factors, it was further reasoned, might have minimal implications for basic development, structure, or processes of the brain or mind, in which case the consideration of social factors would be entirely irrelevant (Scott, 1991). Even if relevant, the consideration of social factors might render the study of the human mind and behavior too complicated

Editor's Note

John T. Cacioppo received the Award for Distinguished Scientific Contributions. Award winners are invited to deliver an award address at the APA's annual convention. This award address was delivered at the 110th annual meeting, held August 22–25, 2002, in Chicago. Articles based on award addresses are not peer reviewed, as they are the expression of the winners' reflections on the occasion of receiving an award.

to sustain scientific progress (see, e.g., Wilson, 1998). Needless to say, social and cultural forces and their impact on human cognition, emotion, and behavior were far too important to await the full explication of cellular and molecular mechanisms, so social and biological perspectives each developed, for the most part, insulated from developments in the other (see Berntson & Cacioppo, 2000).

The 20th century was a time of remarkable advances within the neurosciences, cognitive sciences, and social sciences (see, e.g., Gilbert, Fiske, & Lindzey, 1998; Kandel & Squire, 2000; Wilson, 1998). As science enters the 21st century, scientists are in a position to move beyond simplifying assumptions, as evidenced by the emergence of perspectives such as social neuroscience (see, e.g., Cacioppo, 1994; Cacioppo & Berntson, 1992; Cacioppo, Berntson, et al., 2002; Klein & Kihlstrom, 1998; Ochsner & Lieberman, 2001; Sternberg, 2000), to develop more comprehensive theories of mind and behavior. The purpose of this address is to review the emergence, breadth, and logic of this perspective.

To be clear from the outset, all human behavior at some level is biological, but this is not to say that biological reductionism yields a simple, singular, or satisfactory explanation for complex behaviors or that molecular forms of representation provide the only or best level of analysis for understanding human behavior. Molar constructs such as those developed by the social sciences provide a means of understanding highly complex activity without needing to specify each individual action's simplest components, thereby providing an efficient means of describing the behavior of a complex system. Chemists who work with the periodic table on a daily basis nevertheless use recipes rather than the periodic table to cook not because food preparation cannot be reduced to chemical expressions but because it is not cognitively efficient to do so. The scientist who uses social, cognitive, and biological levels of analysis to understand behavior is no more a dualist than a chemist who uses both culinary and chemical levels of analysis to understand cuisine.

The Emergence of Social Neuroscience

Human survival depends in large part on the formation of alliances and accurate social judgments. Affiliation and nurturant social relationships, for instance, are essential for physical and psychological well-being across the life span (Cacioppo, Berntson, Sheridan, & McClintock, 2000). Disruptions of social connections, whether through ridicule, separation, divorce, or bereavement, are among the most stressful events people endure (Gardner, Gabriel, & Diekmann, 2000; Kiecolt-Glaser, Glaser, Cacioppo, & Malarkey, 1998), and social isolation is as large a risk factor for broad-based morbidity and mortality as high blood pressure, obesity, and sedentary lifestyles even after statistically controlling for known biological risk factors, social status,

and baseline measures of health (House, Landis, & Umberson, 1988). Indeed, the effect size for social isolation and morbidity is as large as that for high blood pressure or obesity (House et al., 1988). The case of Phineas Gage in the late 1800s vividly established the importance of the frontal cortex for orchestrating normal social discourse (Macmillan, 2000), and although the entire brain contributes to the social enterprise, research in this area is yielding findings of very specific social behaviors related to circumscribed regions (Adolphs, 1999; Winston, Strange, O'Doherty, & Dolan, 2002). Therefore, various authors have argued that evolutionary forces operating over thousands of years have sculpted the human genome to be sensitive to and succoring of relationships with others, to be wary of others, and to recognize the intentions and predispositions of others (Cacioppo et al., 2000; Gould, 1980; Kropotkin, 1989) and that elementary cognitive operations have evolved or been adapted to perform social functions (Winston et al., 2002).

Within the cognitive and social sciences, it has long been recognized that self-reports and overt behavior provide incomplete information on the human mind (Cacioppo & Sandman, 1981; Nisbett & Wilson, 1977). Methods and principles from the neurosciences have offered valuable additional information from which to draw inferences about social and psychological processes (Cacioppo & Tassinary, 1990) and have contributed to (a) an appreciation for the complexity of the mechanisms underlying social behaviors (see, e.g., Berntson, Boysen, & Cacioppo, 1993; Cacioppo & Berntson, 1994; Damasio, 1994; Phelps et al., 2000), (b) empirical tests of conflicting theoretical accounts of social behavior (see, e.g., Lieberman, Ochsner, Gilbert, & Schacter, 2001; Winkielman & Cacioppo, 2001), (c) more comprehensive accounts of mental and physical disease (Cohen, 1991, 1996; Harris, in press; Seeman, 2000; Taylor & Brown, 1988; Uchino, Cacioppo, & Kiecolt-Glaser, 1996), (d) an expanded understanding of physiological processes ranging from anabolic and catabolic processes (Cacioppo, Hawkley, Crawford, et al., 2002; Taylor et al., 2000) to immunology and disease (Glaser & Kiecolt-Glaser, 1994; Seeman, Singer, Rowe, Horwitz, & McEwen, 1997), and (e) conceptualizations of social phenomena ranging from attachment, morality, and social prejudices to social cognition and decision making (Adolphs, 1999; Cacioppo & Berntson, 2001; de Waal, 1996; Dolan, 1999; Frith & Frith, 2001).

Corresponding developments within the neurosciences have also contributed to the emergence of social neuroscience. One of the most obvious contemporary developments is brain imaging procedures such as positron emission tomography, event-related brain potentials (ERPs), and functional magnetic resonance imaging, which have been used to examine social processes such as face recognition (Gauthier, Skudlarski, Gore, & Anderson, 2000; George et

al., 1999), evaluative and attitudinal processing (Cacioppo, Crites, Berntson, & Coles, 1993; O'Doherty, Kringelbach, Rolls, Hornak, & Andrews, 2001), social categorization (Golby, Gabrieli, Chiao, & Eberhardt, 2001; Ito & Cacioppo, 2000), attributional reasoning (Winston et al., 2002), moral reasoning (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001), and theory of mind (Siegal & Varley, 2002).

The Breadth of Social Neuroscience

Despite the impressive impact of the imaging technologies on the funding and conduct of research over the past decade, it should be remembered that functional imaging studies have significant limitations (Uttal, 2001) and account for less than five percent of the studies reported at recent Society for Neuroscience meetings (Lorig, 2000). The frontiers of cognitive and social neuroscience depend fundamentally on the rigorous foundation of cellular and molecular research ("The Public Face of Neuroscience," 2002). It is important, therefore, that advances within the neurosciences favoring the emergence of a social neuroscience perspective run deeper than brain imaging techniques (Sarter, Berntson, & Cacioppo, 1996).

Viewing the nervous, endocrine, and immune systems as operating outside the reach of sociocultural influences allowed focused study of isolated anatomical systems with a resulting specification of component structures and processes. The simple marine mollusc *Aplysia* (e.g., sea slug), for instance, has been the focus of innumerable studies of learning and memory in the neurosciences. The *Aplysia* has only about 20,000 neurons in its system, less than 0.00002% of those found in the human. Furthermore, the neurons in the *Aplysia*, an invertebrate, are large and identifiable, and their organization is limited to a few ganglia, making systematic manipulation and observation of neural processes possible.

The *Aplysia californica* has an orifice (called a siphon) used to pump out waste and seawater; the siphon is located near a gill used for breathing in the middle of its body. The siphon and gill are essential for the animal's survival, so an intense or threatening stimulus such as a jab to the gill or a shock to the tail results in a reflexive withdrawal of these essential structures. A light touch to the gill does not initially elicit the siphon withdrawal reflex (SWR), but if a light touch to the gill is paired with a shock to the body (the conditioned stimulus and unconditioned stimulus, respectively), after repeated pairings a light touch is sufficient to elicit the SWR (a conditioned response). The *Aplysia fasciata* has also served as a model for it changes its responsiveness to a food on the basis of whether or not it succeeds in consuming it. Successful attempts to consume a palatable food lead to increased responsiveness to the food, whereas failed attempts lead to decreased responsiveness to the food. This simple and accessible neural cir-

cuitry, combined with a predictable behavioral repertoire, has made the *Aplysia* a model for cellular studies of learning and memory (Kandel, 1979, 2001).

As noted above, humans are not only information-processing machines, they are also social animals with developmental capacities for attachment (Maestriperi, 2001), speech and face recognition (Farah, Wilson, Drain, & Tanaka, 1998; Pascalis, de Haan, & Nelson, 2002), and representing their own and other people's mental states (Frith & Frith, 2001), and they require a web of interpersonal relationships, alliances, and cultures to thrive (Baumeister & Leary, 1995; Cacioppo, Hawkley, Berntson, et al., 2002; Felthous, 1997). My colleagues and I therefore reasoned that knowledge of biological and social domains may be necessary to develop comprehensive theories in either domain. It is interesting that even the *Aplysia fasciata* spends most of its time in contact with conspecifics; when isolated, the *Aplysia* actively locomotes toward conspecifics (Lederhendler, Herriges, & Tobach, 1977). In the presence of conspecifics, the *Aplysia* stops responding to a palatable food that is too tough to swallow (Susswein, Schwarz, & Feldman, 1986), but when these *Aplysia* are socially isolated, this learning is blocked (Schwarz & Susswein, 1992)—an effect that has been found to be attributable to the absence of pheromones secreted by conspecifics (Schwarz, Blumberg, & Susswein, 1998).

Much of the research in the neurosciences relies on animal models, where problems of generalizing to humans are always a concern. Research on rats by Meaney and colleagues has, for instance, revealed that transient early-life stress (e.g., brief handling) attenuated the behavioral and neuroendocrine responses to stressors encountered in adulthood, whereas early-life exposure to more severe stressors (e.g., protracted separation from the dam) accentuated responses to stressors in adulthood (Anisman, Zaharia, Meaney, & Merali, 1998). The brief handling of rat pups led to an increase in distress calls by the rat pups, greater maternal nurturance, a consequent increase in glucocorticoid receptor binding sites in the hippocampus and frontal cortex, and a subsequent lowering of hypothalamic-pituitary-adrenal reactivity in adulthood; severe early life stress had the opposite effects (Anisman et al., 1998; Meaney et al., 1996). As adult rats, the offspring of mothers that exhibited more licking and grooming and nurturance of pups during the first 10 days of life were not only characterized by reduced adrenocorticotrophic hormone and corticosterone responses to acute stress but also, as mothers, tended to lick and groom their pups more (Liu et al., 1997). In this way, brain anatomy and behavior were transmitted across generations via the influence of social behavior on genetic expression and neural development rather than through the transmission of different genotypes. Whether the development of the human brain and behavior is affected similarly by transient early-life stressors is an active area of research

(Committee on Future Directions for Behavioral and Social Sciences Research at the National Institutes of Health, 2001; Sternberg, 2000).

The Logic of Social Neuroscience

These impressive advances in molecular biology and genetics make it easy to fall into thinking about an organism as indifferent to the physical and social environment and to conclude that the scientific study of mind and behavior is best pursued exclusively at the level of the gene or cell (cf. Temple, McLeod, Gallinger, & Wright, 2001). The seminal observations of Claude Bernard (1878/1974), Lewontin (2000), Gould (1980), de Waal (1996), MacLean (1985), and Kropotkin (1989) speak eloquently against such a notion, however (cf. Harris, in press). Bernard over a century ago observed that the extracellular fluid constitutes the immediate environment—the internalized sea—for plants and animals. He noted the relative constancy of this internal milieu and regarded this constancy and the physiological mechanisms that serve to maintain it as providing protection against the powerful entropic forces that threaten to disrupt the biological order essential for life. Mammals are far from being indifferent to their surroundings, Bernard further observed, but must be in close and intimate relation to them, continually compensating for and counterbalancing external variations. This interplay between organismic and environmental conditions is orchestrated at multiple levels to maintain a balance within the organism. In Lewontin's (2000) terms, "organisms not only determine what aspects of the outside world are relevant to them by peculiarities of their shape and metabolism, but they actively construct, in the literal sense of the word, a world around themselves" (p. 54). Additionally in humans, the physical environment has been shaped profoundly by the social world. Indeed, Dawkins (1990) has argued for a social equivalent of a gene, the meme, which is a unit of cultural information, such as a cultural practice or idea, that is transmitted verbally or by repeated action from one mind to another, altering the course of a culture and those who live in it.

Accordingly, increased collaboration among neuroscientists, cognitive scientists, and social scientists should be to the benefit of all who are interested in behavior. Consider the phenotypic expression of strains of mice with specific genes inactivated (i.e., knockout mice), which is known to depend on the genetic background (see, e.g., Gerlai, 1996)—so much so that the effects of the social context were thought either to be unimportant or to alter phenotypes in a monotonic fashion (cf. Lewontin, 2000). Crabbe, Wahlsten, and Dudek (1999) reported a remarkable finding to the contrary. Six mouse behaviors (locomotor activity in the open field, an anxiety test based on the exploration of two enclosed and two open arms of an elevated plus maze, walking and balancing on a rotating rod, learning to swim

to a visible platform, locomotor activation after cocaine injection, and preference for drinking ethanol vs. tap water) were tested simultaneously in three laboratories using the same inbred strains and one null mutant strain. Large genetic (strain) effects on all behaviors were found, which was expected because strains that were known to differ markedly on the behavioral tasks had been chosen. Importantly, despite the fact that Crabbe et al. "went to extraordinary lengths to equate test apparatus, testing protocols, and all possible features of animal husbandry" (Crabbe et al., 1999, p. 1670), significant effects for site were found for nearly all behaviors, with the pattern of strain differences varying substantially for several behaviors. Crabbe et al. issued a cautionary note: "Experiments characterizing mutants may yield results that are idiosyncratic to a particular laboratory" (Crabbe et al., 1999, p. 1670). From the present perspective, these data exemplify the point that understanding the behavioral manifestations of specific genetic mutants may require a consideration of physical and social factors. In sum, understanding the whole should contribute to an understanding of the pieces.

The effects of the social context on phenotypic expression are not limited to animal models. The full complement of DNA is in each cell of the newborn, but evidence is mounting that signals from the internal and external environment play an important role in the constitution and transcription of DNA and in the translation of RNA to proteins (see, e.g., Bronfenbrenner & Ceci, 1994; Gottlieb, 1998). Wu, Devi, and Malarkey (1996) localized growth hormone messenger RNA (GH mRNA) in human immune organs, including the thymus, lymph nodes, spleen, and peripheral blood, as well in thymomas and lymphomas. The extant literature on growth hormone suggests that it can influence cellular immunity by altering the efficacy of lymphocytes in responding to antigens. The genetic transcriptions responsible for the production of lymphocyte growth hormone (L-GH) are in part predetermined, as evidenced by the robust finding that L-GH secretion decreases with aging. However, Malarkey et al. (1996; Wu et al., 1999) also found evidence for the modulation of L-GH levels by social stressors: Caregivers of spouses with Alzheimer's disease had markedly lower L-GH concentrations compared with age- and gender-matched controls. Stress hormones such as adrenocorticotrophic hormone, cortisol, and catecholamines are thought to play a role via their regulatory effects on lymphocytes (Wu et al., 1999), with recent work raising the possibility that the kinetics as well as the level of hormonal variations may affect lymphocyte function (Cacioppo, Kiecolt-Glaser, et al., 2002).

More generally, it may be unreasonable to assume that complex systems such as the human organism can be understood as a simple extrapolation from the properties of their elementary components. Unless the properties of the system are the simple sum of those of its elementary com-

ponents, a focus on elementary components contributes to an explanation only when considered in conjunction with events occurring at different levels of the system. Interested readers may wish to see related discussions of the principles of multiple determinism, nonadditive determinism, and reciprocal determinism (Cacioppo & Berntson, 1992).

The Elaboration of Basic Approach-Withdrawal Response Organizations

Evaluations underlying attitudes, affect, and preferences have traditionally been conceptualized as a unitary process with simple components and representations accessible through self-reports (Osgood, Suci, & Tannenbaum, 1957; Thurstone, 1931; cf. Cacioppo & Berntson, 1994). Refined feelings of approval/disapproval or admiration/condemnation may be foremost in human minds, but these feelings represent the product of a host of resident processes that have evolved over millennia. The study of evaluative processes, therefore, is an area in which understanding the pieces has contributed to understanding the whole and vice versa.

Like the *Aplysia*, humans are equipped with defensive withdrawal reflexes that can be classically conditioned for protection from nociceptive stimulation. Differentiating hostile from hospitable others and events is such a critical capacity that all animals have rudimentary reflexes for categorizing and approaching or withdrawing from certain classes of stimuli and for providing metabolic support for these actions (Berntson et al., 1993; Cacioppo & Gardner, 1999). Evaluative discriminations are performed in simple organisms by hardwired stimulus-response connections or fixed action patterns. Human infants are also endowed with a finite set of hardwired evaluative discriminations—startle-response to sudden intense noises and retreat from nociceptive stimuli (Berntson et al., 1993). A remarkable feature of humans is the extent to which the evaluative discrimination of stimuli is shaped by learning, cognition, modeling, and culture (Petty & Cacioppo, 1981).

The 19th century neurologist John Hughlings Jackson (1884/1958) emphasized the hierarchical structure of the brain and the re-representation of functions at multiple levels within this neural hierarchy. Berntson and colleagues (Berntson, Cacioppo, & Sarter, in press; Berntson et al., 1993) summarized evidence that primitive protective responses to aversive stimuli are organized at the level of the spinal cord, as is apparent in flexor (pain) withdrawal reflexes that can be seen even after spinal transection. These primitive protective reactions are expanded and embellished at higher levels of the nervous system. The evolutionary development of higher neural systems, such as the limbic system, endowed organisms with an expanded behavioral repertoire, including escape reactions, aggressive responses, and even the ability to anticipate and avoid

aversive encounters (Berntson et al., 1993). Evolution not only endowed human beings with primitive, lower level adaptive reactions but also sculpted the remarkable information-processing capacities of the highest levels of the brain. Thus, neurobehavioral mechanisms are not localized to a single level of organization within the brain but rather are represented at multiple levels of the nervous system. At progressively higher (more rostral) levels of organization (spinal, brain stem, limbic, cortical regions), there is a general expansion in the range and relational complexity of contextual controls and in the breadth and flexibility of discriminative and adaptive responses (Berntson et al., 1993).

Adaptive flexibility of higher level systems has costs, given the finite information-processing capacity of neural circuits (Berntson et al., in press). Greater flexibility implies a less rigid relationship between inputs and outputs, a greater range of information that must be processed, and a slower, serial-like mode of processing. Consequently, the evolutionary layering of higher processing levels onto lower substrates has adaptive advantage in that lower and more efficient processing levels may continue to be used and may be sufficient in some circumstances (Berntson, Sarter, & Cacioppo, 1998). Higher neurobehavioral processes, however, can come to suppress or bypass pain withdrawal reflexes (Boysen, Berntson, Hannan, & Cacioppo, 1996). If an individual unknowingly touches a hot flame, the individual reflexively withdraws his or her hand from the painful fire. If, however, the person hears a child on the other side of a wall of flames, he or she can override this defensive reflex and push through the flames. This is neither the only nor the most likely action that such an individual would take; instead, he or she would likely show a more flexible, contextually appropriate response such as looking for a doorway or passage to the child that was not engulfed by flames or donning fire-retardant covering (e.g., wet blanket) before challenging the flames to retrieve the child.

My colleagues and I have used ERPs in variations of the oddball paradigm to study evaluative processes, with a small positive (P1) component emerging within 140 ms over the corresponding sensory cortex (e.g., occipital region for visual stimuli; Smith, Cacioppo, Larsen, & Chartrand, in press) and a functionally and stochastically separate late positive potential (LPP) emerging several hundred milliseconds later and peaking approximately 600 ms after stimulus onset over associative cortex (centroparietal regions; Cacioppo, Crites, et al., 1993).

The P1 component is sensitive to negative stimuli and to affectively congruent stimuli (Smith et al., in press). Two sources of evidence have led to the hypothesis that a neural circuit involving the superior colliculus, posterior pulvinar nucleus, and amygdala underlies the P1 negativity bias (Smith et al., in press). First, patients with striate cor-

tex lesions show preserved abilities to localize and discriminate visual stimuli that are not consciously perceived (blindsight). Second, neuroimaging studies have revealed correlations between amygdala, superior colliculus, and pulvinar cerebral blood flow in masked ("unseen") emotional conditions (see, e.g., Morris, Öhman, & Dolan, 1999). Thus, although the striate cortex visual pathway affords high-resolution visual processing, the superior colliculus and pulvinar pathway affords relatively fast but low-resolution visual processing that can guide (motivate) attention without intention or awareness (LeDoux, 1995). Such an affective asymmetry serves to guide attentional and cognitive resources to potential threats in the environment even before they can be recognized (Smith et al., in press).

The later ERP component, the LPP, is sensitive to subtler variations in stimuli ranging from foods (Cacioppo, Crites, et al., 1993) and evocative pictures (Ito, Larsen, Smith, & Cacioppo, 1998) to personality traits (Cacioppo, Crites, Gardner, & Berntson, 1994; Crites, Cacioppo, Gardner, & Berntson, 1995) and racial categories (Ito & Cacioppo, 1999). The evaluative processes marked by LPP also can occur spontaneously (Ito & Cacioppo, 2000), uncoupled from verbal report (Crites et al., 1995), however. In an illustrative study, Ito and Cacioppo (2000) assessed the implicit and explicit categorization of stimuli along evaluative (pleasant, unpleasant) and nonevaluative (people, no people) dimensions. Participants were exposed to stimuli that simultaneously varied along both dimensions, but half the participants were instructed to count the number of pictures that depicted people or the absence of people (nonevaluative categorization task), and half were instructed to count the number of pictures that depicted pleasant or unpleasant scenes (evaluative categorization task). As in prior research, the LPP was sensitive to participants' explicit categorization task. For instance, the LPP was larger in the evaluative task when a pleasant picture was presented within a series of unpleasant pictures than within a series of pleasant pictures and when an unpleasant picture was presented within a series of pleasant pictures than within a series of unpleasant pictures, and the LPP was larger in the evaluative task when an unpleasant picture was presented within a series of pleasant pictures than when a pleasant picture was presented within a series of unpleasant pictures (i.e., the negativity bias; cf. Cacioppo, Gardner, & Berntson, 1999; Peeters & Czapinski, 1990; Taylor, 1991).

More interestingly, the LPP also revealed implicit categorization along the non-task-relevant dimension—with clear evidence of an implicit negativity bias in which rare aversive stimuli spontaneously received greater processing than rare appetitive stimuli. The explicit task of categorizing stimuli along a nonevaluative dimension neither diminished nor delayed the LPP to variations in the evaluative

dimension. As would be expected at low levels of hedonic activation, the negativity bias and implicit categorization effects have not been observed when using mildly evocative experimental stimuli such as words (*pleasant, unpleasant*; Cacioppo, Crites, & Gardner, 1996; Crites & Cacioppo, 1996) rather than more evocative emotional pictures (see, e.g., Ito & Cacioppo, 2000; Ito et al., 1998). These results suggest the operation of adaptively beneficial implicit categorization processes, triggered by significant proximal stimuli, serving broad, cross-situational goals.

The attitudinal and behavioral implications of the heterarchical organization of evaluative processes have also been examined (see, e.g., Boysen et al., 1996). An implication of the rapid operation of lower evaluative mechanisms is that their ascending input may mildly predispose an individual's thoughts, feelings, or preferences for a stimulus. For instance, my colleagues and I found that individuals became more positive toward initially neutral and unfamiliar Chinese ideographs if the individuals were first exposed to the stimuli when their arms were in a state associated with approach reactions (flexing the arm, as if pulling something toward them) than if they were first exposed to the stimuli when their arms were in a state associated with avoidance reactions (extending the arm, as if pushing something away) even though participants were unaware of any link between their arm positions and motivational or affective responses (Cacioppo, Priester, & Berntson, 1993). The presence of prior knowledge or feelings about the stimuli should diminish these subtle ascending influences, a prediction supported by Priester, Cacioppo, and Petty (1996): The effects of arm flexion and extension on subsequent preferences for stimuli were evident for neutral, pronounceable, and novel nonwords (e.g., *balet*) but not for neutral, familiar words (e.g., *table*).

Implicit social prejudices (e.g., racism) represent an evaluative response predisposition that is not apparent in self-reports (Greenwald, McGhee, & Schwartz, 1998). Imaging studies have suggested that the strength of implicit racial prejudices covaries with the activation of the amygdala in response to photographs of unfamiliar African Americans (Phelps et al., 2000), and social psychological studies have suggested that implicit racial prejudices may have subtle but broad discriminatory effects (Ashburn-Nardo, Voils, & Monteith, 2001) while also being difficult to modify by an act of will (Greenwald et al., 1998). Preliminary work from our lab indicates that implicit social prejudices may be modifiable by the silent ascending influences of somatic expressions.

Rapid stimulus processing by lower evaluative mechanisms may also predispose an individual's behavior toward appetitive stimuli and away from aversive stimuli prior to more detailed processing of the stimuli. A test of this hypothesis was performed by Chen and Bargh (1999), who instructed some participants to push a lever away from

them if the stimulus word presented was positive and to pull the lever toward them if the stimulus word was negative; other participants received the opposite instructions. Results confirmed that participants were faster to respond to positive stimuli when pulling the lever rather than pushing the lever and faster to respond to negative stimuli when pushing rather than pulling the lever. In a second study, Chen and Bargh removed the conscious goal to evaluate the stimuli: Half the participants pushed and half pulled the lever as quickly as possible when a word appeared. As in the prior study, participants who were instructed to push the lever in this simple reaction-time task were faster in response to negative than to positive stimuli, and those who were instructed to pull the lever were faster for positive than for negative stimuli:

Immediately and unintentionally, then, a perceived object or event is classified as either good or as bad, and this results, in a matter of milliseconds, in a behavioral predisposition toward that stimulus. When the conscious mind is elsewhere, automatic evaluative processes prepare the individual to make the appropriate response. (Bargh & Chartrand, 1999, p. 475)

In sum, neither is there a singular rational thought process underlying all attitudes and behavior nor are all evaluative processes automatic. Instead, there are multiple neurobehavioral mechanisms across the neuraxis. *Ceteris paribus*, rostral relative to caudal mechanisms are (a) slower, more serial like; (b) subject to greater contextual control; (c) characterized by greater response flexibility; and (d) capable of multiple modes of appetitive and aversive activation (e.g., ambivalence; Berntson et al., in press; Cacioppo, Larsen, Smith, & Berntson, in press).

Conclusion

As neuroscientific approaches are applied to more complex questions, what were thought to be basic principles are being revisited. This is the case for principles in the neurosciences as well as in the social sciences. Social neuroscience is premised on the notion that biological, cognitive, and social levels of analysis, as well as a dialogue and integrative collaborations among scientists working at these levels of analyses, will contribute to more comprehensive explanations of the human mind and behavior.

It seems obvious that understanding the pieces fosters understanding the whole and that comprehension of the whole fosters an understanding of the pieces. The social and psychological sciences have long been viewed as a weak sister to the physical and biological sciences (Wilson, 1998), however, and the lure of popular approbation of a retreat to solely biological levels of analysis can be strong. It seems fair to say that the Decade of Behavior has not received the same scientific or public acclaim, or the congressional support, as the Human Genome Project or the Decade of the Brain even though more than a half-dozen

reports have been issued recently by the National Research Council calling for more integrative research between the social and biological sciences (Berkman, 2002). In a recent issue of the popular science magazine *Scientific American*, the editors observed that “whenever we run articles on social topics, some readers protest that we should stick to ‘real’ science” (“The Peculiar Institution,” 2002, p. 8). The editors went on to say:

Ironically, we seldom hear these complaints from working physical or biological scientists. They are the first to point out that the natural universe, for all its complexity, is easier to understand than the human being. If social science seems mushy, it is largely because the subject matter is so difficult, not because humans are somehow unworthy of scientific inquiry. (“The Peculiar Institution,” 2002, p. 8)

Technical and methodological developments now enable biological measures of ongoing human behavior, including electrophysiological recording, functional brain imaging, and neurochemical techniques. Conversely, social methods for studying behavior and ambulatory recordings of biological function can now be applied to animals and humans living in complex environments, providing a more fruitful model for the dynamic interaction between biological mechanisms and social context. Changes in medical science, worldwide health problems (e.g., AIDS, chronic disease), and U.S. demographics have further fueled basic social and biological research on societal problems. With both means and motive now available, there is growing evidence that a more comprehensive understanding of the mind and behavior will be fostered by integrative, theoretical analyses that span the biological and social levels of organization.

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References

- Adolphs, R. (1999). Social cognition and the human brain. *Trends in Cognitive Sciences*, 3, 469–479.
- Allport, G. W. (1947). Scientific models and human morals. *Psychological Review*, 54, 182–192.
- Anisman, H., Zaharia, M. D., Meaney, M. J., & Merali, Z. (1998). Do early-life events permanently alter behavioral and hormonal responses to stressors? *International Journal of Developmental Neuroscience*, 16, 149–164.
- Ashburn-Nardo, L., Voils, C. I., & Monteith, M. J. (2001). Implicit associations as the seeds of intergroup bias: How easily do they take root? *Journal of Personality and Social Psychology*, 81, 789–799.
- Bargh, J. A., & Chartrand, T. L. (1999). The unbearable automaticity of being. *American Psychologist*, 54, 462–479.
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachment as a fundamental human motivation. *Psychological Bulletin*, 117, 497–529.
- Berkman, L. F. (Ed.). (2002). *Through the kaleidoscope: Viewing the contributions of the behavioral and social sciences to health—The Barbara and Jerome Grossman Symposium*. Washington, DC: National Academy Press.
- Bernard, C. (1974). *Lectures on the phenomena of life common to animals and plants* (H. E. Hoff, R. Guillemin, & L. Guillemin, Trans.). Springfield, IL: Thomas. (Original work published 1878)
- Berntson, G. G., Boysen, S. T., & Cacioppo, J. T. (1993). Neurobehavioral organization and the cardinal principle of evaluative bivalence. *Annals of the New York Academy of Sciences*, 702, 75–102.
- Berntson, G. G., & Cacioppo, J. T. (2000). Psychobiology and social psychology: Past, present, and future. *Personality and Social Psychology Review*, 4, 3–15.
- Berntson, G. G., Cacioppo, J. T., & Sarter, M. (in press). Bottom-up: Implications for neurobehavioral models of anxiety and autonomic regulation. In R. J. Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), *Handbook of affective sciences*. New York: Oxford University Press.
- Berntson, G. G., Sarter, M., & Cacioppo, J. T. (1998). Anxiety and cardiovascular reactivity: The basal forebrain cholinergic link. *Behavioural Brain Research*, 94, 225–248.
- Boysen, S. T., Berntson, G. G., Hannan, M. B., & Cacioppo, J. T. (1996). Quantity-based choices: Interference and symbolic representations in chimpanzees (*Pan troglodytes*). *Journal of Experimental Psychology: Animal Behavior Processes*, 22, 76–86.

- Bronfenbrenner, U., & Ceci, S. J. (1994). Nature–nurture reconceptualized in developmental perspective: A bioecological model. *Psychological Review*, *101*, 568–586.
- Cacioppo, J. T. (1994). Social neuroscience: Autonomic, neuroendocrine, and immune responses to stress. *Psychophysiology*, *31*, 113–128.
- Cacioppo, J. T., & Berntson, G. G. (1992). Social psychological contributions to the Decade of the Brain: Doctrine of multilevel analysis. *American Psychologist*, *47*, 1019–1028.
- Cacioppo, J. T., & Berntson, G. G. (1994). Relationship between attitudes and evaluative space: A critical review, with emphasis on the separability of positive and negative substrates. *Psychological Bulletin*, *115*, 401–423.
- Cacioppo, J. T., & Berntson, G. G. (2001). The affect system and racial prejudice. In J. Bargh & D. K. Apsley (Eds.), *Unraveling the complexities of social life: A Festschrift in honor of Robert B. Zajonc* (pp. 95–110). Washington, DC: American Psychological Association.
- Cacioppo, J. T., Berntson, G. G., Adolphs, R., Carter, C. S., Davidson, R. J., McClintock, M. K., et al. (2002). *Foundations in social neuroscience*. Cambridge, MA: MIT Press.
- Cacioppo, J. T., Berntson, G. G., Sheridan, J. F., & McClintock, M. K. (2000). Multilevel integrative analyses of human behavior: Social neuroscience and the complementing nature of social and biological approaches. *Psychological Bulletin*, *126*, 829–843.
- Cacioppo, J. T., Crites, S. L., Jr., Berntson, G. G., & Coles, M. G. H. (1993). If attitudes affect how stimuli are processed, should they not affect the event-related brain potential? *Psychological Science*, *4*, 108–112.
- Cacioppo, J. T., Crites, S. L., Jr., & Gardner, W. L. (1996). Attitudes to the right: Evaluative processing is associated with lateralized late positive event-related brain potentials. *Personality and Social Psychology Bulletin*, *22*, 1205–1219.
- Cacioppo, J. T., Crites, S. L., Jr., Gardner, W. L., & Berntson, G. G. (1994). Bioelectrical echoes from evaluative categorizations: I. A late positive brain potential that varies as a function of trait negativity and extremity. *Journal of Personality and Social Psychology*, *67*, 115–125.
- Cacioppo, J. T., & Gardner, W. L. (1999). Emotion. *Annual Review of Psychology*, *50*, 191–214.
- Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (1999). The affect system has parallel and integrative processing components: Form follows function. *Journal of Personality and Social Psychology*, *76*, 839–855.
- Cacioppo, J. T., Hawkley, L. C., Berntson, G. G., Ernst, J. M., Gibbs, A. C., Stickgold, R., & Hobson, J. A. (2002). Lonely days invade the nights: Social modulation of sleep efficiency. *Psychological Science*, *13*, 385–388.
- Cacioppo, J. T., Hawkley, L. C., Crawford, L. E., Ernst, J. M., Bursleson, M. H., Kowalewski, R. B., et al. (2002). Loneliness and health: Potential mechanisms. *Psychosomatic Medicine*, *64*, 407–417.
- Cacioppo, J. T., Kiecolt-Glaser, J. K., Malarkey, W. B., Laskowski, B. F., Rozlog, L. A., Poehlmann, K. M., et al. (2002). Autonomic glucocorticoid associations with the steady state expression of latent Epstein-Barr virus. *Hormones and Behavior*, *42*, 32–41.
- Cacioppo, J. T., Larsen, J. T., Smith, N. K., & Berntson, G. G. (in press). The affect system: What lurks below the surface of feelings? In A. S. R. Manstead, N. H. Frijda, & A. H. Fischer (Eds.), *Feelings and emotions: The Amsterdam Conference*. New York: Cambridge University Press.
- Cacioppo, J. T., Priester, J. R., & Berntson, G. G. (1993). Rudimentary determinants of attitudes: II. Arm flexion and extension have differential effects on attitudes. *Journal of Personality and Social Psychology*, *65*, 5–17.
- Cacioppo, J. T., & Sandman, C. A. (1981). Psychophysiological functioning, cognitive responding, and attitudes. In R. E. Petty, T. M. Ostrom, & T. C. Brock (Eds.), *Cognitive responses in persuasion* (pp. 81–104). Hillsdale, NJ: Erlbaum.
- Cacioppo, J. T., & Tassinary, L. G. (1990). Inferring psychological significance from physiological signals. *American Psychologist*, *45*, 16–28.
- Chen, M., & Bargh, J. A. (1999). Nonconscious approach and avoidance behavioral consequences of the automatic evaluation effect. *Personality and Social Psychology Bulletin*, *25*, 215–224.
- Cohen, S. (1991). Social supports and physical health: Symptoms, health behaviors and infectious disease. In A. L. Greene, E. M. Cummings, & K. H. Karraker (Eds.),

Life-span developmental psychology: Perspectives on stress and coping (pp. 213–234). Hillsdale, NJ: Erlbaum.

Cohen, S. (1996). Psychological stress, immunity, and upper respiratory infections. *Current Directions in Psychological Science*, 5, 86–90.

Committee on Future Directions for Behavioral and Social Sciences Research at the National Institutes of Health. (2001). *New horizons in health: An integrative approach*. Washington, DC: National Academy Press.

Crabbe, J. C., Wahlsten, D., & Dudek, B. C. (1999, June 4). Genetics of mouse behavior: Interactions with laboratory environment. *Science*, 284, 1670–1672.

Crick, F. (1970, August 8). Central dogma of molecular biology. *Nature*, 227, 561–563.

Crites, S. L., Jr., & Cacioppo, J. T. (1996). Electrocortical differentiation of evaluative and nonevaluative categorizations. *Psychological Science*, 7, 318–321.

Crites, S. L., Jr., Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (1995). Bioelectrical echoes from evaluative categorization: II. A late positive brain potential that varies as a function of attitude registration rather than attitude report. *Journal of Personality and Social Psychology*, 68, 997–1013.

Damasio, A. R. (1994). *Descartes' error: Emotion, reason, and the human brain*. New York: Grosset/Putnam.

Dawkins, R. (1990). *The selfish gene* (2nd ed.). New York: Oxford University Press.

de Waal, F. (1996). *Good natured: The origins of right and wrong in humans and other animals*. Cambridge, MA: Harvard University Press.

Dolan, R. J. (1999). On the neurology of morals. *Nature Neuroscience*, 2, 927–929.

Farah, M. J., Wilson, K. D., Drain, M., & Tanaka, J. N. (1998). What is “special” about face perception? *Psychological Review*, 105, 482–498.

Felthous, A. R. (1997). Does “isolation” cause jail suicides? *Journal of the American Academy of Psychiatry and the Law*, 25, 285–294.

Frith, U., & Frith, C. (2001). The biological basis of social interaction. *Current Directions in Psychological Science*, 10, 151–155.

Gardner, W. L., Gabriel, S., & Diekmann, A. B. (2000). Interpersonal processes. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (2nd ed., pp. 643–664). New York: Cambridge University Press.

Gauthier, I., Skudlarski, P., Gore, J. C., & Anderson, A. W. (2000). Expertise for cars and birds recruits brain areas involved in face recognition. *Nature Neuroscience*, 3, 191–197.

George, N., Dolan, R. J., Fink, G. R., Baylis, G. C., Russell, C., & Driver, J. (1999). Contrast polarity and face recognition in the human fusiform gyrus. *Nature Neuroscience*, 2, 574–580.

Gerlai, R. (1996). Gene-targeting studies of mammalian behavior: Is it the mutation or the background genotype? *Trends in Neurosciences*, 19, 177–181.

Gilbert, D. T., Fiske, S. T., & Lindzey, G. (1998). *The handbook of social psychology* (4th ed.) Boston, MA: McGraw-Hill.

Glaser, R., & Kiecolt-Glaser, J. K. (1994). *Handbook of human stress and immunity*. San Diego, CA: Academic Press.

Golby, A. J., Gabrieli, J. D. E., Chiao, J. Y., & Eberhardt, J. L. (2001). Differential responses in the fusiform region to same-race and other-race faces. *Nature Neuroscience*, 4, 845–850.

Gottlieb, G. (1998). Normally occurring environmental and behavioral influences on gene activity: From central dogma to probabilistic epigenesis. *Psychological Review*, 105, 792–802.

Gould, S. J. (1980). *Ever since Darwin: Reflections in natural history*. Harmondsworth, Middlesex, England: Penguin.

Greene, J. D., Sommerville, R. B., Nystrom, L. E., Darley, J. M., & Cohen, J. D. (2001, September 14). An fMRI investigation of emotional engagement in moral judgment. *Science*, 293, 2105–2108.

Greenwald, A. G., McGhee, D., & Schwartz, J. (1998). Measuring individual differences in implicit cognition: The Implicit Association Test. *Journal of Personality and Social Psychology*, 74, 1464–1480.

Harris, J. C. (in press). Empathy, autism, and the integration of the triune brain. In R. Gardner, Jr., & G. A.

- Corey, Jr. (Eds.), *The evolutionary neuroethology of Paul MacLean: Convergences and frontiers*. Westport, CT: Greenwood-Praeger.
- House, J. S., Landis, K. R., & Umberson, D. (1988, July 29). Social relationships and health. *Science*, *241*, 540–545.
- Ito, T. A., & Cacioppo, J. T. (1999). Measuring racial prejudice with event-related potentials. *Psychophysiology*, *36*, S62.
- Ito, T. A., & Cacioppo, J. T. (2000). Electrophysiological evidence of implicit and explicit categorization processes. *Journal of Experimental Social Psychology*, *36*, 660–676.
- Ito, T. A., Larsen, J. T., Smith, N. K., & Cacioppo, J. T. (1998). Negative information weighs more heavily on the brain: The negativity bias in evaluative categorizations. *Journal of Personality and Social Psychology*, *75*, 887–900.
- Jackson, J. H. (1958). Evolution and dissolution of the nervous system (Croonian Lectures). In J. Taylor (Ed.), *Selected writings of John Hughlings Jackson* (pp. 154–204). New York: Basic Books. (Original work published 1884)
- Kandel, E. R. (1979). *Behavioral biology of Aplysia: A contribution to the comparative study of opisthobranch molluscs*. San Francisco: Freeman.
- Kandel, E. R. (2001, November 2). The molecular biology of memory storage: A dialogue between genes and synapses. *Science*, *294*, 1030–1038.
- Kandel, E. R., & Squire, L. R. (2000, November 10). Neuroscience: Breaking down scientific barriers to the study of brain and mind. *Science*, *290*, 1113–1120.
- Kiecolt-Glaser, J. K., Glaser, R., Cacioppo, J. T., & Malarkey, W. B. (1998). Marital stress: Immunologic, neuroendocrine, and autonomic correlates. *Annals of the New York Academy of Sciences*, *840*, 656–663.
- Klein, S. B., & Kihlstrom, J. F. (1998). On bridging the gap between social-personality psychology and neuropsychology. *Personality and Social Psychology Review*, *2*, 228–242.
- Kosslyn, S. M., & Andersen, R. A. (1992). *Frontiers in cognitive neuroscience*. Cambridge, MA: MIT Press.
- Kropotkin, P. I. (1989). *Mutual aid: A factor of evolution*. Montreal, Quebec, Canada: Black Rose.
- Lederhendler, I. I., Herriges, K., & Tobach, E. (1977). Taxis in *Aplysia dactylomela* (Rang, 1828) to water-borne stimuli from environmental factors. *Animal Learning and Behavior*, *5*, 355–358.
- LeDoux, J. E. (1995). Emotion: Clues from the brain. *Annual Review of Psychology*, *46*, 209–235.
- Lewontin, R. (2000). *The triple helix: Gene, organism, and environment*. Cambridge, MA: Harvard University Press.
- Lieberman, M. D., Ochsner, K. N., Gilbert, D. T., & Schacter, D. L. (2001). Attitude change in amnesia and under cognitive load. *Psychological Science*, *12*, 135–140.
- Liu, D., Diorio, J., Tannenbaum, B., Caldji, C., Francis, D., Freedman, A., et al. (1997, September 12). Maternal care, hippocampal glucocorticoid receptors, and hypothalamic–pituitary–adrenal responses to stress. *Science*, *277*, 1659–1662.
- Lorig, T. S. (2000, October) *Spheres of influence: Psychophysiology's place in a universe of neuroscience*. Paper presented at the meeting of the Society for Psychophysiological Research, Denver, CO.
- MacLean, P. (1985). Brain evolution relating to family, play, and the separation call. *Archives of General Psychiatry*, *42*, 404–417.
- Macmillan, M. (2000). *An odd kind of fame: Stories of Phineas Gage*. Cambridge, MA: MIT Press.
- Maestriperri, D. (2001). Biological bases of maternal attachment. *Current Directions in Psychological Science*, *10*, 79–83.
- Malarkey, W. B., Wu, H., Cacioppo, J. T., Malarkey, K. L., Poehlmann, K. M., Glaser, R., & Kiecolt-Glaser, J. K. (1996). Chronic stress down-regulates growth hormone gene expression in peripheral blood mononuclear cells of older adults. *Endocrine*, *5*, 33–39.
- Meaney, M. J., Bhatnagar, S., Larocque, S., McCormick, C. M., Shanks, N., Sharma, S., et al. (1996). Early environment and the development of individual differences in the hypothalamic–pituitary–adrenal stress response. In C. R. Pfeffer (Ed.), *Severe stress and mental disturbance in children* (pp. 85–127). Washington, DC: American Psychiatric Press.

- Morris, J. S., Öhman, A., & Dolan, R. J. (1998, June 4). Conscious and unconscious emotional learning in the human amygdala. *Nature*, *393*, 467–470.
- Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, *84*, 231–259.
- Ochsner, K. N., & Lieberman, M. D. (2001). The emergence of social cognitive neuroscience. *American Psychologist*, *56*, 717–734.
- O'Doherty, J., Kringelbach, M. L., Rolls, E. T., Hornak, J., & Andrews, C. (2001). Abstract reward and punishment representations in the human orbitofrontal cortex. *Nature Neuroscience*, *4*, 95–102.
- Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. (1957). *The measurement of meaning*. Urbana: University of Illinois Press.
- Pascalis, O., de Haan, M., & Nelson, C. A. (2002, May 17). Is face processing species-specific during the first year of life? *Science*, *296*, 1321–1323.
- The peculiar institution. (2002, April). *Scientific American*, *286*(4), 8.
- Peeters, G., & Czapinski, J. (1990). Positive–negative asymmetry in evaluations: The distinction between affective and informational negativity effects. In W. Stroebe & M. Hewstone (Eds.), *European review of social psychology* (Vol. 1, pp. 33–60). New York: Wiley.
- Petty, R. E., & Cacioppo, J. T. (1981). *Attitudes and persuasion: Classic and contemporary approaches*. Dubuque, IA: Brown.
- Phelps, E. A., O'Connor, K. J., Cunningham, W. A., Funayama, E. S., Gatenby, J. C., Gore, J. C., & Banaji, M. R. (2000). Performance on indirect measures of race evaluation predicts amygdala activation. *Journal of Cognitive Neuroscience*, *12*, 729–738.
- Posner, M. I., & Raichle, M. E. (1997). *Images of mind*. New York: Scientific American Library.
- Priester, J. R., Cacioppo, J. T., & Petty, R. E. (1996). The influence of motor processes on attitudes toward novel versus familiar semantic stimuli. *Personality and Social Psychology Bulletin*, *22*, 442–447.
- The public face of neuroscience. (2002). *Nature Neuroscience*, *5*, 183.
- Sarter, M., Berntson, G. G., & Cacioppo, J. T. (1996). Brain imaging and cognitive neuroscience: Toward strong inference in attributing function to structure. *American Psychologist*, *51*, 13–21.
- Schwarz, M., Blumberg, S., & Susswein, A. J. (1998). Social isolation blocks the expression of memory after training that a food is inedible in *Aplysia fasciata*. *Behavioral Neuroscience*, *112*, 942–951.
- Schwarz, M., & Susswein, A. J. (1992). Presence of conspecifics facilitates learning that food is inedible in *Aplysia fasciata*. *Behavioral Neuroscience*, *106*, 250–261.
- Scott, T. R. (1991). A personal view of the future of psychology departments. *American Psychologist*, *46*, 975–976.
- Seeman, T. E. (2000). Health promoting effects of friends and family on health outcomes in older adults. *American Journal of Health Promotion*, *14*, 362–370.
- Seeman, T. E., Singer, B., Rowe, J. W., Horwitz, R., & McEwen, B. (1997). The price of adaptation: Allostatic load and its health consequences. *Archives of Internal Medicine*, *157*, 2259–2268.
- Siegal, M., & Varley, R. (2002). Neural systems involved in “theory of mind.” *Nature Reviews: Neuroscience*, *3*, 463–471.
- Smith, N. K., Cacioppo, J. T., Larsen, J. T., & Chartrand, T. L. (in press). May I have your attention please: Electrocortical responses to positive and negative stimuli. *Neuropsychologia*.
- Sternberg, E. (2000). *The balance within: The science connecting health and emotions*. New York: Freeman.
- Susswein, A. J., Schwarz, M., & Feldman, E. (1986). Learned changes of feeding behavior in *Aplysia* in response to edible and inedible foods. *Journal of Neuroscience*, *6*, 1513–1527.
- Taylor, S. E. (1991). Asymmetrical effects of positive and negative events: The mobilization-minimization hypothesis. *Psychological Bulletin*, *110*, 67–85.
- Taylor, S. E., & Brown, J. D. (1988). Illusion and well-being: A social psychological perspective on mental health. *Psychological Bulletin*, *103*, 193–210.

Taylor, S. E., Klein, L. C., Lewis, B. P., Gruenewald, T. L., Gurung, R. A., & Updegraff, J. A. (2000). Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight. *Psychological Review*, *107*, 411–429.

Temple, L. K. F., McLeod, R. S., Gallinger, S., & Wright, J. G. (2001, August 3). Defining disease in the genomics era. *Science*, *293*, 807–808.

Thurstone, L. L. (1931). The measurement of attitudes. *Journal of Abnormal Psychology*, *26*, 249–269.

Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K. (1996). The relationship between social support and physiological processes: A review with emphasis on underlying mechanisms and implications for health. *Psychological Bulletin*, *119*, 488–531.

Uttal, W. R. (2001). *The new phrenology: The limits of localizing cognitive processes in the brain*. Cambridge, MA: MIT Press.

Wilson, E. O. (1998). *Consilience: The unity of knowledge*. New York: Knopf.

Winkielman, P., & Cacioppo, J. T. (2001). Mind at ease puts a smile on your face: Psychophysiological evidence that processing facilitation elicits positive affect. *Journal of Personality and Social Psychology*, *81*, 989–1000.

Winston, J. S., Strange, B. A., O'Doherty, J., & Dolan, R. J. (2002). Automatic and intentional brain responses during evaluation of trustworthiness of faces. *Nature Neuroscience*, *5*, 277–283.

Wu, H., Devi, R., & Malarkey, W.B. (1996). Localization of growth hormone messenger ribonucleic acid in the human immune system—A clinical research center study. *Journal of Clinical Endocrinology and Metabolism*, *81*, 1278–1282.

Wu, H., Wang, J., Cacioppo, J. T., Glaser, R., Kiecolt-Glaser, J. K., & Malarkey, W. B. (1999). Chronic stress associated with spousal caregiving of patients with Alzheimer's dementia is associated with downregulation of B-lymphocyte GH mRNA. *Journals of Gerontology: Series A, Biological Sciences and Medical Sciences*, *54*, M212–M215.

