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Social Psychological Contributions to the Decade of the Brain

Doctrine of Multilevel Analysis

John T. Cacioppo and Gary G. Berntson
Ohio State University

The 1990s were declared by Congress to be the "decade of the brain." This declaration is important to all psychologists, not only neuroscientists, because with this declaration come expectations of the cognitive and behavioral sciences generally and because the brain does not exist in isolation but rather is a fundamental component of developing and aging individuals who themselves are mere actors in the larger theater of life. This article examines the importance of a multilevel, integrative approach to the study of mental and behavioral phenomena in the decade of the brain, reviews how this approach highlights the synergistic relationship between theoretical and clinically relevant research, and illustrates how this approach can foster the transition from microtheories to general psychological theories.

My concern is that the character of psychology is increasingly manifest in the rapid proliferation of narrowly focused and compulsively insular camps, a proliferation that seemingly knows no limits. (Bevan, 1991, p. 475)

Panoramic photographs of earth from space reveal agricultural runoffs that stretch hundreds of miles out to sea and vast clouds of fossil fuel emissions blanketing industrial areas. These disquieting images reflect the collective action of individuals, but the effect of these actions cannot be fully appreciated unless these phenomena are studied from a point of view that extends well beyond the level of individual actions. From this ionospheric perspective, one could easily visualize effects that could not be fully comprehended from a closer focal point. This simple example from space science illustrates a principle that seems so obvious in the physical sciences but that often appears incomprehensible in the psychological sciences and neurosciences. There are phenomena that may be explicable in terms of events at a microlevel of analysis but that are more easily studied and more fully comprehended by reference to broader and multiple levels of analysis.

Our aims in this article are to outline the importance of a multilevel, integrative approach to the study of mental and behavioral phenomena in the decade of the brain; to review how this approach highlights the synergistic relationship between theoretical and clinically relevant research; and to explore how this approach might foster

the transition from microtheories to general psychological theories. We begin by examining the decade of the brain and its relevance to the social and psychological sciences. We then review several psychological principles underscoring the thesis that basic research cutting across levels, including the cultural, social, psychological, and biological, is an imperative rather than a luxury if the decade of the brain is to produce satisfactory answers to complex psychological phenomena and disorders.

Decade of the Brain

A fundamental assumption in the natural science of psychology is that neurophysiological processes underlie adaptive and maladaptive psychological phenomena. William James (1890/1950) was one of the first psychologists to articulate this assumption; to recognize that developmental, environmental, and sociocultural factors influence neurophysiological processes underlying psychological phenomena; and to acknowledge that these influences *could* be studied as neurophysiological transactions. James also asserted that unnecessary diseconomies and conundrums would result if neurophysiological events were the exclusive focus of psychological investigations (Cacioppo & Tassinari, 1990a).

William James drew these conclusions over a century ago. In decades past, studies of the neurophysiological

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The determinism principles examined in this article were developed in recent conferences of the Behavioral Sciences Basic Research Branch of the National Institute of Mental Health (NIMH) and most notably by the NIMH Behavioral Sciences Assessment Panel. This panel met during 1987 and 1988 to develop a conceptual framework for the advancement of research in the behavioral sciences ("New Frontiers," 1989). The present article was developed from John T. Cacioppo's work on a subsequent panel.

We are grateful to the inaugural panel members, including Marilyn Brewer, Glen Elder, Walter Kintsch, Lewis Lipsitt, Martha McClintock, Anne Petersen (Chair), Robert Plomin, David Reiss, and Arnold Sameroff. We also thank Molly Oliveri, Diane Ruble, Phil Costanza, and an anonymous reviewer for comments on a draft of this article.

Correspondence concerning this article should be addressed to John T. Cacioppo or Gary G. Berntson at the Department of Psychology, Ohio State University, 1885 Neil Avenue, Columbus, OH 43210-1222.

structures and functions associated with psychological events were limited primarily to animal models, post-mortem examinations, and observations of the occasional unfortunate individual (e.g., Phineas Gage, H.M.) who suffered trauma to or disorders of the brain. Developments in electrophysiological recording, brain imaging, and neurochemical techniques within the neurosciences have increasingly made it possible to investigate the role of neural structures and processes in normal and disordered thought in humans. The importance of these technical developments was underscored by Congress's declaration of the 1990s as the decade of the brain.

The congressional declaration of the decade of the brain is important to all psychological sciences for two reasons. First, this declaration may confer higher appropriations, but it clearly confers higher expectations for the unraveling of the mind's knots and nightmares. The credibility of the cognitive, behavioral, and social sciences, not just the neurosciences, is therefore at stake.

Second, the brain does not exist in isolation but rather is a fundamental but interacting component of a developing or aging individual who is a mere actor in the larger theater of life. This theater is undeniably social, beginning with prenatal care, mother-infant attachment, and early childhood experiences and ending with loneliness or social support and with familial or societal decisions about care for the elderly. In addition, mental disorders such as depression, schizophrenia, and phobia are both determined by and are determinants of social processes; and disorders such as substance abuse, juvenile delinquency, child and spousal abuse, prejudice and stigmatization, family discord, worker dissatisfaction and productivity, and the spread of acquired immunodeficiency syndrome (AIDS) are quintessentially social as well as neurophysiological phenomena. Social psychology, with its panoramic focus on the effects of human association and the impact of society on the individual, is therefore a fundamental although sometimes unacknowledged complement to the neurosciences.¹

The importance of a social psychological perspective to the neurosciences is revealed in research demonstrating both that (a) neurochemical events influence social processes and (b) social processes influence neurochemical events. Studies of mating behavior in the ring-necked dove, for instance, indicate that social behaviors (e.g., male strutting and cooing) trigger hormonal changes (e.g., increased production of estrogen in the female) that predispose the female toward a new set of behaviors (e.g., courtship and copulation), which results in yet additional reciprocal influences between hormones and social behaviors until the newborns are reared (Erikson & Lehman, 1964; Lehrman, 1964; Martinez-Vargas & Erikson, 1973). These reciprocal influences have also been found in primates. Testosterone levels in male primates, for example, have been found to promote sexual behavior, whereas the availability of sexually receptive females, in turn, has been found to influence testosterone levels in male primates (Bernstein, Gordon, & Rose, 1983; Bernstein, Rose, & Gordon, 1974; Rose, Gordon, & Bernstein,

1972; see, also, Davidson, Camargo, & Smith, 1979). Indeed, our understanding of the function of hormones would be far more rudimentary if not for analyses of their effects on social behavior and for the effects of social behavior on hormonal changes. Thus, comprehensive theoretical accounts of hormonal regulation (not just sexual behavior) necessitate consideration of social factors. There are, of course, physiological mechanisms underlying these phenomena, but the identification and understanding of these mechanisms are better served by systematic investigations within and across multiple (including social) levels of analysis rather than by a reductionistic focus alone.

The differences in social psychological and neuroscientific levels of analysis have occasionally obscured commonalities and isolated related research on and contributions to a psychological phenomenon. Before considering these commonalities and potential mutual contributions, we will review briefly ways in which the term *level of analysis* has been used in social psychology and in the neurosciences. We will then define how the term will be used here, review several basic principles in which the construct of levels is fundamental, and examine the implications of these principles for psychological theory and research.

Level of Analysis: Single Level Versus Multilevel Analysis

Single Level Analysis

The term *level of analysis* has been used in psychology to refer to the level of structural organization (e.g., Tolman, 1959; P. Weiss, 1941), the level of explanation (e.g., Shaw & Turvey, 1981), and the level of processing (e.g., Churchland & Sejnowski, 1988; Craik & Lockhart, 1972). In the present article, we will focus on the first usage of the term *levels*, which refers to the different scales into which the brain or behavior can be represented. What constitutes a level of organization, at least for lower mechanisms, is usually guided by knowledge of anatomy or physiology; but the ultimate criterion is the usefulness of the posited organization in shedding light on some designated biological, psychological, or behavioral phenomenon. Thus, the level of organization of psychological phenomena can vary from the molecular, to the cellular, to the tissue, to the organ, to the system, to the organism, to the physical environment, to the sociocultural context.

¹ We chose to focus here on social psychological contributions to the decade of the brain for two reasons. First, its complementarity to a neuroscience perspective is less understood than other psychological perspectives. Cognitive, behavioral, and developmental neuroscience, for instance, are all active areas of research, but social neuroscience strikes some as being an oxymoron (see Scott, 1991). It is not, as we hope to illustrate in this article. Second, the social and neuroscience perspectives represent two ends of a continuum of levels of organization studied in psychology. By illustrating the importance of considering both social and neuroscience perspectives and their intersections, we hope to illustrate the general importance of multilevel, integrative analyses of complex psychological phenomena.

Levels of analysis in the neurosciences generally encompass the lower end of this spectrum, whereas in social psychology they capture the higher end—the individual and group within a sociocultural system. Thus, these fields differ in the level at which behavioral phenomena are unitized, although they need not differ in terms of the behavioral phenomenon under investigation. For instance, although both neuroscientists and social psychologists may study sexual behavior, aggression, or addiction, the elements into which the phenomena are partitioned and the dimensions of the measurements of these two levels of analysis are discordant. Consequently, the conceptual units and dimensions of one level seldom map isomorphically into those of another. This lack of isomorphism is inherent across levels of analysis because (a) higher levels entail functional outcomes of interactive aggregates of lower processes and (b) a given outcome may arise from differing aggregates or states. Thus, social psychological analyses focus on social structures and processes that characterize *functional* aspects of neurophysiological mechanisms, but a particular function cannot be readily characterized in the terminology and concepts of neurophysiology. Moreover, a given function can be implemented by one or more neurophysiological mechanisms whose boundaries may not be obvious, at least initially, from anatomical considerations (Cacioppo & Tassinary, 1990b; Fodor, 1968).

Multilevel Integrative Analysis

Important advances have been made and will continue to be made using single levels of analysis. Indeed, one of the themes of this article is that such research is important and bears on issues relevant to investigators working on the same psychological phenomenon even when their particular level of analysis is quite different. We suggest there is an additional benefit to be gained, however, from a multilevel analysis of the phenomenon, wherein one considers not only the elements from two or more levels of analysis that bear on some phenomenon but also the relational features among these elements. Thus, by multilevel analysis we mean the study of a phenomenon from various structural scales or perspectives, ranging from the neuroscientific (“microscopic”) to the social psychological (“macroscopic”). By integrative, we mean simply that analyses of a phenomenon at one level of organization can inform, refine, or constrain inferences based on observations at another level of analysis and, therefore, can foster comprehensive accounts and general theories of complex psychological phenomena. Given differences in the unitization of a phenomenon across levels of analysis, multilevel analyses require special considerations, which we will consider below.

There are at least three reasons to expect that multilevel analyses of complex social and behavioral problems will be integrative. First, complex systems as a rule cannot be understood as a simple extrapolation from the properties of their elementary components (Marr, 1982). Unless the properties of the system are the simple sum of those of its elementary components, a focus on elemen-

tary components contributes to an explanation only when considered in conjunction with events occurring at different levels of the system. Indeed, Fodor (1968; Fodor & Pylyshyn, 1988) observed that there are causal structures at each level of organization and that the causal structures at the macroscopic level in science cannot be predicted by the microscopic.² “No one expects the theory of protons to look very much like the theory of rocks and rivers, even though, to be sure, it is protons and the like that rocks and rivers are ‘implemented in’” (Fodor & Pylyshyn, 1988, p. 63). Fodor and Pylyshyn further noted:

Clearly it is pointless to ask whether one should or shouldn’t do cognitive science by studying ‘the interaction of lower levels’ as opposed to studying processes at the cognitive level since we surely have to do *both*. Some scientists study geological principles, others study ‘the interaction of lower level units’ like molecules. But since the fact that there are genuine, autonomously-statable principles of geology is never in dispute, people who build molecular level models do not claim to have invented a ‘new theory of geology’ that will dispense with all that old fashioned ‘folk geological’ talk about rocks, rivers, and mountains! (p. 66)

For this reason, the study of the elements of a system (i.e., reductionism) may produce eloquent descriptions while falling short of a useful and comprehensive explanation.

We should emphasize that we are not suggesting that the study of the behavior of elementary components has disutility or is irrelevant to molar analyses but rather that reductionistic inquiries can precede (or co-occur or follow) and, in turn, stimulate (or be informed by) relatively molar research on the behavior of complex systems. The example from space science with which we began this article is a case in point. The study of the system as an aggregate may produce detailed descriptions of the molar behavior of the system while falling short of defining the underlying origins of this behavior (i.e., individual and collective actions in the case of the pollution). Learned helplessness exemplifies a molar psychological phenomenon that was subsequently informed by, and in turn informed, lower levels of analysis. Early research demonstrated that inescapable shock led to a depressive syndrome characterized by inactivity, loss of escape/avoidance reactions, and a decrease in reactivity to pain (Seligman, 1975). This research led to a specific psychological explanation that ascribed this state of helplessness to the learning of a lack of contingency between responses and outcomes and to a pessimistic attributional style (Abramson, Seligman, & Teasdale, 1978; Peterson & Seligman, 1984). Research in the neurosciences, however, has further demonstrated that (a) brain catecholamine

² Fodor’s (1968) emphasis was on concepts and theories rather than elements (units, dimensions). Differences in the unitization of a phenomenon across levels of analysis and the consequent lack of isomorphism become even more notable when one progresses from elements to conceptual or theoretical schemata that must also specify relational features among dissimilar and nonisomorphic elements.

depletion can yield a similar syndrome, (b) inescapable shock can lead to a decrease in central catecholamines and an opiate-mediated analgesia, and (c) this syndrome can be effectively treated by antidepressants or other agents that enhance central catecholamines or block opiate receptors (Basbaum & Fields, 1984; Bodnar, 1990; Maier, 1984, 1986; Simson, Weiss, Hoffman, & Ambrose, 1986; J. M. Weiss, Goodman, Losito, Corrigan, & Bailey, 1981; J. M. Weiss et al., 1986). Thus, lower levels of analysis have illuminated physiological mechanisms that may underlie this helplessness syndrome and in turn may inform certain cases of human depression (Maier, 1984; J. M. Weiss et al., 1981). On the other hand, it has also become apparent that (a) there are both associative and nonassociative behavioral determinants of helplessness (Lysle & Fowler, 1988; Maier, Jackson & Tomie, 1987; Minor, Dess, & Overmeir, 1991; Seligman, 1975), (b) the degree of stress-induced catecholamine depletion is related to the psychological factors of predictability and controllability (Maier, 1984; J. M. Weiss et al., 1981), and (c) physiological mechanisms for both opiate and non-opiate stress-induced analgesia are differentially invoked on the basis of the behavioral context (Bodnar, 1990; Maier, 1986, 1989). These reciprocal interactions between behavioral and physiological domains would seriously cloud studies limited to a single level of analysis. The point is that distinct levels of analysis might better be viewed as complementary rather than alternative approaches. The relationship between catecholamine depletion and depression in helplessness, for instance, did not originate in research on central catecholamine regulation but in research on the effects of uncontrollable stressors on behavior and cognition.

A second reason multilevel analyses of complex social and behavioral problems tend to be integrative is that each level of organization constitutes a particular kind of representation with which to examine human mentation and behavior. Any particular representation makes certain information explicit at the expense of other information and, hence, renders some operations or insights easy and others quite difficult. Thus, no single level of behavioral organization is best for all psychological questions. An example can be found in the relative utility of specifying the sociocognitive versus the neurophysiological basis of patient delay following the onset of gynecologic cancer. Women can now survive most gynecologic cancers if the disease is diagnosed and treated early. Indeed, research on gynecologic cancer indicates that the prognosis for survival and for quality of life following medical treatment is directly related to the stage of the cancer at diagnosis (Andersen, 1986). Moreover, women with advanced rather than early-stage disease at diagnosis, even if they survive, are more likely to suffer depression, experience marital and family problems, and require extended and expensive medical treatment. Hence, patient delay in seeking a diagnosis is a serious problem that carries large and long-term personal, family, and societal costs. The form of the representation of patient delay offered by neuroscientific analyses of patient delay, although perhaps ultimately

contributing to a more complete understanding of the phenomenon, is not optimal for identifying the determinants of patient delay or for developing effective interventions to minimize such delay. Huge savings in resources and human suffering are there to be reaped, not through a specification of the brain circuits underlying patient delay but by well-conceived public health campaigns that identify the early signs of cancer and minimize the material, emotional, and social costs of seeking diagnosis and treatment (Andersen, 1986; see also Rossi, 1991).

Third, Fodor and McLaughlin (1990) noted that precision is often gained when one moves from generalizations about operations on molar elements to generalizations about operations on microelements. However, this increased precision does not yield a truer depiction of the causal mechanism nor is the conceptual price paid for the precision necessarily worth the gain in precision. As Fodor and McLaughlin noted, if by moving to the more microscopic level of analysis one finds the macro-level processes are not really causal, then it must mean the microlevel processes underlying these macrolevel processes are not causal either. Moreover:

We get *still more* precision when we go down from unit-sensitive operations to molecule-sensitive operations to quark-sensitive operations. The moral is not, however, that the causal laws of psychology should be stated in terms of the behavior of quarks. Rather, the moral is that whether you have a level of causal explanation is a question, not just how much precision you are able to achieve, but also of *what generalizations you are able to express*. The price you pay for doing psychology at the level of units is that you lose causal generalizations that symbol-level theories are able to state. (Fodor & McLaughlin, 1990, p. 204)

Thus, if some designated set of neural events is a sufficient cause for a psychological phenomenon, the effects documented in experimentation in which the designated events are manipulated will be *replicable*. The illusion of generality may be achieved by the study of the behavior of simple systems rather than complex phenomena because of the replicability of an effect across laboratories worldwide. However, although lawfulness is established when a psychological phenomenon (e.g., aversive conditioning) is invariably affected by the manipulation of a specific neurophysiological system (e.g., lesions of the amygdaloid nucleus; see LeDoux, Iwata, Cicchitti, & Reis, 1988), generality is not established. Only if these neural events are also a necessary cause are the effects fully *generalizable*. If the designated events are sufficient but not necessary to produce the psychological phenomenon (e.g., the psychological phenomenon is multiply determined by independent sets of neural events), experimental manipulations of the designated events may reliably produce the psychological phenomenon only because other sufficient causes have been controlled in a particular experimental paradigm or assessment context.³ In such cases, a "generalizing problem"

³ It is rare for a single factor or determinant to assume a necessary and sufficient relationship with a complex psychological phenomenon

is to be expected in natural (e.g., clinical) settings or populations. A well-known example can be found in the research on the physiological detection of lying. Although lying about a significant event typically produces an electrodermal response, efforts to detect lying on the basis of electrodermal responses are characterized by high false-alarm rates unless the myriad other sufficient causes of electrodermal responding have been controlled in the assessment procedure (Iacono & Patrick, 1988). From this point of view, the generalizing problem does not reflect a methodological quagmire but rather represents a theoretical challenge. That is, the observation that effects documented in carefully controlled experimentation lack generalizing power may not reflect any dubious feature of experimentation or particular level of analysis but may simply reflect the multiply determined nature of the phenomenon of interest.⁴ Thus, boundary conditions for theories can be identified and new theoretical organizations can be discovered when generalizing problems arise. In this light, reductionistic studies demonstrating the sufficiency of a neurophysiological mechanism as a cause of some psychological phenomenon are immensely important, largely because they guide and constrain general theories of the psychological phenomenon.

Doctrine of Multilevel Analysis

We have suggested that multilevel analyses spanning neural and social perspectives can foster comprehensive accounts of psychological phenomena. The doctrine of multilevel analysis states that there are psychological phenomena that derive from events at one level of analysis and that are only or more distinctly observable across levels of analysis. Consequently, order can uniquely emerge when psychological phenomena are examined from multiple levels of analysis.

The doctrine of multilevel analysis specifies that microanalyses of a psychological phenomenon can be particularly effective when pursued in addition to or in conjunction with molar analyses. It also holds a key argument for maintaining psychology as a coherent scientific discipline. Scott (1991) reflected on what he viewed to be the inevitable fractionation of psychology as a scientific discipline, with the growing abyss, for example, between the fields of social and biopsychology: "Most biopsychology students consider a core course in social psy-

chology to be an impediment toward becoming a neuroscientist. . . . I assume that our students in social psychology reflect that sentiment about their core experience in biopsychology" (p. 975).

Methodological fractionation may be inevitable with the maturation of the subdisciplines in psychology. Furthermore, the expansion of basic empirical data and theory within these subdisciplines increases the difficulty of mastering the methods and theories of multiple levels of analysis. The doctrine of multilevel analysis makes it equally apparent, however, that the inevitable consequence of this fractionation is a devolution into fact lists and elaborated microtheories with limited generality. The demand for general theories of psychological phenomena may therefore be better served by at least a rudimentary training of graduate students in multiple subdisciplines within psychology and by forming multi-investigator research teams working together to bring differing levels of analysis to bear on a psychological problem.

The doctrine of multilevel analysis is composed of three principles and a corollary:

1. The principle of multiple determinism: A target event at one level of organization (e.g., neuroeffector response, evaluative response predisposition) may have multiple antecedents within or across levels of organization.

2. The corollary of proximity: The mapping between elements across levels of organization becomes more complex (e.g., many-to-many) as the number of intervening levels of organization increases.

3. The principle of nonadditive determinism: Properties of the collective whole are not always predictable from the properties of the parts until the properties of the whole have been clearly documented and studied across levels.

4. The principle of reciprocal determinism: There can be mutual influences between microscopic (e.g., biological) and macroscopic (e.g., social) factors in determining brain and behavioral processes.

An example of the principle of multiple determinism can be found in the extensive literature on drug abuse. It now seems clear that endogenous brain opioid receptor systems constitute ultimate bases for the physiological, cognitive, and affective actions of opiate drugs of abuse. Studies of these systems have illuminated, and will continue to clarify, the underlying dynamics and physiological consequences of drug self-administration. However, central opioid systems are common across individuals, only some of whom will succumb to drug abuse. Hence, central opiates merely constitute permissive substrates for substance abuse. The proximate and powerful determinants of drug abuse include the social factors of economics,

(Ψ), at least in a contextually generalized fashion. Rather, psychological phenomena are often subject to multiple determinants. This multiple determinism may assume one or both of two general forms. The first we term *parallel determinism*, in which any one of a number of factors is sufficient to evoke the psychological phenomenon. Thus, if the manipulated factor or treatment (τ) is a sufficient but not a necessary cause of Ψ , then evidence of the psychological phenomenon should be observed whenever τ has occurred and may be observed even when τ has not occurred. In a second form of multiple determinism, termed *convergent determinism*, the convergence of a number of factors (or one or more factors in a specific context) is required to evoke the psychological phenomenon. Thus, if the manipulated factor or treatment is a necessary but not a sufficient cause of Ψ , then evidence of Ψ should not be observed if τ has not occurred, and Ψ may or may not be observed if τ has occurred (Cacioppo & Berntson, 1992).

⁴ If a psychological phenomenon is multiply determined by synergistic variables that coexist in the laboratory but not typically in nonlaboratory settings, then a generalizing problem will again be encountered. The resolution of this generalizing problem will again rest on insight into the multiply determined nature of the psychological phenomenon.

opportunity, peer group influences, and family dynamics. These determinants will not be understood at an exclusively neuroscientific level in the near future. Rather, the interactions between social processes and the underlying neural substrates that support drug administration represent some of the most important issues currently facing our society. As is so often the case, it was the molar features of a phenomenon that prompted and guided inquiry into underlying mechanisms. Indeed, it was the profound psychological effects of the opiates and their abuse potential that stimulated research leading to the discovery of central opioid systems.

Considerable additional evidence has amassed over the past several decades demonstrating that elements in the physiological domain and elements in the psychological domain can be influenced by a multiplicity of factors within and across levels of organization (e.g., see Plomin, 1989). Consideration of these sets of factors can foster more comprehensive theoretical accounts than are achievable by limiting empirical and theoretical inquiries to the factor with the largest effect size or to a single level of analysis. This can be illustrated by returning to our example of drug (e.g., alcohol) abuse. An understanding of osmoreceptive mechanism and volume detectors, which monitor body water balance, can offer an eloquent account of facilitated ingestive reflexes, and the action of alcohol on central gamma-aminobutyric acid (GABA) receptors may constitute a partial explanation for its incentive value. These mechanisms, however, offer only a partial account of an animal bar-pressing for water, for which the principles of learning must be invoked. Nor do they tell us much about the drinking behavior of alcoholics in bars, which is heavily determined by social and contextual factors. Conversely, even extensive studies limited to operant performance or barroom behavior would be relatively uninformative about the fundamental mechanisms of thirst or alcoholism if conceptualized in isolation of the psychobiological underpinnings. Studies of the opiate system and addictive behavior, for example, have shown that drug administration results in opiate receptor changes, which in turn contribute to drug tolerance and addiction, which incline larger drug administrations, opiate changes, and so on. However, whether or not these developments result in a positive feedback loop and drug addiction depend also on the individual's social context. Clearly, research that specifies the conditions under which each of a set of factors or processes is operative, and that specifies the relationship between empirical observations at differing levels of analysis, sets the stage for integral theoretical advances.

A supplement to the principle of multiple determinism is the *corollary of proximity*, which states that the mapping between elements across levels of organization becomes more complex (e.g., many-to-many) as the number of intervening levels of organization increases. This is because an event at one level of organization (e.g., depressive or schizophrenic behavior) can have a multiplicity of determinants at an adjacent level of organization (e.g., cognitive), which in turn may have a multiplicity of

implementations at the next level of organization (e.g., neurophysiological), and so forth. The implication is not to avoid venturing across the abyss separating the macroscopic and the microscopic levels of organization but to proceed incrementally across levels of analysis. These measured efforts can pay handsome dividends. As illustrated in research on learned helplessness (see above), understanding a behavioral problem at multiple levels of organization can result in a more general theory and can improve the selection and application of clinical interventions.

The principle of nonadditive determinism further highlights the order in behavioral data that can emerge when one uses a multilevel analysis to examine a phenomenon. According to this principle, properties of the collective whole are not always predictable from the properties of the parts until the properties of the whole have been clearly documented and studied across levels (Marr, 1982). Consider an illustrative study by Haber and Barchas (1983), who found that the administration of amphetamine appeared to have no reliable effect on primate behavior until the primate's position in the social hierarchy was considered. When this social factor was considered, amphetamine administration was found to increase dominance behaviors in primates high in the social hierarchy and to increase submissive behaviors in primates low in the social hierarchy. The importance of their study derives from its demonstration of how the effects of physiological changes on behavior can *appear* unreliable until the analysis is extended across multiple levels of organization. A physiological analysis, regardless of the sophistication of the measurement technology, may not have unraveled the orderly relationship that existed between the physiological manipulation and behavior. There are, of course, physiological mechanisms underlying these phenomena, but the identification and understanding of these mechanisms are often better served by systematic investigations within and across multiple (including social) levels of organization than by a reductionistic focus alone.

The evidence for the principle of reciprocal determinism further establishes the complementarity between social psychological and neuroscientific levels of analysis. Reciprocal determinism between biological and social factors is, of course, inherent in evolutionary analyses of social species. More interestingly, Plomin (1989) reviewed evidence in behavior genetics that suggests a wide variety of genetic influences are repressed unless or until certain environmental factors are introduced. Within social psychology, Zillmann (1984, 1989) has demonstrated that violent and erotic material influences the level of physiological arousal in males and that the level of physiological arousal has a reciprocal influence on the perceptions of and tendencies toward sex and aggression. As discussed earlier, testosterone in male primates promotes sexual behavior, and the availability of sexually receptive females influences testosterone levels in male primates (Bernstein et al., 1983; Rose et al., 1972). Testosterone affects aggressive as well as sexual behavior, and increasing the

level of testosterone in a castrated chimpanzee leads to behaviors by the primate that elevate his social rank (Clark & Birch, 1945; see, also, Bernstein, Rose, & Gordon, 1974). In addition, alterations of social rank influence testosterone levels. In an intriguing naturalistic investigation, for instance, Jeffcoate, Lincoln, Selby, and Herbert (1986) obtained repeated plasma samples from five men confined on a 38-foot boat during a 14-day sailing holiday around the north coast of Scotland. The men were physicians and were used to having blood samples taken. One of the five men surreptitiously recorded dominance/aggressive behaviors (e.g., bossiness, insistence on undertaking "important" tasks) to document the social hierarchy that emerged over the course of the holiday. Results revealed that the remaining four men had comparable testosterone levels before and after the holiday. Nevertheless, by the end of the second week on the boat, the individuals who had achieved the highest ranking in the social hierarchy also exhibited the highest testosterone levels, whereas the least dominant pair had the lowest levels of testosterone (see also Keverne, Meller, & Eberhart, 1982). Of course, the reciprocal determinism between biological and social systems cannot be mapped if either level of organization is regarded as irrelevant, and achieving comprehensive accounts of the role of these systems in behavior is difficult in the absence of a mapping of their mutual influence.

It follows from each of the foregoing principles that an exclusive focus on a reductionistic (e.g., neurophysiological, molecular, genetic) level of analysis can mask contributions of other levels of organization to mental order and disorder and thereby constrain theoretical accounts of psychological phenomena. This supposition is apparent in research on the putative role of dopamine systems in schizophrenia. The hypothesis that excessive dopaminergic activity underlies schizophrenia was developed in part from correlative evidence linking the clinical efficacy of antipsychotic drugs with their ability to block dopamine receptors (Losonczy, Davidson, & Davis, 1987; Seeman, Lee, Chau-Wong, & Wong, 1976). Evidence that dopamine antagonists (neuroleptics) produce improvements in schizophrenic behavior has led to interpretations ranging from dopamine's being a "marker" of schizophrenia to the dopaminergic system's representing the mechanism responsible for the disorder. The fact that elevated dopamine levels produce autonomic and behavioral effects similar to those found in schizophrenics (e.g., Zahn, Rapoport, & Thompson, 1981) does not necessarily imply that the emergence or maintenance of schizophrenia is invariably (or even usually) initiated by excessive levels of dopamine. Indeed, dopamine abnormalities may not be present in all cases (Haracz, 1982; Losonczy et al., 1987; Meltzer, 1987). Thus, (a) the dopaminergic system may represent but one of many physiological mechanisms capable of producing schizophrenia; (b) dopamine may be one of a complex of biochemical variables in which subsets (coalitions) are capable of generating schizophrenia; or (c) an overabundance of dopamine is not an antecedent of schizophrenia

but rather, like schizophrenia, a consequence of some other underlying process (Patterson, 1976; Spohn & Patterson, 1979; Zahn, 1986). However, the processes underlying schizophrenia may be best conceptualized and investigated across levels of analysis. For instance, there is no longer any doubt about the importance of genetic, social, and environmental events in triggering schizophrenia (e.g., Turpin, Tarrier, & Sturgeon, 1988). It is also clear that environmental stressors that can exacerbate schizophrenic symptoms exert powerful modulatory influences on central neurochemical systems (including dopamine). Clearly, the ultimate explication of the bases of schizophrenia will require attention to interactions between genetic and environmental factors and multiple central neurochemical systems.

In summary, the predictable yield from isolated research on discrete determinants of a multiply determined psychological outcome is a portfolio of fact lists and disparate microtheories. Each of these microtheories provides a limited account for the phenomenon of interest, however, and is at best a piece of a larger conceptual puzzle. Even determinants of a phenomenon that account for a modicum of variance are noteworthy if the goal is to achieve a comprehensive theory of the psychological phenomenon rather than a microtheory of the determinant. In addition, knowledge of the body and brain can usefully constrain and inspire concepts and theories of psychological function, inasmuch as there are any number of ways in which a particular outcome might be achieved. Knowledge about the functional organization of ordered and disordered mental activities, however, can also usefully guide the study of the underlying brain processes, because the nature of the particular physiological mechanisms and events could be suggested by the observed mentation, behavior, or interaction. Although there are neurophysiological processes that are affected, for instance, by human association and that underlie the associated psychological and social phenomena, these phenomena shape physiological events in ways that may not be evident from studies of the physiology isolated from the social or environmental context in which they manifest. Hence, without attention to basic social psychological factors and processes, the decade of the brain may yield some spectacular images and experimental effects but rather limited answers to the problems of mental health.

Social Neuroscience?

We have thus far reviewed principles of behavior that underscore the theoretical utility of examining complex psychological phenomena and mental disorders from multiple levels of analysis. Although Bevan (1991) and Leshner (1991) have suggested that investigating the processes underlying mental health from multiple points of view may be the look of the future, it is not entirely new to social psychology. As Gordon Allport (1968) noted:

An individual is a member of many publics, of many institutions, of many social systems. . . . It was Sapir who advised all social

and psychological scientists to form the habit of looking at their data both from the concrete individual point of view and from the abstract social point of view. It enriches research and theory to do so. (p. 55)

Social psychological contributions to the neurosciences are particularly apparent in, and served as the impetus for, the explosive development of the field of psychoneuroimmunology. Classically, immune functions were considered to reflect specific and nonspecific physiological responses to pathogens or tissue damage (Roitt, Brostoff, & Male, 1985). It is now clear that immune responses are heavily influenced by central nervous processes that are shaped by psychological factors (see reviews by Ader, 1981; Kennedy, Glaser, & Kiecolt-Glaser, 1990). Indeed, effects of psychological context now appear to be among the most powerful determinants of the expression of immune reactions. It is clear that an understanding of immunocompetence will be inadequate in the absence of considerations of psychosocial factors. Research on these interactions was activated by research demonstrating the direct and moderating effects of psychosocial factors (e.g., conditioned stimuli, bereavement, social support, major life events) on immune competence (e.g., see Kennedy et al., 1990). Thus, major advances in the neurosciences can derive from increasing the scope of the analysis to consider the contributions of social factors and processes.

Our more general theme throughout this article, however, has been that reciprocal benefits and more general psychological theory can be achieved by considering or pursuing jointly macrolevel and microlevel analyses of psychological phenomena. Social psychological contributions to the understanding of complex, multiply determined mental processes and problems may be limited unnecessarily in scope to the extent that a parochial perspective is adopted by neuroscientists *or* by social psychologists. To illustrate, consider social psychological research on attitudes, which has produced a large corpus of data and theory, much of which can and has been applied to the study and resolution of mental problems (e.g., see Cooper & Aronson, 1992; Petty & Cacioppo, 1986). Theories of attitudes and attitude change, however, have only infrequently considered physiological factors and mechanisms or research on appetitive and defense motivational systems. Evaluative categorizations and response predispositions—criterial attributes of the construct of attitudes—are fundamental and ubiquitous in behavior. Mechanisms for differentiating hostile from nurturing environmental stimuli are imperative for the survival of species and for the formation and maintenance of social units. Indeed, all organisms have biological mechanisms for approaching, acquiring, or ingesting certain classes of stimuli and withdrawing from, avoiding, or rejecting others (Berntson, Boysen, & Cacioppo, in press; Cacioppo, 1991). Knowledge of the organization and operating characteristics of these underlying mechanisms may therefore lay down, at least in broad strokes, the rules by which biological and social factors alter evaluative categorizations and evaluative response dispositions. Protective flexor-withdrawal reflexes to pain stimuli

are apparent, for example, even in the isolated spinal cord, and both decerebrate humans and rats display stereotyped orofacial ingestion/ejection reflexes to relevant gustatory stimuli (Grill & Berridge, 1985; Steiner, 1979). Although of constitutional origin and generally stereotyped in form, reflexive responses nevertheless demonstrate a sensitivity to motivational variables. Orofacial ingestion reflexes can be primed by metabolic deficits and can be modulated by conditioned taste aversions, even in the decerebrate organism (Berridge, 1991; Grill & Berridge, 1985). These inherent dispositions allow an organism, even at early stages of development and without previous experience, to adaptively respond to important classes of environmental stimuli.

There is an enormous additional adaptive advantage when an individual member of a species is also able to acquire new evaluative response dispositions (e.g., attitudes) toward the stimuli in its particular environment as a consequence of the contingencies in that environment. Thus, adaptive reflexes are functionally limited, but they represent only a single level in what appears to be a continuity of evaluative mechanisms (Berntson et al., in press; Cacioppo, Petty, & Berntson, 1991). Although decerebrate organisms display orofacial ingestion/ejection responses to gustatory stimuli, they do not evidence normal appetitive goal-seeking behavior (Berntson & Micco, 1976; Grill & Berridge, 1985). With the involvement of additional subcortical structures, such as the limbic system and striatum, the reactions of the decorticate animal to pain stimuli entail additional response components and evidence greater directedness, integration, serial coherence, and contextual adaptability (Berntson & Micco, 1976; Goldstein & Oakley, 1985). Furthermore, the ingestive behavior of the decorticate is more fully responsive to metabolic signals, and appetitive or goal-seeking components are apparent. These findings suggest that evaluative mechanisms are not localized to specific neuraxial levels but evidence a hierarchy or representation throughout the central nervous system. With progressively higher organizational levels in evaluative mechanisms, there appears to be a general expansion in the range and relational complexity of contextual controls and in the breadth and flexibility of adaptive response (Berntson et al., in press; Cacioppo et al., 1991). Although research on the interactions between evaluative mechanisms at differing levels of the neuraxis is still in its early stages, there appears to be considerable common ground for dialogue between social psychologists and neuroscientists.

In summary, reductionism has contributed to the solution of some of the most perplexing scientific problems in human history (e.g., see Boorstin, 1983) and has much to contribute to our understanding of social and psychological phenomena. However, it is counterproductive to presume that reductionism will convert the abstractions of the psychological sciences to “real” science in the coming millennium, just as it is counterproductive to presume that reductionism produces insights that are irrelevant to theories of social processes and phenomena. To do either ignores the distinction between levels of ex-

planation, the scientific breakthroughs that can result from research at each of the levels of explanation and at or across levels of organization, the rich theoretical insights about the nature and timing of the relationships among variables that can be derived from descriptions of phenomena from multiple scales or perspectives, and the economy of thought to be reaped by capitalizing on the form of representation most appropriate for the task. In addition, it undermines multilevel, integrative analyses; alienates scientists working at "unchosen" levels of organization who might otherwise contribute relevant data and theory; and renders it acceptable to ignore relevant theory and data on a phenomenon of interest simply because they were not born from one's own level of analysis. Given there are phenomena that derive from events at one level of analysis that are only or distinctly observable at other or broader levels of analysis, then multilevel integrative analyses will play an important role in providing the empirical data and theoretical insight needed for a comprehensive understanding of basic behavioral processes, mental health, and mental disorders. Thus, the decade of the brain is more likely to be a gateway to a new millennium of the mind if we recognize that the brain is a single, pivotal component of an undeniably social species and if we recognize that the nature of the brain, behavior, and society is, in Bevan's (1991) words, orderly in its complexity rather than lawful in its simplicity.

REFERENCES

- Abramson, L. Y., Seligman, M. E., & Teasdale, J. D. (1978). Learned helplessness in humans: Critique and reformulation. *Journal of Abnormal Psychology*, 87, 49-74.
- Ader, R. (1981). *Psychoneuroimmunology*. San Diego, CA: Academic Press.
- Allport, G. H. (1968). The historical background of modern social psychology. In G. Lindzey & E. Aronson (Eds.), *The handbook of social psychology* (Vol. 1, pp. 1-80). Reading, MA: Addison-Wesley.
- Andersen, B. L. (1986). *Women with cancer: Psychological perspectives*. New York: Springer-Verlag.
- Basbaum, A. L., & Fields, H. L. (1984). Endogenous pain control systems: Brainstem spinal pathways and endorphin circuitry. *Annual Review of Neuroscience*, 7, 309-338.
- Bernstein, I. S., Gordon, T. P., & Rose, R. M. (1983). The interaction of hormones, behavior, and social context in nonhuman primates. In B. B. Svare (Ed.), *Hormones and aggressive behavior* (pp. 535-561). New York: Plenum Press.
- Bernstein, I. S., Rose, R. M., & Gordon, T. P. (1974). Behavioral and environmental events influencing primate testosterone levels. *Journal of Human Evolution*, 3, 517-525.
- Berntson, G. G., Boysen, S. T., & Cacioppo, J. T. (in press). Neurobehavioral organization and the cardinal principle of evaluative bivalence. In F. M. Crinella & J. Yu (Eds.), *Brain mechanisms 1990: Papers in memory of Robert Thompson*. New York: New York Academy of Sciences.
- Berntson, G. G., & Micco, D. J. (1976). Organization of brainstem behavioral systems. *Brain Research Bulletin*, 1, 471-483.
- Berridge, K. C. (1991). Modulation of taste affect by hunger, caloric satiety, and sensory specific satiety in the rat. *Appetite*, 16, 103-120.
- Bevan, W. (1991). A tour inside the onion. *American Psychologist*, 46, 475-483.
- Bodnar, R. J. (1990). Effects of opioid peptides on peripheral stimulation and "stress"-induced analgesia in animals. *Critical Reviews in Neurobiology*, 6, 39-49.
- Boorstin, D. J. (1983). *The discoverers: A history of man's search to know his world and himself*. London: J. M. Dent & Sons.
- Cacioppo, J. T. (1991, May). *Attitudes*. Invited address at the annual meeting of the Midwestern Psychological Association, Chicago.
- Cacioppo, J. T., & Berntson, G. G. (1992). The principles of multiple, nonadditive, and reciprocal determinism: Implications for social psychological research and levels of analysis. In D. Ruble, P. Costanzo, & M. Oliveri (Eds.), *Basic social psychological processes in mental health* (pp. 328-349). New York: Guilford Press.
- Cacioppo, J. T., Petty, R. E., & Berntson, G. G. (1991). Persuasion. In R. Dulbecco (Ed.), *Encyclopedia of human biology* (Vol. 5, pp. 799-810). San Diego, CA: Academic Press.
- Cacioppo, J. T., & Tassinari, L. G. (1990a). Centenary of William James' *Principles of Psychology*: From the chaos of mental life to the science of psychology. *Personality and Social Psychology Bulletin*, 16, 601-611.
- Cacioppo, J. T., & Tassinari, L. G. (1990b). Inferring psychological significance from physiological signals. *American Psychologist*, 45, 16-28.
- Churchland, P. S., & Sejnowski, T. J. (1988). Perspectives on cognitive neuroscience. *Science*, 242, 741-745.
- Clark, G., & Birch, H. G. (1945). Hormonal modifications of social behavior: 1. The effects of sex-hormone administration on the social status of male-castrate chimpanzee. *Psychosomatic Medicine*, 7, 321-329.
- Cooper, J., & Aronson, J. M. (1992). Attitudes and consistency theories: Implications for mental health. In D. Ruble, P. Costanza, & M. Oliveri (Eds.), *Basic social psychological processes in mental health*. New York: Guilford Press.
- Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 11, 671-684.
- Davidson, J. M., Camargo, C. A., & Smith, E. R. (1979). Effects of androgen on sexual behavior in hypogonadal men. *Journal of Clinical Endocrinology and Metabolism*, 48, 955-958.
- Erikson, C., & Lehrman, D. (1964). Effects of castration of male ring doves upon ovarian activity of females. *Journal of Comparative and Physiological Psychology*, 58, 164-166.
- Fodor, J. A. (1968). *Psychological explanation*. New York: Random House.
- Fodor, J. A., & McLaughlin, B. P. (1990). Connectionism and the problem of systematicity: Why Smolensky's solution doesn't work. *Cognition*, 35, 183-204.
- Fodor, J. A., & Pylyshyn, Z. W. (1988). Connectionism and cognitive architecture: A critical analysis. *Cognition*, 28, 3-71.
- Goldstein, F. C., & Oakley, D. A. (1985). Expected and actual behavioral capacity after diffuse reduction in cerebral cortex: A review and suggestions for rehabilitative techniques with the mentally handicapped and head injured. *British Journal of Clinical Psychology*, 24, 13-24.
- Grill, H. J., & Berridge, K. C. (1985). Taste reactivity as a measure of the neural control of palatability. In J. M. Sprague & A. N. Epstein (Eds.), *Progress in psychobiology and physiological psychology* (Vol. 11, pp. 1-61). San Diego, CA: Academic Press.
- Haber, S. N., & Barchas, P. R. (1983). The regulatory effect of social rank on behavior after amphetamine administration. In P. R. Barchas (Ed.), *Social hierarchies: Essays toward a sociopsychological perspective* (pp. 119-132). Westport, CT: Greenwood Press.
- Haracz, J. L. (1982). The dopamine hypothesis: An overview of studies with schizophrenic patients. *Schizophrenia Bulletin*, 8, 438-469.
- Iacono, W. G., & Patrick, C. J. (1988). What psychologists should know about lie detection. In A. K. Hess & I. B. Weiner (Eds.), *Handbook of forensic psychology* (pp. 205-233). New York: Wiley.
- James, W. (1950). *Principles of psychology* (Vol. 1). New York: Dover. (Original work published 1890)
- Jeffcoat, W. J., Lincoln, N. B., Selby, C., & Herbert, M. (1986). Correlation between anxiety and serum prolactin in humans. *Journal of Psychosomatic Research*, 30, 217-222.
- Kennedy, S., Glaser, R., & Kiecolt-Glaser, J. (1990). Psychoneuroimmunology. In J. T. Cacioppo & L. G. Tassinari (Eds.), *Principles of psychophysiology: Physical, social, and inferential elements* (pp. 177-190). New York: Cambridge University Press.
- Keverne, E. B., Meller, R. E., & Eberhart, A. (1982). Dominance and

- subordination: Concepts or physiological states? In A. B. Chiarelli & R. S. Curricini (Eds.), *Advanced views in primate biology*. Berlin, Germany: Springer.
- LeDoux, J. E., Iwata, J., Cicchetti, P., & Reis, D. J. (1988). Different projections of the central amygdaloid nucleus mediate autonomic and behavioral correlates of conditioned fear. *Journal of Neuroscience*, 8, 2517-2529.
- Lehrman, D. (1964). The reproductive behavior of ring doves. *Scientific American*, 211, 48-54.
- Leshner, A. I. (1991). Psychology research and NIMH: Opportunities and challenges. *American Psychologist*, 46, 977-979.
- Losonczy, M. F., Davidson, M., & Davis, K. (1987). The dopamine hypothesis of schizophrenia. In H. Y. Meltzer (Ed.), *Psychopharmacology: A second generation of progress* (pp. 715-726). New York: Raven Press.
- Lysle, D. T., & Fowler, H. (1988). Changes in pain reactivity induced by unconditioned and conditioned excitatory and inhibitory stimuli. *Journal of Experimental Psychology: Animal Behavior Processes*, 14, 376-389.
- Maier, S. F. (1984). Learned helplessness and animal models of depressions. *Progress in Neuro-Psychopharmacology & Biological Psychiatry*, 8, 435-446.
- Maier, S. F. (1986). Stressor controllability and stress-induced analgesia. *Annals of the New York Academy of Sciences*, 467, 55-72.
- Maier, S. F. (1989). Determinants of the nature of environmentally induced hypoalgesia. *Behavioral Neuroscience*, 103, 131-145.
- Maier, S. F., Jackson, R. L., & Tomie, A. (1987). Potentiation, overshadowing, and prior exposure to inescapable shock. *Journal of Experimental Psychology: Animal Behavior Processes*, 13, 260-270.
- Marr, D. (1982). *Vision: A computational investigation into the human representation and processing of visual information*. New York: Freeman.
- Martinez-Vargas, M. C., & Erikson, C. J. (1973). Some social and hormonal determinants of nest-building behaviour in the ring dove (*Streptopelia risoria*). *Behaviour*, 45, 12-37.
- Meltzer, H. Y. (1987). Biological studies in schizophrenia. *Schizophrenia Bulletin*, 13, 77-111.
- Minor, T. R., Dess, N. K., & Overmeir, J. B. (1991). Inverting the traditional view of "learned helplessness": A reinterpretation in terms of anxiety and modulator operations. In M. R. Denny (Ed.), *Aversive events and behavior* (pp. 87-133). Hillsdale, NJ: Erlbaum.
- New frontiers in the behavioral sciences and mental health: An assessment*. (1989). [Working paper.] Rockville, MD: National Institute of Mental Health, Behavioral Sciences Research Branch, Division of Basic Sciences.
- Patterson, T. (1976). Skin conductance responding/nonresponding and pupillometrics in chronic schizophrenia: A confirmation of Gruzelić and Venables. *Journal of Nervous and Mental Disease*, 163, 200-209.
- Peterson, C., & Seligman, M. E. (1984). Causal explanations as a risk factor for depression: Theory and evidence. *Psychological Review*, 91, 347-374.
- Petty, R. E., & Cacioppo, J. T. (1986). *Communication and persuasion: Central and peripheral routes to attitude change*. New York: Springer-Verlag.
- Plomin, R. (1989). Environment and genes: Determinants of behavior. *American Psychologist*, 44, 105-111.
- Roitt, I., Brostoff, J., & Male, D. (1985). *Immunology*. St. Louis, MO: Mosby.
- Rose, R. N., Gordon, T. P., & Bernstein, I. S. (1972). Plasma testosterone levels in the male rhesus: Influences of sexual and social stimuli. *Science*, 178, 643-645.
- Rossi, J. S. (1991). Cancer risk and behavior change. *Science*, 254, 501.
- Scott, T. R. (1991). A personal view of the future of psychology departments. *American Psychologist*, 46, 975-976.
- Seeman, P., Lee, T., Chau-Wong, M., & Wong, K. (1976). Antipsychotic drug doses and neuroleptic/dopamine receptors. *Nature*, 261, 717-719.
- Seligman, M. E. P. (1975). *Helplessness*. San Francisco: Freeman.
- Shaw, R., & Turvey, M. T. (1981). Coalitions as models for ecosystems: A realist perspective on perceptual organization. In M. Kubovy & J. R. Pomerantz (Eds.), *Perceptual organization*. Hillsdale, NJ: Erlbaum.
- Simson, P. G., Weiss, J. M., Hoffman, L. J., & Ambrose, M. J. (1986). Reversal of behavioral depression by infusion of alpha₂-adrenergic agonist into the locus coeruleus. *Neuropharmacology*, 25, 385-389.
- Spohn, H. E., & Patterson, T. (1979). Recent studies of psychophysiology in schizophrenia. *Schizophrenia Bulletin*, 5, 581-611.
- Steiner, J. E. (1979). Human facial expressions in response to taste and smell stimulation. *Advances in Child Development and Behavior*, 13, 237-295.
- Tolman, E. C. (1959). Principles of purposive behavior. In S. Koch (Ed.), *Psychology: A study of a science* (pp. 92-157). New York: McGraw-Hill.
- Turpin, G., Tarrier, N., & Sturgeon, D. (1988). Social psychophysiology and the study of biopsychosocial models of schizophrenia. In H. L. Wagner (Ed.), *Social psychophysiology and emotion: Theory and clinical applications* (pp. 251-272). New York: Wiley.
- Weiss, J. M., Goodman, P. A., Losito, B. G., Corrigan, S., & Bailey, W. H. (1981). Behavioral depression produced by uncontrollable stress: Relationship to norepinephrine, dopamine and serotonin levels in various regions of the rat brain. *Brain Research Reviews*, 3, 167-205.
- Weiss, J. M., Simson, P. G., Hoffman, L. J., Ambrose, M. J., Cooper, S., & Webster, A. (1986). Infusion of adrenergic agonists and antagonists into the locus coeruleus and ventricular systems of the brain. *Neuropharmacology*, 25, 367-384.
- Weiss, P. (1941). Self-differentiation of the basic patterns of coordination. *Comparative Psychology Monographs*, 17(4), 1-96.
- Zahn, T. (1986). Psychophysiological approaches to psychopathology. In M. G. H. Coles, E. Donchin, & S. W. Porges (Eds.), *Psychophysiology: Systems, processes, and applications* (pp. 508-610). New York: Guilford Press.
- Zahn, T., Rapoport, J. L., & Thompson, C. L. (1981). Autonomic effects of dextroamphetamine in normal men: Implications for hyperactivity and schizophrenia. *Psychiatry Research*, 4, 39-47.
- Zillmann, D. (1984). *Connections between sex and aggression*. Hillsdale, NJ: Erlbaum.
- Zillmann, D. (1989). Aggression and sex: Independent and joint operations. In H. Wagner & A. Manstead (Eds.), *Handbook of social psychophysiology* (pp. 229-260). New York: Wiley.