CHAPTER 1

Foundations of Social Psychophysiology

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INTRODUCTION

> It is often said that science progresses as new means are found to observe, measure, and quantify the phenomena of interest. . . . Social psychology, concerned with human behavior in a social context, is one of several disciplines . . . that has been turning to psychophysiology as a way of augmenting its tools of investigation. (Shapiro & Schwartz, 1970, p. 87)

Social psychophysiology can be characterized by the use of noninvasive procedures to study the relationships between actual or perceived physiological events and the verbal or behavioral effects of human association. This emerging field represents the intersection of the disciplines of social psychology and psychophysiology and is surprisingly comprehensive and vigorous given two parental disciplines so disparately focused. Social psychology, the older of the two spawning disciplines, is directed toward understanding the phenomenological and behavioral effects of human association (past, present, and future). Psychophysiology, on the other hand, employs noninvasive procedures to study the interrelationships between physiological events and a person's reportable and/or overt behavior. Social psychology is partitioned into conceptual areas of research (e.g., attitudes and persuasion, interpersonal attraction, aggression, altruism) and is replete with abstract theories (e.g., Deutsch & Krauss, 1965; Shaw & Costanzo, 1970; West & Wicklund, 1980). Psychophysiology, in contrast, is more often partitioned into anatomical areas of research (e.g., cardiovascular system, gastrointestinal system) and is laden with technically sophisticated preparations and instrumentation (e.g., Greenfield & Sternbach, 1972; Hassett, 1978; Stern, Ray, & Davis, 1980).

Recent research has shown that the differences between these disciplines can be complementing rather than defeating. For example, advances have been made by employing social psychophysiological procedures in studies of attitudes (see Cacioppo & Sandman, 1981), aggression (e.g., Zillmann, Johnson, & Day, 1974), sexual arousal (e.g., Cantor, Zillmann, & Bryant, 1975; Geer, 1975), dissonance arousal (e.g., Fazio, Zanna, & Cooper, 1977; see Kiesler & Pallak, 1976), social facilitation (see Geen & Gange, 1977), persuasion (e.g., Cacioppo & Petty, 1979), decision making (e.g., Blascovich, Nash, & Ginsburg, 1978; Gerard, 1967), and other areas. Moreover, these and the advances reported in this book may mark only the beginning, since research in which physiological, verbal, and behavioral assessments are all made within a single experiment is becoming increasingly common (see Cacioppo & Petty, in press-b; Schwartz & Shapiro, 1973).

Social psychophysiological research that has employed electrophysiological procedures has already explored a wide variety of response systems (see Schwartz, 1982). These include electrodermal (EDA) (Cooper, 1959; Mewborn & Rogers, 1979), electromyographic (EMG) (Cacioppo & Petty, 1981a, 1981b), pupillographic (Collins, Ellsworth, & Helmreich, 1967; Hess, 1965), vasomotor (Gerard, 1967), differential electroencephalographic (EEG) (Cacioppo, Petty, & Quintanar, 1982), and cardiac (Buckout, 1966; Cacioppo, Sandman, & Walker, 1978) activity. The physiological measures are generally obtained continuously throughout an experimental session, whereas data relevant to the sequence of reportable and behavioral states, although occasionally monitored continuously, are generally collected at discrete intervals during or following the experimental treatment(s) (see Cacioppo & Petty, 1981a).

Social psychophysiological research has historically been defined by the collection of electrophysiological measures, and it most often has meant recording galvanic skin responses (GSRs) during what in all other respects would be regarded as a traditional social psychological experiment (Schwartz & Shapiro, 1973, review and critique a number of these studies). Social psychophysiological research, however, can no longer be characterized by any single measure or methodology (e.g., electrophysiological recording), as the relationship between social psychological variables and bodily states has now been studied using misattributional procedures (e.g., Zanna & Cooper, 1976; Zillmann, 1978), drugs (e.g., Cooper, Zanna, & Taves, 1978; Schachter & Singer, 1962), hypnosis (Maslach, 1979), cardiac pacemakers (Cacioppo, 1979), exercise (Pennebaker & Lightner, 1980), and operant training procedures for shaping physiological activity (Cacioppo *et al.*, 1978). This broader conception of the field of social psychophysiology is reflected in the succeeding chapters.

The contributions to this book provide evidence for the notion that, although a social psychophysiological perspective harbors no privileged pathway to social psychological or psychophysiological processes, it does offer a host of advantages when used to complement the traditional approaches in the parental disciplines (cf. Cacioppo & Petty, in press-a). What are some of these advantages? First, social psychophysiological research can help to advance our understanding of the determinants of people's physiological responses and the operation of physiological mechanisms by expanding the set of independent and dependent variables in psychophysiology to include powerful social factors. Second, a social psychophysiological viewpoint can lead to the discovery and ultimately the explanation of instances of complex human behavior that are shaped by a combination of social, dispositional, and physiological factors. Third, psychophysiological procedures can provide means for assessing the construct validity of theoretical concepts in social psychology. Fourth, a social psychophysiological orientation can lead to refinements (e.g., greater specification) of existing theories, and to the development of new theories, of social processes when the extant abstract formulations within social psychology are found to be incompatible with the present state of knowledge about the structure and function of physiological systems. Fifth, a social psychophysiological approach can bring about refinements in or extensions of existing theories, and the development of new heuristics and theories, bearing on psychophysiological data. Finally, a general, social psychophysiological perspective can lead to important discoveries in applied areas such as behavioral medicine since the regulation (or deregulation) of the human organism is viewed within a broader social context. You will find these benefits illustrated in many of the chapters comprising this book. Our goal in the remainder of this introductory chapter is to review briefly the historical roots of social psychophysiology (see also Cacioppo & Petty, in press-a; Crider, Chapter 2, this volume), some of the fundamental concepts of psychophysiology that are of particular interest to social psychologists, and outline the general organization and contents of the remainder of the book.

BRIEF HISTORY

Evolution of a Perspective

In an early study, Kaplan, Burch, Bloom, and Edelberg (1963) investigated whether a strong affective relationship between members of a small group was reflected in more correlated social behavior and electrodermal activity (amplitude of EDA and number of spontaneous skin conductance responses). Medical students served as subjects in four-member groups, which were organized to represent affectively positive, affectively negative, and affectively neutral interpersonal relationships among group members. Each group met for five 45-minute discussions, during which time each participant's social behavior and EDA were recorded. Kaplan *et al.* (1963) observed that the social behavior and EDA of persons who initially either liked or disliked each other were more correlated than the behavior and EDA of persons who initially felt neutrally toward one another. Although it is not clear from this study whether the observed differences in overt behavior contributed to or accounted for the patterns of EDA that were obtained (a point to which we will return), the study is notable in its attempt to address the relationship between physiological and social psychological processes (see also Smith, 1936, described in Crider, Chapter 2).

The *earliest* writings reflecting an interest in the relationship between physiological and psychological processes appear to date back to the time of the ancient Greeks (e.g., about 500 B.C. in Plato's *Theatetus*). Plato conceived of the intellectual, emotional, and instinctual aspects of human behavior as being located in the head, heart and spinal marrow, and lower spinal cord and liver, respectively. Galen (a Roman physician of about A.D. 150) and Erastratos (a physician during the reign of Alexander the Great) were apparently among the first to use *psychophysiological* observations (e.g., the initiation of an irregular pulse beat when one's lover's name was mentioned) to isolate the *social* cause of a person's distress (i.e., "lovesickness"—see Mesulam & Perry, 1972).

Empirical research, even in the general area of psychophysiology, is still fairly recent, though, having begun only about 100 years ago (e.g., Angell & Thompson, 1899, provide an interesting review of some of this early research). Stern *et al.* (1980) suggest that the influential Platonic belief that empirical research was misleading because our senses deceived us, deflected scholarly efforts to acquire knowledge about the interrelationships between psychological processes and physiological events from scientific inquiry and into philosophical argument. Following the Renaissance and with the onset of the Age of Reason, this Platonic belief and occult superstitions that had developed began to give way to scientific thought about and studies of psychophysiological relationships. Still, prior to the development of the oscillograph (polygraph), the emergence of this research perspective was mired by technical problems in obtaining measures of gross physiological events that were reasonably free of artifacts and that were amenable to psychological interpretation (see Hoff, 1936). Hence, the coagulation of the scientific study of psychophysiology was closely coupled with the development and refinement of the oscillograph (Sternbach, 1966). In addition, the measures from early instrumentation were insensitive unless the investigator was particularly skillful. Consequently, much of the early research was characterized by the use of powerful experimental treatments that allowed an investigator to observe event-related physiological responses despite his or her somewhat noisy measures. Chester Darrow (1929), for instance, once used an unexpected gunshot to elicit a startle response. This research tactic, of course, seriously limited the utility of psychophysiological methods for studying subtle physiological events and syndromes, which theoretically were imbued

with information regarding specific psychological states and processes (e.g., Darwin, 1872/1904; James, 1884).

In the 1940s, technical advances in electronics set the stage for the emergence of and improvements in the oscillograph, which allowed researchers to measure a variety of subtle electrical and physical forces within a person. In the 1960s, a pair of influential books on techniques in psychophysiology appeared (Brown, 1967; Venables & Martin, 1967), and for the first time the state of the art of sensing, amplifying, recording, and quantifying gross physiological responses in intact humans was widely available to researchers in other disciplines.

It is pertinent to note that almost all of the chapters in these early books centered on discussions of the physiological events being sought and the proper use of polygraphic instrumentation for monitoring these events. This meant that issues dealing with sensing and amplifying bioelectrical events subsumed most of the discussion, and issues surrounding the quantification of the data and the experimental context were paid little heed (cf. Martin & Venables, 1980, p. 2).

However, physiological variables, as Shapiro and Crider (1969) noted, are measures of nothing but themselves and cannot be taken as intrinsically more revealing indicators of psychological constructs than overt behaviors. "A response measure, whether of overt or covert functioning, has meaning only in the context of observation" (Shapiro & Crider, 1969, p. 3). As instrumentation and issues surrounding the proper use of the polygraph were more or less resolved (e.g., Jennings, Berg, Hutcheson, Obrist, Porges, & Turpin, 1981), important and troublesome issues regarding data quantification, analysis, and interpretation came to the forefront. For instance, there is a developing consensus that a physiological response must not only be interpreted within the context of other physiological events (e.g., see Schwartz, 1982), but also within the experimental and subjective (phenomenological) contexts in which it occurs (e.g., Cacioppo & Petty, 1982a; Shapiro & Reeves, 1982). As a consequence, the questions asked in early social psychophysiological research are being reconsidered with increasing sophistication and scientific yields (see Fridlund & Izard, Chapter 9, this volume).

In sum, the standardization and modernization of recording procedures have raised the likelihood that reliable, comparable, and valid measurements of physiological events can be collected by researchers with relatively brief training and access to technical consultants. The sophistication of equipment has increased over the years, but subjects are being made ever less aware of the (potentially) intimidating apparatus involved in much of this research. The experimental treatments to which subjects are now commonly exposed need not be nearly as traumatizing as was the case several decades ago, and the sample and sensitivity of the electrophysiological measures are greatly improved. Finally, the use of an oscillograph is no longer a defining attribute of research in social psychophysiology (or psychophysiology in general—see Martin & Venables, 1980, p. 2), as new instrumentation (e.g., laboratory computers) and innovative methodologies (e.g., rating photographic composites, misattribution procedures) yield important findings bearing on the interdependence of physiological processes and social stimuli.

Research Strategies: Illustration of Correlational and Experimental Approaches

Perhaps the major guiding conception held by psychophysiologists is that physiological and psychological events occur within the same biological system and constitute interdependent aspects of the same process. This does not mean that information from these domains is redundant, or that one field of inquiry can profitably be reduced to the other (cf. Cacioppo, 1982; Furedy, 1981; Lang, 1971; O'Connor, 1981). In the preceding section, we alluded briefly to a number of ways that the relationships between physiological and social psychological processes have been studied. (A more detailed discussion of this issue is provided by Crider, Chapter 2, this volume.) In this section we review the two most common design strategies employed, correlational and experimental studies, as they apply to current research in social psychophysiology.

The oldest and least demanding of the two research strategies is based on the simple view that behavioral and physiological events are strictly covariants (Porges & Coles, 1976). Often the motive for studies employing a correlative approach is that knowledge of a physiological event will serve as an index for an emotional state or behavioral predisposition. Cooper (1959), in an article in *Science* entitled "Emotion and Prejudice," for instance, argued that an individual's prejudice could be gauged by monitoring the size of the momentary change in EDA following his or her exposure to the attitude object or issue (but see Cacioppo & Sandman, 1981; Petty & Cacioppo, Chapter 3, this volume). Although investigators have not always heeded the interpretive limitations of correlational studies, no assertion regarding the influence of one event (e.g., the accessing of a prejudice) on another (e.g., increased EDA) is justified.

One task in social psychophysiology stimulated by this analytic approach is the specification of *which* significant social and physiological events covary. Perfect covariation is theoretically not to be found since covert and overt responses are also thought to contain unique information about the underlying mechanisms of each (see Schwartz, 1982). Hence, a second, complementing task is to specify the psychological significance of *failures* to find covariation between these classes of events. For example, Tursky, Lodge, and Reeder (1979) conducted a cross-modal (psychophysical and psychophysiological) study to determine the race-relatedness of political words and phrases. Psychophysical measures included category and magnitude scaling, whereas the psychophysiological measure was skin conductance responses (SCRs) following the classical conditioning of these responses (i.e., they served previously as conditioned responses) to black-related and white-related words and phrases (e.g., "slavery" and "Caucasian" served as the conditioned stimuli, whereas 1-second white-noise blasts served as the unconditioned stimulus). As expected, the psychophysical and psychophysiological measures both yielded gradients of race-relatedness when test words were presented in the second part of the experiment. However, there were differences in both the order and amplitude of the responses obtained from these psychophysical and psychophysiological measures. Although no definitive evidence was provided, Tursky *et al.* (1979) suggested that "it is possible that the automatic response properties of the autonomic nervous system override the intellectual or social desirability properties which produced the similar judgmental responses (on the psychophysical tasks)" (p. 461; for more details, see Tursky & Jamner, Chapter 4, this volume).

The explanation of associations and dissociations between psychophysiological and social events is best evaluated using the more powerful, experimental research strategy. Often the guiding assumption in studies employing this approach is that if a manipulation of one (e.g., social) event leads to an increase or decrease in the magnitude of another (e.g., psychophysiological) event, then the former is causally related to the latter. One problem with this line of reasoning, however, is in specifying what exactly constitutes a social event. For instance, in the Kaplan *et al.* (1963) study on affective relationships and EDA reviewed above, the manipulation of the intensity of the interpersonal attachments were confounded with the intensity (i.e., amount of physical and cognitive activity) of the social interactions. This made it impossible to determine whether the cognitive, conative, or affective component of the social interactions was responsible for the observed differences in EDA.

A second problem involves specifying exactly what constitutes a "physiological event." For instance, a wetness of the palms may correlate with intense concentration, muscular exertion, or a warm environment. The single physiological response, palmar sweating, does not constitute the most appropriate physiological response to study if one wants to understand these various events. Although the output at the palms may appear the same, the antecedent physiological processes and the output at various other physiological effectors[1] (e.g., the heart) may differ among these conditions (e.g., see Fowles, 1982; Schwartz, 1982). For example, heart rate

1. The term "effector" refers to the smooth muscle cells of the viscera and the blood vessels, striated skeletal-muscular cells, and glandular cells that are innervated by (i.e., receive neural signals from) efferent (outwardly traveling) neurons.

may decrease during intense attention, increase during muscular exertion, and remain fairly constant when the ambient temperature rises slightly—while palmar sweating may increase in each instance (e.g., see B. C. Lacey & Lacey, 1974). For this reason, the *pattern* of physiological responses, rather than the intensity of the output of any single physiological effector, is in many instances regarded as the most informative "physiological response" for study.

The problems regarding the interpretation of experimental studies in social psychophysiology are by no means limited to this field, but are illustrated briefly here because of the relative novelty of their form. More detailed discussion of experimental psychophysiological methods are provided in the chapters by McGuigan (Chapter 22), McHugo and Lanzetta (Chapter 23), and Cacioppo, Marshall-Goodell, and Gormezano (Chapter 24). In the following section, selected concepts, heuristics, and principles from the field of psychophysiology that will be encountered throughout this book are surveyed.

OVERVIEW OF SELECTED CONCEPTS

The human organism possesses two major systems for biological control and communication. The fastest is the nervous system with its nerve cells spanning the distances between the brain and internal or peripheral receptors and effectors. The endocrine system, which operates through the release of chemical hormones from glands into the blood, is slower and generally more diffuse acting (at least when the hormones are released outside the brain) than the nervous system. Although increasing attention is being directed by psychophysiologists toward the endocrine system (e.g., see Christie & Woodman, 1980), by far most work in social psychophysiology concerns physiological events associated directly with the functioning of the human nervous system. For that reason, the contributions comprising this book are slanted toward discussions of the human nervous system rather than the endocrine system. The endocrine system *is* described briefly in this chapter to familiarize the reader with a potentially important domain for future study.

The Nervous System

The human nervous system serves to transmit quickly information concerning the external (i.e., physical) and internal (i.e., biological) environments to reflexive response mechanisms (e.g, the simple reflex arc of the knee) and/or to integrative neural structures in the brain. These neural structures are, in turn, the source of decisions and instructions to the skeletal muscles to act (or inhibit action) on the external environment and to the viscera and glands to act (or inhibit action) on the internal environment. The incoming information travels along *afferent* or sensory neural pathways, whereas the instructions travel along *efferent* or commandatory neural pathways.

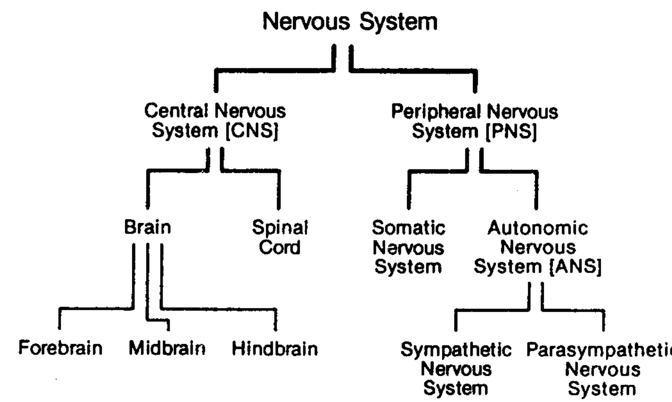

FIGURE 1-1. Classification of the divisions of the human nervous system.

The human nervous system can be divided anatomically into distinct segments (see Figure 1-1). The *central nervous system* (CNS) represents the majority of the neural fibers in the body and is comprised of the brain and spinal cord located within the vertebral column and the cranium. The portion of the nervous system that extends from the CNS to the outlaying areas of the body is termed the *peripheral nervous system* (PNS) and is comprised of the somatic and autonomic nervous systems. Simply speaking, the primary function of the PNS is to detect internal and external environmental changes, transmit this information to the CNS in temporally and spatially summated afferent volleys,[2] and carry the consequent instructions to the appropriate effector organs. The CNS primarily serves to integrate the incoming information, store or alter the storage of the detected events, and initiate preparatory or compensatory actions. Not all of the information that impinges on sensory receptors is transmitted to the CNS (e.g., sensory receptors are not stimulated by X rays), and not all of the information that is received by the CNS is reportable even when this information affects behavior (e.g., we cannot typically report the sensory information used to maintain various postures). (These and other points regarding bodily sensation and perception are discussed below.)

2. Afferent volleys refer to the sensory information traveling to the CNS. These afferent signals consist of the firing of neurons that are oriented in such a manner as to link a receptor to the CNS. Any single neuron either fires (depolarizes) or not, depending on such factors as the intensity of the stimulus and the prestimulus state of the neuron. Unique trains of afferent signals can derive from a single neuron firing at various frequencies (called temporal summation) and/or from multiple neurons spread across an area of the body firing nearly simultaneously (called spatial summation).

The PNS can be further divided into the *somatic nervous system* and the *autonomic nervous system*. The somatic system carries information to and from the external sense receptors (exteroceptors, which includes teleceptors such as the eyes), skeletal muscles (e.g., biceps), and somatic receptors (proprioceptors, providing information about muscle tension) and regulates the bodily processes commonly thought to be controlled voluntarily (e.g., muscle movements). The autonomic nervous system traditionally is considered only an output system. The autonomic nervous system carries information to glands (e.g., thymus) and smooth muscles (e.g., stomach), and regulates the bodily processes over which it is generally more difficult to exert direct, voluntary control (e.g., heart rate). Feedback from these effectors travels along visceral afferents which are distinguished by definition from the autonomic nervous system. Obviously, however, the signals traveling along the visceral afferents are a function of autonomic activity.

The autonomic nervous system functions primarily to maintain equilibrium (i.e., homeostasis) in the internal environment and can be further subdivided into the *sympathetic* and *parasympathetic nervous systems* because of their anatomical, neurochemical, and functional distinctions (Van Toller, 1979). The sympathetic system consists of nerve fibers that originate in the thoracic and lumbar portions of the spinal cord, between the cervical (neck) and sacral (lower spinal) regions (see Figure 1-2). The sympathetic system tends (though not invariantly) to act as a unit and in a manner that excites the organs and glands to which it travels. These effects are depicted graphically in Figure 1-2.

The parasympathetic branch of the autonomic nervous system consists of nerve fibers originating in the areas of the cranium and spinal cord above and below the sympathetic branch (i.e., cranial and sacral regions). Unlike the sympathetic branch, the parasympathetic branch tends to act in a specific fashion, affecting one organ at a time, and usually in a manner that quiets or decreases activity. There are important exceptions to the principle that sympathetic and parasympathetic activity are antagonistic, some of which are evident by an inspection of Figure 1-2. More detailed discussions of this topic can be found in Gardner (1975) and Van Toller (1979).

The brain occupies the crowning and ruling position in the human nervous system. The brain can be broken down into three gross components: hindbrain, midbrain, and forebrain. Although a comprehensive review of brain structures and functions is well beyond the scope of this chapter or book, the rudimentary nature of the brain, the most complex and powerful integration center in the body, can be obtained from this gross categorization.

The brain, now accepted as the nesting place of cognitive processes (see Hassett & Danforth, 1982, and Uttal, 1975, for historical views), emerges from the spinal cord as the *hindbrain* (see Figures 1-3 and 1-4). The

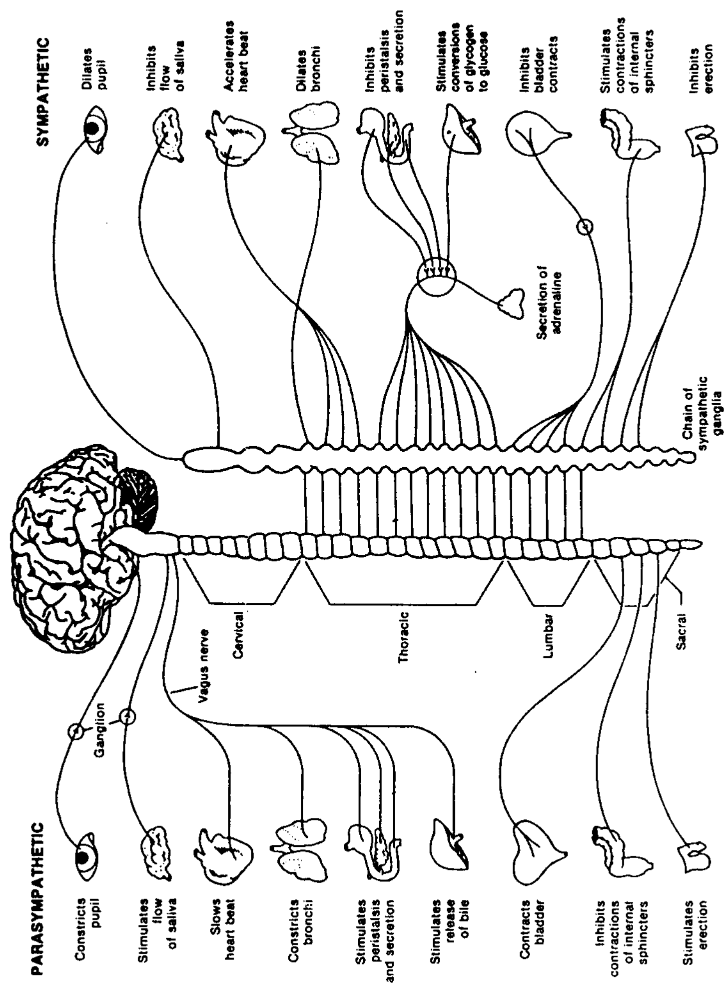

FIGURE 1-2. Divisions of the autonomic nervous system, and the influences of the sympathetic and parasympathetic branches. Adapted from Netter (1974).

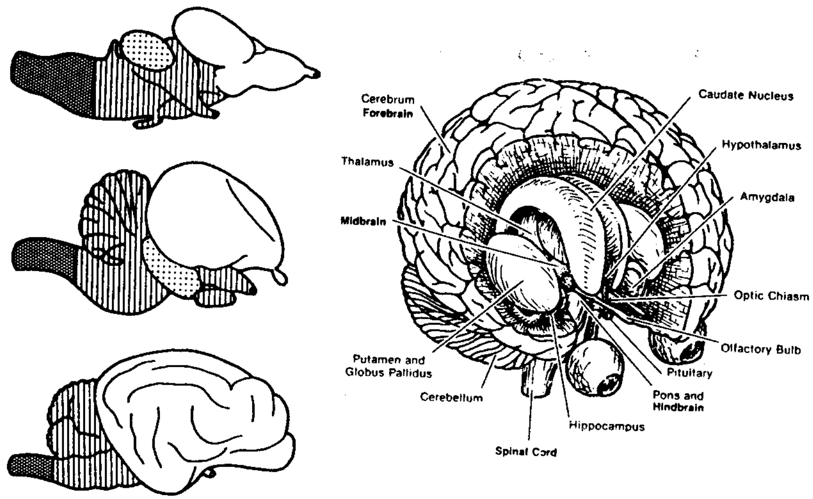

FIGURE 1-3. The central nervous system (CNS) can be subdivided into smaller segments according to gross appearance, embryology, or cellular organization. In the left panel (adapted from Nauta & Karten, 1970) are pictured schematics of the CNS of the frog (top-left panel), pigeon (middle-left panel), and cat (bottom-left panel). The human brain is depicted in the right panel (adapted from Nauta & Feirtag, 1979). Note that the drawings are made on very different scales.

hindbrain is the most primitive component of the human brain and maintains the general tubular structure of the spinal cord. As is apparent in Figures 1-3 and 1-4, the hindbrain includes the subcortical neural structures called the medulla and the pons. The medulla is the port for most (7 of 12) of the cranial nerves and contains specific nuclei (clusters of neural cell bodies) that are associated with the autonomic nervous system, specifically the life-sustaining functions of cardiac, respiratory, and gastrointestinal activity. The pons is located just above the medulla and (the pons proper) bridges between the cerebrum and cerebellum. The pons also serves as a relay for motor fibers connecting the cortex and the spinal cord (e.g., actions in nuclei in the pons can inhibit or facilitate movement and respiratory activity).

The *midbrain*, which appears to have evolved after and above the hindbrain, is located just above the pons and retains the basic tubular form of the spinal cord. The lower portion of the midbrain houses nuclei important in the control of eye movement and neural tracts interconnecting the upper and lower portions of the brain. The upper portion of the midbrain, which is bounded at the top by the thalamus and hypothalamus, houses nuclei that act as important relays for the auditory and visual systems (see Figures 1-3 and 1-4).

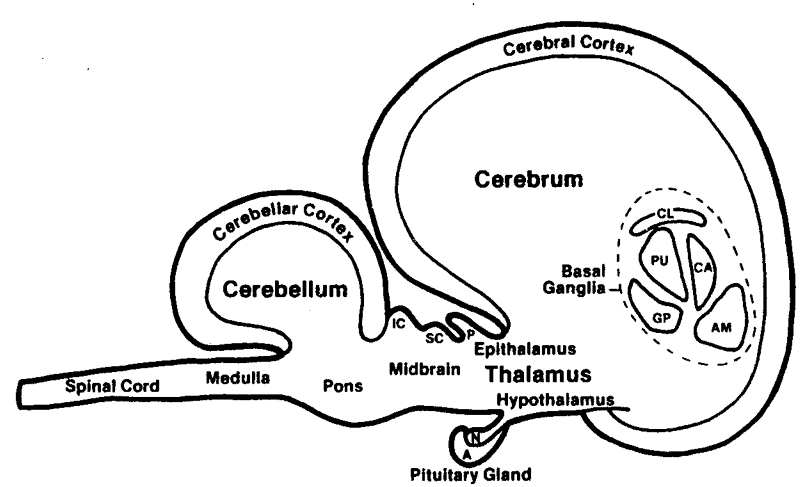

FIGURE 1-4. Highly schematized representation of some major structures of the mammalian central nervous system. The spinal cord, as it enters the cranium, becomes the medulla, pons, midbrain, and thalamus. These are somewhat arbitrary divisions (they have no specific "functions" except as improperly designated in classical texts), and the portion inside the cranium (the medulla, pons, midbrain, and thalamus) is known as the brainstem. Pairs of cranial nerves (to and from the brainstem) and pairs of spinal nerves (to and from the spinal cord) form the segments of the CNS. Usually, the number of cranial nerves is considered to be 12, and the number of spinal nerves depends on the species (humans have 31). Thus, 43 pairs (left and right) of nerves constitute the peripheral nervous system (somatic and autonomic—see Figure 1-1) of humans. Superimposed on the brainstem are the two suprasegmental structures, the cerebellum and the cerebrum. The major link to the cerebrum is the thalamus and the major links to the cerebellum are the pons and medulla. However, all parts are interconnected: There are approximately 10^{11} units (the neurons), and each unit makes about 10^4 connections, yielding 10^{15} interconnections within the brain (DeFeudis & DeFeudis, 1977). The outer layer of the cerebellum and the cerebrum consists of cell bodies of neurons and are called the cerebellar and cerebral cortex, respectively. Another dense collection of cell bodies is found in the cerebrum, the basal ganglia (caudate, putamen, globus pallidus, amygdala, claustrum). There are glandular structures attached to the thalamus called the pineal gland and the pituitary gland. The pineal gland produces melatonin, an antigonadal substance, and the pituitary produces at least 10 substances which control peripheral endocrine glands, reproductive physiology, milk production and milk let-down, and other metablic processes. Abbreviations: P,pineal gland; IC,inferior colliculus, SC,superior colliculus (both forming the roof of the midbrain); N,neurohypophysis, A,adenohypophysis (both forming the pituitary gland); AM,amygdala, CA,caudate, PU,putamen, GP,globus pallidus, CL,claustrum (forming the basal ganglia). Figure and description courtesy Walter L. Randall.

Also pervasive in the hindbrain and midbrain is a network of cell bodies, fibers, and nuclei extending from the spinal cord to the thalamus known as the reticular formation. The reticular formation has been suggested as serving the function of controlling the level of cortical excitation or general physiological arousal (e.g., Lindsley, 1951):

> In terms of evolution it is probable that, at a certain period of time in nervous tissue development, an animal existed having an internal vegetative nervous system and a brain that was little more than a hindbrain with a general activating role. This system would roughly correspond to what we now understand as the reticular activating system. Thus, we might expect to find a special and close relationship between the reticular activating system and the autonomic nervous system arising from an earlier evolutionary stage. (Van Toller, 1979, p. 43)

As Van Toller (1979) notes, however, this statement is speculative. More recently, disputes about the specificity of the actions of the reticular formation have emerged (e.g., see Grossman, 1973). As Van Toller (1979) notes, the reticular activating system is not a simple homogeneous structure, but rather "complex aggregations of nuclei and neuronal pathways that can be shown to have specific effects" (p. 85).

Perhaps the simplest illustration of the orchestrated actions of the hindbrain and midbrain (including the reticular formation) comes from animal (e.g., cat) studies in which all brain tissue above the midbrain is removed. These animals can continue to live for extended periods of time. The vast repertoires of behavior that these animals normally display are lost; nevertheless, these animals are more than simply "aroused or not." They can walk and sleep, eat and vocalize, move about, and in notably simple forms, express emotion and display learning (e.g., Norman, Buchwald, & Villablanca, 1977). It should not be surprising that people are generally unaware of the activities transpiring under the "control" of the hindbrain and midbrain and yet are influenced substantially by bodily processes occurring here that are more complex than subcortical arousal.

The most recent evolutionary development, the *forebrain*, is the focus of most investigations in mental processes such as perception, voluntary movements, thinking, learning, and memory. The forebrain, although anatomically distinct (it no longer is characterized in form by the tubular structure of the spinal cord), operates in conjunction with the hindbrain and midbrain, and ascriptions of "functions" to specific loci in the brain are oversimplifications (adopted here for didactic purposes only). With this cavaet, we proceed to outline briefly the actions in which the following components of the forebrain appear to be influential: thalamus, hypothalamus, limbic system, and cerebral cortex.

The thalamus, which you may recall is located just above the midbrain, serves as a sensory relay station. Nuclei within the thalamus receive neural signals from afferent pathways and channel them to specific regions

in the cerebral cortex (e.g., the somatic sensory, visual, or auditory cortex). The thalamus appears to be among the systems of nuclei that modulate the EEG activity of the cortex.

A cluster of nuclei just above the midbrain and beneath the thalamus (just above the top of the mouth) is called the hypothalamus, which, through its influence on the endocrine system (via the pineal gland), is related to feeding, fighting, fleeing, sexual behavior, sleeping, drinking, and regulating body temperature. The hypothalamus is also part of a wide-ranging set of neural structures called the limbic system. Like the lower portions of the brain, the limbic system appears to be related to the regulation of the autonomic nervous system, although these influences are not necessarily redundant. The limbic system is also interconnected with regions in the cerebral cortex, most notably with regions in the temporal and frontal cortex. The limbic system has been said to suppress the activities of the more primitive hindbrain and midbrain (Isaacson, 1974), interpret the total sensory input as pleasant or unpleasant and thereby contribute to somatovisceral approach–avoidance actions (Watts, 1975), and regulate the expression of emotion and motivation (Thompson, 1967—see Van Toller, 1979).

Finally, the uppermost portion of the human brain is the cerebral cortex. The major divisions of the cortex are the frontal, temporal, parietal, and occipital lobes. Although oversimplified, you might find it useful to think of visual percepts arising from a portion of the occipital cortex, skin, and muscle percepts arising from the forward portion of the parietal lobe, auditory percepts arising from parts of the temporal cortex, and the control of voluntary movements emanating from a strip of cortex separating the frontal and parietal lobes. The remaining portions of the cortex are called association areas since these areas are presumably involved in more complex associative processes. For instance, association areas within the frontal lobe are related to planning and temporal ordering, and association areas within the temporal lobes are involved in language and spatial processes. The specificity in form and function that exists in the human nervous system serves well the vast and flexible behavioral repertoires of humans. It also calls into question the overreliance on or simplistic notions of physiological arousal.

Physiological Arousal

Physiological arousal, which has been an important heuristic in social psychology as well as psychophysiology, refers to the intensity of physiological functioning. Physiological arousal has typically been defined as the degree of general or diffuse physiological responding (e.g., speed of heart rate, amount of EDA), and synonyms have included activation, excitation, and energy mobilization.

Although there are subtle distinctions among some of the early arousal theories (Duffy, 1957; Lindsley, 1951; Malmo, 1959), the major points of these theories can be stated simply (see Shapiro & Crider, 1969): Behavioral processes are viewed as consisting of a directional component, which represents the orientation of the person toward a goal, and an intensive component, which specifies the concomitant degree of energy expenditure. The intensive component is viewed as being synonymous with the level of neural activity in the CNS and as exerting an effect on performance. According to arousal theory, behavioral efficiency increases as arousal increases to some optimal level, after which point behavioral efficiency decreases as arousal continues to increase. Malmo (1959), for instance, monitored the heart rate and bar-pressing activities of rats across 72 hours of food deprivation. He found that the heart rate of the rats increased steadily across the 72-hour period, whereas bar pressing for water increased for the first 36 hours and then decreased in frequency. Hebb (1955) proposed that the brain arousal system is the neural basis of generalized motivational states, or drive; Hebb's notion of the brain arousal system was based on Lindsley's (1951) suggestion that the EEG reflected the neural substrates of behavioral arousal.

As theoretically appealing as the concept of arousal has been for social psychologists and psychophysiologists, matters regarding this concept are more complicated than are typically acknowledged. The finding and mapping of the reticular formation (Moruzzi & Magoun, 1949), which initially appeared to serve as a general arousal mechanism for the brain, for a time provided a physiological locus for the construct of arousal. But as noted above, the reticular formation is not as homogeneous as was first believed. Apparently, it is a collection of nuclei that can have specific effects depending on the site of stimulation as well as divergent effects depending on the intensity of stimulation (see Grossman, 1973; Van Toller, 1979). This suggests that even if a noninvasive measure of reticular activation was feasible, it might be an insufficient index of a general and diffuse state of physiological, reportable, and behavioral arousal.

In addition, in the last several decades of research, specific conceptual problems have been raised regarding arousal notions. The basic assumption regarding the measurement of physiological arousal has been that, although some general measure of the level of excitation characterizing the CNS would be best, *any* measure of the extent that the sympathetic dominated the parasympathetic nervous system would serve as a valid and sensitive measure. For instance, the degree of activation of an autonomic (e.g., heart rate) *or* somatic (e.g., general muscle tonus) measure could serve as a convenient indirect measure of arousal within the CNS (Duffy, 1957). Still other researchers suggested that the EEG be used to index physiological arousal more directly (e.g., Lindsley, 1957). They point out that during sleep, EEG activity is typically slow. During waking, thinking

states, EEG activity is much faster and asynchronous. Finally, since these various physiological processes were presumed to covary (Cannon, 1939), it was not considered crucial which peripheral measure of physiological arousal was used; all were believed to yield approximately the same information regarding the excitation of the CNS. It was, therefore, an influential criticism of the conceptualization of physiological arousal when J.I. Lacey (1967) indicated that this basic assumption was incorrect; that electrocortical, autonomic, somatic, and behavioral measures do not tend to covary. Indeed, Lacey has argued that even the physiological responses obtained from effectors within a single system (e.g., the autonomic nervous system) are not highly correlated. J. I. Lacey, Kagan, Lacey, and Moss (1963), for example, found that when subjects performed a task that required them to monitor flashing lights, the subjects' heart rate decreased while electrodermal activity increased. This *directional fractionation* of physiological responding across and within physiological systems constitutes an important problem for arousal theory: Are the subjects more aroused (as, e.g., their electrodermal activity might indicate) or less aroused (as their heart rate might suggest) during than before the task?

A second issue that has emerged concerns the relationship between physiological arousal and reportable arousal. Mackay (1980) has suggested that a person's self-report of arousal may be a good or better measure of actual physiological arousal than any one physiological measure. This suggestion, however, ignores the empirical independence that has been found to exist among physiological, reportable, and behavioral states (e.g., Lang, 1971; Lazarus, Averill, & Opton, 1970) and the work indicating that felt (reportable) arousal subsides more quickly than do the increases in heart rate and blood pressure that follow exercise (Zillmann, 1978; see Zillmann, Chapter 8, this volume). It would seem to be more useful *at this stage* not to assume that general physiological arousal, reportable levels of felt physiological arousal, and overt behavioral arousal necessarily covary (see Cacioppo & Petty, 1982a). Treatment of these constructs as being independent may allow a speedier identification of suitable operationalizations of each, what factors lead to their convergence (e.g., following dramatic events such as a near accident—see Lang, 1971; Mewborn & Rogers, 1979), and the relationship between each and social behavior (e.g., see Kelley & Byrne, Chapter 16, this volume).

In sum, although the concept of arousal has been important in psychophysiology and social psychology, the existing data still support Shapiro and Crider's (1969) conclusion that "the major contribution of arousal theory has been to provide a unifying hypothesis for encouraging . . . research rather than its ability to organize the data so obtained" (p. 25). The evidence that a single physiological measure cannot be used to gauge the state of general physiological arousal suggests that aggregates of physiological measures of CNS excitation (see McHugo & Lanzetta, Chapter 23, this volume) or changes in hormonal levels (see Mason, 1972) may serve as the best index, while analyses of the profiles of multiple physiological responses may harbor yet additional information about social psychological processes (e.g., see Fridlund & Izard, Chapter 9). It is to the issue of physiological response patterning that we turn next.

Response Patterns

It is useful to think of any single physiological response as the result of multiple influences operating on a physiological mechanism at any one moment in time. Physiological arousal may be one of these influences, but certainly it is not the only or most influential one. Five other influences that are described in this section are individual response stereotypy, stimulus response stereotypy, cognitive sets, the orienting response, and the defense response.

Individual Response Stereotypy (IRS)

IRS represents the tendency for the same person to display the same profile of physiological response to a wide variety of eliciting situations and stimuli. This characteristic manifests as a *response hierarchy*. This means that, for any one individual, stimuli consistently elicit the greatest change in responding from one effector (e.g., a change in heart rate), the second greatest change in responding from some other effector (e.g., electrodermal changes), and so on. Thus, which effector responds most, second most, and so forth, to stimuli varies across individuals. The ordering of which effector responds most, second most, and so on, constitutes the individual's response hierarchy. Differences among people in their response hierarchies constitute the notion of IRS (J. I. Lacey, 1959; J. I. Lacey & Lacey, 1958).

Stimulus Response Stereotypy (SRS)

SRS represents the tendency for a situation or stimulus to elicit a common pattern or profile of responses from various people. A horrific picture (e.g., a photograph of an autopsy), for instance, tends to elicit a slowing of heart rate and an increase in electrodermal activity in almost everyone (e.g., Cacioppo & Sandman, 1978; Hare, Wood, Britain, & Shadman, 1971). In other words, SRS refers to the inclination for the same physiological pattern to be evinced by most individuals when confronted by a particular situation or stimulus (J. I. Lacey, 1959; J. I. Lacey *et al.*, 1963). These response profiles may serve as useful indices of social psychological constructs within particular contexts (e.g., see Chapter 3); in addition, the Laceys (1974) have suggested that they reflect different reciprocal transactions between the person and the environment.

Cognitive Sets

Another influence on physiological responding is termed cognitive set (Sternbach, 1966). This refers to the effect on physiology of a person's expectations or interpretations of a stimulus. It is this influence that has been the focus of much of the research on psychosomatic disorders. This concept is illustrated in psychophysiology by the finding that people who believe they are being touched by the leaves of a tree to which they are allergic display an allergic reaction even when they are, in fact, being touched by harmless leaves (Ikemi & Nakagawa, 1962). That is, their physiological responses are influenced as much by their subjective interpretation of the stimulation as by the objective attributes of the stimulus (see also O'Connor, 1981).

Orienting Response (OR)

The notion of an orienting or "what-is-it" response emerged from Pavlov's (1927) studies of classical conditioning in dogs. Pavlov observed that a dog's conditioned response to a stimulus would fail to appear if some unexpected event occurred:

> It is this reflex [the OR] which brings about the immediate response in men and animals to the slightest changes in the world around them, so that they immediately orientate their appropriate receptor organ in accordance with the perceptible quality in the agent bringing about the change, making a full investigation of it. The biological significance of this reflex is obvious. (Pavlov, 1927, p. 12)

An OR occurs in response to a novel stimulus to facilitate a possible adaptive behavioral response to the stimulus (Sokolov, 1963). Lynn (1966) has summarized the physiological profile of an OR as: decreased heart rate, increased sensitivity of the sense organs, increased skin conductance and general muscle tonus (but a decrease in irrelevant muscle activity), pupil dilation, vasoconstriction in the limbs and vasodilation in the head, and more asynchronous, low-voltage EEG activity.

Defense Response (DR)

Stimuli that would normally elicit an OR, if extremely intense, would elicit a DR instead. Thus, the DR appears to be the complement of the OR and functions to protect an organism from intense stimulation. For instance, there is a decrease rather than an increase in the sensitivity of sense organs, vasoconstriction occurs in both the limbs and head, heart rate increases, and postural shifts are away from rather than toward the stimulus (see Lynn, 1966).

Interestingly, whether a stimulus elicits a DR or OR can be affected by an individual's cognitive set. An interesting study illustrating this point is reported by Hare (1973). Subjects were shown slides of spiders and of more neutral content (e.g., landscapes). Hare (1973) found that subjects who were very afraid of spiders evinced the physiological pattern of a DR to the slides of spiders, whereas subjects who were not afraid of spiders exhibited the physiological pattern of an OR to these slides.

In sum, there are subtle distinctions among the concepts of physiological arousal, stimulus and individual response stereotypies, cognitive sets, and orienting and defense responses that are important to consider when interpreting psychophysiological data. Each concept refers to a different form of influence on psychophysiological relationships, and several of these influences can coexist within the organism at any one moment in time.

Law of Initial Values

Thus far we have discussed topics including the intensity (arousal) and direction of physiological responses as they are affected by the stimulus (stimulus response stereotypy), the individual's physiological response hierarchy (individual response stereotypy), the individual's interpretation of or subjective response to the stimulus (cognitive set) and the individual's orienting or defensive responses to stimuli. It should be obvious now why observing one or two physiological responses provides equivocal information regarding the "arousal" of the organism. Another factor influencing the direction and intensity of physiological responses (and thus the pattern of activity and the meaning of any single response) is the degree to which the output at the effector is elevated (or reduced) from the homeostatic level *prior* to the presentation of a stimulus. Consider two people standing quietly when a passing car backfires unexpectedly. These people are likely to display quite a change in their level of activity. Their facial expressions might change quite drastically, and they might jump away from the source of the noise. But now consider these same two people jogging instead of standing in this area. Their muscles are already tense and active. When the car backfires, the intensity and perhaps even the direction of the *change* in muscle activity (i.e., the "event-related responses") may be different in the persons when jogging than when simply standing calmly.

Any evoked, short-term physiological response may be determined in part by the prestimulus level of activity. This possible relationship has been described as the "law of initial values" (Benjamin, 1963; Wilder, 1931/1976). According to this "law," the response to a stimulus is smaller (and eventually, inverted) the higher the prestimulus level of activity in the effector (e.g., cardiovascular) system. The implication of this principle is that the relationship between covert and overt responses may appear in one of a variety of forms, depending on the initial level of physiological

activity.[3] Thus, the pattern of physiological responses may vary slightly if a person is calm or anxious when the experimental stimuli are introduced.

To circumvent this problem, most psychophysiological investigations involve persons who display a fairly calm and quiet physiological state prior to the introduction of any experimental manipulation. This feat is accomplished most often by having subjects sit quietly in (i.e., "adapt to") the laboratory for several minutes prior to the introduction of any experimental stimuli. Sometimes, subjects are also given a tour of the laboratory and explanation of the experimental procedure a week or so before they participate in the study (see Cacioppo *et al.*, Chapter 24, this volume). The generalizability of the associations that are found using these procedures to more active environments is, of course, uncertain at present. The development of telemetric measures (compact electrophysiological recording devices that allow a person to move freely) and alternative procedures to electrophysiological measures should be especially informative in this regard.

Habituation

Thus far we have described various contributors to bodily events evoked by a stimulus. The next concept that is discussed is *habituation*, which is a process that complements the process of evoked physiological responding. When the same stimulus is presented repeatedly, there is a diminution of physiological responding (e.g., ORs) to it. This decrement in evoked physiological responsivity is called habituation. Habituation occurs more slowly when, for some reason, the stimulus is attention getting or meaningful. If the stimulus is novel, unique, or complex, physiological responses to it will habituate more slowly than if it is boring or indistinctive. Intense, infrequent, and irregular presentations of a stimulus also slow habituation. Unless the stimulus is extremely intense, however, repeated presentation of the stimulus will eventually cease to be accompanied by (i.e., will fail to evoke) these physiological responses (see also Geen, Chapter 13, this volume).

Depending on the focus of one's study, habituation can be an aid or a hinderance. Researchers typically are not interested in subjects' physiological responses to the laboratory setting per se. Hence, experiments are generally preceded by an "adaptation" period, which is included to allow the subject's physiological responses evoked by the laboratory setting per se to subside. To facilitate this adaptation, the subjects' chambers are

3. This "problem" is not as pervasive as it once seemed. For instance, the law of initial values appears to apply to changes in skin resistance but not substantially to heart rate (see Martin & Venables, 1980; Tursky & Jamner, 1982).

usually characterized by familiar, soothing colors, sound-attenuating walls, ambient temperatures, and a minimum of novel or intimidating-looking furniture and equipment. In other words, precautions are taken to reduce the likelihood that ORs or DRs are elicited by the laboratory (see Chapters 23 and 24). On the other hand, when the independent variable is presented repeatedly, the person *may* habituate to it, too, which can make obtaining a stable-appearing measure of event-related bodily events more difficult. Procedures for securing valid, reliable, and sensitive measures of evoked physiological responses or profiles of responses are discussed in detail in Section III.

Interactive Effects

One characteristic of social psychophysiology is that the object of study is the natural functioning human system in a social context rather than a dissected component or animal model of that system. Interactive effects refer to the characteristics or output of an operating system that could not be predicted additively from knowledge about the characteristics of the components or parts of the system (e.g., see Schwartz, 1982).

A psychophysiological study illustrating this point was reported by Schwartz, Davidson, and Pugash (1976). They taught individuals how to control the EEG activity of the right and left hemispheres of the brain. When the subjects quickened the activity of the right hemisphere of their brain, they reported experiencing an increase in spatial types of thoughts and images. When the subjects activated the left hemisphere, they reported an increase in the frequency of verbal or numerical thoughts. But when both sides of the brain were activated, subjects reported feeling a state of concentration, an effect not predictable by applying an additive model to the previous results. Several chapters in this book contain reports of other instances in which interactive effects have revealed surprising findings with implications for social psychologists and psychophysiologists.

Bodily Sensation and Perception

Although the study of actual physiological responses is unquestionably interesting in its own right and empirically fruitful for advances in social psychology, focus on this information alone yields an incomplete picture of social psychophysiological processes. The physiological responses may be detected by the person, or they may not. If they *are* detected, the physiological reactions may be detected internally as symptoms (i.e., felt bodily sensations) or they may be detected externally as signs (e.g., discoloration of the skin). We suggested this tripartite of bodily responses as a heuristic for interpreting psychophysiological effects in a recent review of attitude

change (Cacioppo & Petty, 1982a). For instance, the role of bodily responses in social psychological processes could be considered after classifying the bodily response as a "symptom" (i.e., detected proprioceptively or interoceptively), "sign" (i.e., detected exteroceptively), or undetected. This tripartite yields categories of bodily response that are surprisingly similar to the distinctions drawn in the field of applied pathologic physiology. For instance, MacBryde and Blacklow (1970), in their opening comments in *Signs and Symptoms*, explained:

> As broadly and generally employed, the word *symptom* is used to name any manifestation of disease. Strictly speaking, symptoms are subjective, apparent only to the affected person. *Signs* are detectable by another person and sometimes by the patient himself. Pain and itching are symptoms; jaundice, swollen joints, cardiac murmurs, etc., are physical signs. Some phenomena, like fever, are both signs and symptoms. (p. 1)

In the tripartite applicable to social psychophysiological studies, signs and symptoms are partially overlapping categories of physiological responding, whereas these categories do not overlap with undetected physiological responses. Symptoms refer to the subjective component of a physiological reaction (whether that reaction is constituted by changes in a single effector system or several such systems and whether or not there are identifiable physiological concomitants of the perception), but the physiological reaction need not refer to manifestation of disease. Hence, our use of the term "symptom" is compatible with, but more general than, that characterizing the field of applied pathologic physiology. Signs in the present tripartite refer to the objective component of a physiological reaction that the affected person detects himself or herself. Thus, signs are physiological reactions that are verifiable by others and about which the person learns through an objective procedure, perhaps with the aid of sophisticated instrumentation. As with symptoms, it is not necessary that the "objective" signs have actual physiological manifestations. Thus, bogus feedback (e.g., a faulty thermometer) would be considered a sign. Signs differ from symptoms in that the former is open to public verification or disconfirmation, whereas the latter is not. Signs differ from *undetected* physiological responses *not* in each's potential for being quantified, but rather in the person's awareness that a change in physiological functioning has occurred. For instance, a slight speeding of the heartbeat might be detected by an investigator using an electrocardiogram but go undetected by the individual whose heart rate is being monitored. This response would be termed an undetected response. If the investigator provided feedback to the individual about his or her heart rate, however, the physiological response would act as a sign to the individual even if the feedback is unveridical. Finally, if the individual felt a "speeding" of his or her heart beat, possible because of its association with a concomitant increase in stroke volume, the feeling of a speeding heart beat would serve as a symptom even if this perception were inaccurate.

Given that these distinctions among bodily responses may be important, it is necessary to address the basis of people's sensations and perceptions of bodily events. Traditionally, investigators in sensation and perception have focused on "long-range" senses such as vision and hearing. Fortunately, the search for lawful relationships between physiological events acting as stimuli on humans and the reportable states and overt behaviors they evoke is now being assumed by psychophysiologists (e.g., see Brener, 1977) and social psychologists (see Pennebaker, Chapter 19; Blascovich & Katkin, Chapter 17). In this section, issues and terminology from the area of sensation and perception are surveyed.

Sensation and perception occur only when a stimulus is appropriate and intense enough to activate a particular sense receptor. A physical stimulus can have a substantial influence on an organism without being sensed (e.g., we can be burned by ultraviolet light), but a physical stimulus that *does* lead to a sensation can then be characterized along four dimensions: (1) the *quality* or kind of physical energy that evoked the sensation (e.g., eyes respond to electromagnetic light); (2) the *intensity* of the physical stimulation, which is nonlinearly related to the sensation; (3) the *duration* of the sensation; and (4) the *extent* or area of the stimulation (e.g., localized versus diffuse tactile stimulation).

No one of these dimensions is preeminent. For instance, the electromagnetic waves to which people's eyes respond can vary in length from 380 to 780 nm (a nanometer is one-billionth of a meter). People are exposed, however, to electromagnetic waves that vary from about 10-trillionths of an inch in the case of cosmic rays to several miles in the case of radio waves. This illustrates that people can perceive only a very small segment of the spectrum of physical stimulation even when the quality of the stimulation is appropriate for the receptor mechanism. Similarly, a burst of electromagnetic energy within the range 380 to 780 nm that lasts for a fraction of a millisecond does not lead to the perception of light, even though other necessary characteristics of the stimulus are present (e.g., quality, intensity). In other words, there are *segments* of each of the four dimensions of physical stimulation described above that are necessary preconditions for a percept to be evoked. As is illustrated in Figure 1-5 and in chapters by Scheier, Carver, and Matthews (Chapter 18), Zillmann (Chapter 8), Blascovich and Katkin (Chapter 17), and Pennebaker (Chapter 19), even these factors are necessary but not sufficient for the recognition of a bodily response.

There are three functional classifications for receptors (Schmidt, 1978). *Exteroceptors* transmit information on the immediate environment and include the skin receptors associated with tactile events and the long-

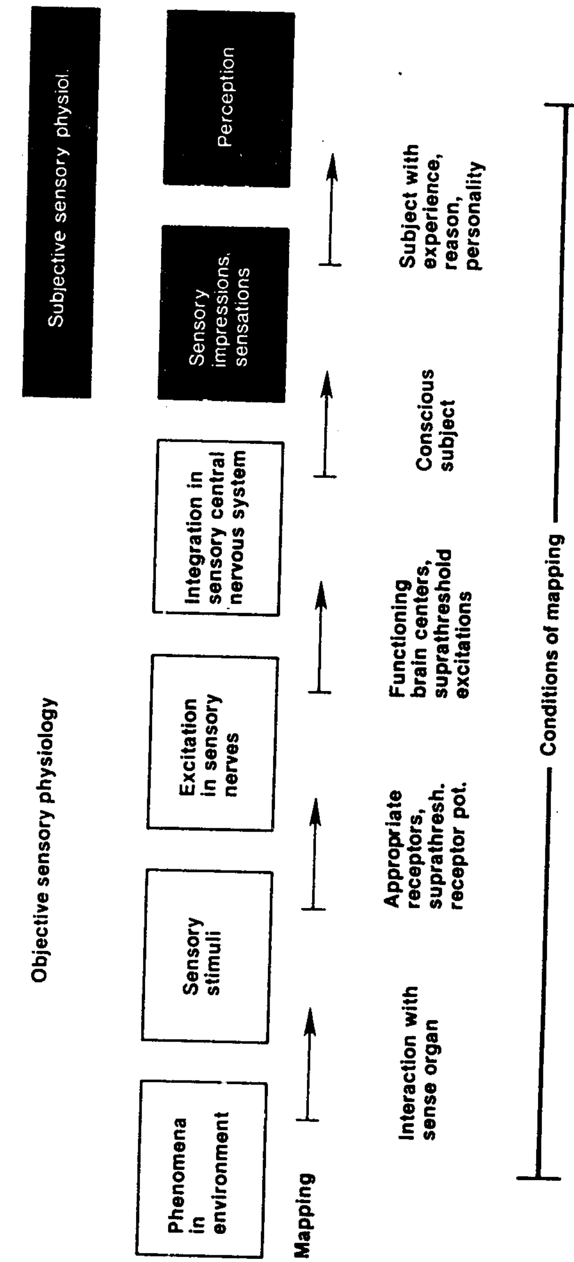

FIGURE 1-5. The words in the boxes denote basic phenomena of sensory physiology, and the arrows between them indicate the "mapping" of sensory physiology. Below the basic phenomena, the conditions for mapping are shown. From **Fundamentals of sensory physiology** by R. F. Schmidt, New York: Springer-Verlag, 1978, p. 6. Copyright 1978 by Springer-Verlag, Inc. Reprinted by permission.

distance receptors ("teleceptors" such as ears) that transmit information about the distant environment. *Proprioceptors* furnish information about the orientation and position of the body in space and include receptors in the muscles, tendons, and joints. Proprioception, the sensory information traveling to the CNS from proprioceptors, enables people to know when they are smiling, distending their stomach, or pointing their finger. Proprioception also facilitates fine motor movements (e.g., balancing a pencil on a finger) and overlearned movements and motor adjustments (e.g., riding a bicycle). Finally, *interoceptors* provide information about the events that occur in the viscera (internal organs). Interoception, the sensory information traveling to the CNS from interoceptors, enables a person to feel hunger and thus know to eat; and bladder pressure and thus know to excrete. Interoceptors are less localized than other sensory receptors and hence lead to more diffuse or inaccurately localized sensations. For example, the sensation of pain in the abdomen and back may indicate an inflammation of the pancreas (i.e., pancreatitis) or an erosion of an area on the stomach (i.e., a peptic ulcer—see Wasson, Walsh, Sox, & Tomkins, 1975). For the most part, various contributors to this book focus on interoceptive and/or proprioceptive processes and influences.

The Endocrine System

Physiological reactions, and the perceptions of physiological reactions, are influenced by hormonal as well as direct CNS instructions. Since the study of social psychophysiological events is destined to be incomplete until consideration is given to the integrated actions of the nervous and endocrine systems, some highlights in this area are reviewed in this section (see Spitzer & Rodin, Chapter 20, this volume, for one instance). For more detail, the interested reader may wish to consult Mason (1972), Van Toller (1979), or Christie and Woodman (1980).

There are two types of glands in the human body: the *exocrine glands*, which secrete either onto the surface of the body (e.g., sweat or tear glands) or into a cavity within the body (e.g., digestive or salivary glands), and the *endocrine glands*, which secrete their chemical products directly into the bloodstream. Figure 1-6 displays the location of endocrine glands in the human body. Two endocrine mechanisms are described in this section to illustrate their potential interest to social psychologists. These are the sympathetic–adrenomedullary and pituitary–adrenocortical complexes (see Figure 1-6).

The integrated actions of the nervous and endocrine systems are suggested immediately in a survey of the sympathetic–adrenomedullary system. The sympathetic nervous system (via the splanchnics) directly stimulates the medullary cells of the adrenal gland, causing the release of

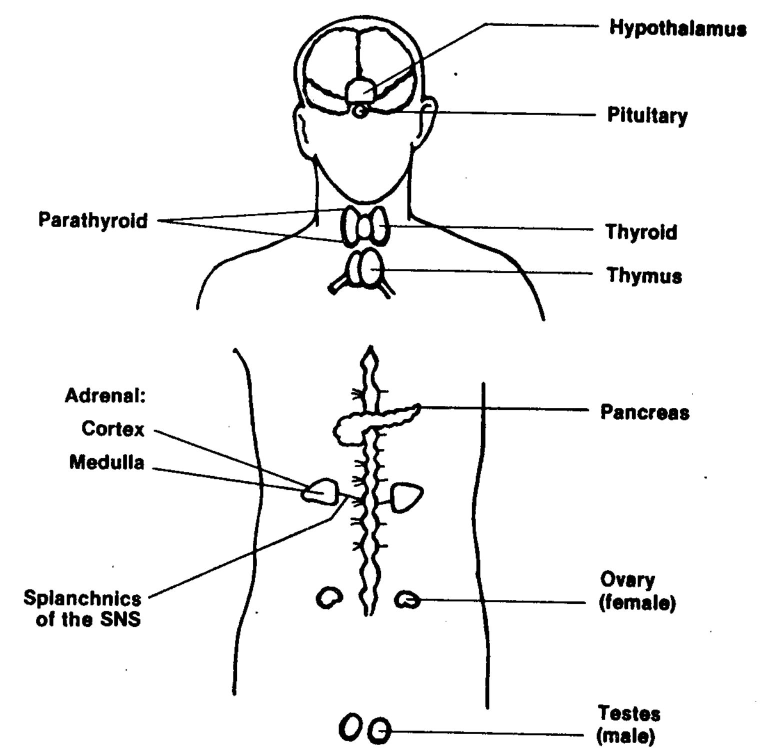

FIGURE 1-6. The endocrine glands are located throughout the central portion of the body and secrete their chemical messengers directly into the bloodstream. The hypothalamus exerts an influence over the pituitary gland, which in turn affects the other endocrine glands.

the catecholamine hormones, epinephrine and norepinephrine. Cannon (1929) believed that the sympathetic-adrenomedullary system was activated primarily during emergency (fight-or-flight) responses and played a role in maintaining homeostasis within the body and adapting to environmental and psychological stressors (see Mason, 1972; Van Toller, 1979).

The actions of the sympathetic-adrenomedullary mechanisms are attributable primarily to epinephrine. These physiological actions include an increase in muscular efficiency (accomplished by reducing muscular tonicity *and* the threshold for firing), increased arterial blood pressure in the muscles and cardiovascular system, and release of glycogen reserves ("animal starch" that the body breaks down to a simple sugar for energy).

Because of differences in the receptors in the arterial walls, catecholamines cause vasodilation within the internal organs (e.g., the brain, heart) and vasoconstriction in the periphery (e.g., at the surface of the skin, in the fingers and hands). This pattern of perfusion has adaptive utility: In emergencies, the CNS and muscles need more blood to mobilize and cope with the situation; the constriction of peripheral areas not only facilitates the rapid redistribution of blood within the body, but also minimizes the loss of blood should an injury be incurred. The physiological effects of norepinephrine (the neurotransmitter of the sympathetic nervous system), although not as general or as powerful as those of epinephrine, are important in regulating cardiovascular and sympathetic tone, thereby allowing blood to be channeled to needed organs and areas. Finally, with the presence of pressure-sensitive receptors in the arterial walls (e.g., Bonvallet & Allen, 1963), circulatory changes initiated by the release of epinephrine and norepinephrine can feed back and alter the activity of the human nervous system.

Since the sympathetic-adrenomedullary system is directly innervated by the sympathetic nervous system, it may respond more quickly than the pituitary-adrenocortical system to stressors. The latter, however, has more general effects, since the pituitary gland serves as a kind of "master gland" in the endocrine system. Briefly, a release of a hormone (adrenocorticotrophic hormone, or ACTH) from the pituitary can be initiated from the hypothalamus and causes the adrenal gland to secrete carbohydrate-active steroids that have wide-ranging effects on the body's metabolism (see Figure 1-6). Selye (1936, 1956) demonstrated that physical stressors resulted in morphological changes in the adrenal cortex, and Mason (1972) indicated that psychological stressors could also elevate the actions of the pituitary-adrenal cortex system. The pituitary-adrenal cortex system now seems to be one of the important physiological mechanisms underlying what Selye termed the "general adaptation syndrome" (GAS) to stress. The initial physiological reaction in the GAS is an emergency fight-or-flight response believed to be, in most instances, adaptive. If ineffective behavioral coping results, additional compensatory actions occur, such as increased and sustained secretions of steroids and decreased secretions of catecholamines (epinephrine and norepinephrine), which result in altered homeostatic levels for a number of physiological systems (e.g., water retention, circulatory pressure). If the stress continues for a protracted period without relief, the physiological coping mechanisms may not be able to prevent permanent physiological damage to organs or the demise of the organism. Although social psychologists have generally not examined the endocrinological effects of social factors, a recent review of stress and cancer suggests that social factors, such as housing conditions, can have profound hormonal, neural, and immunological effects (Sklar & Anisman, 1981).

ADUMBRATION

Social psychophysiology is a young field, diverse in both its theoretical focus and methodologies. You can anticipate open disagreements among contributors regarding the proper methodological approach to a question and the interpretation of empirical data. Where appropriate, we have asked these contributors to consider explicitly what appears in related chapters. Our aim was to make the exchanges more meaningful to readers rather than to promote one point of view over another.

You can also expect to be informed about a wide variety of issues emerging from the field. To facilitate this, we have partitioned the book into four major sections: Overview of Social Psychophysiology, Basic Social Psychophysiological Research, Methods of Social Psychophysiology, and Epilogue. In addition, the section on Basic Social Psychophysiological Research, which is the most wide-ranging component of the book, has been partitioned into the areas of Attitudes and Social Cognition, Affect and Emotions, Interpersonal Processes, and Contributions to Health.

The overview consists of two chapters designed to provide a brief history of the field and a discussion of the perspectives that now characterize the field. Together, these chapters should provide a broad survey of research and orientations in social psychophysiology.

The second section deals with a number of basic theoretical issues in social psychology. The many successful applications that are illustrated in this portion of the book underscore the value of the study of bodily processes, both as independent and dependent variables, and both through electrophysiological and nonelectrophysiological methods. In the first set of chapters, authors consider various aspects of attitudes and social cognition. Following these chapters is a subsection containing descriptions of research on the determinants and communication of affect and emotion. Several of the chapters detail research programs that are enjoying currency in other areas of psychology, but for one or another reason have escaped the perusings of many social psychologists. A third clustering of chapters deals with a number of classic issues pertaining to individual differences and group processes. The final subsection of chapters deals with applications of social psychophysiological research to the field of health. Social psychophysiology itself is rather new as a distinct and recognized approach, but its applications to real-world issues, particularly to health-related concerns, is straighforward and fruitful. The chapters in this section alert the reader to new directions that are emerging.

The third section on the methods of social psychophysiology is designed to make it possible for interested readers to adopt a psychophysiological perspective in their own studies of social psychological phenomena. An effort has been made to caution readers about common types of methodological pitfalls and misinterpretations. Laboratory issues are discussed, and inexpensive microcomputer-based data acquisition systems are described. The discussion of methods is not confined to psychophysiological recording techniques, however, as a number of important advancements in the field have grown out of alternative procedures, such as misattribution and drug ingestion.

The final section consists of an epilogue chapter designed to provide a retrospective on the various contributions of this book. A brief and selective review of Soviet psychophysiological research is used to highlight the unique perspective adopted by the contributors to this volume.

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