Chapter 6

Social Psychophysiology and Embodiment

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In 1969, in the second edition of *Handbook of Social Psychology,* David Shapiro and Andrew Crider authored a chapter titled "Psychophysiological Approaches to Social Psychology," describing theory and research relating biological and social psychological processes; this is the first and only such chapter in this series. Reflecting growing interest and research in neurophysiological approaches to social psychology, the editors of this fifth edition recognized a need for not one but two chapters relating biology and social psychology: one focuses on intracranial processes (see Lieberman, this volume) embodied via the brain, and one (this chapter) focuses on peripheral neurophysiological processes embodied via the visceral, somatic, and endocrine systems. The function of the separation of these chapters is primarily organizational as both levels of processing are inexorably intertwined (cf. Niedenthal, 2007; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005).

Although the goals for social psychologists exploring relevant central and peripheral neurophysiological processes are not mutually exclusive, they differ in emphasis. A current important goal for social psychologists exploring the brain itself is to understand how online and offline neural substrates of conscious and unconscious affective, cognitive, motivational, and motor processes comport with social psychological theories, and to use such knowledge to bolster, bound, or expand them. An important goal of those exploring visceral, somatic, and peripheral endocrine systems is to understand how such bodily expressions relate to centrally controlled affective, cognitive, and motivational processes, and how such peripheral responses can be used to index social psychological constructs to measure critical independent and dependent variables more precisely than might otherwise be the case. Another goal

of exploring peripheral neurophysiology is to understand how embodied somatic activity catalyzes social psychological processes including, for example, social cognition, memory, emotion, and mimicry (cf. Niedenthal, 2007). The central and peripheral approaches are certainly compatible, and the goals are not mutually exclusive. Both fit within a field that has come to be known as *social neuroscience*. Indeed, many social psychologists work in both domains.

The section topics included in this chapter are deemed by us as the most relevant for the intended audience of graduate students, researchers, and readers desiring some familiarity with its entitled topics, though much more could have been included about social psychophysiology and embodiment were it not for page restrictions inherent in a project such as the *Handbook of Social Psychology*. Furthermore, this chapter is not intended to be an exhaustive review of the relevant empirical literature, but rather, given its didactic intent, a selective one.

In the first section, Roots of Social Psychophysiology and Embodiment, we provide a historical analysis of how modern-day social psychophysiology and embodiment came to be, followed by a discussion of the value of these topics for social psychology. The second section, Neurophysiological Systems, focuses on the unique value of neurophysiological indexes of social psychological constructs for research. The third section, Relative Advantages of Peripheral and Central Neurophysiological Indexes for Social Psychology, describes neurophysiological systems and functions in broad terms with some discussion comparing the relative value of various uses of peripheral and central neurophysiological measures in social psychology. In the fourth section, Peripheral Neurophysiological Indexes, we describe the basis on which validation of

peripheral neurophysiological indexes of social psychology should rest. This is followed by a fifth section, Evolution of Social Psychophysiological Theories, which reviews social psychophysiological theories, more specifically, reasonably prominent theories incorporating peripheral neurophysiological processes and constructs. In the final section, Uses of Peripheral Neurophysiological Indexes In Social Psychology, we review representative constructs that are relevant to social psychology and have been examined using peripheral neurophysiological indexes.

ROOTS OF SOCIAL PSYCHOPHYSIOLOGY AND EMBODIMENT

One can trace historical elements of social psychophysiology and embodiment nearly three millennia in both Eastern and Western cultures. Indeed, heart rate was reportedly used to infer emotion (i.e., "love") as early as the third century BC (Mesulam & Perry, 1972). Not surprisingly, overt embodiments, especially those involving nonverbal behaviors (e.g., mutual gaze) were known by ancient peoples to signify intimacy or the desire for it.

Monism and Dualism

In many ways, this long history reflects a dialectical struggle between proponents of mind-body monism and proponents of mind-body dualism among scholars interested in mind-behavior issues including philosophers, psychologists, physiologists, and neuroscientists. Generally, the struggle has been about the corporeal nature of the mind, though even the reality of the physical nature of the body has been questioned in some quarters. Basically, monism is the view that mind and body are not ontologically distinct entities, whereas dualism is the view that they are. In its strong Cartesian form, or "substance dualism," mind and brain are composed of different "substances" (e.g., body and soul). In a weaker form, or "property dualism," the mind is thought of as a group of independent properties that emerge from, but cannot be reduced to, the brain even though the mind is not made up of distinct substances (e.g., Searle, 1992).

As might be expected, Cartesian dualism led to a bifurcation of philosophy of mind on the one hand and physiology on the other. Western physiology, freed by Cartesian dualism from concern with the mind, began making rapid advances. For example, William Harvey, the Western anatomist, "first" described the cardiovascular (CV) system in the 17th century, though the Arab physician, Ibn al Nafis, did so (and also described the pulmonary system) four centuries earlier (Gregory, 2001). By the mid-19th century, Theodor Schwann, Matthias Schleiden, and Rudolf Virchow had solidified cell theory. As the living cell became generally accepted as the common structural and reproductive component of all organic substances, including those in both plants and animals, the field of biology came into its own.

Psychology became distinguished from philosophy only in the mid- to late-19th century. During that time, clinicians claimed that certain psychic (e.g., hysteria) and sometimes even physical abnormalities (e.g., catatonia) had no apparent physiological causes, and empiricists applied observational techniques, including experiments, to their study of mind and behavior. Arguably, property dualism, as described earlier, provided the metaphysical underpinnings of such psychological luminaries as Sigmund Freud, Carl Jung, Wilhelm Wundt, William James, and others.

Wundt, a structuralist, and James, a functionalist, differed as the former proceeded introspectively to infer common mental structures and processes to explain psychology. James looked more outwardly, examining the person's adaptive relationship with the environment. However, their philosophies of mind, like those of many other founding fathers of modern psychology, comport with the metaphysical assumptions of property dualism more than substance dualism or strict monism; that is, mental activity derives from bodily processes but is not necessarily reducible to it. The monism–dualism debate was avoided altogether by Watsonian and Skinnerian behaviorism, which held sway in psychology for 50 years or longer. Radical behaviorism, as it applied to humans, eschewed anything to do with the mind and brain, considering it metaphorically a "black box," the operation of which was unimportant to understanding human behavior. Rather, the behaviorists looked to environmental contingencies to explain behavior.

By the last half and particularly the last quarter of the 20th century, a number of factors contributed toward the reemergence, weak at first, but stronger by the dawn of the new millennium, of mind-body interaction in social psychology and related fields. These factors included seminal theoretical and empirical work by social psychologists, such as Schachter and Singer's (1962) neo-Jamesian model of emotions; by personality psychologists, such as Friedman and Rosenman's (1974) Type A dispositional construct; and by health psychologists' mind-body connectionism, such as Ader and Cohen's (1975) seminal psychoneuroimmunology work. It also included work on metaphysical assumptions underlying social neuroscience. Social psychologists John Cacioppo and Louis Tassinary (e.g., 1990) espoused the "identity thesis," arguing that all mental, and hence psychological, states and processes are embodied corporeally. In 1994, neuroscientist Antonio

Damasio published his landmark work, *Descartes' Error: Emotion, Reason and the Human Brain*, putting another, perhaps final, nail in the philosophical coffin of mind-body substance dualism (also see Taylor; Keltner & Lerner; and Funder & Fast, this volume).

The rejection of Cartesian mind-body dualism and the drift toward monism led Blascovich and Seery (2006) to delineate several implications of the view of mind and body stated in Cacioppo and Tassinary's *identity thesis*. For one, the identity thesis implies that understanding bodily responses can inform our understanding of mental states and processes and vice versa. For another, biological and psychological levels of analysis must be integrated for social psychologists to understand mind-body relationships. Third, the modern monistic view as elucidated in the identity thesis argues against reductionism (i.e., that a complex system is only the sum of its parts and, therefore, can be understood and explained by reducing it to accounts of those parts) and determinism (i.e., that everything, including affect, cognition, and behavior, is causally determined by an unbroken chain of prior occurrences), as well as pure psychologism (i.e., that mental states play the pivotal causal role for behavior). Finally, the identity thesis implies that state-of-the-art training in social psychology must include training in neurophysiology without abandoning social psychology's substantive purviews.

Body and Mind

That the body and mind are two sides of the same coin is arguably the essence of the identity thesis and the current more monistic, or at least, property dualistic metaphysical view of human nature. The common Western view is that the metaphorical coin is the brain or, as we have described it, the site of primary control over body and mind.

In his essay "Where am I?" philosopher of mind Daniel Dennett (1978) grapples with the location of the self. He implies that if the brain were somehow remote from the rest of the body, lying in a nutrient bath connected by wires or telemetric microwaves distally to their bodies, most people would identify their "self" as located in brain. Such "common sense" replies are consistent with the theme, one that is science fiction to some and a remote possibility to others that human brains sans bodies could simply communicate with one another, directly eliminating the need for physical bodies. But would the need for bodies really be eliminated? According to embodiment theory, it would not.

The embodiment theory perspective is that a reciprocal relationship exists between peripheral bodily expressions (e.g., of memories, emotions, and sensorimotor skills) and central nervous system (CNS) processing of information from those domains (cf. Niedenthal et al., 2005). To put it more simply, the proverbial detached brain would be impoverished in terms of information processing without peripheral embodiments.

Modern theoretical embodiment accounts of social psychological constructs can be traced to Charles Darwin (1872), who argued that attitude is a collection of postural motor behaviors revealing an organism's emotional response toward an object. A decade or so later, William James and Carl Lange independently arrived at similar but physiologically expanded notions regarding the nature of the relationship between body and emotion. James (1884) and later Lange and James (1922) held that emotion is the perception of peripheral physiological conditions (including those of the musculature viscera) that result from some stimulus. The mind's perception of stronger heartbeat, increased or decreased muscle tension, higher adrenaline levels, sweaty palms, and so forth *is* the emotion according to these theorists; that is, physiological reactions form the basis of subsequent emotional reactions. Walter Cannon and Philip Bard (Bard, 1929; Cannon, 1929) challenged the James-Lange theory. They postulated that perception of a stimulus leads to both the emotion and peripheral physiological activity, and that, indeed, many different emotions shared the same peripheral physiological responses.

Much later, Stanley Schachter and Jerome Singer (1962) modified the James-Lange view maintaining that people perceive peripheral physiological responses and interpret them emotionally taking account of the context within which they find themselves. In their classic experiment, they injected experimental participants with epinephrine and found that those who did not expect to be affected physiologically by the injection but, in reality, were affected nonetheless labeled their emotions positively or negatively in line with contextual social cues. This was one of the first experiments within the tradition of modern embodiment theory. However, several statistical and other critiques (e.g., Plutchik & Ax, 1967; Stern, Botto, & Herrick, 1972; Stricker, 1967), as well as replication failures such as those by Maslach (1979) and Marshall and Zimbardo (1979), eventually dimmed the impact of the neo-Jamesian perspective.

Interoceptive (i.e., perception of visceral organ activity) accuracy became the target of much research in the 1970s and 1980s when psychophysiologists such as Jasper Brener (e.g., Brener & Kluvitse, 1988), Gary Jones (e.g., Brener & Jones, 1974), Edward Katkin (e.g., 1985), William Whitehead (e.g., Whitehead & Drescher, 1980), and others investigated the role of people's perceptual acuity (i.e., interoceptive accuracy) for detecting peripheral physiological signals. Stimulated, in part, by Miller's (1978) notion that accurate visceral perceivers would benefit more from biofeedback therapy (e.g., for relaxation) than less accurate

perceivers, these and other investigators spent more than a decade perfecting research paradigms for assessing the accuracy of individuals' perceptions of visceral signals, concentrating, for the most part, on heartbeat detection (though the idea that accurate visceral perceivers would need external biofeedback seems to be counterintuitive).

In general, most work on interoception (e.g., Katkin, Blascovich, & Goldband, 1981) demonstrated that men, and especially women, were extraordinarily poor visceral perceivers—though men benefited somewhat from performance feedback training in discriminating their own bodily signals (i.e., heartbeats) from simulated ones—calling into question any functional relationship between visceral perceptual ability and emotional expression. Although one or two studies in this research tradition supported the neo-Jamesian perspective on emotion, a few others suggested the opposite. For example, Hantas, Katkin, and Blascovich (1982) found that more accurate heartbeat detectors self-reported greater emotional reactions to emotionally evocative photographs than inaccurate ones. Later, consistent with affect intensity theory (Larsen & Diener, 1987), Blascovich et al. (1992) demonstrated that poor heartbeat detectors tended to exaggerate their reported emotions more than good heartbeat detectors. Still later, Barrett, Quigley, Bliss-Moreau, and Aronson (2004) proposed and found evidence that visceral interoceptive ability was positively related to the intensity of emotional experience as delineated in Barrett's core affect model (Barrett & Bliss-Moreau, in press). In sum, the role of interoception in emotion is undoubtedly more complicated than researchers in the past have theorized, and more sophisticated theory and research are needed to explain the seemingly oppositional effects of interoceptive ability and emotion reported in the literature.

Clearly, data from interoception experiments suggest, in general, that there is little consistent relationship between *conscious* visceral interoception and psychological processes such as emotional ones (cf. Barrett et al., 2004). However, embodiment theorists would argue that visceral and proprioceptive information (i.e., perception of skeletal muscle activity) need not rise to the level of consciousness to affect emotion. For example, based on Waynbaum's (1907) novel ideas relating cerebral blood flow and facial expressions, Zajonc, Murphy, and Inglehart (1989) proposed the vascular theory of emotional efference. Specifically, they hypothesized that facial muscle movements regulate the temperature of venal blood in the cavernous sinus in the brain that, in turn, is causally related to emotional experience (with decreases in blood temperature accompanied by more positive affect and increases in blood temperature accompanied by more negative affect). Accordingly, in the James-Lange tradition, facial somatic changes lead to emotional experience.

Key to emotional efference theory is the likelihood that affectively driven facial muscle contortions differentially cool venal blood flow that passes near the cavernous sinus via a heat exchange mechanism with the ambient environment. In a series of sophisticated experiments using essentially "one-of-a-kind" noninvasive technology to measure forehead temperature at critical locations related to venal blood flow, Zajonc and colleagues (1989) demonstrated that such differential cooling was correlated with the hypothesized differences in affect. Interestingly, these experiments were run with the ambient temperature in the room in which they were conducted at lower levels (probably around room temperature) than the range of normal human blood temperature (e.g., around 98–99° F). If the ambient temperature (e.g., around 110° F) were greater than normal blood temperature, then the predictions based on the heat exchange principle should be reversed. If local environmental ambient temperature is less than body temperature, facial expressions (e.g., smiling) associated with cooling venal blood should result in positive affect. In contrast, if local environmental ambient is higher than body temperature, those same facial expressions (e.g., smiling) should be associated with warming venal blood and negative affect, thereby providing stronger inferential evidence for Zajonc and colleagues' hypothesized mechanism. As far as we know, such an experiment has never been conducted.

Although the blood temperature mechanism that Zajonc and colleagues (1989) specified has received relatively little attention and remains unverified in strong ways empirically, these theorists, themselves, foresaw the importance of facial expressions as embodiments of emotion regardless of their hypothesized blood temperature regulation mechanism. Specifically, they stated:

> Independent of the validity of the *particular* physiological processes that could be involved in producing subjective effects, the basic principle that facial efferents may have regulatory functions, and thereby subjective consequences, has a great deal of plausibility and, if true, profound theoretical importance. (p. 397)

Their idea that facial muscular embodiments of emotional states, as well as other muscular embodiments, play a causal role in affective and emotional experience has been taken up by many researchers, albeit via hypothesized mechanisms other than venal blood temperature regulation.

Niedenthal and colleagues (Niedenthal, 2007; Niedenthal et al., 2005) maintain that attitudes, memories, emotion, and social perceptions involve perceptual, visceral, and motoric "reexperiencing" or "embodiment." Niedenthal and her colleagues' literature reviews and explanatory offerings

provide strong evidence for embodiment processes and pose a theoretical explanation. With regard to the evidence on affect-related somatic embodiments (e.g., facial expressions and postures), Niedenthal (2007) concludes: (1) emotion-specific posturing leads to experience of specific affect/emotions (e.g., Cacioppo, Priester, & Berntson, 1993; Wells & Petty, 1980); (2) facilitation of emotion-specific postures increases posture-consistent attitudes (e.g., Duclos et al., 1989); and (3) inhibition of emotion-specific postures interferes with experience of posture-specific emotions (e.g., Strack, Martin, & Stepper, 1988).

Furthermore, Niedenthal maintains that such embodiments are involved in both online and offline processing of psychological states such as attitudes, memories, emotions, and so forth. More specifically, actual or online postural movements affect the experience and encoding of such psychological states. Hence, online embodiments facilitate the initial capture of information relevant to psychological states, whereas offline embodiments are thought to aid recall, reenactment, reexperience, among others, of those psychological states. In the words of Niedenthal et al:

> In theories of embodied cognition, using knowledge—as in recalling memories, drawing inferences, and making plans—is thus called "embodied" because an admittedly incomplete but cognitively useful reexperience is produced in the originally implicated sensory-motor systems, as if the individual were there in the very situation, the very emotional state, or with the very object of thought. (Niedenthal et al., 2005, p. 18)

For example, in an experiment conducted by Rauscher, Krauss, and Chen (1996), participants watched a cartoon. Afterward, participants who had been prevented from gesturing compared with those who were unfettered were slower to recall cartoon details. Glenberg and Kaschak (2002) demonstrated that participants more quickly judged the sensibility of sentences when motion meaning comported with the arm motion described (e.g., "Close the drawer.").

Although Zajonc et al. (1989) suggested blood temperature regulation as a possibility for the physiological mechanism linking facial postures (i.e., expressions), Niedenthal and colleagues (2005) suggested the operation of motor neurons, specifically mirror neurons, as the physiological mechanism linking not only facial postures but all somatic embodiment postures. Although explicit and detailed discussion and debate regarding the concept, operation, and evidence of mirror neurons is more within the scope of our sister chapter on social neuroscience, it seems at the time this chapter was written, that mirror neurons represent a plausible mechanism linking peripheral somatic embodiments to both online and offline central processing of underlying social psychologically relevant psychological states. Nevertheless, the evidence is strong that such embodiments play important roles in the development and operation of the processes underlying psychological states.

Values of Psychophysiology and Embodiment in Social Psychology

The scientific values of examining the interplay among neurophysiological and social processes within social psychology fall into three categories: theoretical, methodological, and applied.

Theoretical

Social psychological theories are strengthened as behavioral scientists (with social psychologists being no exception) continue to become more sophisticated about neurophysiological processes. By no account does this mean that social psychologists should become reductionistic, deterministic thinkers, thereby abandoning the explanatory value of social psychology as an important level of analysis. Rather, it means that such knowledge can improve the precision of social psychological theories.

Methodological

In addition to possible theoretical advances stemming from an understanding of mind-body relationships, there are substantial methodological, particularly measurement, advantages as well. Indeed, many social psychologists have attempted to test hypotheses and bolster theories by including neurophysiological indexes of social psychological constructs. However, the value of such indexes depends on the quality of the physiologically based linkages between measures and constructs as social neuroscientists have maintained for more than a quarter of a century (e.g., Blascovich, 2000; Blascovich & Seery, 2006; Cacioppo, Tassinary, & Berntson, 2000; Cacioppo & Tassinary, 1990; Obrist, 1976). *If* a social psychological construct is well defined, *if* a strong theoretical case for its neurophysiological underpinnings is made, and *if* a neurophysiological index (typically but not necessarily incorporating multiple measures) is independently validated, then the methodological advantages of neurophysiological measures in social psychology are substantial. These advantages accrue from the fact that neurophysiological measures can best be measured continuously, covertly, and in an online manner.

Continuous measurement eliminates the loss of information that typically occurs with point time estimates. One can examine the topology of construct expression via neurophysiological indexes over time. For example, the four continuous functions revealed in Figure 6.1
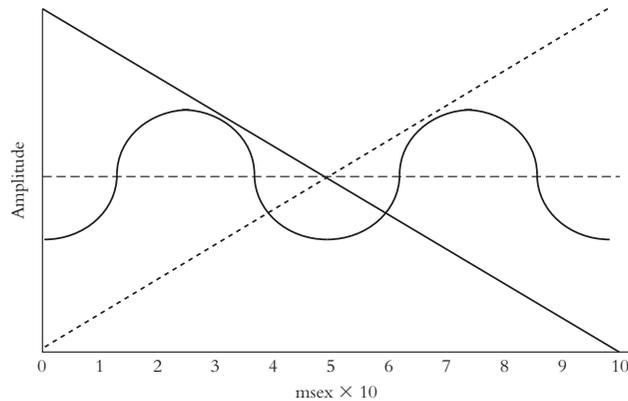
Figure 6.1 Four examples of hypothetical activation of a neurophysiological response over time.

depict examples of a hypothetical activation of a single neurophysiological measure over some period. As can easily be seen, each function has the same mean and median over the epoch, but the distributions of data they represent differ substantially over time. The difference in form can not only provide a more fine grained distinction between processes underlying the multiple functions, but it can also better inform theory development.

Covert or implicit measurement, as is well known among social psychologists, avoids the pitfalls of impression management artifacts that can plague self-report–based measurement. Nearly all neurophysiological and embodiment-based measures can be considered in this category.

Online neurophysiological measurement provides for accurate synchronization of neurophysiological indexes with the activities of participants during the measurement epoch, typically the critical periods of an experiment. Indeed, online measurement also provides the possibility that certain experimental activities (e.g., presentation of stimuli, requirements of action, etc.) can be triggered by levels of neurophysiological activity on some variable or variables over time; for example, when facial electromyography (EMG) reveals that a participant is in a positive or negative affective state. Furthermore, online neurophysiological measures do not suffer problems associated with prospective and retrospective self-reports.

Applied

Given social psychology's value for understanding how the exigencies of everyday social life can impact one's health, neurophysiological indexes of constructs such as stress (Ader & Cohen, 1975; Matthews, 1986; McEwen, 2002), threat (Blascovich & Tomaka, 1996; Tomaka, Blascovich, & Kelsey, 1993), and coronary prone behavior

(Friedman & Rosenman, 1974) have been related to health outcomes. Indeed, voluminous literature links peripheral neurophysiological measures including neuroendocrine and immunological ones to a variety of disease states but is beyond the scope of this chapter (but see Taylor, this volume).

Future performance can also be predicted via theory-based neurophysiological indexes. For example, research has demonstrated that patterns of CV markers related to motivational states during appropriate assessment tasks can predict future physical and cognitive performance (Blascovich, Seery, Mudridge, Norris, & Weisburch, 2004; Kassam, Koslov, & Mendes, in press; Schmader, Forbes, Zhang, & Mendes, 2009). Discriminatory hostile behavior can be predicted from specific somatic responses permitting body and head movements. For example, McCall, Blascovich, Young, and Persky (2009) have shown that Anglo-American individuals who maintain more interpersonal distance and more gaze aversion between themselves and African-American opponents display more hostile and perceived fatal gunfire toward them than Anglo-Americans who maintain less distance. Such an effect does not occur in Anglo-American to Anglo-American pairings.

NEUROPHYSIOLOGICAL SYSTEMS

Human physiology can be modeled as a cybernetic or continuous feedback system involving control and operational systems (see Figure 6.2). The primary *control systems* are intracranial and include the CNS—that is, the brain and spinal cord, and the pituitary gland. The hypothalamus, a brain structure, links the CNS and the pituitary gland via a structure called the "median eminence." The CNS controls the endocrine system via the hypothalamic-pituitary configuration but with feedback from the peripheral endocrine system via the bloodstream (as the arrows illustrate). Hence, together, the CNS and cranial endocrine executive, the pituitary, control the lower-level operational systems neurally via the peripheral nervous system and peripheral endocrine glands.

Major *operational systems* include the immune, visceral, skeletal-motor or somatic, and endocrine systems. Our distinction between control and operational systems does not preclude control functions at the operational systems level or even lower within operational components (e.g., heart, thymus). Control and operational functions are even embedded in cells, the basic building blocks of all life (e.g., reuptake receptors near neuronal synapses), but the higher-level organization fits our purposes here. Importantly, our distinction between control and operational systems is not meant to imply primacy of intracranial processes as the originating
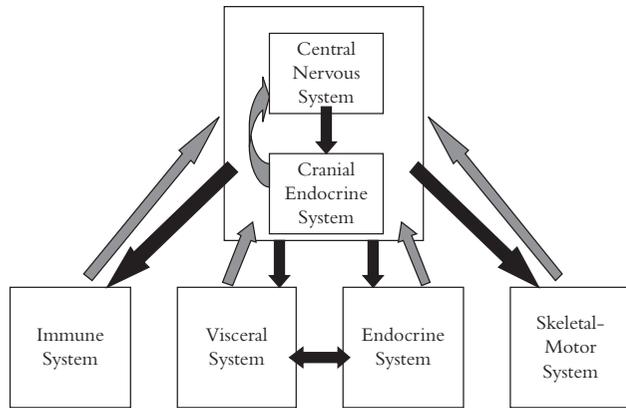
Figure 6.2 Cybernetic feedback system of human physiology.

source of all psychological and social-psychological processes. Although such may or may not be the case during dream and hallucinatory episodes, inputs to the CNS come from sensory intake and feedback from peripheral neurophysiological systems including, importantly, kinesthetic information (cf. Niedenthal et al., 2005).

Cybernetic cranial-based control of operational systems permits continuously operating physiological processes to vary from, and return to, homeostatic levels for functional purposes. The CNS transmits instructions to the operating systems via efferent neurons and receives feedback via afferent neurons. Central endocrine control occurs via pituitary generated gland-specific hormones that transmit instructions to the endocrine operating system (i.e., glands) and receive feedback via circulating glandular hormones, as well as peripheral and central neural feedback. Endocrine systems communicate with other operational systems, especially the visceral systems (i.e., pulmonary, CV, gastrointestinal, renal, hepatic, bladder), often synergistically.

RELATIVE ADVANTAGES OF PERIPHERAL AND CENTRAL NEUROPHYSIOLOGICAL INDEXES FOR SOCIAL PSYCHOLOGY

As discussed at the outset, this chapter focuses on the value of peripheral visceral, somatic, and endocrine processes as indexes of psychological constructs that can advance social psychological theory. Both peripheral and central neurophysiological indexes share certain methodological measurement advantages over subjective measures by virtue of their properties (i.e., continuous, online, and covert). Peripheral and central measures each have relative advantages over the other, and neither is a measurement nor assessment panacea.

Employment of peripheral neurophysiological embodiments currently enjoys a few advantages over CNS embodiments but only insofar as they are used as indexes of psychological constructs. These include practical and inferential ones. *Cost, intrusiveness*, and *accessibility* are some relative practical advantages. For the most part, the monetary costs of recording, scoring, and analyzing peripheral measures remain under the costs for recording, scoring, and analyzing central neurophysiological measures such as bloodborne signals via positron emission topography (PET) and blood oxygen level–dependent signals via functional magnetic resonance imaging (fMRI), and are typically somewhat below the costs of high-density electroencephalography.

Peripheral measures are typically less intrusive than central ones. Although neither central nor peripheral measures need be invasive, both types can be (e.g., intravenous injection of radio-opaque dyes, collection of blood). The technological requirements for peripheral measures, even for relatively sophisticated technology such as impedance cardiography, does not overly restrict postures and movements, allowing for unconstrained interactions and experiences in a more naturalistic settings. Such is not currently the case with PET- and fMRI-based measures. Generally, physiological recording equipment for peripheral measures is more easily accessible, requires little, if anything, in the way of a specialized recording environment, and has been miniaturized, thereby permitting even ambulatory measurements in the field.

Given the varied types of peripheral physiological processes, such as sympathetic and parasympathetic branches of the autonomic nervous system (ANS), muscle activity, skin temperature, hormonal and immune changes, to name a few, measures based on them might have an advantage over central measures in certain contexts because one can examine convergence and divergence across various systems simultaneously, whereas the limited mobility required as part of fMRI and PET procedures, at present, circumscribes looking at multiple system responses concomitantly with the induction of specific mental states.

Currently, a number of peripheral neurophysiological indexes of certain psychological constructs have been experimentally validated, but their counterpart upstream CNS indexes have not yet been. For example, CV indexes of challenge and threat motivational states can be indexed peripherally via patterns of CV responses (Blascovich & Tomaka, 1996; Tomaka et al., 1993; see later). However, the hypothalamic differentiation putatively underlying these peripheral patterns has not yet been and, perhaps, cannot yet be distinguished via fMRI- or PET-based brain imaging. For example, functional brain imaging data may be able to demonstrate activation of the hypothalamus but has

not yet been shown to distinguish between the oppositional motivational states resulting from that activation. Peripheral indexes are currently necessary for the latter. On the other hand, there is little agreement regarding valid peripheral neurophysiological indexes of basic level emotions, pointing to the possibility that neural activation might be able to identify emotional responses where peripheral physiological indexes have failed to do so (see Cacioppo, Berntson, Larsen, Poehlmann & Ito, 2000, for meta-analysis).

However the brain works, we can often discern something about what it has done via peripheral neurophysiological responses. If the brain has "chosen" to increase cardiac output, we can measure it via peripheral CV measurement (Tomaka et al., 1993). If the brain has caused the endocrine system to increase cortisol level, we can measure it via its in saliva, urine, or blood (Dickerson & Kemeny, 2004). If the brain has caused a change in head orientation, we can measure head movements in a variety of ways (e.g., McCall et al., 2009).

In addition, there are several current impediments to the development of brain-based indexes of psychological states. The issues of *complexity, plasticity, individual differences*, and "*dark matter*" must be overcome before we can better take advantage of brain-based indexes of social psychological constructs.

Regarding complexity, the structure and functions of the human brain represent perhaps the most complex and massive living system on earth. Estimates of brain structures range as high as 100 billion neurons, each synapsing, on average, to 10,000 other neurons. This presents an important quantitative challenge to brain science, and presents difficulties in terms of determining specific purposes and functions of all neural connections, subsystems, "modules," and so forth in the brain. The brain is also highly plastic (i.e., adaptable) in the sense that certain cortical areas in the brain devoted to one kind of mental activity can take over mental activities that are normally supported by other areas that are permanently or temporarily "out of order" (Ramachandran, Rogers-Ramachandran, & Stewart, 1992). Hence, the psychological processes may appear externally (i.e., peripherally) exactly the same across individuals, but the spatial or temporal location, or both, of CNS control differs. Apart from insult-caused control dislocations in the brain, there is also a great deal of between-individual variability in certain measures of CNS operations. For example, Miller et al. (2002) have found that brain images aggregated across individuals pointing to localized brain control of specific cognitive and affective processes often mask considerable individual differences in location. Aggregation techniques can actually point to activation of a brain location across participants that no single participant actually exhibits. Finally, Marcus

Raichle, a pioneering brain imager and leading figure in human cognitive neuroscience argues, via his "dark matter" metaphor, that the subtractive techniques inherent to imaging techniques such as fMRI and PET can be misleading because they highlight certain brain activity while seemingly downplaying other brain activity that actually is involved (Raichle, 2006).

However, if one's intent is to understand the affective, cognitive, somatic, and motoric *processes* underlying social behavior, central neurophysiological measures have the advantage inferentially. No one doubts that affective, cognitive, somatic, and motivational outputs are processed by the brain, albeit with inputs from the environment and from peripheral physiological operational systems (i.e., embodiments). Potential direct causal explanation of mind-body relationships lies much more in the realm of central neurophysiological than peripheral neurophysiological processes.

PERIPHERAL NEUROPHYSIOLOGICAL INDEXES

One of the challenges facing researchers interested in exploiting the methodological advantages that neurophysiological indexes bring to social psychological research is how to select among the seeming plethora of possible ones to use. Just as an investigator would not use just any existing paper and pencil or behavioral measure to index any social psychological construct, one should not select just any physiological measure or measures. Rather, one should be concerned about the validity of a neurophysiological measure as an index of a particular construct and, therefore, search for validated neurophysiological indexes of that construct (several are discussed later). In the absence in the literature of such a validated neurophysiological index, one can take on the task of melding appropriate neurophysiological theory with psychological processes underlying the target construct, and developing and validating such an index,[1] though that can be a daunting task.

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[1] Blascovich and Seery (2006) outlined a methodological approach to establishing and using peripheral neurophysiological indexes of social psychological constructs including "first principles" and "propositions" building on Cacioppo and Tassinary's (1990) "strength of inference" classification scheme. In contrast with many self-report and even some behavioral measures, most peripheral neurophysiological measures have little, if any, face validity with regard to their applicability to social psychological constructs. Consequently, the identification and validation of such indexes is more complicated than subjective and behavioral ones. As discussed later in the chapter, some of this work has already been accomplished, but not to the degree that a plethora of practical validated peripheral neurophysiological indexes of constructs exists.

Alternatively, one can manipulate independent variables and choose dependent variables for which there are extant validated peripheral neurophysiological indexes. At first read, the previous sentence may seem to be suggesting changing what one wants to investigate. However, that is not necessarily the case. Because the inferentially strongest peripheral neurophysiological indexes that exist are ones associated with superordinate categories of affect (i.e., positive vs. negative) or motivation (i.e., challenge vs. threat), and they can be indexed at the superordinate level. Given that social psychologists are often interested in affect and motivational measures, these can be indexed validly neurophysiologically and relatively easily at the superordinate level. Unless it is important for the investigator to distinguish happiness from love or fear from anxiety, indexing positive and negative affect neurophysiologically provides important information to the investigator via the stated advantages of physiological measures.

Propositions for Validating Neurophysiological Indexes of Social Psychological Constructs

Cacioppo and colleagues (Cacioppo & Tassinary, 1990; Cacioppo, Tassinary, & Berntson, 2000, 2007) specified three dimensions that yield the taxonomy of psychophysiological relationships presented here

(see Figure 6.3). The three dimensions are generality (context), specificity, and sensitivity, and combined produce four categories of psychophysiological relationships: outcomes, concomitants, markers, and invariants that can vary in sensitivity.

Generality or context refers to the continuum of situations, and varies from very limited or "context-dependent" situations to unlimited or "context-independent" situations. Context-independent indexes are more desirable than context-dependent ones in terms of the generalizability of results based across all situations. However, they are difficult and, in some cases, impossible to achieve especially in terms of neurophysiological indexes of social psychological constructs. However, context-dependent indexes can be valuable provided that the context represents a reasonable domain within which the social-psychological processes represented by the construct operate. Indeed, given Lewin's dictum that social psychology represents the study of the interaction between person and situation, context-specific indexes, or "markers" in Cacioppo and Tassinary's taxonomy, validated in the specified contexts can be valuable and, therefore, a reasonable goal.

Specificity refers to the nature of the relationship between the index and target construct. Optimal specificity is a singular or "one-to-one" relationship between index and construct. Specifically, if the index is positive, the construct is expected to be present; and if the index
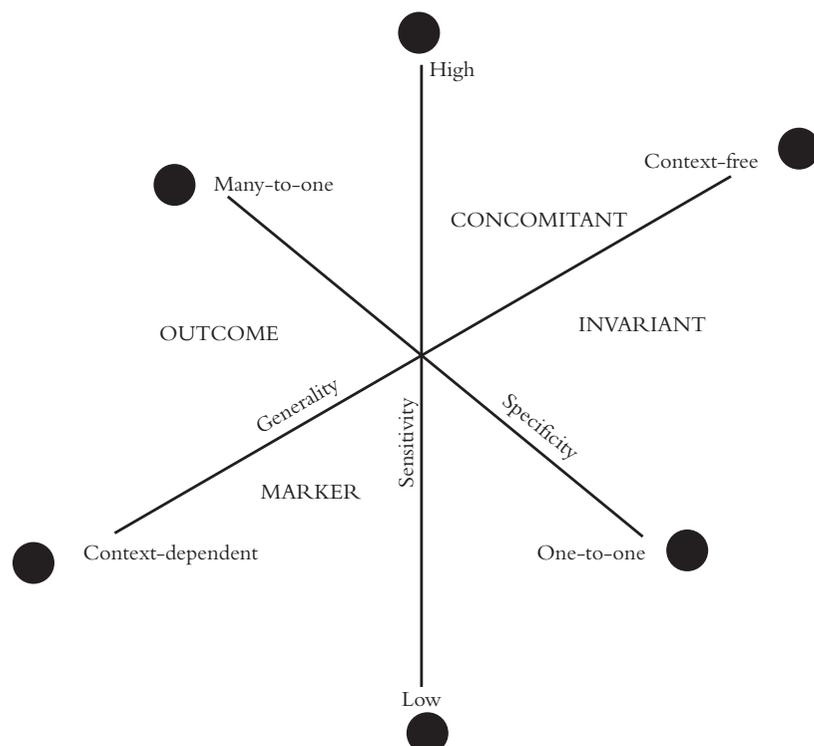

Figure 6.3 Cacioppo and colleagues' taxonomy of psychophysiological inference.

is negative, the construct is expected to be absent. Furthermore, the relationship is symmetrical so that if the construct is present or absent, the index is correspondingly positive or negative; and if the index is positive or negative, the construct is present or absent, correspondingly. Although this description of a one-to-one relationship between an index and construct is a dichotomous one, one-to-one relationships are certainly possible with continuous bipolar indexes as well.

Sensitivity refers to the likelihood that a physiological response will covary with a psychological state. At low levels of sensitivity, a physiological response might simply signal the presence or absence of a psychological state. At higher levels of sensitivity, the amplitude and temporal trajectory are specified to respond to the variable intensity of the psychological event. For example, if skin temperature were highly sensitive to the experience of anger, one would expect that as anger increased there would be a linear relationship with skin temperature that could index the "amount" of anger experienced.

These dimensions are by no means the only dimensions by which psychophysiological indexes can be established. Indeed, Blascovich and Seery (2006) expanded on these dimensions within an organizing framework of a multi-trait multimethod matrix as a way to explore divergent and convergent validity of physiological indexes and their relationship to mental states.

Summary

Achieving one-to-one relationships between social-psychological constructs and peripheral neurophysiological indexes is advanced by targeting less inclusive rather than more inclusive contexts in which to use them. Establishing valid indexes is optimized by using a divergent validational approach, by including a physiologically theoretically meaningful pattern of multiple neurophysiological responses, and by assessing such patterns over time. Note that a neurophysiological index based on a single physiological response can provide basis for inference. However, strong inference (i.e., a marker or invariant) is less likely though not logically impossible.

EVOLUTION OF SOCIAL PSYCHOPHYSIOLOGICAL THEORIES

As described earlier, the goal of social psychophysiology is to understand the links between social-psychological and neurophysiological theories. Toward this end, social psychophysiological theories have emerged with roots in psychophysiological, especially neuroendocrine- and autonomic-based systems, and social-psychological theories. Importantly, at this juncture, additional psychophysiological theories are ripe for increasing our understanding of social-psychological processes.

Historically, psychophysiological theories have focused on one or both of the two primary biological systems that are active during the operation of affective and cognitive processes underlying motivation and performance: the *sympathetic adrenal medullary* (SAM) and *hypothalamic-pituitary-adrenal cortical* (HPA) axes. At the risk of oversimplification, one can think of the SAM system as activating during fight-or-flight situations, whereas the HPA system is more conservative and activates after longer exposure to stress, such as preparing for comprehensive examinations. When the SAM system is activated, epinephrine is released from the adrenal medulla, which contributes to several changes in the body, including increasing heart rate and blood pressure, dilating pupils, and inhibiting the gastrointestinal tract. HPA activation is initiated in the hypothalamus, which releases corticotropin-releasing hormone, which triggers the anterior pituitary to release adrenocorticotropin hormone, which travels to the adrenal cortex, which sits on top of the kidneys, and stimulates an area of the adrenal cortex called the "zona fasciculata" to release cortisol.

These systems can operate relatively independently, though in some contexts are coactivated and can moderate each other. Although the SAM and HPA axes can be activated concomitantly, their onset and offset times can differ. The SAM system can fully respond and peak within seconds on exposure to a stimulus, thought, or emotion, and its response can be measured in terms of changes in the ANS and increasing circulating catecholamines. In contrast, the HPA system activates more slowly and generally takes minutes rather than seconds to reach its peak response. Similarly, recovery time (i.e., return to homeostatic levels) is longer after activation of the HPA compared with the SAM axis.

Some of the primary questions concerning these systems for psychophysiologists, and especially social psychophysiologists, include: What are the different eliciting psychological factors associated with activating these systems? How do emotions and individual differences influence activation? How can social situations influence responses? and What can we learn about people's experiences and behavior by examining how these systems activate and recover? To begin to examine how social psychophysiologists have tried to answer some of these questions linking mind and body, it is important to look at how modern research in the area of physiological responses to mental states began. Though one could point to many starting points, an especially important figure in the 20th century was Hans

Selye and what ended up being his clumsy, but fortuitous, approach to studying rats.

Selye's General Adaptation Syndrome

One of the pioneers in stress research, endocrinologist Hans Selye is largely credited with identifying the coordinated bodily responses that occur with *stress* (Selye, 1956). As a medical student in 1925 at the University of Prague, Selye noted that stress responses could influence the body in general ways. Although patients differed in primary diagnoses, they shared common symptoms and identifiable manifestations; for example, they looked and felt ill, their tongues were coated, they experienced loss of appetite, and reported pain in their joints. Even though a common disease was not inflicting these patients, they shared similar symptoms suggesting a general bodily response that co-occurred with specific diseases of the body.

Selye's early observations were confirmed a decade later when he was attempting to identify a new ovarian hormone. In these experiments, he injected rats with a variety of hormonal extracts, but apparently being a bit short on dexterity, Selye struggled with injecting the rats and would often end up dropping and chasing the rats around the laboratory. When he autopsied the rats, regardless of the extract (or placebo) injected, all the rats had developed the same triadic syndrome that included enlargement of the adrenal cortex, shrinking of lymphatic structures, and bleeding ulcers. Apparently, Selye had created his own laboratory-based stressor and his rats showed evidence of chronic stress. Selye recalled his early observations as a medical student and surmised that the triadic syndrome of bodily response was meaningful, and that such responses to general or nonspecific demands might explain a general sickness behavior. Thus, the *general adaptation syndrome* (GAS) was born, which Selye argued was a universal response to stress that included coordinated changes in the body.

The GAS identifies three stages of stress. The first stage is *alarm*, in which the body signals the fight-or-flight response. Under continued stress, *resistance* follows, which results in the body trying to cope or adapt with the new demands. If the stress continues, the bodily demands are depleted and the final stage, *exhaustion*, occurs. Selye argued that, in the latter stage, the body is most susceptible to new illnesses or exacerbation of existing diseases. By adopting the GAS model, many researchers explicitly or implicitly argued that stress responses were unidirectional and assumed that all stress responses were the same.

Although Selye may have influenced researchers to focus on the damaging effects of stress, he also emphasized the importance of differentiating harmful and damaging *distress* from the positive or less damaging *eustress*. This idea, that changes in the body caused by stress could be beneficial, is a recurring theme in contemporary psychophysiological theory and one we will return to often in this chapter.

In contemporary psychophysiological research, the word "stress" is rarely used, most likely because of the weak inference and fuzzy construct it represents. Instead, contemporary researchers use "allostasis" as a general term to represent changes in the body from homeostasis. *Allostasis* is a combination of the Greek word *allos* or "variable" and *statis* or "stable," thus "remaining stable by being variable." Allostasis refers to the body's response to external demands by activating the *fight-or-flight* response and is viewed as the body's "swift and efficient method of dealing with danger" (McEwen, 2002, p. 5). In contrast, the term that is used to highlight the deleterious effects on the body is "allostatic load" and is reserved for occasions when the allostasis response is not turned off and the body begins to break down defenses.

Psychophysiological Models of Hypothalamic-Pituitary-Adrenal and Sympathetic Adrenal Medullary Responses

The importance of James's, Cannon-Bard's, and Selye's theories is unquestionable in terms of generating attention to the links between mental states and bodily responses, in contrast with James, however, the latter two theories treated changes in physiological responses as *nonspecific*. Little attention was paid to the different eliciting conditions, and thus little or no specificity was identified regarding the mental states that preceded the physiological changes. In subsequent years, several theories attempted to remedy this problem by focusing on relative changes in the two primary stress systems described earlier and by defining which psychological antecedents were associated with specific profiles of activation.

For example, Frankenhäuser (1986) examined changes in epinephrine (indexing SAM activation) and cortisol (indexing HPA activation), and focused on individuals' perceptions of effort and distress. She theorized that different levels of effort and distress would result in unique physiological patterns related to SAM and HPA activation. When individuals were distressed but no effort was expended, cortisol production was hypothesized to increase together with small increases in epinephrine production. When individuals felt distressed and exerted effort, both epinephrine and cortisol responses increase, though epinephrine predominated. Finally, when individuals expended effort but there was not a concomitant experience of distress, epinephrine production would increase, but cortisol would

not. Theoretically, these patterns of responses map onto a continuum of helplessness (distress without effort) to mastery (effort without distress), with the question of perceived control influencing where one fell on the continuum.

A similar model was proposed by Henry (1980, 1986), who also focused on control as a critical psychological factor that determined patterned physiological responding. In this model, *defense* was linked to SAM activation and *defeat* to HPA. Henry further differentiated defense into *control* and *striving*. Specifically, *control* indicated when a potential threat was effectively managed and under control, whereas *striving* indicated a threat that still needed active management. Henry's model produced three distinct psychological states and multiple outcomes related to behavior, emotion, neuroendocrine, and autonomic responses. His *control* state was believed to result in aggressive behavior toward the potential threat, elation and loss of anxiety, and increases in norepinephrine, testosterone, blood pressure, and cardiac output. In contrast, the *striving defense* was characterized by struggle, tension, fear, and high epinephrine levels, moderate increases in cortisol, and moderate blood pressure and cardiac output increases. Finally, loss of control or the *defeat* response was characterized as helplessness, anxiety, depression, high cortisol and low testosterone, and little or no changes in autonomic reactivity.

Although the comparison between Frankenhäuser and Henry highlights the fact that the profiles of physiological responses tend to be similar across theories, what differentiates the theories are the specific psychological antecedents that best represent the eliciting conditions associated with the physiological profiles. The profiles that Frankenhäuser and Henry outlined can be seen in whole or in part in many subsequent theories, all of which have their own explication of the experiential component that brings about these profiles.

Dienstbier's Theory of Physiological Toughness

Similar to Frankenhäuser and Henry, Richard Dienstbier focused on the possibility that not all changes in physiological responses in a potentially distressful or threatening situation should be viewed negatively and took seriously Selye's notion of *eustress*. Even with psychoneuroendocrinologists attempting to differentiate SAM and HPA activation, relatively little attention was paid to beneficial or adaptive physiological changes, and the prevailing zeitgeist of the 1970s and 1980s was that increases in peripheral physiological responses were associated with negative psychological states and inherently did damage to biological systems, as well as impair cognition. Richard Dienstbier's *physiological toughness* model (1989) directly questioned these "negative views of arousal," and he reviewed the many and varied ways peripheral changes could be

associated with adaptive functioning, improved immune system, and better performance.

Incorporating animal and human studies, Dienstbier's premise was that small stressors experienced by an animal or human could "toughen" them so that subsequent stressors were better coped with physiologically. This perspective was in sharp contrast with stress models that assumed that all peripheral increases signified damage and impaired cognitive performance. For example, Dienstbier reviewed evidence that strongly questioned the commonly held belief that arousal would be related to cognitive or behavioral performance in a curvilinear relation (similar to the Yerkes-Dodson principle). Instead, he observed strong linear relations between higher catecholamines and better cognitive and physical performance. Most typically, greater catecholamine increases from baseline were associated with better math performance among students (especially for epinephrine relative to norepinephrine). Physical performance also yielded a similar finding: Greater increases in catecholamines were associated with better technical competence among military paratroopers in training.

In contrast, strong evidence has been reported that end products of HPA activation, specifically cortisol, do show an inverted U-relation with performance (Lovallo & Thomas, 2000). For example, memory is improved when there are small increases in cortisol, but impaired at higher levels of cortisol. Disease models and neural regions associated with memory provide insight into this finding. Patients with Cushing disease, characterized by an overactive HPA response, resulting in chronically high levels of circulating glucocorticoid responses, tend to have poor memory and smaller hippocampi because of degeneration. The hippocampus, strongly linked to memory, has high-affinity and low-affinity receptors for cortisol. At low levels of cortisol production, high-affinity receptors are activated, which improves memory, but at higher levels or chronically activated cortisol, low-affinity receptors are activated, which can impair memory (Reul & de Kloet, 1985).

The physiologically tough pattern extends to better psychological adjustment as well. Greater increases in catecholamines from resting levels are associated with ego strength, stress tolerance, low neuroticism, and daily stress scores. In contrast, clinically anxious individuals respond to laboratory challenges with lower sympathetic nervous system (SNS) increases.

What characterizes a *physiologically tough* (adaptive) response from a *weak* (maladaptive) one? Much of the differences lie in the baseline or resting levels, and in the temporal trajectory once the organism is exposed to a stressor. In Figure 6.4, the hypothesized changes in end products of SAM and HPA activation (specifically SNS changes and
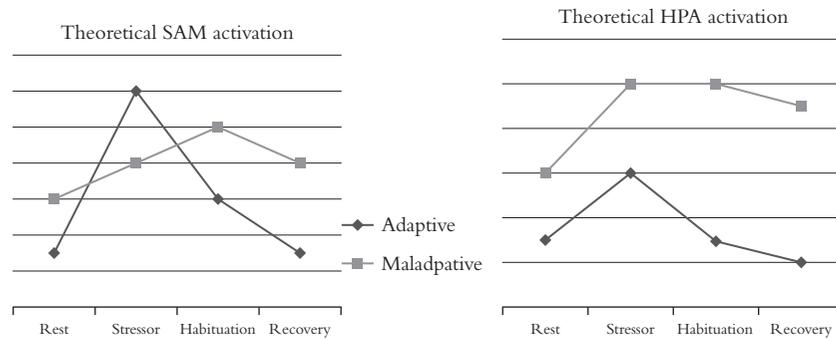
Figure 6.4 Hypothesized activation of sympathetic adrenal medullary (SAM) and hypothalamic-pituitary-adrenal cortical (HPA) responses from Dienstbier's model of physiological toughness.

cortisol responses, respectively) are depicted to contrast adaptive profiles from maladaptive responses.

For example, Dienstbier (1989) described an adaptive SAM profile to include low resting baseline responses (e.g., low heart rate, low levels of epinephrine), a strong and immediate increase in response to a stressor, followed by quick habituation and recovery. In contrast, an adaptive HPA response is characterized by low cortisol, small increases after the initiation of a stressor, and quick habituation and recovery. When examining a maladaptive profile, the resting and response reactions are quite different. First, in terms of SAM levels, there are higher resting levels of catecholamines, at the onset of the stressor there is a sluggish increase in activation, an increase in activation over the course of the task (rather than habituation), and then a sluggish recovery once the stressor is complete. The HPA response that characterizes a malignant profile, according to Dienstbier, is increased cortisol level at rest, a large increase in cortisol level in response to a stressor, together with sluggish habituation and recovery.

Obrist's Somatic Coupling/Uncoupling

Arguably one of the most important psychophysiologists of the 20th century was Paul Obrist. His varied and far-reaching contributions to CV psychophysiology included using pharmacological agents to constrain physiological responses, exploring psychological precursors of essential hypertension, and highlighting the importance of *context* when examining the link between psychology and physiology. Indeed, in his presidential address to the Society for Psychophysiological Research, Obrist (1976) claimed that, "Cannon was right, he just failed to understand situational specificity" (p. 103).

In his early work, Obrist (1968) published evidence that cardiac changes were concomitant with *somatic-motor* (i.e., bodily movement) changes. Using aversive conditioning paradigms, Obrist exposed participants to paired trials of light (conditioned stimulus [CS]) and shock (unconditioned stimulus [UCS]), but also varied the delay between the CS and UCS. When the intertrial interval was long (i.e., 7 s), heart rate *decreased* and muscle activity (in the neck, arm, and chin) *increased*, and these responses were correlated (i.e., the lower the heart rate the greater the muscle activity). However, with shorter intertrial intervals (e.g., 1 s), a correlation also existed between cardiac and somatic (body) responses, but in this case, both responses increased: *increased* heart rate and *increased* muscle activity. These data were critical in establishing that biological systems could respond in a coordinated fashion; however, the *context* could change the relationship.

But even the coupled relationship between cardiac (heart) and somatic (body) activity at short and long intervals proved to be dependent on situational factors. In later research, Obrist (e.g., 1976) established that cardiac-somatic coupling occurred in the context of passive stressors—for example, during aversive events that were minimally involving or engaging—primarily because in these situations the heart is controlled by *vagal* (i.e., parasympathetic) innervation. Regarding the physiological changes in *passive coping* tasks (such as aversive shock), Obrist commented that they were "biologically trivial and . . . tell little about the psychological state of the organism other than . . . momentarily suspended somatic activity" (p. 103). Indeed, he speculated that the cardiac-somatic coupling might simply be caused by momentary changes in posture and body positioning, rather than a function of a psychological or experiential response. In contrast, Obrist was quite optimistic about the value of physiological changes brought about during *active* tasks, or ones that allowed an individual to act or cope. Not only were changes in cardiac responses much larger than those seen in passive tasks, but now cardiac and somatic activity were *uncoupled*. Changes in body positioning could no longer explain changes in cardiac responses; thus, the psychological state of the individual was the likely candidate for the observed physiological changes.

Context distinctions are critical for understanding mind-body interactions for several reasons. For one, the functions of the SNS are primarily for fight or flight, but in our modern age, we often experience SNS changes when no or

minimal metabolic demand is required. Obrist's point was that there was little, if any, value in examining peripheral physiology during passive stressors, and that any changes seen represent somatic or motoric changes that are independent of psychological experience. Instead, active tasks, which require an opportunity to cope with environmental or internal demands, would result in meaningful peripheral changes that would correspond to psychological states. Obrist's observation is critically important when we review emotion and motivational research that has occasionally ignored this distinction often to the detriment of research progress.

Blascovich and Colleagues' Biopsychosocial Model of Challenge and Threat

One of the direct descendants of Dienstbier's distinction of physiological toughness (vs. weakness) and Obrist's specification of active coping states is Challenge and Threat Theory (Blascovich & Mendes, 2000; Blascovich & Tomaka, 1996; Tomaka et al., 1993; cf. Wright & Kirby, 2003). This theory states that in situations that are active and goal relevant (based on Obrist's notion of active tasks), a combination of evaluations of situational demands and personal resources to cope produce distinct psychological states. At the most general level, when evaluated demands are greater than perceived resources to cope, individuals experience a psychological state of *threat*. In contrast, when resources are greater than demands, individuals experience a *challenge* state (see Lazarus & Folkman, 1991). Of course, many factors influence the evaluated demands and resources in a motivated performance situation. Factors that have been identified as likely to increase demand evaluations include danger, uncertainty, novelty, and required effort, and there are likely additional ones not yet specified (Blascovich & Mendes, 2000).

For example, danger, either psychological or physical, can be signaled in multiple ways during an active, goal-relevant task. At a psychological level, danger can be associated with fear of negative evaluation, such as an unsympathetic or hostile audience during a talk. Physical danger, though rare in active coping tasks used in the laboratory (studies using electrical shock are done so in passive coping situations with no opportunity for escape), also conceivably would increase demand evaluations. Situational novelty increases demand evaluations, whereas situational familiarity decreases demand evaluations. Finally, effort also has an effect on demand evaluations. In some cases, effort can be viewed as strictly metabolic—as physical demands are placed on metabolic output the total demands are likely to be exceeded. But effort can also relate to strictly cognitive demands. As more information or distraction in the environment is introduced, internal states can be compromised (e.g., cognitive load) and situational demands will be increased, and all else being equal, a person will experience a threat state.

If the *demand* construct was all there was to the theory, the Challenge and Threat model would be closer to Selye's GAS model, which highlighted *stress* factors associated with activation and exhaustion of bodily states. However, even in the presence of elevated demands (e.g., danger, uncertainty, and required effort), increases in *resources* can offset demands and ultimately produce challenge states. These resource factors include but are not limited to *dispositions, knowledge* and *abilities*, and *external support*. Dispositions, such as optimism, control, and self-esteem, can be construed as personal resources that can be brought to bear on a task (see Tomaka & Blascovich, 1994; Seery, Blascovich, Weisbuch, & Vick, 2004). For example, individuals who score high in a *Belief in a Just World* typically experience *challenge* states when exposed to an ambiguous social stressor compared with those low in *Belief in a Just World*, who typically experience more *threat*. How individuals evaluate their knowledge and abilities can influence resources as well, especially when the knowledge is relevant to the task at hand (Blascovich, Mendes, Hunter, & Salomon, 1999). For example, an advanced degree in math during the final *Jeopardy* round would be helpful if the category is Euclidian geometry, less so if the category is Adriatic port cities. In this case, it is anticipated that greater knowledge results in greater evaluated resources. The final identified resource is social support, which can increase feelings of security and hence result in increased perceived resources.

The physiological changes that co-occur with the onset of challenge and threat states have focused primarily on CV changes. Specifically, CV responses exhibited during challenge states tend to be associated with greater SAM activation, thus increasing ventricular contractility, cardiac efficiency, and vasodilation in the arterioles, which provides greater blood flow to the periphery. The CV pattern of reactivity associated with challenge is similar (if not identical) to the pattern-1 (activational) response identified by medical researchers (see Brownley, Hurwitz, & Schneiderman, 2000). Similar to challenge states, threat states also are characterized by an increase in sympathetic activation, but in contrast with challenge states, threat states consist of less efficient cardiac responses and vasoconstriction. Similar to the pattern-2 (inhibitional) response, CV reactivity during threat states is believed to be associated with avoidant and defeat-related motivation (Brownley et al., 2000).

Although challenge and threat can be linked to high "arousal" positive and negative emotional states, respectively, more accurately, the states are proposed as motivational

rather than affective (Blascovich, 2008; Herrald & Tomaka, 2002; Mendes, Major, McCoy, & Blascovich, 2008), and thus are orthogonal to valence. As such, challenge states index approach motivation and not necessarily positive emotion. One implication of this is that approach-negative emotions, such as anger, should be more closely related to challenge than threat.

Table 6.1 presents the psychological states of challenge and threat together with the emotional, motivational, and physiological responses that differentiate these psychological states. Notably, the general profile of threat states, in terms of its physiological concomitants, is considerably more pernicious in the amount of damage the physiological response could enact on the CV system. Indeed, those who experience more *threat* responses compared with *challenge* responses during stressful laboratory tasks show accelerated biological aging measured with *telomerase*, an enzyme that protects chromosomal DNA during replication, which has been directly linked to disease outcomes (see Mendes & Epel, 2009).

Porges' Polyvagal *Theory*

Whereas challenge and threat theory focuses exclusively on differentiating responses associated with SNS activation, there is growing interest in the responses associated with parasympathetic nervous system (PNS) changes and specifically the role of the vagus nerve (also known as "cranial nerve X"), which originates in the medulla oblongata and extends to the face, heart, stomach, and most abdominal organs. One way to examine vagal nerve influences on the heart is by examining variability of the cardiac cycle. Initially, heart rate variability was believed to be a measurement artifact or nuisance, but further exploration into spontaneous changes in the timing of the heart cycle proved to be psychologically and physiologically meaningful. Though disagreements still occur on the specifics related to measurement, quantification, and psychological meaningfulness of vagal tone and cardiac vagal reactivity (see Porges, 2007), these measures might prove to be especially important for social and personality psychologists interested in emotion or mental effort.

One theory that has received much attention in terms of the psychological inferences one can draw from vagal nerve influences is Porges' polyvagal theory (e.g., Porges, 2007). The polyvagal theory specifies that heart rate variability, measured as respiratory sinus arrhythmia (RSA), indexes a specific branch of the vagus, unique to primates and not found in reptiles (but see Grossman & Taylor, 2007), which has evolved as part of the social engagement system. One of the postulates of polyvagal theory is that social factors (affiliation, social engagement, self-conscious emotions), personality factors (pessimism, self-esteem, mindfulness), and clinical factors (depression, autism) can modulate vagal activity.

Specifically, Porges argues that higher RSA at rest (higher cardiac vagal tone) can be used as an index of adaptive emotional regulation and responsiveness to the social environment. Similarly, cardiac vagal reactivity (changes in RSA) might also index appropriate social engagement in that *increased* vagal reactivity during a task might be associated with calmness, equanimity, and a lack of distress.

Though most work has focused on resting cardiac vagal tone and its links to dispositions and responses to social and emotional situations, there is also a growing literature on cardiac vagal reactivity—focusing on RSA changes—and vagal rebound. Vagal rebound is the extent to which RSA responses return to or even overshoot baseline levels after suppression of the vagal brake (i.e., decreases in vagal activity).

Though typically vagal responses have been linked to emotional or attentional processes, a recent theory has linked self-esteem with vagal tone (Martens, Greenberg, & Allen, in press). This theory argues that high vagal tone and high self-esteem buffer individuals from experiences of threat. These researchers then draw specific links to suggest that these two outcomes, high vagal tone and high self-esteem, might be linked. For example, they point out that depression and sadness can co-occur with low levels

Table 6.1 Emotional, Motivational, and Behavioral Responses Associated with Psychological States of Challenge and Threat

Challenge	Threat
Evaluations:	Evaluations:
Resources > Demands	Resources < Demands
Affect:	Affect:
Pride/↑ self-esteem/anger	Shame/anxiety/↓ self-esteem
Autonomic nervous system (ANS) reactivity:	ANS reactivity:
↑ CO (cardiac output)	No change in CO
↑ VC (ventricle contractility)	↑ VC
↓ TPR (total peripheral resistance)	↑ TPR
Behavior:	Behavior:
Open posture, leaning toward approach	Rigid, freeze, withdraw, closed posture, moving away from stimulus, defeat
Recovery:	Recovery:
Quick sympathetic nervous system (SNS) recovery, vagal rebound (parasympathetic nervous system [PNS] activity *overshooting* baseline levels), and quick cortisol recovery	Slow SNS, PNS, and cortisol recovery

Note: ↑ = increases; ↓ = decreases.

of vagal tone, and that vagal nerve stimulation, resulting in an increase in vagal tone, can reduce depressive symptomatology. These authors also present preliminary evidence showing that increases in self-esteem can result in increased vagal reactivity. As intriguing as this theory is, it remains to be seen how strong and specific the relationship is between self-esteem and vagal tone.

Adding some complexity to both polyvagal theory and the link between self-esteem and vagal tone, however, is the nature of the social context and its influence on vagal responses. Indeed, in highly stressful situations or tasks that require some amount of mental attention or effort, one expects a withdrawal of the vagal brake (resulting in lower RSA) to indicate greater attentional control and effort. Indeed, cognitive psychophysiologists have used decreases in RSA as an index of attention or mental effort for several years (Tattersall & Hockey, 1995).

Cacioppo and Colleagues' Doctrine of Autonomic Space

Though most of the psychophysiological theories of the 20th century acknowledged the interplay between sympathetic and parasympathetic branches, these theories treated the relationship between these two branches of the ANS as lying on a single continuum of reciprocity—as one system increased the other decreased. Indeed, the view that these systems have a reciprocal relationship is an enduring myth still promulgated in some physiological textbooks. The psychophysiological team of Gary Berntson, John Cacioppo, and Karen Quigley (1991) argued convincingly against this doctrine, and showed that there were multiple modes of autonomic control and the standard reciprocity principle had limited utility. Their autonomic space model outlined a two-dimensional space that includes the various relationships between sympathetic and parasympathetic responses, which can be reciprocal, uncoupled, or co-activated. This distinction is important for reconciling uncoupled relationships between the SNS and PNS. For example, the orienting response is characterized by cardiac deceleration (increased PNS), pupil dilation (decreased PNS), and increases in electrodermal responses (increased SNS). If the systems were completely reciprocal, there would be great difficulty in explaining reactions to an orienting response.

Understanding the multiple modes of autonomic control sheds light on how situational specificity can differentially influence ANS responding. For example, the orienting response is typically associated with heart rate deceleration. If one examines heart rate during a task designed to be an orienting task and observes no deceleration of heart rate, they might conclude that the orientating response was not present. However, during novel compared with familiar tasks, sympathetic and parasympathetic systems tend to be co-activated rather than reciprocal. Hence, one cannot simply look at the outcome, heart rate deceleration, and conclude that a psychological state was not present. One has to consider both the psychophysiological theory *and* the context of the task, both of which can influence SNS and PNS responding.

The doctrine of autonomic space provides a critical specification of the relationship between the sympathetic and parasympathetic systems. However, the potential exploitation of this model for developing strong inferential psychophysiological theories has yet to be realized. Because of the critical importance of *context* in the doctrine of autonomic space, perhaps future social psychophysiologists will take advantage of this model to develop theories linking psychological states to physiological responses associated with the autonomic space model.

Dickerson & Kemeny's Neuroendocrine Model of Social Evaluative Threat

Returning to the other stress system, the HPA, a recent theory proposes the importance of examining how different social factors and eliciting conditions could activate this system. To examine the sensitivity of the HPA system to various social factors, Dickerson and Kemeny (2004) conducted a meta-analysis of 208 studies that examined cortisol increases in the context of a laboratory stressor to test their *social evaluative threat theory*. This theoretical model specifies that during motivated performance situations (i.e., situations likely to engender SAM activation), specific contextual and experiential factors will activate HPA responses, specifically perceived uncontrollability of the situation and the extent to which the person's social esteem is threatened. *Social evaluative threat* hypothesizes that situations that could possibly lead to failure or loss of social esteem would be more likely to activate the social preservation system indicated by activation of the HPA.

The results of the meta-analysis strongly supported the theory and showed that strong situational effects were related to cortisol increases. When studies examined cortisol changes during passive tasks, even ones with aversive elements such as shock, noise exposure, or watching a scary movie, they did not observe increases in cortisol level; indeed, the grand mean across the studies showed a decrease in cortisol from baseline to after the task when the task was passive (likely representing the circadian decreases of cortisol throughout the day). Also, the presence of a motivated performance situation (i.e., an active task) was not sufficient by itself to increase cortisol responses; again, the grand mean of cortisol changes was less than zero. Instead, when motivated performance situations included an element of *social evaluative threat*—potential loss of social esteem—or

an uncontrollable task, the authors observed significant increases in cortisol. Uncontrollability and social evaluative threat also appeared to have independent and additive effects on cortisol increases, because when these factors were examined collectively, the highest cortisol responses occurred when motivated performance situations included both social evaluative threat and uncontrollability.

Summary

Many of the psychophysiological theories described earlier (a nonexhaustive subset of all such theories) involve the effects and interplay of two neurophysiological systems. In terms of indexing social psychological constructs, research supporting some of these theories measured SAM changes more directly and inferred HPA responses (e.g., challenge and threat theory; but see Mendes, Ayduk, Akinola, & Epel, 2009); other theories measured HPA changes directly and inferred SAM activation (e.g., social evaluative threat). Overall, however, there is much agreement regarding the physiological and biological outcomes when these systems are activated, but the eliciting conditions and psychological states that co-occur or engender these responses are still debated. Table 6.2 organizes the various theories by using the relative activation of the two neuroendocrine systems with the various psychological elicitors.

For example, at high levels of SAM and low levels of HPA activation, the psychological experiences tend to have a flavor of *eustress* and approach-related behavior that might be associated with dominance and control. In contrast, high SAM and high HPA tends to characterize distress and threat, and possibly submissiveness and lack of control. In contrast, the final column identifies high HPA responses with low SAM activation. In laboratory settings focused on human participants, this might be the most difficult combination to study because it requires activation of the more conservative neurophysiological systems (e.g., HPA) without engagement of the SAM activation—in other words, strong alarm signals without the organism trying

to fight, flee, or cope in any active way. This state might be best characterized by defeat or helplessness, which includes stress signals but without behavioral intentions to change or modify the situation or the experience.

USES OF PERIPHERAL NEUROPHYSIOLOGICAL INDEXES IN SOCIAL PSYCHOLOGY

As described earlier, psychophysiology can play important theoretical and empirical roles in social psychology. In the previous section, we described the evolution of social psychophysiological theories. In this section, we focus more on the empirical role of physiological indexes for social psychology, ones that provide valid and powerful empirical physiological indexes of social psychological and related constructs. This focus is not meant to imply that the theoretical and empirical roles are independent; indeed, they are very much related. Nor is our selection of useful peripheral physiological indexes meant to be exhaustive. For example, we did not include important work that has relied on physiological measures in the development of theory such as emotion regulation/suppression, effort mobilization, decision-making processes, self-enhancement, or aggression. Many of these topics are covered in other chapters (e.g., see Bushman, volume 2; Keltner & Lerner, this volume; and Taylor, this volume). In this section, we begin by reviewing intrapersonal processes, such as affect, attitudes, emotion, consciousness, and self-control and self-regulatory processes. We then move to interpersonal and intergroup processes such as social facilitation, social interactions, discrimination, intergroup interactions, and social support processes.

Affect

Among the superordinate constructs central to social psychology is affect. Social psychologists have been concerned with positive and negative affect in many contexts including

Table 6.2 Mental States Associated with Activation of the Sympathetic Adrenal Medullary and Hypothalamic-Pituitary-Adrenal Cortical Axes

SAM: Medium to large increases	SAM: Medium to large increases	SAM: No to small increases
HPA: No to small increases	**HPA: Medium to large increases**	**HPA: Medium to large increases**
Effort without distress	Effort and distress	Helplessness
Challenge	Threat	Defeat
Defense	Self-preservation theory	Withdrawal
Anger	Striving for control	
Being in control	Uncertainty	
	Fear	

HPA, hypothalamic-pituitary-adrenal; SAM, sympathetic adrenal medullary.

attitude, emotion, and well-being. Affect might best be measured using facial EMG, which requires placement of sensors over muscle regions to detect electrical activity to indicate contractions of muscles. With EMG, one of the more useful measures of affect is *startle modulation*, which can provide a powerful and elegant tool to differentiate positive and negative affect.

Startle modulation theory (Lang, Bradley, & Cuthbert, 1990) relies on the observation that most mammals have a strong defensive reflex to a sudden, unexpected sensory event. This reflex takes the form of a full-body startle reflex and can include, but is not limited to, a sudden and strong eye-blink response, retraction of the head, tensing of muscles, and deceleration of heart rate. The sensory events that elicit these responses can be audible, visual, or tactile. It was first noted by Brown, Kalish, and Farber (1951) that animals under threat of attack or pain showed an exaggerated startle reflex.

Capitalizing on this finding and other findings demonstrating potentiated startle responses to negative-affective stimuli, as well as *attenuated* startle responses on exposure to interesting (compared with dull) stimuli, Bradley, Lang, and Cuthbert proposed a model of startle reflex modulation (e.g., Bradley, Cuthbert, & Lang, 1990; Bradley & Lang, 2007; Lang, Bradley, & Cuthbert, 1997). This model examines how concomitant emotional experiences can modulate the startle reflex. Specifically, startle modulation theory posits that because emotions are organized superordinately in terms of affective states, and the startle reflex is a hedonically negative response, when there is a match between superordinate affective states and the hedonic tone of the reflex—that is, negative emotions and defensive responses—the startle response will be potentiated. In contrast, when there exists a mismatch between hedonic tone and reflex, there will be attenuation in the startle response.

Support from this theory comes from a variety of experiments that span clinical science, personality, and social contexts. Methodologically, most research uses the eye-blink response as its primary startle measure most likely because of the ease in which the eye blink response can be measured using *EMG* (recording electrical impulses generated by muscle activity to index the onset, strength, and offset of that muscle activity). To measure the blink response, researchers place two sensors on the *orbicularis oculi* (i.e., the muscle surrounding the eye), typically below the eye, and then present *startle probes* typically in the form of a 95-decibel sound burst. Researchers then measure the magnitude and latency of the eye-blink response. The initial studies looking at the eye-blink response as a result of a startle probe found that the magnitude of muscle activity underlying the startle-blink response was smaller when participants were viewing pleasant pictures compared with

unpleasant pictures. Furthermore, as the normative arousal rating of the pictures increased, the difference between the blink magnitudes was exacerbated, with very pleasant pictures attenuating startle and very unpleasant pictures potentiating blink responses to auditory startles (see Bradley, 2000, for a review).

Measuring affective states using a startle modulation paradigm requires the use of startle probes; however, there are circumstances in which researchers want to glean affective response without using a probe as an elicitor. In these circumstances, we can still look to the face to provide indications of emotional state. One commonly used method to examine more specific emotional responses is measuring changes in specific muscle activation in the face corresponding to *facial expressions of emotions*. Ekman and Tomkins's detailed taxonomy of the facial muscles relating to emotional expressions provides social psychophysiologists a useful map to determine placement of facial EMG sensors to detect small changes in muscles related to positive or negative affect, as well as specific emotional expressions such as disgust and fear (Fridlund & Cacioppo, 1986). Capitalizing on this technique, Cacioppo, Petty, Losch, and Kim (1986) used facial EMG to examine affective responses to valenced stimuli that differed in intensity. Muscle region activity differed by valence and intensity: Brow muscles responded to negative stimuli, whereas cheek muscles showed greater activity to positive stimuli. Some evidence also existed that intensity of stimuli was monotonically related to targeted muscle activity: *moderately* negative stimuli produced more corrugator activity than *mildly* negative stimuli. Importantly, the muscles activated were so small that when observers examined the videotaped responses of participants, they could not detect muscle movement that facial EMG detected.

Attitudes

Much of social psychological research has been devoted to the role of attitudes. Indeed, in the *Journal of Personality and Social Psychology*, social psychology's top-tiered journal, one-third of the journal space is dedicated to attitudes and social cognition. Here, we illustrate what psychophysiological and embodiment theory and methods have brought to bear on our understanding of individuals' evaluation of the positive or negative qualities associated with an entity.

Assessing attitudes or evaluations associated with attitudinal objects seems like a relatively easy task to accomplish—simply ask people what they like or dislike. However, much attitude research is replete with problems associated with this seemingly straightforward

technique, some of which we have already described: demand characteristics, social desirability, need for introspection, and online continuous recording. Indeed, this last obstacle, obtaining online changes in attitudes, has been addressed using nonphysiological solutions. During election seasons, a ubiquitous sight on television coverage of presidential debates is a continuous, online, horizontally scrolling waveform that represents shifts in viewers' attitudes during the candidates' answers and comments. Such "audience response systems" allow observers to track how viewers are feeling at any given moment toward a candidate's speech. Though such online devices represent prodigious leaps in advancing election research, they still suffer from at least two intractable problems. First, respondents can still mask their "true" attitudes, indeed even deliberately overcorrecting by indicating that they are more (or less) persuaded than they actually are (Mendes & Koslov, 2009). The second problem is that participants have to continuously introspect about how they feel so that they can indicate their attitudes. It is unclear what the process of conscious introspection does, and indeed, the data are equivocal on this point (e.g., Lieberman et al., 2007). Both of these problems can and have been overcome with the use of peripheral psychophysiological methods in attitude research.

Although early on attitude researchers attempted to use heart rate and skin conductance changes as indexes of attitudes, these endeavors were inherently flawed and made little progress (e.g., Rankin & Campbell, 1955). This is not surprising given that, as described earlier, changes in heart rate are multiply determined and skin conductance changes can be brought on by multiple psychological states that are not necessarily valenced and, as such, provided weak inferences of attitudes. This does not mean that more complex ANS measures are inappropriate for studying attitudes (as we will review later). However, the most successful psychophysiological indexes of attitudes have capitalized on facial EMG and startle modulation, both of which provide information along valence and intensity dimensions.

Facial Electromyography

In the late 1990s, Vanman and his colleagues exploited facial EMG to test subtle affect changes on exposure to White and Black target faces with the expressed motive of imagining completing a cooperative task with the target person (Vanman, Paul, Ito, & Miller, 1997). Across three studies, Vanman and colleagues found that White participants displayed more negative affect (a composite of corrugator [brow] and zygomaticus major [cheek] activity) when exposed to Black targets compared with White targets. In addition, they found that at greater levels of explicit racial bias (measured with the Modern Racism

Scale), activity around the brow muscles increased when exposed to Black targets relative to White targets. Measuring facial muscles was especially informative in this research because the physiological measures "told" a different story than the self-reported measures. In all three studies, participants' self-reported liking of Black targets was greater than their reported liking of White targets.

A subsequent examination of affect measured with facial EMG underscored the predictive validity of these measures (Vanman, Saltz, Nathan, & Warren, 2004). In this study, participants chose one of three students for a prestigious teaching award. The students' pictures (two White and one Black students, same sex as the participant) were presented together with other favorable information in a folder. The students were later recruited for a second "unrelated" study in which their facial EMG was recorded while simply looking at White and Black faces and evaluating how friendly they appeared. They found that facial muscle activity predicted the race of the candidate chosen. Specifically, when participants showed more cheek activity to White over Black faces, they were more likely to choose a White candidate. When no detectable cheek bias was present (responses to White and Black faces were not different in terms of the activity at the zygomaticus major muscle), participants were more likely to choose the Black candidate.

Racial attitudes were also the focus of a study using startle responses on exposure to ingroup (White) or outgroup (Black) targets (Amodio, Harmon-Jones, & Devine, 2003). Unlike the previous studies, individual differences in attitudes were measured with a standard questionnaire, then each participant's startle-blink response was measured and used as an indication of their automatic evaluation of the target. This investigation also manipulated the latencies of the startle probe with the justification that at shorter latencies (400 ms) between target presentation and startle probe, controlled processes could not be used and only automatic attentional responses would be observed. In contrast, at longer latencies between target and probe (4000 ms), controlled processes are theoretically available and, consequently, a different pattern of eye-blink responses were predicted that captured affective responses. In the longer latency conditions, participants' racial bias predicted startle responses. Specifically, for those who internalized their motivation not to be prejudiced and were not concerned with external pressure to appear unprejudiced, there were no differences in startle responses to White or Black faces. However, for those lower in internal motivation not to be prejudiced or high on both motivations, startle responses were greater to Black faces than to White faces.

These examples focus on affective responses that might be influenced or shaped by particular attitudes one holds.

What is the effect of processing new information for attitudes that are not well developed? Bombarded with information from our social world, we often have to process multiple sources of information. Information that is easy to process is liked more. Consider the two sentences, "Stormy seas tossed the *boat*," and "Stormy seas tossed the *lamp*." Not surprisingly, the former is pronounced faster and judged more pleasant than the latter. Similar to the *mere exposure effect* (exposure to a target can increase liking for it), liking of target objects can be increased by familiarity, which makes targets easier to process. Winkielman and Cacioppo (2001) tested their hedonic fluency model, which is the idea that processing ease is associated with positive affect regardless of the valence of the judgment context (i.e., focusing on positive vs. negative evaluations). In their first study, they presented neutral line drawings and had participants rate whether they liked or did not like the drawing (unipolar ratings of affect) while they measured facial EMG linked to positive and negative affect, specifically zygomaticus major activity (positive affect) and corrugator supercilii activity (negative affect). They also manipulated whether a subliminal prime (16 ms) presented just before the target object matched the configural display of the target stimulus. Consistent with their hedonic fluency model, zygomaticus activity was greater when the prime matched the target outline and when participants were focused on positive evaluation. Self-reported liking of the targets was also greater in this condition.

In study 2, instead of subliminally priming matched or mismatched figures, they increased presentation time in 200-ms intervals—a duration time imperceptible to participants—so that target pictures were presented at 300, 500, 700, or 900 ms. Also, instead of unipolar ratings of evaluation, all participants completed bipolar ratings of liking. Again, target pictures that were easier to process—that is, those that were presented at the longest durations—resulted in more zygomaticus activity compared with pictures presented for briefer duration. Taken together, these studies support the idea that targets that are easy to process are associated with positive affect.

Cardiovascular Patterns

Covertly measuring attitudes with physiological responses, specifically facial muscles and the startle response, has revealed complex relationships between attitude intensity and valence, and how they are related to self-reported attitudes. However, there is also the interesting and long-lived question of the function of attitudes. Fazio (1989) argued that the chronic accessibility of an attitude from memory determines the power and attitude functionality. Therefore, well-established or rehearsed attitudes function to ease decision making, and when attitudes are not effortlessly and chronically accessible, quick decision making is difficult and potentially "stressful."

To explore the idea that attitude accessibility reduces distress during decision making, researchers examined CV responses during quick decision-making trials as a function of chronically accessible or inaccessible attitudes (Blascovich et al., 1993). Attitudes were induced experimentally by having participants rehearse their attitudes to a series of abstract paintings by stating their degree of liking for each painting aloud. After the rehearsal task, participants performed a rapid pairwise preference task during which they had to choose which of two paintings they preferred in a repetitive forced-choice task. The participants had been randomly assigned to making these rapid pairwise judgments between pairs of the familiar paintings for which they had well-rehearsed attitudes or between pairs of paintings they had not seen before. Physiological responses showed greater sympathetic activation during decision making when participants did not have well-rehearsed attitudes and little to no increases in sympathetic activation when participants had well-rehearsed attitudes. A physiological interpretation of these findings is that when a well-rehearsed attitude is available to the person, the body does not have to mobilize responses to cope with the potentially stressful rapid pairwise preference task. Instead, the body can maintain homeostasis during the quick decision-making task.

Emotion

Lay theories and observations abound regarding how our bodies respond to emotional states: hearts pound with fear, skin burns with anger, palms sweat from anxiety, and cheeks turn red from embarrassment. Indeed, the relationship between bodily changes and emotional responses seems so inextricably linked that William James stated, "The only emotions I propose expressly to consider here are those that have a distinct bodily expression" (1884, p. 189). Given what appear to be strong links between emotional states and bodily changes, one would think that linking discrete emotional states to patterned physiological responses would be a relatively easy endeavor. Unfortunately, emotion-specific ANS profiles have proven quite elusive.

In more modern times, Levenson, Ekman, and their colleagues (Ekman, Levenson, & Friesen, 1983; Levenson, Ekman, Heider, & Friesen, 1992) led the way in exploring the link between specific emotions and distinct changes in the ANS. In an early article (Ekman et al., 1983), they argued that specific ANS changes would result from the experience of discrete emotions. Empirically, these researchers attempted to manipulate specific emotions

using two techniques. One, the *directed facial action task*, required participants to isolate and manipulate specific facial muscles until the facial expression associated with a discrete emotion was formed. Participants were then instructed to maintain these facial expressions while ANS responses were recorded. Their rationale was based on embodiment notions (see earlier), similar to the facial feedback hypothesis (Strack et al., 1988), which argues that the manipulation of specific facial muscles linked to happiness (e.g., zygomaticus major muscle region), for example, can subsequently engender more happiness. More specifically, if somatic embodiment informs emotional experience, then posed facial expressions linked to emotions should increase the target emotion that, in turn, should elicit specific patterns of autonomic responses (see also Adelmann & Zajonc, 1989). The second technique Ekman, Levenson, and colleagues used to engender emotion was the relived emotional experience task, in which participants are asked to imagine specific emotion-eliciting events while peripheral changes in ANS are recorded.

Based on Ekman's distinctions of *basic* emotions, Levenson, Ekman, and colleagues (1992, 1993) focused on surprise, disgust, sadness, anger, fear, and happiness, and measured a variety of ANS responses. Results showed some support for ANS differences in discrete emotions, especially from responses during the posed facial expressions. Specifically, emotional manipulations of happiness, disgust, and surprise resulted in lower heart rate; fear and sadness were associated with higher heart rate and lower skin temperature; and anger was associated with higher heart rate and higher skin temperature.

To determine some degree of the *universality* of discrete emotions influencing patterned ANS responses, Levenson and colleagues trekked to a remote region of West Sumatra to examine whether people in a non-Western culture, specifically the Minangkabau, exhibited similar patterns of ANS responses to posed facial expressions as Westerners (Levenson et al., 1992). Indeed, patterns of ANS responses after discrete posed expressions were similar for the Minangkabau to those observed in the United States. These researchers viewed this evidence as support for the idea that ANS responses to specific emotions were universal.

Since these early studies, many other researchers have taken up the challenge and investigated the possibility that discrete emotions might be characterized by specific patterning of ANS responses. Cacioppo and colleagues conducted a meta-analysis and performed subsequent updates on the meta-analysis for editions of *Handbook of Emotions* (Cacioppo, Bernston, Klein, & Poehlmann, 1997; Cacioppo, Bernston, et al., 2000). Though the meta-analytic evidence showed some patterns of emotion

specificity—for example, heart rate responses tended to be greater for anger than happiness—commonalities in autonomic responses across specific emotions were also observed that were predictable by common emotion valence and underlying motivation.

For example, Cacioppo and colleagues (1997, 2000) reported stronger ANS changes during negative than positive emotions, and differential patterning for approach compared with withdrawal emotions. The emotion elicitation technique also might have mattered. Consistent with Obrist's (1981) distinction between passive and active coping situations, relived emotional experiences, a passive task, was an especially poor manipulation for revealing ANS patterns of emotion specificity. Furthermore, facial muscle manipulation might reliably influence cognitive components associated with emotion, but might be too weak and passive to reliably influence somatovisceral changes.

In a landmark study, Stemmler (1989) investigated emotion-specific ANS responses using a multitrait multimethod approach to examine convergent and discriminant validity. In one of his first studies, female participants *experienced* or *imagined* two target emotions: fear and anger. To manipulate the experience of fear, researchers had participants sit in a room in which the lights were dimmed, a warning was heard that "something will happen that is out of your control," and participants then listened to Edgar Allen Poe's "The Fall of the House of Usher," which was mixed with dramatic music (Prokofiev's *2nd Symphony)*. The fear induction ended with an unexpected darkness for 1 minute. To manipulate imagined fear, researchers asked participants to first recollect and then speak about a frightening life episode. The critical *imagined* phase occurred after the speech when participants were instructed to imagine their speech vividly with their eyes closed. To manipulate the experience of anger, researchers required participants to solve a series of anagrams during which an experimenter interrupted them and aggressively stated that they were not speaking loud enough. The experimenter interrupted a second time with a brusque "Louder please!" and then a third interruption "Can't you speak up?" The imagined anger phase was similar to the imagined fear in which participants first spoke about an "annoying life episode"; then for the critical *imagined* phase, participants sat quietly with their eyes closed and imagined their story vividly.

Stemmler found that self-reports of emotional states were consistent across contexts (imagined or experienced). However, distinct ANS responses associated with specific emotions occurred only in the experienced condition. In the imagined condition, discrete emotions resulted in similar physiological changes. One explanation of these findings follows from Obrist (1981), who suggested that cardiac and

vascular changes associated with active tasks are likely to result in more ANS specificity, whereas passive tasks are unlikely to produce patterned responses. A second possible explanation is that the intensity of the emotional experience drives the ANS patterning.

Subsequently, Stemmler, Heldman, Pauls, and Scherer (2001) again compared experienced versus imagined emotions, and again focused on fear and anger, but this time they introduced a "control" condition that consisted of informing participants of everything that would happen in the emotion eliciting conditions *before* induction. In other words, participants experienced the context exactly the same as in the *experienced* condition, but they were fully informed of all elements before the emotion-eliciting tasks. Based on their model of *context-deviation specificity*, they argued that it is necessary to partition the effects associated with the metabolic demands needed to complete the task from the effects of experiencing the emotions. In this study, they examined self-reported emotional responses and 29 physiological responses (all somatovisceral) during fear and anger inductions that were either experienced or imagined. Consistent with previous research, imagined emotions tend to produce much less ANS differentiation than experienced ones. Also, informing participants of the nature of the upcoming manipulation before it reduced both the self-reported experience of the emotion and somatovisceral responses relative to the experimental conditions. Finally, experienced fear and anger did show *some* differentiated ANS responses, though these differences might have resulted from underlying motivation that differentiates anger from fear.

Although the search for ANS differentiation of discrete emotions has yet to produce reliable findings, many proponents of embodied emotion specificity simply claim that the reason we have yet to observe reliable differences of biological responses of emotion specificity is that we have not used the right tools. This perspective is based on the expectation that advances in neurophysiological measurement techniques will eventually reveal clear and persistent differences in emotions. Whether this claim is eventually supported or rejected remains to be seen (see Kemeny, 2003; Panksepp, 2007; cf. Barrett et al., 2007).

Consciousness

The meaning of consciousness has been debated for thousands of years, and little consensus exists. What consciousness is, or consists of, is sometimes called the "hard consciousness problem" (Chalmers, 2007). Distinguishing among processes that are unconscious (also known as "subconscious," "preconscious," or "automatic" mental processes), conscious (also known as "first order thought" processes; e.g., a

person's awareness of actually running), and metaconscious (also known as "higher order thought" processes, such as thinking about thinking or experiencing experience; e.g., a person's wonderment at their awareness of running) exemplifies what is known as "the easy" conscious problem.

Importantly, metaconsciousness, an explicit type of higher order thought (Smallwood & Schooler, 2006), provides humans with the ability to interact mentally not only with others but also with themselves. Theorists at least since James have argued that we have many social selves and these reflect the input of others' views of us (cf. Cooley, 1902). More than seven decades after James, Erving Goffman expanded James's notions in his *Presentation of Self in Everyday Life* (1959).

During the first three quarters of the 20th century, social-psychological aspects of consciousness were examined nearly exclusively by sociologists and sociological social psychologists. However, in the late 1970s and early 1980s, social psychologists took up the challenge. Work by Nisbet and Wilson (Nisbet & Wilson, 1977; Wilson & Nisbet, 1978), Schneider and Shiffrin (1977), and Bargh and colleagues (e.g., Uleman & Bargh, 1989) approached some of these issues directly. The published debate (1984) in the *American Psychologist* between Richard Lazarus and Robert Zajonc on the primacy of affect versus cognition highlighted the conscious-unconscious distinction in social psychology. During the ensuing quarter century, social cognitive psychologists (e.g., Uleman & Bargh, 1989; Wegner, 2002) verified the important roles played by unconscious or automatic processes in social behavior. Such work is discussed more fully in other chapters of this handbook (Dijksterhuis, chapter 7).

In terms of social neuroscience, most neurophysiological work attempting to distinguish conscious from unconscious processes has focused on the brain (cf. Gazzaniga, Ivry, & Mangun, 2002). Also, there is much in the literature hypothesizing and demonstrating unconscious relationships between psychological factors, including social psychological ones, and peripheral physiological states related to health (e.g., Ader & Cohen 1975, Friedman & Rosenman, 1974). However, relatively little attention has been paid directly to the relationships among peripheral physiological activity, social psychological stimuli, and the simple consciousness problem. However, some efforts have been worth noting.

Misattribution of Arousal

Perhaps the most frequent incursion, albeit most likely unwittingly, within social psychophysiology into the realm of consciousness research (i.e., on the simple consciousness problem) fits within the general rubric of "misattribution of arousal," a descriptor stemming from Schachter's

(1964) two-factor theory of emotion and empirically on Schachter and Singer's (1962) and others' experiments (for a review, see Cotton, 1981). Unlike embodiment theory, in which proponents do not stake a claim to conscious influence of proprioceptive and interoceptive experiences, misattribution of arousal theory proponents tends toward a claim of conscious awareness (cf. Schachter & Singer, 1979, but see Valins, 1966) of phasic, increased neurophysiological activity (i.e., nonhomeostatic bodily states), with little or no consciousness awareness of its cause. According to most versions of relevant misattribution theories, residual arousal stemming from some prior event or context has an effect on the current context that may (e.g., Schachter & Singer, 1962; 1979; Zillman & Bryant, 1975) or may not be conscious (e.g., Nisbett & Wilson, 1977). Importantly, with few notable exceptions (e.g., Zillmann & Bryant, 1975), few of the studies testing misattribution of arousal theories have actually assessed physiological responses. Indeed, as Cotton (1981) has written, few have even assessed participants' awareness of increases in physiological activity.

"Unconscious" Stimuli

In more recent work, social psychophysiologists have examined the effects of unconscious or subliminal stimuli on motivational states during performance situations (Dijksterhuis, this volume, chapter 7). In two experiments, Weisbuch-Remington, Mendes, Seery, and Blascovich (2005) subliminally presented (i.e., < 20 ms) positive and negative Christian religious icons (e.g., angels, devils) outside of participants' conscious awareness. During a potentially threatening speech task that immediately followed the stimuli presentations, Christian, but not non-Christian, participants exhibited patterns of CV responses consistent with challenge and threat motivational states (see earlier), particularly when the speech topic required participants to reflect on their own mortality. Nonreligious icons did not influence Christian participants, and Christian icons did not influence non-Christian participants' CV responses. One can conclude from this study that meaningful unconscious stimuli can affect motivational states, and the *appraisal* process that precedes challenge and threat responses does not require conscious awareness of resources.

Consistent with the idea that many thoughts and emotions lie beyond individuals' ability to consciously reflect on them but can still influence behavior is work by Bechara and colleagues (Bechara, Damasio, Tranel, & Damasio, 1997). These investigators measured skin conductance responses (SCRs; a change in the amount of sweat in the *eccrine* glands) while participants engaged in a decision-making task ("Iowa gambling task") involving

the blind selection of the top card from one of four decks of facedown cards. Depending on the card turned up on each trial, participants could either win or lose a lot or a little bit of money. The decks differed in their proportions of gain and loss cards, with two decks providing big gains, but also big losses, and the other two decks providing smaller gains, but also smaller losses. Overall, the two latter decks provided the optimal choice in terms of money won. Participants' self-reported "hunches" regarding the biased nature of the decks of cards began to develop by the 50th trial (for non-brain-damaged participants). However, SCRs related to the biased nature of the decks typically occurred by the 10th trial, thereby preceding conscious awareness by approximately 40 trials. Specifically, SCRs suggested an intuition of an impending loss as their hand reached out to the decks with the higher probability of loss before participants' conscious awareness or hunches of them.

Self-Control and Self-Regulatory Processes

Self-regulation is especially well suited for physiological investigation. The capacity for self-regulation appears to be a limited and consumable resource, such that one act of self-control reduces one's subsequent self-control (Baumeister, 1998). Self-regulation is thus vulnerable to fatigue, and as demands on the executive self increase, one is more likely to experience failures of self-regulation: inability to remain vigilant about the status of one's goals and to inhibit one's prepotent responses. But what are the underlying mechanisms of self-regulation and loss of regulatory strength, and what can peripheral physiology tell us about self-control and loss of control?

Goal setting and self-enhancement are often considered in the framework of self-regulatory tasks. Some of the questions from this line of research include: Do self-enhancement strategies promote achievement? Are subtle exaggerations of our accomplishments deliberate obfuscations to convince others that we are better than we know ourselves to be, or can these exaggerations signify an optimistic projection of future goals? This question has been explored by examining responses associated with exaggeration, specifically focusing on emotional composure (assessed with parasympathetic activity). In previous studies, roughly 50% of students exaggerated their grade point averages (GPAs), and these students tended to improve academically more than those who did not exaggerate (Willard & Gramzow, 2009). Was this exaggeration a form of implicit goal setting, or was it simply a form of anxious repression? To examine this, Gramzow, Willard, and Mendes (2008) measured RSA reactivity to differentiate anxious orientation from motivated goal setting. In this study, participants

first reported their GPA and course grades in private and then met with an experimenter to review their academic history. During this interview, the participant's electrocardiogram (ECG: the electrical signal of the heart cycle) and respiration were recorded. The investigators found that the more participants exaggerated, the greater the increase in RSA from baseline to interview. This pattern suggested that participants who exaggerated their GPA were not anxious about their exaggerated standards and may have a positive orientation toward the academic domain. Converging evidence from nonverbal behavior coded during the interview revealed that exaggerators appeared composed rather than anxious. In addition, those who had greater increases in RSA when discussing their (exaggerated) GPA tended to improve their academic performance in a subsequent semester, suggesting emotional composure (and possibly RSA itself) as a possible mediator for why implicit goal setting results in improved performance.

Interpersonal Processes

It is fair to say that since the late 1970s, social psychological experiments that involve actual interaction between two individuals, let alone among more than two, occur relatively rarely, and many of those that do involve a confederate as one of the interacting parties (Baumeister, Vohs, & Funder, 2007). Social psychophysiological experimentation involving actual interaction is rarer still and work involving CNS measures even more so. There are several reasons for this paucity including a focus more on social cognitive processes; the time and work associated with developing actual interaction scenarios and procedures; the use of proxies for interactants including vignettes, audio and video recordings, and confederates; the near abandonment by experimental social psychologists of small-group research to scholars in other disciplines; and expense. The latter factor is even greater in studies that involve the relatively higher expense of taking neurophysiological measures, especially CNS measures.

Nonetheless, some social psychophysiologists have persisted in creating experiments in which actual social interaction occurs while assessing peripheral neurophysiological indexes. Here, we look at some of the latter with a focus, first, on basic interpersonal social influence processes including social facilitation, social comparison, and social support, and second, with a focus on intergroup interactions including stigma, stereotypes, and discrimination.

Social Facilitation

Triplett (1898) is usually credited with reporting the first experiment in modern social psychology (cf. Allport, 1954; Gardner, Gabriel, & Diekman, 2000). Triplett's identification of the influence of the physical presence of others on an individual's behavioral performance gave rise to perhaps the most basic of all interpersonal effects, social facilitation and its subsumed counterpart, social inhibition.

Social facilitation and inhibition refer to the enhancement and impairment of performance, respectively, brought on by the presence of others whether mere observers or co-actors. This seemingly simple consequence of the presence of others (i.e., an audience) on actors has been examined and reexamined for more than a century, producing nearly 300 published articles including many more experiments and more than a half-dozen theoretical accounts (see Bond & Titus, 1983; Kent, 1994; Sanders, 1984, for reviews).

Triplett (1898) reported a naturalistic observational study and a controlled experiment exploring social facilitation effects. The former described his observation that competitive cyclists raced faster against other cyclists than against the clock. The controlled experiment included children spinning a fishing wheel-like apparatus either alone or in co-action with other children. Supporting the social facilitation hypothesis, 50% of the children performed faster in the coaction condition, whereas 25% performed about the same and 25% performed worse in the presence of the coactors than alone. That is, Triplett found both social facilitation (i.e., performance enhancement) and social inhibition (i.e., performance impairment) effects. Over the years, research indicated that co-actors were unnecessary for social facilitation and inhibition effects to occur, only the presence of others proved necessary (Kent, 1994).

Working independently, Thibaut and Kelly (1959) and Zajonc (1965) introduced the concept of physiological arousal as a major motivational factor in their theoretical accounts of social facilitation/inhibition effects. Zajonc, for example, postulated that the presence of others increases arousal that, in turn, facilitates dominant responses and inhibits nondominant responses that lead to improved performance on simple or well-learned tasks and decreased performance on complex or novel tasks. Based on this notion of arousal (one that is at best metaphorical in nature; cf. Carver & Scheier, 1981; Sanders, 1981), many investigators have measured unitary physiological responses (falsely positing or implicitly assuming that autonomic measures were interchangeable) in social facilitation studies. However, Bond and Titus's meta-analysis (1983) reported that there were only weak effects on palmer sweating (e.g., galvanic skin response), leading Cacioppo and Petty (1984) to conclude that more sensitive physiological measures were needed.

Based on the biopsychosocial model of challenge and threat motivation (Blascovich, 2008; Blascovich & Mendes, 2000; Blascovich & Tomaka, 1996), Blascovich, Mendes, Hunter, and Salomon (1999) undertook Cacioppo and Petty's (1986)

prescription for more valid and sensitive physiological measures to untangle the role of peripheral physiology in social facilitation processes. They reasoned that the presence of others during a person's performance increases the self-relevance of task performance and increases task engagement for that performer. If the performer evaluates his or her resources as overcoming the task demands, he or she will be challenged during the task. If the person does not make such an evaluation, he or she will be threatened. Hence, a well-learned task should lead to challenge and better performance, and a novel task should lead to threat and worse performance.

The researchers tested these hypotheses in a 2 (presence of others: audience vs. alone) by 2 (task mastery: well learned vs. unlearned) completely randomized experimental design. In the first phase of the experiment, participants practiced one of two randomly assigned moderately difficult categorization tasks until they reached a proficiency criterion of 80% correct on consecutive blocks of task trials. In the second phase, participants went on to perform either the learned or unlearned task (randomly assigned) in the presence of others (i.e., a male and a female observer) or alone.

The physiological results (specifically, increased ventricular contractility and heart rate) indicated that participants who performed either the well-learned or novel task with the audience were more task engaged during the task than those performing alone. Furthermore, participants performing the well-learned task with an audience exhibited challenge responses (specifically, increased cardiac output and decreased peripheral vascular resistance), whereas participants performing the novel task exhibited threat responses (specifically, decreased cardiac output and increased peripheral vascular resistance). Behavioral results were consistent with social facilitation theory: Participants performing the well-learned task in the presence of others performed better when being watched than alone, and those completing the novel task performed worse when being watched compared with being alone.

This study adds substantially to our knowledge of social facilitation effects. Theoretically, the authors suggest that heightened self-relevance and its ensuing task engagement brought on by an audience has much to do with an individual's evaluations of his or her own resources to meet the demands of a performance situation. Methodologically, this study illustrates the value of using peripheral neurophysiological markers consisting of patterns of physiological responses to test predictions regarding *arousal* as a likely mediator of cognitive-behavioral effects.

Social Support

Humans are gregarious, at times seeking out and at other times providing support to each other, especially during times of actual or potential emotional distress, be it due to loss, infirmity, or performance. Furthermore, it is assumed that, in general, social support provides health-promoting effects, in part, by buffering acute and chronic stress responses (Uchino, Cacioppo, & Kiecolt-Glaser, 1996). For example, classic studies (e.g., Glaser, Kennedy, Lafuse, & Bonneau, 1990; Kiecolt-Glaser, Speicher, Holliday, & Glaser, 1984) have shown that compared with gregarious ones, lonely medical students exhibit greater decreases in immune functionality.

Individuals who provide social support to others also benefit from receiving social support themselves. For example, caregivers of patients with Alzheimer disease (Kiecolt-Glaser, Dura, Speicher, Trask & Glaser, 1991) or patients with cancer (Baron, Cutrona, Hicklin, Russell, & Lubaroff, 1990) who lack social support are more likely to be immune suppressed than caregivers who receive social support themselves.

Positive effects of social support on physiological activity appear to operate largely within the domain of emotional support. Gardner et al. (2000) suggest two mechanisms by which the chance to discuss a stressful emotional situation may help the support target. First, the chance to discuss one's distressful emotional state may cause a more benign reappraisal of the situation (cf. Tomaka, Blascovich, Kibler, & Ernst, 1997) and decrease the likelihood of pathophysiological response patterns. Second, the chance to discuss one's problems provides the substantial benefits of confiding in others (cf. Pennebaker, 1989), and both reappraisal and confiding may interact in a synergistically beneficial way.

The plausibility of both of these mechanisms is reinforced in studies in which others were present but without opportunity to provide emotional support, and hence, the possible benefits of reappraisal or confiding in others, or both, were absent. For example, Allen, Blascovich, Tomaka, and Kelsey (1991) measured autonomic responses (i.e., skin conductance, systolic and diastolic blood pressure, and heart rate) in middle-aged women during a stressful serial subtraction task in the presence of no supportive other, their best female friend, or their beloved pet dog (the experimenter was present in all three conditions). Friends were instructed not to talk or touch the participant, and petting the dog was not allowed. In the presence of their best female friend, autonomic reactivity was significantly greater on all measures compared with the presence of the experimenter and the pet dog. Indeed, the mere presence of the dog was associated with significantly lower autonomic reactivity during the serial subtraction task for participants than either of the other two conditions. Later, Allen, Blascovich, and Mendes (2002) replicated these findings with 240 male/female married couples in the presence of

no one, their spouse, their pet dog or cat (for pet owners), their best friend (for non-pet owners), their spouse and pet (for pet owners), and their spouse and best friend (for non-pet owners). Again, they found greater reactivity in the presence of the human friend or spouse and lower reactivity in the presence of the pet.

The higher reactivity in the friend/spouse conditions of the Allen et al. (1991) study can be contrasted with a study reported by Kamarck, Manuck, and Jennings (1990) in which half the participants were accompanied by a supportive other (i.e., a personal friend). Because the supportive others in that study were instructed to silently cheer the participant on, gently touch the participant's wrist, and wore noise-abating headphones, they could not *evaluate* participant, which is the likely reason the authors found a *reduction* in CV reactivity when the participant's friend was present.

That the pets had a lowering effect on autonomic reactivity in both of Allen et al.'s studies (1991, 2002) provides additional support for the reappraisal mechanism, albeit perhaps an unconscious one. More specifically, the presence of the dog or cat for pet owners may provide a sense of security or positive affect, or both, that minimizes the psychological danger of the situation, thereby resulting in more challenge rather than threatening appraisals (cf. Blascovich & Mendes, 2000).

On the other side of the social support coin is the extent to which people lack social networks or have a sense of being *lonely*. Cacioppo and his colleagues have studied loneliness and its far-reaching and profound effects on physical health, primarily by looking at physiological responses that are concomitant with loneliness as a way to determine how loneliness gets under the skin to influence health (Cacioppo et al., 2002; Cole, Hawkley, Arevalo, Sung, Rose, & Cacioppo, 2007; Cacioppo, Hawkley, & Bernston, 2003). This group has shown in various settings that individuals reporting greater levels of loneliness are more likely to show lower cardiac output (less efficiency of the heart) and higher vascular resistance (more constriction of the blood vessels) than individuals reporting lower levels of loneliness. This effect has been found in both laboratory-based settings in response to social evaluation and field studies using ambulatory impedance and blood-pressure devices. In the field study, because of lack of ability in determining whether individuals were actually in a *motivated performance situation*, the authors interpreted these profiles as indicating passive versus active coping styles (Sherwood, Dolan, & Light, 1990), with lonely individuals adopting more passive coping styles within the context of their day. Adding causal evidence to the deleterious effects of loneliness, Zadro, Richardson, and Williams (2005) examined social isolation with an ostracism manipulation and found that the experience of ostracism brought on CV changes consistent with *threat* states.

In sum, the effects of social support (or lack of it) on physiological response patterns associated with ill health and motivational threat are somewhat complicated. The nature of the social support provider, the substance of the support, and the context all matter.

Intergroup Interaction

The use of psychophysiological theory has been especially useful for social psychologists interested in studying social interactions with stigmatized or racial outgroup members because of increased impression management concerns that can influence self-report and deliberate behavioral responses during such interactions. Though there are several early examples of attempts to find physiological differences on exposure to ingroup versus outgroup members (e.g., Rankin & Campbell, 1955), these early investigations were based on putative measures of general "arousal" (e.g., heart rate and skin conductance) in fairly unconstrained settings, thus lacking specificity and inference power (see also Gaertner & Dovidio, 1977; Vrana & Rollock, 1998). It should not come as a surprise (given the discussion in the early sections of this chapter) that these investigations revealed few, if any, differences between individuals interacting with outgroup or ingroup members. It was not until social psychophysiologists paid attention to the specificity and inferential quality of their measures and/or constrained the context that their research endeavors proved to be fruitful.

By constraining the emotional context, specifically to a fear conditioning paradigm, Banaji and her colleagues examined whether individuals might be evolutionarily "prepared" to fear outgroup members (Olsson, Ebert, Banaji, & Phelps, 2005). In this study, electric shocks were paired with either ingroup or outgroup male faces. Electrodermal activity was measured to indicate changes in sympathetic activation, as evidenced by the amplitude of the SCRs in response to the pictures. In the learning phase, the shock (UCS) was repeatedly linked with the ingroup or outgroup picture (CS). Later, the shock was removed and SCRs were examined on exposure to the CS. The critical examination was the length of extinction, or how long it took participants to no longer show a SCR to the CS once the aversive element was removed. Indeed, when shocks were paired with outgroup faces compared with ingroup faces, SCRs persisted longer and were of greater magnitude in the extinction phase. In this example, SCRs could be interpreted as fear responses because the context was constrained to a fear-eliciting (shock) situation.

In a subsequent extension of this work, Navarette and colleagues (2009) tested the boundary conditions of this work within the theoretical context of the subordinate

male hypothesis (Sidanius & Pratto, 2004), which takes an evolutionary perspective on intergroup conflict suggesting that racial tension should be especially pronounced among men and not women. These researchers replicated the Olsson study discussed earlier with one additional factor: the gender of the people depicted in the pictures. The subordinate male hypothesis would predict that only male faces would produce the effect observed in the original study, and that outgroup female faces would not show a sustained fear response during the extinction trials. Consistent with the theory, results showed that SCRs persisted longer to outgroup male faces than any other condition (outgroup female, ingroup male, ingroup female).

Group boundaries and social categories of race, gender, class, and so forth are mutable and can be influenced by presence of other more distinct outgroups or by context. One might not think of their gender category while sitting in the audience listening to a symphony, but might be acutely aware of their gender category if they are in the numerical minority at a boxing match or a fashion show. In academic environments, subtle and not so subtle cues regarding one's status might influence one's feelings of acceptance and expected performance. For example, if there was only one women's restroom in an entire building dedicated to math, but six men's restrooms, a female math major might be reminded on a daily basis that she was in the numerical minority. What are the effects for these environmental cues that remind some that they are not part of the majority? A study from Stanford University explored how environments based on the imbalance of males to females influenced SNS responses (Murphy, Steele, & Gross, 2007). In this research, male and female participants viewed one of two videos that presented either a gender-balanced group of students or a gender-unbalanced (mostly white males) group of students in the domain of a math and engineering science camp. Changes in SNS activation (especially skin conductance levels) from a baseline period to watching the videos were computed. The investigators found that women showed greater increases in SNS activation when watching the gender-unbalanced video than when watching the gender-balanced video, and male participants did not differ in their SNS responses as function of the gender composition of the video. The authors concluded that the gender imbalance was especially threatening for women.

Stigma

People's interactions with members of stigmatized groups have received a great deal of attention among social psychologists since the 1950s. Goffman (1963) surmised that interactions between stigmatized and nonstigmatized individuals are threatening to members of both groups.

Not surprisingly, stigma theorists (e.g., Crocker, Major & Steele, 1998) maintain that such interactions cause interactants, particularly nonstigmatized interactants, uncertainty, discomfort, anxiety, and danger during social encounters.

Only in the new millennium, however, have researchers produced physiological evidence of threat in actual social interactions between stigmatized and nonstigmatized interactants. Based on the biopsychosocial model of challenge and threat, Blascovich, Mendes, Hunter, Lickel, and Kowai-Bell (2001) hypothesized that nonstigmatized individuals would exhibit threat as evidenced physiologically even in cooperative performance situations as a result of resource/demand evaluations in which demands for them outweighed resources.

In their first two studies, these researchers created dyads of nonstigmatized and stigmatized individuals as cooperative partners in performance situations involving speech and word-finding tasks. They manipulated stigma by Kleck and Strenta's (1980) technique of using opaque or transparent makeup to manipulate the appearance of facial birthmarks on confederates. The latter interacted with nonstigmatized others in the cooperative tasks. Their results showed that CV response patterns associated with threat were evidenced by the nonstigmatized partners during the interactions with partners with birthmarks, and challenge was evidenced during interactions with partners without birthmarks. In a separate article (Mendes, Blascovich, Lickel, & Hunter, 2002), they found similar effects when White individuals interacted with African Americans of the same sex. Interestingly, in the stigma studies by Mendes, Blascovich, and colleagues, many possible moderators of physiological threat responses were attempted. However, the only one to prove reliable was intergroup contact. In the third study of the Blascovich, Mendes, Hunter, Lickel & Kowai-Bell. (2001) article, a pretest measure of intergroup contact with African Americans moderated the threat effect such that White participants who had high-quality intergroup contact with African Americans (e.g., had dinner at the home of an African American friend) showed CV responses similar to participants interacting with a same race partner.

Based on a theoretical argument of the role of uncertainty, Mendes, Blascovich, Hunter, Lickel, and Jost (2007) focused on one of several possible mechanisms contributing to threat experienced by members of nonstigmatized groups when interacting with stigmatized groups. Specifically, they focused on the uncertainty created when members of stigmatized groups violate expectancies of members of nonstigmatized groups during social interactions. In their first two experiments, nonstigmatized participants interacted with confederates who either violated or confirmed expectancies based on ethnicity and socioeconomic status (SES). They found that participants

interacting with stereotypical partners (low-SES Latinos or high-SES Whites) showed the benign challenge pattern, whereas participants interacting with counterstereotypical partners (high-SES Latinos or low-SES Whites) exhibited CV responses consistent with threat. In the third and final experiment, they extended the expectancy violation test from counterstereotypical partners to atypical partners. Specifically, they paired participants with either a White or Asian confederate who either spoke with an expected or southern U.S. accent. Confirming the uncertainty hypothesis, when participants were paired with Asian partners *and* they spoke with southern U.S. accents, they exhibited the greatest levels of CV threat reactions.

Stereotype Threat

Steele and Aronson (1995) argue that performing in a domain (e.g., academia) in which one's group's performance is negatively stereotyped leads to anxiety, uncertainty, and other reactions. Such *stereotype threat* is created by the possibility that one's performance will confirm the negative stereotype by placing increasing task-unrelated situational demands on the stereotyped individual, impairing performance. In 2001, Blascovich, Spencer, Quinn, and Steele published an article demonstrating heightened blood pressure responses among stereotype threatened African Americans taking a verbal abilities test.

In a stereotype threat study relying on the interpretation that decreased heart rate variability indexes mental effort, Croizet et al (2004) examined changes in RSA (a type of heart rate variability) during a stereotype threat paradigm. They found that participants assigned to receive a stereotype threat prime had a greater decrease in RSA and poorer performance than those in the control condition, and that RSA changes mediated the relationship from the condition to the performance effects.

More recently, Vick, Seery, Blascovich, and Weisbuch (2008) tested the stereotype threat hypothesis and confirmed threat response via the challenge/threat CV response patterns. In the Vick et al. experiment, participants took a difficult math test, one that they had been led to believe was either gender-fair or gender-biased in favor of male individuals. During the test, stereotype-threatened women exhibited a CV pattern associated with threat, whereas nonstereotyped threatened women exhibited challenge. Interestingly, the CV patterns were reversed for men. Specifically, men exhibited challenge when a male gender bias was implied, but threat when it was not, suggesting that male participants were threatened by the absence of the female stereotype.

Discrimination

Health disparities because of racial identity are large, with African Americans at least two times more likely to be hypertensive than European Americans, and disparities in coronary heart disease are increasing (National Center for Health Statistics, 2003; Willems, Saunders, Hunt, & Schorling, 1997). One possible explanation for racial disparities in physical health is that perceiving discrimination engenders physiological responses that are harmful to health (Clark, Anderson, Clark, & Williams, 1999). Among the many complicated facets of this research has been the confounding of the *expectation* of discrimination from the *experience* of discrimination. Several research programs have attempted to differentiate these types of discrimination experiences to examine the physiological sequelae to attempt to understand how discrimination may get under the skin to affect physical health.

Evidence is growing that based on past experiences with discrimination, some individuals develop a schema that the world is a threatening place and become vigilant to signs of prejudice and discrimination in their environment (Allport, 1954; Barrett & Swim, 1998). That is, they are likely to *expect* social rejection in interactions with the nonstigmatized, and *interpret* negative or ambiguous social evaluations in terms of discrimination (Frable, Blackstone, & Scherbaum, 1990; Major, Quinton, & McCoy, 2002). Furthermore, these individuals may perceive discrimination even in situations where it does not objectively exist.

Karen Matthews and her colleagues have examined how discrimination might influence resting and changes in CV responses as a function of perceived discrimination (e.g., Guyll, Matthews, & Bromberger, 2001). Although no evidence was found linking baseline blood pressure responses to perceptions of discrimination, they did find that African American women who reported that past interpersonal treatment was due to racial discrimination exhibited significantly larger increases in diastolic blood pressure when speaking of a potentially racially charged event (i.e., being accused of shoplifting).

But what about situations in which discrimination is not retrospective, but rather online? Do minority and stigmatized targets respond with shame, negative affect, and threat when experiencing negative treatment that they attribute to discrimination? Although the lay intuition might be to conclude that racial minorities would be the most distressed in clear discriminatory situations, *attributional ambiguity theory* suggests a different response (Crocker & Major, 1989). In their original theory, Crocker and Major suggested that the ability to attribute negative feedback or reactions from others to external reasons rather than internal causes might be protective for some stigmatized group members. This ability to attribute negative responses to external rather than internal causes might protect self-esteem of stigmatized group members.

To test these ideas and the possibility that previous work had yielded increases in self-esteem because of defensive responding, a recent study measured CV responses during a dyadic social interaction between same-race (White-White; Black-Black) or different-race (White-Black) partners (Mendes et al., 2008). During the social interaction, partners (i.e., confederates) provided explicit written negative or positive social feedback immediately after the participant completed a speech regarding "why they made a good friend." Social rejection was chosen for manipulation because of its powerful effects on emotions, such as shame, sadness, and even depression (Ayduk, Mischel, & Downey, 2002; Williams, 2001), and its far-reaching negative effects on physical health (Cacioppo et al., 2003; Stroud, Tanofsky-Kraff, Wilfley, & Salovey, 2000) and mental health (Williams, 2001). Following attributional ambiguity theory, the prediction was that social rejection from an outgroup member would be more likely to be attributed to discrimination than the same feedback from an ingroup member. Indeed, when a different race partner gave negative social feedback, participants attributed the feedback to discrimination. Importantly, in a subsequent cooperative interaction with the partner, participants who received negative social feedback from an outgroup partner did not exhibit threat-related CV responses; instead, they exhibited large increases in cardiac responses and decreases in vascular resistance—a pattern consistent with challenge. When nonverbal behavior manifested during the interaction was coded, it appeared that participants who perceived the rejection as caused by discrimination were angry not ashamed. Therefore, the challenge-related responses, in this case, were signaling approach-related motivation, which was consistent with the experience of anger.

Section Summary

In this section, we have illustrated a variety of constructs of interest to social psychologists for which physiological measures have been utilized as indexes. Most, if not all, of these constructs represent superordinate psychological states and processes such as positive and negative affect, approach- and avoidance-type motivation, and functional and dysfunctional self-regulation. These indexes have been derived on the basis of psychophysiological and social psychophysiological theories that span multiple biological systems including autonomic, neuroendocrine, and neural ones.

Notably, these indexes differ in the strength of inference they provide to theorists regarding the psychological states that they index vis-à-vis Cacioppo and Tassinary's taxonomy as described earlier. Noticeable is the relative paucity of measures that fit the definition of an invariant. This is not surprising given the requirements for such inferential strength. Indeed, some may argue that the single invariant, startle modulation, may actually be context bound, occurring only in passive rather than active performance situations (Schneider, 1997). The fact that a psychophysiological index may be context bound or can be linked to many different psychological states does not mean that it is not valuable for the study of social psychological processes. It merely means that there are few, if any, physiological indexes that have symmetrical one-to-one relationships with specific social psychological constructs. However, investigators utilizing physiological indexes must be aware of the strength of the inferences drawn from these indexes and be responsible in the interpretation of the meaning of physiological responses within the context of their experimental protocols.

SUMMARY

Scholars have been interested in the relationship of physiology to topics such as affect and emotion experiences, motivational states, and cognitive processes for millennia, though with a respite of several hundred recent years in Western societies created by adherence to Descartes' mind-body dualism. With the fall of mind-body dualism over the past century, scholars in many of the psychological science subdisciplines have increasingly integrated biological, psychological, and social processes into "biopsychosocial" causal explanations of their phenomena of interest. Social psychologists are no exception.

Although the label social psychophysiology came into being only in the last 40 years ago or so, the integration of social psychology and physiology can be traced to seminal integrative notions of William James, Walter Cannon, Hans Selye, and Stanley Schachter and Jerome Singer. David Shapiro and Andrew Crider's (1969) chapter in the second edition of this handbook helped propel a relatively small coterie of "social psychophysiologists," to articulate and illustrate the ways in which neurophysiological measures could be used to advance social psychological theory and research (e.g., Cacioppo & Petty, 1984; Waid, 1984). John Cacioppo first integrated social psychological and physiological theory, applying principles of inference to neurophysiological indexes.

Part of the initial and continuing appeal of social neuroscience to social psychologists is the proven value of peripheral neurophysiological measures for advancing social psychological research and theory. Not surprisingly, what initially may have seemed to be, or hoped by some to be, a quick and fruitful marriage turned out to be a much

more complex relationship than expected. But it is a much stronger marriage for that complexity.

In this chapter, we have illustrated the evolution of impactful social psychophysiological theories by describing ones that are biopsychosocial in nature and that provide the theoretical bases for developing strong inferential links between social psychological constructs and peripheral neurophysiological indexes of them, which we have also illustrated. Furthermore, the importance of understanding these theories and linkages is highlighted by our brief overview of embodiment theory. The latter argues that peripheral neurophysiological processes at least moderate and may even mediate social psychologically relevant affective, cognitive, and motivational processes often, but perhaps prematurely assumed to be purely within the domain of the CNS.

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