I. Introduction

Social psychophysiology represents a metatheoretical orientation in which there is a joint consideration of the inherent biopsychosocial nature of mentation, emotion, and behavior, and a goal of formulating integrative accounts of these phenomena (Cacioppo & Petty, 1983). Movement toward the development of this orientation appeared promising two decades ago, with the appearances of Shapiro and Crider's (1969) article entitled "Psychophysiological Approaches to Social Psychology" in the Handbook of Social Psychology and of Shapiro and Schwartz's (1970) article entitled "Psychophysiological contributions to social psychology" in the Annual Review of Psychology. These articles were largely ignored by social psychologists, however, and progress toward thinking about social psychophysiology as a metatheoretical perspective rather than as a technically cumbersome methodological tool was stalled for over a decade (see Cacioppo, 1982; Cacioppo & Petty, 1986).  

Consider, for instance, that despite what appeared two decades ago to be an increase in sophistication and interest among social psychologists in psychophysiological approaches, little social psychophysiological research actually occurred, and these early chapters were never revised or updated. Elsewhere, we have discussed the absence of analytical frameworks within which to create treatment comparisons and interpret psychophysiological data as a factor contributing to this dearth of research, and we have outlined and illustrated several analytic frameworks for psychophysiological research on social processes (Cacioppo & Petty, 1986). Hence, these issues are not discussed further here.
Our goal here is to take another look at, and to describe and elaborate a new look for, social psychophysiology. We begin by reviewing briefly the history of research utilizing psychophysiological concepts and measures to address social psychological questions, and we illustrate how reconceptualizing the psychophysiological enterprise can provide a noninvasive means of tracking processes by which the social world impinges on individual action and experience. Next, we survey evidence that interest within social psychology in psychophysiological concepts and techniques has been restricted not only by technical obstacles, but also by sociological and philosophical factors. Finally, research is summarized suggesting not only that psychophysiology has contributions to offer social psychology, but also that theoretical principles that have emerged from analyses of social behavior can be used to extend our understanding of fundamental psychophysiological phenomena and applied problems such as those in the area of health.

II. Background

Traditionally, social psychologists have been interested in the reportable and overt behavioral effects of human association and interaction. Social psychology itself is partitioned into conceptual areas of research such as attitudes, attraction, altruism, aggression, attribution, and so on. The emphasis in research tends to be on the manipulation of independent variables, the control or measurement of potential independent variables, and the collection of verbal report as the dependent variable (e.g., Carlsmith, Ellsworth, & Aronson, 1976; Ellsworth, 1977). This tradition was bequeathed to us by the founders of our discipline. For example, Gordon Allport, in his presidential address on September 4, 1946 before the first annual meeting of the Division of Personality and Social Psychology, observed that (1) investigations in personality and social psychology had quickly established scientific dignity; (2) important advances would be hindered by the adoption of the models, postulates, methods, or language of the physical sciences; and (3) verbal reports by individuals, although imperfect, promise both insight into social behavior and a depiction of human behavior that should prove socially useful (Allport, 1947).

The field of psychophysiology, in contrast, has evolved largely through the efforts of neurophysiologists, electrical engineers, experimental psychologists, clinical psychologists, and psychiatrists (e.g., Kaplan & Bloom, 1960; Porges & Coles, 1976). The diverse goals and interests of these individuals, coupled with the formidable technical obstacles confronting these early investigators, led quite predictably to a partitioning of the discipline not into psychologically interesting conceptual areas of research, but rather into anatomical-measurement areas (e.g., electrodermal, cardiovascular, electrocortical). As might be expected,
the early definitions of psychophysiology were in operational terms such as re-
search in which the polygraph was used (see Sternbach, 1966). Although the
stated goal of psychophysiology subsequently became the use of noninvasive
procedures to study the interrelationships between physiological events and human
cognition, emotion, and behavior, the one common thread linking early psy-
chophysiologists was their equipment and recording technique, and this remains
a point of common discussion and research in the field today.²

Our interest in psychophysiology originated in our attempt to extend our un-
derstanding of attitudes and social cognition (Cacioppo, 1979, 1982; Cacioppo
Cacioppo & Sandman, 1981; Petty & Cacioppo, 1986). We initially anticipated
the promise of this approach to include the following: (1) the conceptual richness
and intricate paradigms that characterize social psychology could be used to pro-
vide an interpretable ecological context for psychophysiological data; (2) the
physiological knowledge base, technical sophistication, and real-time quantitative
measurements that characterize psychophysiology could be used to test and extend
existing theories in social psychology; and (3) the basic principles and phenomena
of each discipline could ultimately be integrated to better understand human be-
havior—or what the Lacey's (e.g., Lacey, Kagan, Lacey, & Moss, 1963) termed
organismic–environmental transactions (see Cacioppo, Tassinary, & Fridlund,
1989). For instance, physiological responses, in contrast to measures such as
response latencies or verbal reports, can be collected continuously without the
individual having to do anything special. The detection and quantification of
physiological signals can be performed with the assistance of computers more
sensitively, reliably, and quickly than can fine-grained analyses of overt behavior.
And analyses of subtle physiological response patterns and their time course may
provide a means of differentiating underlying mechanisms of control even where
overt behavior may be completely undifferentiated (see Cacioppo & Petty, 1986;
Cacioppo & Tassinary, in press).

The notion that there are lawful relationships among physiological, psycho-
logical, and social processes is far from new, of course, dating at least as far
back as the third century B.C. when the Greek physician Erasistratos used his

²As noted elsewhere (Cacioppo, 1984; Cacioppo & Petty, 1986), another obstacle to early efforts
at integrative social psychophysiological research was the physiological background. technical so-
plication, and elaborate and often troublesome instrumentation that was needed for collecting,
reducing, and analyzing interpretable psychophysiological data in already complex social-psychological
contexts. Tremendous advances have been made in the technical aspects of psychophysiological
research, however. Standards for psychophysiological research have now been published for elec-
trodermal (Fowles, Christie, Edleberg, Grings, Lykken, & Venables, 1981), cardiovascular (Jennings,
Berg, Hutcheson, Obrist, Porges, & Turpin, 1981), and electromyographic (Fridlund & Cacioppo,
1986) recordings in humans (see also, Cacioppo & Tassinary, 1989; Coles, Donchin, & Porges,
1986; Martin & Venables, 1980). Moreover, advances in integrated circuits and computer hardware
and software have made relatively inexpensive, user-friendly psychophysiological laboratories a reality
and have greatly reduced the technical obstacles in psychophysiological research.
observations of peripheral physiological responses, such as the disruption of a regular heartbeat in a young man when his stepmother visited, to isolate the social cause of the individual's malady—"lovesickness" (Mesulam & Perry, 1972). However, psychophysiological studies of social behavior did not begin to appear in the social sciences until approximately a half century ago when, for instance, (1) Riddle (1925) studied deception and small group behavior by monitoring the respiratory rhythms of people bluffing during a poker game; (2) Smith (1936) studied social influence by monitoring the skin resistance responses (SRRs) of individuals as they were confronted by the information that their peers held attitudes that were discrepant from their own; and (3) Rankin and Campbell (1955) studied racial prejudice by monitoring the SRRs of individuals as they were exposed to white and black experimenters.

Despite the interesting findings of these early investigations, the emphasis was on identifying the physiological correlates of social psychological constructs and on the use of psychophysiological procedures for the purpose of construct validation (see Shapiro & Schwartz, 1970). The promise of the psychophysiological enterprise in this endeavor appeared to be considerable:

At the very simplest level, the attraction of social psychologists to physiological techniques is not hard to understand. The techniques provide nonverbal, objective, relatively bias-free indices of human reaction that have some of the same appeal as gestural, postural, and other indicators of covert response. (Shapiro & Schwartz, 1970, pp. 89-90)

The key phrase here, as noted by Shapiro and Schwartz, is "relatively bias-free indices." Although physiological measures may be less susceptible to direct cognitive control than verbal or overt behaviors, physiological responses are vulnerable to instructional sets, intentional distortion, and social biases (see Cacioppo et al., 1989; Sternbach, 1966; Tognacci & Cook, 1975).

The fact that physiological indices are not linked invariantly to psychological processes or states proved a disappointment to some and resulted in suggestions that psychophysiology had failed to fulfill its promise (see Lindzey & Aronson, 1985; Stewart, 1984). These grim conclusions appeared justified because the establishment of any dissociation between a physiological measure and a psychological process or state invalidates the psychophysiological enterprise when the original investigation is designed to demonstrate an invariant relationship.3

3An "invariant" relationship between two variables refers here to isomorhia mapping. That is, if A and B are construed abstractly, then to say that there is an invariant relationship between the two means that: (1) B is present if and only if A is present, and (2) A is present if and only if B is present, whether or not they are causally related in an independent issue (see Wheeler, 1974). Another somewhat more contemporary model might be termed "psychological invariants." Briefly, it may be acknowledged that there are one or more metabolic antecedents to physiological responses (e.g., heat leads to thermoregulatory adjustments and increased electrodermal activity [EDA]), but only one psychological process or event that is associated with a change in the physiological response
III. An Alternative Conceptualization

Although some still cling to a view of the psychophysiological enterprise as a search for invariants, this view is, in our opinion, an outdated, overly simplistic, and unnecessarily reductionistic characterization (see Cacioppo & Petty, 1981a, 1985). As Donchin (1982) noted:

It is more sensible to view the psychophysiological measures as manifestations of processes evoked, or invoked, in the organism. Such processes may, or may not, be part of some information processing activity. When they are, their attributes may, or may not, be monotonic functions of some, arbitrarily selected, performance measure. When such functions are found they are of use to the extent that it is possible to address issues of theoretical import by employing psychophysiological measures as a source of data about the organism. (pp. 457–458)

This alternative, albeit less spectacular, conceptualization of the psychophysiological enterprise makes no pretense of promising someday to describe social behavior as a list of physiological correlates of psychological events. Nevertheless, it is quite feasible to make strong inferences about a person’s cognitions, emotions, and conations from physiological response profiles, but these inferences can only be made within the framework of a very structured situation. Knowledge of psychophysiological principles as well as an understanding of the physiological and bioelectrical basis of the phenomena can therefore contribute to the value of the application of psychophysiology to the study of social processes and behavior.  

IV. Illustrating the New Look: Part I

Research on the messages carried by incipient (i.e., visually unobservable) facial actions illustrates the application of this alternative conceptualization of the psychophysiological enterprise. Before proceeding to this research, however, we need to say a bit more about the theoretical basis for the specific psychophysiological relationships with which we deal herein.

(e.g., arousal leads to increased EDA, and any increase in EDA that results, from the manipulation of psychological factors marks the presence of arousal). Our discussion of invariants is designed to apply to either of these conceptualizations. Interested readers may wish also to see Cacioppo and Tassinary (1989, in press).

*Interested readers should see Cacioppo and Tassinary (1989, in press) for a full explication of these statements.
A. RESPONSE PATTERNING

The first century of research on the psychophysiology of behavioral processes dealt with perception, nocturnal dreams, imagination, learning, and problem solving, most of which, at one time or another, were used to elicit responses in the somatic, autonomic, and central nervous systems. A characteristic finding, in part due to the intense nature of the independent variables and the insensitive nature of the dependent measures employed, was that physiological responding increased relative to baseline levels when emotionally evocative stimuli were presented or when people performed motor and cognitive tasks. As a result, several elaborate theories regarding task performance and arousal (in one of its many forms) were developed (see Fowles, 1980).

There were notable exceptions, however, to the focus on and evidence for general physiological arousal. In an illustrative study, Chester Darrow (1929) measured multiple physiological responses simultaneously while subjects performed a variety of tasks (e.g., mental arithmetic, being exposed to the sound of a sudden gun shot, attending to weak stimulation). Darrow observed that the notion of general arousal, though evidenced during many tasks, failed to account for much of the systematic variance in physiological responding. As measurement procedures achieved greater sensitivity and standardization, a greater range of stimulus intensities was examined, and the general finding was, in retrospect, not particularly surprising: The human organism responds to extremely intense stimuli in a fairly stereotyped fashion, whereas it responds to mildly to moderately intense stimuli in a more physiologically differentiated fashion (e.g., Cacioppo & Sandman, 1978; Ekman, Levenson, & Friesen, 1983; Lacey et al., 1963; see Jennings, 1986; Lynn, 1966). Two early principles accounting for the differentiated patterns of physiological responding were (1) individual response stereotypy, which refers to the tendency for the same individual to display a prototypical profile of physiological response to all forms of stimulation; and (2) stimulus response stereotypy, which refers to the tendency for a situation or stimulus to elicit a common pattern or profile of response from people in general.

More recently, two components of individual response stereotypy have been identified: (1) individual consistency—individuals display a reliable hierarchy of physiological responses across stimuli; and (2) individual uniqueness—distinct groups of individuals (e.g., hypertensives vs. normotensives) display responses or patterns of responses that are consistent within groups and differentiated across groups (Fredrikson et al., 1985).

Additional principles were necessary, however, to account for the fact that particular elementary psychological operators—such as attention, positive or negative affect, imagery, and interpreting and encoding incoming verbal information (which are induced by a wide variety of stimuli)—also tended to invoke distinctive patterns of physiological activity. The notions of orienting, defensive,
and startle responses were embraced, and specifying the antecedents, parameters, and consequences of these response syndromes continues to be an active area of research (e.g., Jennings, 1986; Lynn, 1966; Turpin, 1986).

In addition, theoretical analyses of efferent activity during problem solving, imagery, and emotion dating back to Darwin and William James have shared assumptions regarding the specificity and adaptive utility of somatic responses (e.g., see McGuigan, 1978; Schwartz, 1975). To better specify these links, R. C. Davis (1939) postulated the principle of focus of muscular responses, which holds that each task that a subject performs is accompanied by a focus of muscular activity. Davis’s principle of focus of muscular response does not, however, predict where a focal point might be located or why.

Several years ago, we proposed an elaboration of Davis’s postulate, which possessed greater explanatory and predictive power to account for the fact that particular elementary psychological operators tended to manifest in distinctive patterns of somatic activity (Cacioppo & Petty, 1981a). This model consisted of a set of five principles that drew on Davis’s principle of focus of muscular response and extended Darwin’s principles of serviceable associated habit and of antithesis to the level of unobservable somatic actions and patterns. The set of principles was summarily referred to as the “model of somatic patterning.”

1. **There are foci of somatic activity in which changes mark particular psychological processes.** For instance, a student who closes her or his eyes and vividly imagines watching a professor pace forward and back in the room during a lecture might show localized electromyographic (EMG) activity over the orbicularis oculi muscle region (around the eye; see Fig. 1) as if the student were actually squinting and relaxing in order to focus on the pacing professor.

2. **Inhibitory as well as excitatory changes in somatic activity can mark a psychological process.** For instance, in the preceding example, the act of imagining that she or he was watching a professor pacing forward and back in the room led to an increase in periocular EMG activity; however, if the student were to imagine the professor standing motionless and speechless in the middle of the room, this stationary image could actually lead to a diminution of periocular activity.

3. **Changes in somatic activity are patterned temporally as well as spatially.** Thus, consider the case in which a professor was pacing forward and back during her or his lecture, but who, during the course of making a point slowed and then stopped; a student who is imagining this scenario would show predictable changes in EMG activity over the periocular muscle region across time (temporal specificity)—and these changes would be localized rather than expressed generally across somatic sites (spatial specificity).

4. **Changes in somatic activity become less evident as the distance of measurement from the focal point increases.** Thus, in the preceding example, any
Fig. 1. Schematic representation of selected facial muscles. Overt facial expressions of emotion are based on contractions of the underlying musculature that are sufficiently intense to result in visibly perceptible dislocations of the skin and facial landmarks. The more common visible effects of strong contractions of the depicted facial muscles include the following (from Cacioppo, Martzke, Petty, & Tassinary, 1988).

1. **Muscles of the lower face.** Depressor anguli oris—pulls the lip corners downward; depressor labii inferioris—depresses the lower lip; orbicularis oris—tightens, compresses, protrudes, and/or inverts the lips; mentalis—raises the chin and protrudes the lower lip; platysma—wrinkles the skin of the neck and may draw down both the lower lip and the lip corners.

2. **Muscles of the mid-face.** Buccinator—compresses and tightens the cheek, forming a "dimple"; levator labii superioris alaeque nasi—raises the center of the upper lip and flares the nostrils; levator labii superioris—raises the upper lip and flares the nostrils, exposing the canine teeth; masseter—adds the lower jaw; zygomaticus major—pulls the lip corners up and back.
localized changes in EMG activity over the periocular region would be more measurable at sites proximal rather than distal to the source of the bioelectrical signals (e.g., near to, rather than far from, the orbicularis oculi muscle).

5. Foci can be identified a priori by (1) analyzing the overt reactions that initially characterized the particular psychological process of interest, but that appeared to drop out with practice, and (2) observing the somatic sites that are involved during the "acting out" of the particular psychological process of interest. There are, of course, individual differences in the elementary psychologic operations initiated by a stimulus. For instance, most people who are asked to imagine a spiral respond by visualizing an exemplar, although some individuals (e.g., mathematicians) may respond by recalling the mathematical function for a spiral. This individual difference can be a source of error in a priori specifications of somatic foci. Hence, ideographic procedures can be useful to help ensure the particular psychological operation of interest was invoked in response to the experimental stimulus.

B. THE FACIAL RESPONSE SYSTEM

Given that somatic effectors (the striated muscles) provide the final pathway through which people interact with and modify their physical and social environments, it perhaps should not be surprising that analyses of the patterns of efferent neural discharges ("efference") may be informative to social psychologists. To be sure, the pattern of efference is not always as intended (e.g., as when one performs clumsily), not always a veridical reflection of goals (e.g., as when one deceives), and not always obvious (e.g., as when one hides the display of feelings through masking or inhibition), and these influences are important to recognize when specifying under what conditions a given pattern of efference will mark a particular psychological process. But without efference, individuals do not communicate, do not affiliate, do not proliferate, do not interact—in short, are not social.

From a social psychological perspective, the muscles of facial expression may be especially noteworthy, in that these somatic effectors serve such important communicative functions (Fridlund, in press). Even their structure is suggestive

3. Muscles of the upper face. Corrugator superciliis—draws the brows together and downward, producing vertical furrows between the brows; depressor superciliis/procerus—pulls the medial part of the brows downward and may wrinkle the skin over the bridge of the nose; frontalis, pars lateral—raises the outer brows, producing horizontal furrows in the lateral regions of the forehead; frontalis, pars medial—raises the inner brows, producing horizontal furrows in the medial region of the forehead; levator palpebrae superioris—raises the upper eyelid; orbicularis oculi, pars orbital—tightens the skin surrounding the eye, causing "crows-feet" wrinkles; orbicularis oculi, pars palpebrae—tightens the skin surrounding the eye, causing the lower eyelid to raise.
of this communicative function: the muscles of mimicry are linked to connective tissue and fascia rather than to skeletal structures; their influence on the social environment, therefore, is mediated by the construction of facial configurations rather than by direct action through the movement of the skeletal structure (Rinn, 1984). Tomkins (1962), Izard (1971), and Ekman and Friesen (1975) have pioneered work on the face as a multisignal–multimessage response system.

Ekman and Friesen (1975), for instance, have conceptualized the face as a source of (1) static, (2) slow, (3) artificial, and (4) rapid signals. Carried by the rapid signals alone are a variety of messages; individuals have a good deal of control over most of these. The perioral musculature (e.g., orbicularis oris—see Fig. 1), for instance, is densely innervated by the facial (7th cranial) nerve and is capable of extraordinary specificity and flexibility (e.g., as in the case of verbal articulation). Nonverbal facial messages include emblems (symbolic communication—e.g., wink), manipulators (self-manipulative associated movements—e.g., lip bite), illustrators (actions accompanying—highlighting speech—e.g., raising the brows), regulators (nonverbal communication modulators—e.g., nods), and distinctive emotions (Ekman & Friesen, 1975).

Regarding the latter, the states of happiness, sadness, fear, anger, disgust, and surprise have been linked to distinctive facial displays across cultures and infants, whereas variability in facial efference and emotion has been linked to several sources, including differences in the emotion(s) evoked by a stimulus, differences in the timing of the emotional reaction, and differences due to display rules (e.g., Ekman, 1972, 1982; Ekman et al., 1987; Izard, 1977; Scherer & Ekman, 1982; Steiner, 1979).

1. Facial Efference

Of course, not all intra- or interpersonal processes are accompanied by visually or socially perceptible expressive facial actions, and this fact has limited the utility of research linking facial actions to underlying psychological processes (e.g., Graham, 1980; Love, 1972; Rajecki, 1983). Graham (1980), for instance, employed Ekman and Friesen's (1978) comprehensive facial action coding system in an attempt to investigate emotional responses to advertisements. Unfortunately, few facial actions indicative of emotions were visually observed, and those that were observed failed to provide theoretically interesting information about how the viewers were processing the advertisements. Closer analyses of the construc-

5 The presumed adaptive utility underlying the evolution of facial actions and expressions is twofold: (1) facial configurations provide a nonverbal means of communication among and across species, and (2) they serve to provide feedback regarding intrapersonal experience and behavior. Discussions of these functions are beyond the scope of the present article, but interested readers might wish to consult Buck (1980), Cacioppo, Petty, Losch, and Kim (1986a, pp. 266–267), Dimberg (1986), Ekman (1973), Izard (1977), Laird (1984), or Zajonc (1985) for more information.
tion of facial expressions reveals, however, that they are the result of (1) movements of facial skin and connective tissue due to the contraction of facial muscles, which create folds, lines, and wrinkles in the skin, and (2) the movement of facial landmarks, such as the brows and corners of the mouth (e.g., Ekman & Friesen, 1978; Izard, 1971; Rinn, 1984). Although muscle activation must occur if these facial feature distortions are to be achieved, it is possible for muscle activation to occur in the absence of any overt facial action if the activation is weak or transient, or if the overt response is aborted. Indeed, the efferent discharges that are too subtle or fleeting to be identifiable under normal conditions of social interaction may be of interest both because of their prevalence and because they are less likely to undergo the same distortions as overt expressions and actions. Several major facial muscles and actions are outlined briefly in Fig. 1.

Surface EMG is a psychophysiological technique that allows the measurement of both covert and overt facial efference. The validity of this technique is based on the following anatomy and physiology. Briefly, a striated muscle consists of millions of fibers housed in connective tissue and is activated by a specific motor nerve. The motor nerve, in turn, consists of many tiny motoneurons, which terminate on muscle fibers at a region called the motor end plate. These motoneurons have differential critical firing thresholds, such that either progressively larger units are added to or progressively smaller units are subtracted from the total output of a motoneuron pool (size principle; Henneman, 1980). When a particular motoneuron is depolarized, a neural impulse travels to the end plate region, and the chemical transmitter acetylcholine initiates a self-propagating muscle action potential (MAP), which activates the physiochemical mechanism that causes the fiber to contract. Whenever a MAP passes along a muscle fiber, an electrical potential is created, which can be measured at the skin.

It is worth emphasizing that EMG and visual (e.g., videotape) facial scoring procedures are complementary rather than exclusionary (see Cacioppo, Tassinary, & Fridlund, 1989; Ekman, 1982; Fridlund & Izard, 1983). For instance, EMG allows the measurement of minute changes in efferent neural discharges to particular facial muscle regions, whereas visual scoring procedures such as Ekman and Friesen's (1978) facial action coding system provide a sensitive and comprehensive means of examining observable facial actions. Although we commonly obtain unobtrusive video recordings as well as EMG recordings in our research, our focus thus far has been on changes in facial efference that are not socially perceptible. The judges who view and rate the video recordings for emotional signals have ranged from the subjects who participated in the study through an independent group of subjects and laboratory personnel to a practicing clinical psychologist with extensive experience in detecting and decoding subtle emotional messages from clients. Data provided by Ekman, Schwartz, and Friesen (1982, as cited in Ekman, 1982) suggest that responses of the magnitude we have been investigating are also not detectible using comprehensive, frame-by-frame analyses of facial action units. The supposition here, however, is not that more evocative stimuli would not elicit observable facial actions or expressions, but rather that it is possible for muscle activation to occur in the absence of an overt facial expression or action if either the activation is weak or the overt response is aborted.
The acetylcholine is quickly eradicated by the enzyme cholinesterase, and MAP activity and muscle fiber contraction cease without additional neural activity. Contraction of muscle fibers also activates skin receptors, which provide afferent feedback about facial muscle activity. Although the details of the individual MAPs are lost in surface EMG recordings, the discrete microvolt discharges from individual MAPs summate spatially and temporally during motor unit recruitment to yield an aggregate that, with proper placement and amplification, can indicate the action (or inaction) of motoneuron pools. (For further information about surface EMG, see Cacioppo et al., 1989; Fridlund & Cacioppo, 1986).

Consistent with the foregoing model of somatic patterning, research using facial EMG recordings has revealed several interesting somatic links to fundamental psychological operations. (1) Cognitive dimension: somatic links to semantic working memory—somatic activity over the perioral region is greater during cognitive deliberations (e.g., silent language processing, mental arithmetic) than during automatic or visual processing; (2) affective dimension: somatic links to valence of the organismic-environmental transaction—somatic activity over the muscles of mimicry (e.g., corrugator supercilii, or brow region) varies as a function of emotions; and (3) intensity dimension: somatic links to gradations of response—the amount of somatic activity over the perioral region varies as a function of the load on the articulatory loop, and the amount of activity over the facial muscles of mimicry varies as a function of the intensity of an emotional reaction.

2. Skeletomuscular Patterning during Action and Imagery

In an illustrative study (Cacioppo, Petty, & Marshall-Goodell, 1984), subjects were led to believe that they were participating in research on involuntary neural responses during “action and imagery.” Numerous dummy electrodes were also placed on the subjects to deflect attention from the facial placements and to lend credence to the cover story. Subjects on any given trial either: (1) actually lifted what was described as being a “light” (16 gram) or “heavy” (35 gram) weight (action); (2) imagined lifting the “light” or “heavy” weight (imagery); (3) silently read a neutral communication as if they agreed or disagreed with its thesis (action); or (4) imagined reading an editorial with which they agreed or disagreed (imagery).

Based on the model of somatic patterning, we expected the following: (1) perioral (orbicularis oris) EMG activity would be greater during the communicative attitudinal tasks than during the physical tasks, and (2) the emotional processes invoked by the positive and negative attitudinal tasks would lead to distinguishable patterns of EMG activity over the brow (corrugator supercilii), cheek (zygomaticus major), and possibly the nose (levator labii superioris—which is involved in expressions of disgust) regions (see Fig. 1), whereas the simple phys-
physical tasks would lead to distinguishable EMG activity over the superficial forearm flexors (whose actions control flexion about the wrist).⁷

Imagining the performance of tasks, rather than actually performing the tasks, was, of course, associated with lower mean levels of EMG activity. More importantly, and consistent with the model of somatic patterning, multivariate analyses revealed that the site and overall form of the task-evoked EMG responses were generally similar across the levels of this factor. Analyses further revealed support for both predictions. As illustrated in Fig. 2, perioral EMG activity was higher during the attitudinal (language) than physical (nonlanguage) tasks even though the tasks required no overt verbalization. Moreover, EMG activity over the brow, cheek, and nose-wrinkler muscle regions in the face varied as a function

⁷We refer to general anatomical regions (e.g., cheek, brow, forearm, back) when specifying recording sites and avoid technical considerations for didactic purposes only. This is not to suggest that factors such as the specific site and orientation of the electrodes are unimportant. The bioelectrical activity from deep or proximal muscles can give the same appearance in a surface EMG recording as the activation of an underlying superficial muscle, and for this reason one should refer only to the EMG activity detected over muscle (e.g., Corrugator supercilii) regions. However, factors such as the exact site and orientation of the electrodes, the size of the electrodes, the interelectrode distance, the interelectrode impedance, and so on are important in that they determine the validity and sensitivity of surface EMG recordings as measures of the localized activation of muscle regions (Tassinary, Cacioppo, & Green, 1989). The placements specified in Table I and illustrated in Fig. 1, for instance, are not arbitrary, but rather are based on the available anatomical and empirical research on the relationship between specific facial actions and surface EMG activity. It perhaps should also be noted that data reduction involves the identification and assessment and/or removal of recording artifacts. For instance, eye blinks can appear as transient bursts of EMG activity when recording in proximal regions, and these segments should be quantified (e.g., counted, integrated) and analyzed (to assure equivalence across experimental conditions) if not also removed from the EMG recordings over proximal muscle regions not directly involved in the eye blink (see Cacioppo et al., 1988, 1989, in press; Fridlund & Cacioppo, 1986).
of whether subjects thought about the topic in an agreeable or disagreeable manner (see Fig. 3), EMG activity over the superficial forearm flexors was higher during the physical than the attitudinal tasks, and EMG activity over the forearm (but not over the facial muscles) varied across the simple physical tasks (see Fig. 4).

To probe whether our cover story and tasks were effective or whether subjects had suspicions regarding facial efference being the focus of the study, subjects were interviewed at the end of each session and were asked specifically what they believed to be the experimental hypothesis. Because subjects might reason that they should not disclose how much they "knew", we emphasized that it was important that they respond honestly and accurately. The postexperimental interviews failed to reveal any evidence for the operation of experimental demands. All subjects appeared convinced of the cover story (e.g., that the sensors were used to detect involuntary physiological reactions), and no subject articulated anything resembling the experimental hypothesis. Instead, the postexperimental

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Fig. 3. Mean EMG amplitude over the brow (a), cheek (b), nose (c), jaw (d), perioral (e), and forearm (f) muscle regions as a function of attitudinal task. (Adapted from Cacioppo, Petty, & Marshall-Goodell, 1984.)
interviews of subjects indicated that they tended to organize the experimental trials in terms of whether they imagined or performed some task (e.g., lifting a weight or silently reading a text) rather than in terms of whether the task was physical or attitudinal.

Finally, following the study, two judges viewed videotapes of subjects during trials on which the subjects performed positive and negative attitudinal tasks. The judges' task was to guess the valence of the task performed on each trial, based on their observations of the subjects' facial display during the trial (i.e., when EMG recordings were obtained; see Footnote 6). Judges performed at chance level. It is unlikely that subjects deduced and chose to support the experimental hypothesis by making socially imperceptible facial responses to the attitudinal (but not to the physical) tasks. Indeed, Hefferline, Keenan, and Harford (1959) found that they could operantly condition an invisibly small thumb-twitch even though subjects remained ignorant of their behavior and its effect; and they

Fig. 4. Mean EMG amplitude over the brow (a), cheek (b), nose (c), jaw (d), perioral (e), and forearm (f) muscle regions as a function of physical task. (Adapted from Cacioppo, Petty, & Marshall-Goodell, 1984.)
reported that subjects could not produce this covert behavior *in the absence of EMG feedback* when deliberately trying to do so (see McCanne & Anderson, 1987). Together, these data suggest both that experimental demands are not necessary for the selective facial EMG activation observed during emotional processing and imagery and, more interestingly, that social cognition and affect can have discriminable effects on facial EMG patterning.

3. Perioral EMG Activity as a Function of Semantic Working Memory

The data displayed in Fig. 2 are consistent with the notion that problem solving and silent language processing influence perioral EMG activity (see reviews by Garrity, 1977; McGuigan, 1970). However, these data, like previous research, do not provide strong evidence regarding the specificity of the relationship between perioral EMG activity and information processing because the type of stimulus presented and/or the type of subject employed has been varied along with the extent of linguistic processing presumably manipulated. For instance, although poor readers have shown greater perioral EMG activity while reading than good readers (e.g., Edfeldt, 1960; Faaborg-Anderson & Edfeldt, 1958), it is unclear whether this effect resulted from differences in (1) the cognitive work involved either in comprehending or in encoding the material, (2) the manner in which the material is being processed, (3) attentional differences in the readers, (4) differences in apprehension, and/or (5) other factors.

In most of our initial investigations of perioral EMG activity, we employed the instructional manipulations used commonly to vary the load on semantic working memory as part of the encoding process. The paradigm involves presenting target words (e.g., trait adjectives) to subjects while randomly varying the question pertaining to each trait word (Craik & Tulving, 1975). In this paradigm, somatic responses attributable to features of subjects and stimuli are assigned to the error term, and what generally remains is variance due to the instructional factor (the "cue question"), which serves as the operationalization of the predominant type of informational analysis operating during the presentation of the target word (see Baddeley, 1978; Cermak & Craik, 1979). Results of research in this paradigm have generally shown that the more *semantic* (i.e., meaning-oriented) the cued analysis, the more likely subjects are to remember the stimulus word (see review by Craik, 1979), although these effects are especially evident when semantic processes are cued both at the time of encoding and at the time of retrieval (Morris, Bransford, & Franks, 1977; Tulving, 1978). These data have been interpreted as indicating the existence of qualitatively different processes by which incoming information is related to one or more existing domains of knowledge (Cermak & Craik, 1979; Craik, 1979).

The purpose of our initial study on semantic processing was to determine whether perioral (orbicularis oris) EMG activity was higher when subjects per-
formed tasks requiring that they think about the meaning and self-descriptiveness of a word rather than about the orthographic appearance of the word (Cacioppo & Petty, 1979b). EMG activity over a nonoral muscle region (superficial forearm flexors of the nonpreferred arm) and heart rate were also recorded to determine whether task-evoked changes in EMG activity were specific or general (e.g., part of a diffuse arousal response). Subjects were shown cue questions asking them whether or not the succeeding trait adjective was printed in uppercase letters, or whether or not the word was self-descriptive. Half of the trait adjectives were printed in uppercase letters, and half were printed in lowercase; and half of the trait adjectives were highly self-descriptive, whereas half were not at all self-descriptive. Subjects responded yes or no by pressing one of two microswitches.

Results revealed several interesting results (see Fig. 5). First, the self-referent task led to better recall than the orthographic task, replicating previous studies in social psychology (e.g., Rogers, Kuiper, & Kirker, 1977). Second, the self-referent task led to greater increases in perioral EMG activity than the orthographic task. Third, neither EMG activity over the forearm muscle group nor heart rate varied as a function of the orienting task, making it unlikely that the association between self-referent processing and perioral EMG activity was due to subjects being generally more tense or activated when performing the self-referent than the orthographic task.

This orienting-task paradigm has also been used to investigate the possible existence of different processes by which incoming information is related to one
or more existing domains of social knowledge. Studies have shown that trait words are better recalled when rated for their descriptiveness of oneself or one's best friend than of people about whom one has little or no direct knowledge (e.g., Bower & Gilligan, 1979; Keenan & Baillet, 1980). These data have been interpreted as indicating structural differences in domains of social knowledge in memory. As Ferguson, Rule, and Carlson (1983) note, the domains of knowledge (e.g., one's self) accessed by tasks (e.g., self-referent task) that produce relatively better recall of the incoming stimuli are thought to be characterized by greater elaboration (i.e., more associations), integration (i.e., stronger interassociative bonding), and/or differentiation (i.e., more chunking of associations into distinct, but related, subsets).

Ferguson et al. further reported data from this paradigm using a between-subjects design showing that self-referent and evaluative orienting tasks yielded similar response latencies and levels of recall. They argued that (1) evaluation constitutes a central dimension along which incoming information (such as trait words) is categorized and stored, and (2) both evaluative and self-referent tasks facilitated the use of the evaluative dimension and minimized the use of other irrelevant dimensions in rating traits. This led them to conclude that, given the centrality of the evaluative dimension in the organization of memory, "no unique memorial status need be attributed to the self or familiar others" (Ferguson et al., 1983, p. 260).

In an experiment bearing upon both the effects of effortful semantic processing on perioral EMG activity and on Ferguson et al.'s analysis, subjects were exposed to 60 trait adjectives spanning a range of likeability (Cacioppo & Petty, 1981b). Each trait adjective was preceded by one of five cue questions, which defined the processing task. The cue questions were (1) "Does the following word rhyme with _________?" (rhyme), (2) "Is the following word spoken louder than this question?" (volume discrimination), (3) "Is the following word similar in meaning to _________?" (association), (4) "Is the following word good (bad)?" (evaluation), and (5) "Is the following word self-descriptive?" (self-reference).

Finally, as in all of our facial EMG research, subjects in this study knew bioelectrical activity was being recorded, but they did not realize that activity over which they had voluntary control was being monitored.

Results revealed that mean recognition confidence ratings were ordered as follows: self-reference, evaluation, association, rhyme, and volume discrimination (see Fig. 6). Importantly, all means except the last two differed significantly from one another. These data, which were obtained using a within-subjects rather than a between-subjects design, have been conceptually replicated by McCaul and Maki (1984) and by Cacioppo, Petty, and Morris (1985), and they argue against Ferguson et al.'s contention that evaluative and self-referent processing are fundamentally the same.

In addition, we found the following:
1. The mean amplitude of perioral (orbicularis oris) EMG activity was lowest for the nonsemantic tasks of rhyme and volume discrimination, intermediate for the task of association, and equally high for the tasks of evaluation and self-reference (we subsequently found that these, too, could be differentiated using psychophysiological measures by analyzing the form rather than simply the mean amplitude of the EMG responses—Cacioppo et al., 1985; see Cacioppo & Dorfman, 1987)

2. Cardiac activity and the mean amplitude of EMG activity over a peripheral muscle region (i.e., nonpreferred superficial forearm flexors region) did not vary as a function of the type of task performed

3. The association between task and perioral EMG activity was temporally specific, with task-discriminating EMG activity observed only while subjects analyzed the aurally presented trait adjectives and formulated their response.

Together, these results suggest that (1) perioral EMG activity varies as a function of the load on semantic working memory; and (2) not only are there structural differences in domains of social knowledge in long-term memory, but the short-term language processes activated in concert with these knowledge structures differ.
4. Facial EMG Activity as a Function of Persuasive Appeals

Given evidence that perioral EMG activity varies as a function of short-term semantic processing and that EMG activity over selected facial muscle regions (e.g., corrugator supercilii, zygomaticus major) can discriminate between positive and negative emotional states, we reasoned that facial EMG measures might prove informative regarding elementary processes evoked by the anticipation and presentation of personally involving persuasive communications. Elsewhere, for instance, we have outlined specific conditions under which recipients of persuasive communications "cognitively respond" to message arguments, generating new associations, links, and implications central to the merits of an advocacy rather than basing attitudes on relatively simple peripheral cues (e.g., see Petty & Cacioppo, 1981, 1986). Miller and Baron (1973), on the other hand, argued that these conditions did not elicit extensive cognitive activity (see, also, Langer, Blank, & Chanowitz, 1978; Miller, Maruyama, Beaber, & Valone, 1976). Experimental results based on subjects' reported attitudes and the thoughts and ideas they listed in retrospective verbal protocols ("thought listings") provided support for the former position (Petty & Cacioppo, 1977; see Cacioppo & Petty, 1981c; Cialdini & Petty, 1981), but others have expressed reasonable concerns that these data could reflect post hoc rationalizations produced in response to postexperimental questioning rather than processes evoked by the persuasive communication (e.g., Miller & Coleman, 1981).

An initial study supported the applicability of psychophysiological principles and procedures to the particular paradigm of interest: localized increases in perioral EMG activity were observed when individuals followed the experimental instruction to "collect their thoughts" about an impending counterattitudinal editorial (Cacioppo & Petty, 1979a, Experiment 1; see Fig. 7). A follow-up study was conducted in which subjects simply anticipated and heard a proattitudinal, counterattitudinal, or neutral communication (Cacioppo & Petty, 1979a, Experiment 2). Students were recruited for what they believed was an experiment on "biosensory processes," and, as in the previous research, they were unaware that somatic responses were being monitored. After subjects adapted to the laboratory, we (1) obtained recordings of basal EMG activity, forewarned subjects that in 60 sec they would be hearing an editorial with which they agreed, an editorial with which they disagreed, or an unspecified message; (2) obtained another 60 sec of physiological recording while subjects sat quietly; and (3) obtained yet another 120 sec of data while subjects listened to a proattitudinal appeal, counterattitudinal appeal, and a news story about an archaeological expedition. Subjects were not told to collect their thoughts in this study, but rather somatovisceral activity was simply monitored while subjects awaited and listened to the message presentation. This allowed us to assess the extent to which spontaneous perioral activity accompanied the anticipation of a persuasive communication.
As expected, subjects evaluated more positively and reported having more favorable thoughts and fewer counterarguments to the proattitudinal than to the counterattitudinal advocacy. Although unexpected, we also found that subjects reported enjoying the "neutral" news story about an obscure archeological expedition as much as they did the proattitudinal editorial. Analyses of perioral EMG indicated that perioral activity increased following the forewarning of an impending and personally involving counterattitudinal advocacy, and it increased for all conditions during the presentation of the message. This selective increase of perioral EMG activity during the postwarning–premessage period provided convergent evidence for the view that people engage in anticipatory cognitive activity to buttress their beliefs when they anticipate hearing a personally involving, counterattitudinal appeal. Moreover, as illustrated in Fig. 8, the pattern of subtle facial EMG activity was found to reflect the positive–negative nature of the persuasive appeal before and during the message. Presentation of the proattitudinal and "neutral" messages was accompanied by a pattern of facial EMG activity similar to that found to accompany pleasant emotional imagery, whereas both the anticipation and presentation of the counterattitudinal message was associated with a pattern of EMG activity similar to that found to accompany

![Graph](image-url)
unpleasant emotional imagery. In sum, a psychophysiological approach proved useful in addressing theoretical question that had been resistant to customary approaches.

5. Toward a Coalition Model of Emotion

The psychophysiological approach adopted in the foregoing research differed from traditional psychophysiological applications in social psychology in that psychometric as well as physiological features of the measures were emphasized. Moreover, physiological measures have traditionally been viewed in social psychology as useful only in assessing general arousal and therefore incapable of distinguishing between positive and negative emotional states (e.g., see Fishbein & Ajzen, 1975; Rosenberg & Hovland, 1960). The studies reviewed thus far, however, suggest facial efference (as measured by EMG activity) is influenced differentially by positive and negative emotional states, even in situations where there are no changes in overt facial action and autonomic activity.

From these studies, coupled with previous research, we have begun to think of emotion as a coalition of normally loosely coupled control mechanisms that (1) are brought about temporarily to achieve a common purpose (flexible adaptation to an environmental challenge—imagined or real), and (2) produce a generally predictable sequence of recruitment of peripheral response components (e.g., see Cacioppo et al., 1984). For instance, the peripheral physiological ele-
ments of emotion and the order of recruitment of these elements appear at present to be as follows: (1) subthreshold activation of specific facial muscle regions (e.g., the corrugator supercilii region), which reflect the threat-assurance, or valence, of the emotion; (2) visceral activation begins to exceed threshold levels; (3) accumulating activation of these initially incipient facial actions (due to the increased frequency of MAPs and/or to larger MAPs being recruited) and subthreshold activation of additional, specific facial muscles, which also vary as a function of the emotion (or emotional blend); (4) readily recognizable (e.g., socially perceptible) overt expressions of emotion; and, according to the findings of Ekman et al. (1983), (5) autonomic differentiation of some emotional states.

The separate mechanisms of control for autonomic and somatic–expressive responses can introduce variability in this recruitment sequence, as for instance somatic responses are particularly vulnerable to voluntary control or masking. Nevertheless, changes in the central mechanisms of emotion (e.g., activity in the basolateral limbic circuit, dorsomedial thalamus, frontal pathways to limbic and core brain centers) are posited both to precede the peripheral manifestations and to be influenced by the efferent commands and consequent feedback (e.g., through its influence on the septohypothalamomesencephalic continuum).

In addition, an individual's awareness of an emotion is conceived as capable of emerging—or failing to emerge—at any point in the sequence of peripheral physiological manifestation, depending on factors such as focus of attention, available processing resources, and repressive style. That is, the peripheral manifestations of emotion are conceptualized as being contributory rather than necessary or sufficient to activate the subjective component of emotion (see Cacioppo & Petty, 1982; Cacioppo, Petty, Losch, & Kim, 1986, pp. 266–267). This proposition is based on two general heuristics that have emerged from neuroscience research (e.g., Kalat, 1984; Mueller, 1984). First, the reptilian (brain stem and basal ganglia), paleomammalian (limbic system), and neomammalian (neocortex) brain can each independently contribute to peripheral physiological elements of emotion. Second, the subjective component of emotion can be influenced by actions of the former two, but it relies much more fundamentally on an intact neomammalian brain.

This latter observation underlies many contemporary social psychological investigations of emotion. Smith and Ellsworth (1985, 1987), for instance, expected people's reports of emotion to be predicted by the manner in which individuals cognitively appraised the evocative stimulus and circumstance; results from both studies supported these expectations. The conditions under which cognitive appraisal represents a readout of the influences of lower central processes rather than serving as a causal variable in emotion remains uncertain at present.

At present, the coalition model (1) makes such questions salient, (2) provides a theoretical structure for organizing response patterns evoked by emotional stimuli, and (3) outlines in a general way how organizational and specific implementation rules result in emotion. Briefly, various response components of
emotion, such as the subjective, autonomic, somatic–expressive, are conceptualized as being governed by only partially overlapping mechanisms of action, with consequent effects on response components ranging from strongly inhibitory to strongly excitatory (see Fig. 9). To ask what are the response characteristics of emotion and by what process did they manifest is to ask what are the rules governing the coalition. Within this framework, theories of emotion can be conceived as specifications of the organizational rules governing (at least parts of) the coalition. For instance, James's (1890), Cannon's (1927), and Schachter and

![Fig. 9. Illustrative response component by influence matrix (upper panel), and depictions of a response space produced by the unitary organizational rule (lower left panel), unitary rule with a criterion threshold parameter (lower middle panel), and unitary rule with a slope parameter (lower right panel). For simplicity, only the bivariate response space for the autonomic and somatic–expressive response components has been depicted.](image-url)
Singer’s (1962) theories of emotion posit a positive relationship between changes in the autonomic and subjective components of emotion, with James also emphasizing corresponding changes in the somatic–expressive component. The general rule of organization governing the coalition in all three theories could therefore be described as unitary: “all for one and one for all” (see bottom, left panel of Fig. 9). It is the specific rules of implementation (i.e., rules governing the temporal sequence and causal role of each of the components) that differentiate these theories.

The simple organizational rule depicted in the bottom, left panel of Fig. 9 cannot account for the aforementioned hierarchy of peripheral physiological manifestations. Like the behavior of coalitions generally, however, the behavior of the coalition of the control mechanisms underlying emotions can be governed by multiple rules (and by single rules with multiple parameters) at any given time, the weight of each of which can vary dynamically. For instance, the hierarchical manifestation of autonomic and somatic–expressive responses can be explained by the addition of a parameter governing criterion thresholds in which “all are not created equal.” The bottom, middle panel of Fig. 9 depicts the bivariate (autonomic and somatic–expressive) response space for the unitary organizations rule, where the criterion threshold for facial efferent discharges is lower than that for autonomic activation.

As a final example, the externalizing–internalizing distinction in the “emotional discharge model” posits an inverse relationship between somatic–expressive and autonomic activity between subjects and a positive relationship between these components within subjects (e.g., see Buck, 1980; Notarius, Wemple, Ingraham, Burns, & Kollar, 1982). Although the moderating variable for this outcome has not yet been well specified, the effect suggests the existence of an organizational parameter that differs reliably across individuals. Specifically, the organizational parameter underlying the internalizer–externalizer distinction can be viewed as controlling the rate of activation of the autonomic versus somatic–expressive response components, manifesting as differences in the slope of the vector defining the bivariate response space for autonomic and somatic–expressive components. It is easy to show that the family of vectors in this response space, with slopes between one and infinity, result in descriptions of the the responses of “internalizers,” whereas the family of vectors with slopes between zero and one result in descriptions of the responses of “externalizers” (see Fig. 9, bottom, right panel).

To summarize thus far, although the notion of a unitary organizational rule (activation) is embraced as a hypothetical construct in the present model, response patterns, rather than general and diffuse activation across response components,

are expected and explained in terms of the operation of general organizational rules and their parameters. According to the coalition model, therefore, individuals can exhibit a range of responses to an emotionally evocative stimulus, including such disparate combinations as a clear and reportable awareness of a discrete emotion co-occurring with little or no evidence of peripheral physiological response or expression, or the absence of subjective awareness of an emotional response to a stimulus co-occurring with peripheral physiological evidence of emotional evocation. Moreover, the parameters applied to a general organizational (e.g., the unitary) rule are not merely descriptive, but also represent theoretical constructs. For instance, the hierarchical manifestation of peripheral responses as emotional evocation increases is explained in terms of a threshold parameter suggesting a gating mechanism governing the manifestation of peripheral physiological responses, and the internalizer–externalizer distinction is explained by the actions of an independent slope parameter—suggesting a rate-governing gain mechanism. Finally, it is possible to describe individual response stereotypy in terms of these gating and gain mechanisms. One interesting implication of such an application is that the internalizer–externalizer distinction is not unique to emotional discharge, but rather is simply a special case of individual response stereotypy (or, more specifically, individual uniqueness).

The foregoing model of somatic patterning fits well within this framework, as it specifies the organizational rules linking the somatic–expressive and subjective response components. For instance, the subtle, transient patterns of facial EMG activity we have found to be evoked by mild emotional stimulation have also been found to vary in magnitude with the intensity of the feelings expressed about the emotional stimuli (Cacioppo, Petty, Losch, & Kim, 1986b). In an illustrative experiment, subjects were exposed to slides of moderately unpleasant, mildly unpleasant, mildly pleasant, and moderately pleasant scenes. Subjects viewed each slide for 5 sec and rated how much they liked the scene that was depicted, how familiar the scene appeared, and how aroused it made them feel. Judgments of the video recordings of subjects’ facial actions during the 5-sec stimulus presentations indicated that the scenes were sufficiently mild to not evoke socially perceptible facial expressions. Nevertheless, analyses revealed that EMG activity over the brow (corrugator supercilii) and periocular (orbicularis oculi) muscle regions differentiated the direction and intensity of people’s emotional reaction to the scenes: the more subjects like the scene, the lower the level of EMG activity over the brow region; moreover, EMG activity was higher over

Although the model of somatic patterning is usually viewed in terms of its predictions regarding what somatic sites are likely to be activated by specific thoughts, images, and emotions, elsewhere we have discussed how the somatic actions may also influence the eliciting state (see Cacioppo, Petty, Losch, & Kim, 1986b, pp. 266–267). For the sake of brevity, we neither delve into the implementation rules concerning these response components nor detail the parameters (e.g., response thresholds with a criterion level that varies with available attentional capacity) that modify these organizational rules to enable admixtures such as incipient somatic–expressive evidence of emotion in the absence of the subjective component.
the periocular region when moderately pleasant than mildly pleasant or unpleasant stimuli were presented. EMG activity over the cheek (zygomaticus major) region also tended to be greater for liked than disliked scenes, with EMG activity being significantly higher when liked than disliked scenes were presented (see Fig. 10). Importantly, neither EMG activity over the brow region nor EMG activity over the cheek region covaried with reported arousal, nor did EMG activity over the perioral (orbicularis oris) region or a peripheral muscle region (superficial forearm flexors) vary as a function of stimulus likeability. These data, therefore, are more consistent with the view of response patterning and gradations than with the view that somatic activity simply increases in a unitary fashion when affect is aroused.

V. Illustrating the New Look: Part II

A. ERRORS OF INFERENCE

In the psychophysiological enterprise as outlined thus far, the manipulation of a specific psychological operation (such as the extent or the affectivity of information processing) is viewed as being an antecedent rather than the antecedent of the somatovisceral reactions. What is known about the systems underlying the physiological end point and the context in which the measures are obtained are also considered in order to derive specific hypotheses with limited ranges of construct validity and application. For instance, Ekman (1972) and Friesen (1972) have demonstrated that facial actions are clearly controllable and serve deceptive as well as communicative and emotionally expressive functions. In addition, the EMG patterning observed in this research is subtle and is easily

EMG recordings from the periocular (orbicularis oculi) muscle region have been shown to be heightened by expressions of pain, squinting, and so forth (e.g., see Fridlund & Izard, 1983). Activity over this region might be thought, therefore, to reflect variations in fixation rather than incipient facial actions associated with affect. EMG activity over this muscle region was greater when positive than when negative stimuli were presented; however, even when a focal point was used (see Cacioppo et al., 1986b. Pilot Study). Yet another interesting account for these data is based on Darwin's (1872/1965) observations and Ekman and Friesen's (1982) research on "felt" smiles. Darwin suggested that people display a smile—whether happy or not—when they wish to present a happy image but that people display both a smile and crow's feet at the outer edges of their eyes when they feel happy. The common elements in the facial expressions of the person who actually experiences a positive emotion are the actions of two muscles: "the zygomatic major pulling the lip corners upwards towards the cheekbone; and the orbicularis oculi which raises the cheek and gathers skin inwards from around the eye socket" (Ekman & Friesen, 1982, p. 242). Because there was no reason in the experimental setting for subjects to feign positive affective reactions to the experimental stimuli, it was suggested that the heightened EMG activity over the orbicularis oculi region, which we found to differentiate the affective nature of the experimental stimuli, may have been related to the variations in the subjects' positive feelings regarding the stimuli.
Fig. 10. Mean EMG amplitude over the brow (upper left), cheek (upper right), ocular (middle left), perioral (middle right), forehead (lower left), and forearm (lower right) muscle regions as a function of affective valence and intensity. (Adapted from Cacioppo, Petty, Losch, & Kim, 1986b.)

distorted, requiring optimal experimental conditions to obtain (see Cacioppo & Petty, 1987; Cacioppo et al., 1989; Fridlund & Cacioppo, 1986).

Psychophysiological assessments are often viewed as being useful within social psychology, however, only to the extent that investigators can infer the presence or absence of a particular antecedent or process (e.g., affect) when a target physiological response (e.g., increased skin conductance) is observed.

Yet evidence that an event or process is associated with a particular physiological response is *a necessary but not a sufficient condition* for such an inference.
This is due to the fact that a statement and its converse are not logically equivalent. Thus, knowledge that a statement is true (i.e., A implies B) does not imply that the converse is true (i.e., B implies A). Hence, except in the rare circumstance in which one is dealing with an invariant (single-cause, single-effect) relationship (see Footnote 3), establishing that the manipulation of an event or process ("A") leads to a particular physiological response or profile of responses ("B") does not logically imply that "B predicts A." For example, increased electrodermal activity (EDA) is evoked by a variety of factors, ranging from stress to novelty to arousal to significant events. To infer that a person was emotionally aroused based simply on increased EDA, therefore, is to commit the logical error of affirmation of the consequent (Runes, 1961).

How can one minimize dubious inferences while using physiological responses as markers of psychological operations? Although beginning with psychophysiological hypotheses that are compatible with the physiological system from which the responses are being measured is important, so too is viewing the problem as one of identifying the diagnostic (sensitivity and specificity) value of the physiological measures (i.e., a conditional probability problem). For instance, the interpretation of physiological data is aided by knowing not just that the manipulation of some psychological operation of interest leads to a particular physiological response. For accurate interpretation, the experimenter should also know both the likelihood within the assessment context that the target physiological response would be observed in the absence of the psychological operation of interest, and the likelihood that the manipulation of the psychological operation leads to something other than the target physiological response (Cacioppo & Tassinary, in press). Importantly, a physiological reaction (or pattern) that has few antecedents has a wider range of validity (i.e., interpretability) than one with a myriad of antecedents, and for this reason, analyses of response patterns and/or response waveforms can often prove valuable (Cacioppo et al., 1983; Cacioppo & Dorfman, 1987). Startle, orienting, and defense reactions all lead to increased EDA, for example, but they differ with respect to the pattern of somatovisceral activity (e.g., heart rate response, SCR, postural changes) as they unfold over time.

These concerns led us to develop a paradigm in which we could collect information (1) regarding the presence or absence of the psychological operation of interest, given the manifestation of the target physiological response, and (2) regarding the presence or absence of the psychological operation of interest in the absence of the target physiological response. There are now several studies that can be conceptualized within this approach to examine the psychophysiological outcomes discussed thus far.

\[\text{It should be obvious that investigators who wish to infer the presence or absence of a psychological event or process based on psychophysiological data are confronted by this problem even in the unusual case in which the psychological event of interest ("A") is always followed by a given physiological response or profile of responses ("B").}\]
B. FACIAL EMG AS A MARKER OF AFFECT

The research reviewed herein has linked EMG activity over facial muscle regions such as the brow (corrugator supercilii) and cheek (zygomaticus major) to emotional imagery and to emotional reactions to auditory, visual, and social stimuli. The question addressed in a recent study was whether distinctive bursts of activity over the brow region during a clinical interview were associated with more negative thoughts and images than periods in which EMG activity over this region was quiescent (Cacioppo, Martzke, Petty, & Tassinary, 1988).

In addition, previous research has examined the spatial pattern of facial EMG activity evoked by variations in emotion, but this approach can be insensitive when individuals are speaking (e.g., due to the EMG cross talk recorded over the zygomaticus major muscle region, which is attributable to overt articulatory movements and to false smiles) or very mild emotions are involved (e.g., see Cacioppo et al., 1986b; Tassinary, Cacioppo, & Geen, 1989). A potentially important and complementary approach involves specifying with greater precision the form of the EMG responses over the corrugator supercilii muscle region that is predictive of variations in emotion. Such an approach widens (or, in the worst case, leaves unchanged) the range of validity of somatic markers of emotion. Because the goal in this study was to predict mild variations in people's emotional experience as they were speaking during an interview, attention was given to the manner in which the EMG response over the corrugator supercilii muscle region unfolded over time (i.e., its form) while matching for the gross level of EMG activity observed over the zygomaticus major and medial frontalis muscle regions.

Four forms of phasic EMG activity over the corrugator supercilii muscle region were identified during pilot testing. The first represented basal levels of EMG activity over the corrugator supercilii muscle region and was included to establish baselines for reports of emotional experience (EMG Controls or "pseudotrials"; see Johnson & Lubin, 1972). The second represents an acicular burst of EMG activity over the corrugator supercilii muscle region (an EMG spike). Acicular EMG responses could be expected to occur for a variety of reasons. Increases in muscle tonus (which might result from sustained attention to a task) result in changes in spontaneous EMG responding, which can manifest as very brief semi-stochastic unimodal EMG pulses or spikes (i.e., less than a couple seconds in duration). Such activity is said to be spontaneous, or "nonspecific," because the spikes occur in the absence of any known precipitating or associated thought, emotion, or intention (e.g., see Sternbach, 1966, p. 68). Eye-blinks can also manifest in this form. In addition, a fleeting emotion could lead to this form of EMG response, but the transient nature of the emotion, coupled with the various nonemotional determinants of EMG spikes, should weaken the prediction of an individual's emotional experience based on the appearance of an EMG spike during an interview.
The final two forms of EMG response were defined as (1) a relatively smooth response less than 5 sec in duration, marked by a gradual onset and offset (an EMG mound), and (2) a ballistic EMG response also less than 5 sec in duration, which manifests more like a cluster of two or more partially overlapping EMG spikes than an EMG mound (an EMG cluster). Facial actions include those that serve primarily an interpersonal communicative function (e.g., raising of the brows while speaking, to emphasize nonverbally a point made verbally), as well as those, to paraphrase Darwin, that are in direct or indirect service of personal sensations and desires (e.g., see Darwin, 1872/1965, p. 28). Interpersonal communication—verbal and nonverbal—is facilitated by the transmission of high-fidelity signals. In the service of producing clear, unambiguous signals, the train of MAPs that are recruited with interpersonal communicative intent (or of a similar but more feeble state of intention) may be characterized by a relatively smooth sequence of activation (e.g., EMG mounds in contrast to EMG clusters). Of course, there need not be a contradiction between the facial actions that serve interpersonal communication and those that originate from personal sensations or desires; moreover, emotions can rise and fall gradually and, accordingly, may also be associated with relatively smooth increments and decrements of EMG activation. The important point here, however, is that phasic EMG clusters over the corrugator supercilii muscle region are less likely than EMG spikes or mounds to be the consequence of nonemotional events (e.g., spontaneous activation, paralinguistic signalling) and, hence, may be especially likely to mark variations in emotions during an interview.

To summarize, four specific forms of phasic EMG activity over the corrugator supercilii muscle region were investigated as blocking variables in the present research: (1) basal levels of activity, (2) spikes, (3) mounds, and (4) clusters. Because relatively few nonemotional antecedents were thought to exist for EMG clusters over the corrugator supercilii muscle region during an interview, the emotional experiences marked by EMG clusters were predicted to differ from those marked by basal levels, and the emotional experiences marked by EMG spikes and mounds were predicted to fall between these extremes.}

12Indeed, reports of negative thoughts and ideas that followed isolated spikes of EMG activity over the brow region tended to obtain only when individuals were asked immediately afterward to describe what they had just been thinking about, and the negative thoughts that were reported were sometimes described as having been passing through the background rather than the foreground of their stream of consciousness. The videotape reconstruction procedure we employed provided an insensitive test of the link between isolated EMG spikes and negative affect, however, because our pilot data had indicated these thoughts and ideas were fleeting and easily forgotten when a time delay was introduced between the appearance of the EMG spike and the cognitive assessment. We nevertheless decided to introduce such a delay, to minimize the reactive nature of the assessment procedures. In an attempt to gather preliminary data regarding isolated EMG spikes over the brow region and fleeting feelings of negative affect, however, we also administered the Byrne, Barry, and Nelson (1963) repression—sensitization scale to subjects several days prior to their participation in the study. We reasoned that repressors might be less likely than nonrepressors to have access to
Fifteen undergraduate women were recruited to participate in a study on self-disclosure. Following a recruitment meeting, during which time the procedures were described and a cover story was presented, subjects were brought into the laboratory and interviewed individually while unobtrusive video recordings and recordings of facial EMG activity were obtained. Subjects were seated in a dimly illuminated room and were asked to close their eyes and relax throughout the interview. Following adaptation to the lab, subjects were asked to talk about themselves with the goal of disclosing their "true self." The interviewer, an advanced clinical psychology student who was located in a separate room and was blind to the experimental condition, sought descriptions ranging from the superficial (e.g., physical attributes, demographics) to the intimate (e.g., perceived strengths and inadequacies, traumatic experiences). Throughout the interview, two other experimenters blind to the experimental hypothesis and to the subjects' self-disclosures, identified exemplars of each of four types of EMG responses over the brow region: (1) control—quiescent period at least 10 sec in duration; (2) spike—unimodal response with sharp onset and offset; (3) mound—smooth response no longer than 5 sec, characterized by a gradual onset and offset; and (4) cluster—multimodal response from 1 to 3 sec, characterized by an abrupt onset and offset. To assure these periods were otherwise comparable, exemplars were selected only if the individual was speaking, and EMG activity over the corrugator region did not reflect a blink or generalized activation of the facial muscles.

Immediately following the interview, the interviewer conducted a videotape reconstruction with the subject. Subjects watched and listened to the entire video recording, which was paused at 20 separate segments (5 randomly selected exemplars from each of the four preceding response types). At each pause, subjects were asked to report what thoughts and images "flashed through their minds" at that moment during the interview, and the entire videotape reconstruction was audiotaped. Subjects returned within a few days for a final session, at which time they rated each of the 20 verbal descriptions that were recorded during the any fleeting negative thoughts or feelings that accompanied an isolated EMG spike over the brow region (see Bonanno & Singer, 1986). To test this reasoning, subjects were subsequently classified as repressor or nonrepressor based on a median split of their scores on the Byrne et al. (1963) represssion-sensitization scale, and subjects' ratings of the thoughts and images that covaried with EMG spikes and control intervals were contrasted. Analyses of variance revealed an interaction: repressors and nonrepressors rated similarly the insightful nature of the thoughts and ideas that occurred in the absence of EMG activity over the brow region (i.e., during control periods). However, the repressors tended to rate the thoughts and images covarying with EMG spikes over the brow region as less insightful than those that occurred during control intervals, whereas the nonrepressors exhibited the opposite pattern. Hence, it is possible that a subset of the EMG spikes over the brow region marked more transient negative affect, which subjects failed to recall or repressed during videotape reconstruction. Such a possibility awaits further research.
videotape reconstruction along an abbreviated version of the differential emotions scale. All ratings were made on 7-point scales, and the results of these ratings are summarized in Fig 11. Multivariate and univariate analyses revealed that the rating of the reported associations varied as a function of the type of EMG burst: Recollections during the transient spike and control periods were equivalently positive; those during EMG clusters were rated as being more negative; and those during EMG mounds were rated between these extremes. These results support the notion that specific forms of EMG activity over the brow region, when identified within a particular pattern of facial EMG activity, can serve as an episodic marker of negative affect when individuals were unaware of the target physiological response and of the experimental hypothesis (and, hence, were unlikely to engage somatic actions that would inhibit or mask the responses of interest).

In sum, we have suggested that inferences about a person’s cognitive and emotional processes can be formed based on physiological profiles within structured situations, and we have discussed procedures for testing such inferences and any factors that limit these inferences.

C. PERIORAL EMG AS A MARKER OF SILENT LANGUAGE PROCESSING

Interestingly, Shimizu and Inoue (1986) have completed a study of sleep and dreams that bears on the utility of perioral EMG activity as a marker of silent language processing. Electroencephalographic (EEG), electrooculographic (EOG), perioral EMG, and nonoral EMG activity were recorded as subjects slept. Subjects were awakened during either rapid eye movement (REM) or Stage 2 sleep—as determined by inspection of the EEG and EOG recordings. When subjects reported dreaming, subjects were asked whether or not they had been speaking in their dreams. Dream recall during REM sleep occurred in approximately 80% of the awakenings, and it occurred during Stage 2 sleep in approximately 28% of the awakenings. Awakenings without dream recall were excluded from further analyses, as were awakenings preceded by phasic discharges in the perioral musculature that were accompanied by any whispering or vocalization. Results revealed that when phasic discharges over the perioral musculature were observed within the 30 sec preceding the awakening, subjects reported having been speaking in their dreams in 88% of the awakenings from REM sleep and 71% of the awakenings during Stage 2 sleep. Moreover, when phasic discharges over the perioral musculature were not observed within the 30 sec preceding the awakening, subjects reported having been speaking in their dreams in only 19% of the awakenings from REM sleep and in 0% of the awakenings during Stage 2 sleep.
Fig. 11. Mean ratings of the feelings aroused during segments of the interview marked by particular forms of EMG response over the corrugator supercili muscle region. Moments of the interview about which subjects were questioned were selected, based on the individuals speaking about themselves, showing no signs of blinking or general facial tensing, and evincing one of four specific forms of EMG response over the corrugator supercili muscle region. Ratings were expressed on scales labeled merry/gleeful/amused (a), warmhearted/joyful/elated (b), fearful/scared/afraid (c), sad/downhearted/blue (d), disgusted/turned-off/repulsed (e), tense/anxious/nervous (f), irritated/angry/mad (g), contemptuous/scornful/disdainful (h). Each subject's ratings on each scale were standardized across the 20 segments of the interview during which she was asked to express how she felt. (From Cacioppo, Martzke, Petty, & Tassinary, 1988.)
In sum, previous research had indicated that negative emotional reactions influenced the EMG activity over regions of the muscles of mimicry (e.g., the brow) and that silent language and numeric loads on working memory influenced the EMG activity over the perioral muscle region. The research reviewed in this section further suggests that EMG discharges over the brow and over the perioral muscle region can be used to mark episodes of negative affect and silent language processing, respectively. Together, these studies have implications for the specificity and sensitivity of somatic markers when individuals cannot report, will not report, or do not know what to report about ongoing cognitive and emotional operations.

VI. Sociological and Philosophical Obstacles

A. THE BABY AND THE BATHWATER

The conceptualization of the psychophysiological enterprise as concerning in part the identification of episodic markers of behaviorally relevant cognitive and affective processes is a fairly recent development in psychophysiology and is still sometimes misunderstood (see Cacioppo & Petty, 1986; Cacioppo & Tassinary, in press; Donchin, 1982). At least part of this misunderstanding has a factual basis and a long history. For instance, Allport cited the following as being said by Carlston during a then-recent presidential address to the American Psychological Association:

I believe that robotic thinking helps precision of psychological thought, and will continue to help it until psychophysiology is so far advanced that an image is nothing other than a neural even, and object constancy is obviously just something that happens in the brain.

(Allport, 1947, p. 185)

Allport (1947), on the other hand, was concerned about general social problems and moral issues. It is therefore understandable, given the climate of the times, why Allport, in his inaugural presidential address to APA’s Division of Personality and Social Psychology, might have equated psychophysiology with simplistic mechanistic thinking and criticized it (along with animal and infant research) as being reductionistic, inadequate, and a waste of time and energy for those interested in relevant social behavior.

Allport’s (1947) criticisms of reductionism and of the search for psychophysiological invariants to explain social behavior, as well as his early defense of social cognition in the face of the juggernaut of American behaviorism, were important and influential. But rather than questioning the charge that the promise
of psychophysiology was to generate a list of physiological invariants, Allport rejected the entire approach to the study of social behavior:

In taking stock of the situation I observe how many of us seem so stupefied by admiration of physical science that we believe psychology in order to succeed need only imitate the models, postulates, methods and language of physical science. If someone points out the present inutility of mechanical models in predicting anything but the most peripheral forms of human behavior, we are inclined to reply: "Wait a thousand years." (Allport, 1947, p. 182)

B. THE LONG SHADOWS OF INTELLECTUAL FOCUS

There were long shadows cast by the early dismissal of organismic factors as being relevant to the study of social processes and behavior. Even when important formulations were developed that sought to integrate knowledge from multiple domains (e.g., Schachter & Singer, 1962), these formulations were soon stripped of any serious treatment of the organismic domain. Valins (1966), for instance, proposed that actual sensations or changes in physiological arousal were superfluous in emotion, and that instead, the simple belief that a change in physiological arousal occurred was necessary and sufficient to influence emotion by invoking the search for an emotional label. Several years later, Bem (1972) argued persuasively that people are typically insensitive to internal information and cues and, therefore, they were essentially in the same position when trying to understand their own actions as were observers. Psychophysiological concepts and procedures obviously have little place in such formulations.

Schachter and Singer's (1962) integrative cognitive, social, and physiological theory of emotions also did much to advance the concept of physiological arousal as a factor to be reckoned with in analyses or social processes and behavior. Inspection of existing social psychological textbooks and the recent Handbook of Social Psychology reveals, for instance, that the only physiological construct to have had a major impact on theory and research in social psychology is the notion of arousal, a hypothetical construct that represents the intensive component of behavior. Furthermore, changes in physiological arousal have been conceptualized as being general, diffuse, and misattributable if not reportable, which makes their measurements technically simple and their interpretations straightforward: Any single physiological response, performance on drive-sensitive tasks,

\[13\] Note, too, that at no point was it demonstrated that physiological factors were not contributory, only that they were not necessary to obtain the outcome reported by Schachter and Singer (1962). The conclusion drawn by many from these studies, however, was that physiological factors were unimportant.
misattributions of bodily sensations, on simple self-reports of bodily sensations was thought to index a person’s arousal-drive at that moment in time. This conceptualization has led to most studies of physiological processes and social behavior being conducted with little need for physiological recording or concern about the underlying physiological or bioelectrical mechanisms.

Moreover, there is little hint that matters are rapidly improving. In reviewing the literature on cognitive dissonance a decade ago, Kiesler and Pallak (1976) noted in a strikingly contemporary tone (e.g., see Elkin & Leippe, 1986) that:

We use the terms motivation (drive) and arousal loosely and interchangeably. . . . We recognize the continuing controversy regarding these concepts in the literature in experimental psychology. . . . Our simplistic use of the terms does not imply a theoretical stance on our part, but rather reflects the state of the art in social psychology. (p. 1015)

Although this use by social psychologists may have appeared reasonable at one time, it is important to note that, whether intended or not, this viewpoint does represent a theoretical stance—and one that strikes contemporary investigators in other fields as inexplicable if not somewhat naive. As Fowles (1980) summarized in a review of the literature on physiological arousal not long after the appearance of Kiesler and Pallak’s review:

The effect of attempting to assimilate all of these traditions to a single arousal theory was to create a model in which the reticular activating system was assumed to serve as a generalized arousal mechanism which responded to sensory inputs of all kinds, energized behavior, and produced both EEG and sympathetic nervous system activation. . . . As is well-known, this model failed the empirical test rather badly. (p. 88)

All the more striking is that advances in the area of experimental psychology pertaining to cognition have had a large impact on conceptualizations in social psychology during the past decade, while cognitive psychologists and artificial intelligence researchers have begun to show increasing interest in the “wetware” (neural circuitry) of the human organism.

Even the early attraction of psychophysiological conceptualizations and procedures to social psychologists for purposes of construct validation proved a virtual dead end. When physiological procedures were used successfully to validate a social psychological construct, there was little reason to continue using these relatively complex, expensive, and time-consuming procedures to investigate the construct because the validity of the construct had been established, at least to the extent possible using psychophysiological procedures. Therefore, the simpler, less expensive, and less time-consuming verbal or behavioral measures traditionally used by social psychologists had been exonerated as being just as informative. The important concept of residual arousal, for instance, has received wide acceptance and application within social psychology, but the construct validity of this important concept is based almost entirely on a single pilot study.
reported by Cantor, Zillmann, and Bryant (1975), in which both self-report and physiological data were recorded (cf. Cacioppo, Tassinary, Stonebraker, & Petty, 1987).

The situation proved no better when the application of psychophysiological procedures failed to confirm the validity of a verbal measure of a social construct. Breckler (1984), for instance, argued that studies of the attitude tripartite should measure responses from a variety of domains, and in Experiment 1, he recorded heart rate as a measure of the "affective" component of attitudes. Analyses revealed that heart rate was unrelated to his other measures of the affective component. Having failed to confirm the expected link between heart rate and the "affective component" of attitudes, Breckler (1984) conducted a "verbal report analogue" (p. 1200) of his first experiment while deleting all physiological measures in the replication. The deletion of physiological measures produced a pattern of data more friendly to the tripartite conceptualization.

C. OPERATIONAL AND CONCEPTUAL DISCONFIRMABILITY

The empirical disconfirmation of a theoretical prediction can be attributable to a variety of factors, not the least of which is a suspect relation between psychophysiological data and the theoretical construct of interest. Indeed, the relation between social psychological theory and psychophysiological data have been and often continue to be criticized for: (1) naive or questionable operationalizations (e.g., heart rate as an index of affect); (2) inappropriate, artifactual, or insensitive measurement procedures (e.g., heart rate is under tight homeostatic control; the size of SRRs can be affected dramatically by the background level of skin resistance); and (3) naive or inappropriate interpretations (e.g., inferring evidence for general arousal when only one physiological response was monitored or when more than one response was monitored but only one showed significant or expected changes as a function of the treatment). Consequently, unexpected data in construct validation studies have led to the discrediting of the psychophysiological conceptualizations and/or procedures rather than of the theory itself.

The point is not to reify physiological responses, but rather to give them the same thought and attention that we give our verbal and behavioral measures. As when using verbal or behavioral measures, conceptual disconfirmability, and hence theoretical advances in understanding social behavior based on psychophysiological investigations, requires that the relation between concepts and operations first be established confidently (see Greenwald, Pratkanis, Leippe, & Baumgardner, 1986).

Having noted this, yet further hindrances become immediately obvious: (1) there is no apparent purpose in social psychologists learning about or using psychophysiological theory and techniques unless or until the links between psy-
chophysiological data and social psychological constructs have been clearly es-

tablished; and (2) there is little incentive for psychophysio-

lologists to begin the arduous task of establishing these relationships when there is little interest in or

audience for the effort. In the next section, we review evidence suggesting that these obstacles are neither peculiar nor inexorable.

VII. The New Look: Part III

Research on theoretical processes in social psychology ranging from the arousal of cognitive dissonance to the cue processing underlying the sleeper effect has traditionally relied on people's self-reports to assess the efficacy of the experimental manipulations, the effects of these manipulations on verbal and overt behavior, and the operation of the assumed intervening sequence of events. One feature of this research is that ingenious experimental designs have been employed to allow inferences to be drawn regarding the processes underlying these verbal and/or behavioral data. However, these inferences are themselves often followed by ingenious counterarguments and occasionally by theoretical impasses. The number of seemingly irreconcilable debates in social psychology has fueled concerns about the nature of the social sciences generally and social psychology in particular, including aspects of its stability, methodology, and epistemology (e.g., Gergen, 1973; Greenwald, 1975; McGuire, 1973, 1985).

These conditions might be thought sufficient to lead to the consideration, if not embracing, of alternative approaches. Not so, according to Kuhn (1970), who suggests that there is a strong resistance to new paradigms inherent in established disciplines. For instance, social psychological constructs are generally defined in a manner that capitalizes on the methodologies and measures most readily available, thereby maximizing their testability and influence—and minimizing the relevance of alternative domains of knowledge, such as psychophysiological concepts and procedures. Hence, theoretical constructs such as

14It is of interest to note that major figures in psychophysiology as well as in social psychology contributed unwittingly to this dilemma. We have already noted that Gordon Allport (1947) equated psychophysiology with simplistic, mechanistic thinking. A dozen years later, Lacey (1959) cogently criticized poorly controlled psychophysiological studies of psychotherapeutic interactions—social interactions of interest to psychophysiosiologists of that day—and he called for more highly controlled investigations of psychophysiological measurement and relationships. Allport's influential presidential address and subsequent writings cast verbal reports in the starring role and cast psychophysiological concepts and measures as irrelevant to the study of social processes and behavior. Lacey's appeal, on the other hand, diminished the incentive for psychophysio-

logists investigating relatively abstract and intractable social constructs and processes. It is perhaps understandable, therefore, why more was said about physiological factors and mechanisms in the original textbooks on social psychology than in contemporary textbooks and why more was said about social and cultural factors in the original texts in psychophysiology than in the texts that have appeared in the intervening two decades.
physiological arousal become conceptualized in attributional terms, and their influence on individual and group behavior is investigated primarily by using verbal reports and misattribution paradigms (cf. Lindzey & Aronson, 1985; Reis- enzein, 1983).

In sum, analyses of the nature of scientific progress anticipates the resistance of established disciplines to new paradigms because, for instance, existing theories oftentimes make no clear predictions regarding these new measures. This is best viewed as an unintentional consequence of the best of scientific intentions (e.g., in the name of disconfirmability, parsimony).

A. EMPIRICAL ANOMALIES

The conflicting demands of avoiding a policy of immunizing perspectives against refutation while maintaining testable theories and not succumbing too easily before they have been able to make their contributions to the growth of science have long been recognized by philosophers of science. It is noteworthy in this context, however, that a key condition supporting the development of new or more complex perspectives is the observation of phenomena that cannot be assimilated easily into existing paradigms. The growth of systematic research on the relationships between social processes and psychophysiological measures or mechanisms, therefore, may be necessary but not sufficient to foster the consideration of the organism, as well as the individual, when studying social processes and behavior. Ultimately, the prospects for the growth within social psychology of a metatheoretical orientation, wherein there is an integrated consideration of the biopsychosocial aspects of mentation, emotion, and behavior, depends on the ability of this perspective to reveal and explain new and interesting phenomena. In our view, there are promising signs that such is the case.

Consider, for instance, that attitudes and emotions have traditionally been defined, at least within social psychology, in terms of what people report believing or feeling. Constructs such as "unconscious emotion," therefore, are a contradiction in terms, and clinical phenomena such as prospopagnosia—a neurological condition of individuals who are unable to recognize visually the faces of familiar persons, exhibiting large skin conductance responses (SCRs) to faces of persons they had previously known but were not able to recognize (Tranel & Damasio, 1985)—stand as empirical anomalies. So, too, do (1) studies on the effects of environmental noise during various sleep stages, which reveals that sleeping subjects exhibit subtle patterns of facial efference remarkably similar to those observed in waking subjects confronted by unpleasant stimuli (Sumitsuji, Nan’no, Kuwata, & Ohta, 1980); (2) studies showing that subtle adjustments of bodily response, such as head nodding (Wells & Petty, 1980) or transient and specific variations in heart rate (Cacioppo, 1979), can influence attitudes and persuasion; (3) studies showing that emotion can be characterized by specific rather than general and
diffuse physiological responses (e.g., Cacioppo, Petty, Losch, & Kim, 1986b; Ekam et al., 1983); and (4) studies demonstrating physiological (Tassinary, Orr, Wolford, Napps, & Lanzetta, 1984) and behavioral (Greenwald, Klinger, & Liu, 1987) effects of the processing of emotionally laden words whose presentation cannot be reported.

Empirical anomalies within psychophysiology also exist which call for a consideration of social factors. For instance, there is now evidence for a moderating role of social factors (e.g., mere presence) on stimulus changes and physiological reactivity in studies of both autonomic (e.g., Fowles, Roberts, & Nagel, 1977; see, also, Moore & Baron, 1983) and somatic response systems (e.g., Ekman, 1972; Yarczower & Daruns, 1982); and for the role of social factors (e.g., position in a social hierarchy) on the relationship between physiological changes and behavior (e.g., Haber & Barchas, 1984; see, also, Zillmann, 1983).

B. A CHANGING ZEITGEIST

The social and political zeitgeist has also been more influential in social psychology than in many sciences, presumably because of the close relationship between social psychological interests and social events (Jones, 1985). It is significant, therefore, that a major development in Western societies over the past several years is the realization that the leading causes of disability and death (e.g., heart disease, cancer, accidents) have substantial social and behavioral components. The resulting emphasis on preventive medicine and on the social and behavioral factors related to public health has stimulated interest among social scientists in physiological concepts and techniques (e.g., Fleming, Baum, & Singer, 1984; Van Egeren, 1984). A second important consequence is that attention is being given to questions regarding (1) which, when, and how physiological mechanisms moderate the effect of social stimuli on individual action and experience; and (2) which, when, and how social factors and systems moderate the effect of environmental stimuli on physiological reactivity and disease.

Again, not only does psychophysiology have contributions to offer social psychology, but also theoretical principles that have emerged from analyses of social behavior can be used to extend our understanding of psychophysiological phenomena—such as how it is that people detect and interpret the signs (bodily changes detected through exteroceptive sensory channels) and symptoms (bodily changes detected through interoceptive or proprioceptive sensory channels) of disease (e.g., Cacioppo, Andersen, Turnquist, & Petty, 1986a; Leventhal, Meyer, & Nerenz, 1980).

As a case in point, consider one of the most eloquent of social psychological theories—social comparison theory. Although Festinger (1954) proposed his theory of social comparison to stipulate why individuals compared their own opinions and abilities with those of others, with whom these comparisons were
made, and with what effects these comparisons were made, this work served as the springboard for the next three decades of social psychological research on the problem of explicating the cognitive and emotional processes that are initiated by the detection of unexpected bodily events (e.g., see Riesenztein, 1983; Schachter, 1959; Schachter & Singer, 1962).

We have also drawn on this work to suggest that not only do people attempt to evaluate their abilities and opinions to achieve or maintain an explicable social condition, but they also actively evaluate their bodily signs and symptoms to achieve or maintain an explicable physiological condition. Specifically, it was noted that the process of social comparison typically involves comparing one's abilities and opinions with those of others, and it was proposed that the process of psychophysiological comparison typically involves comparison of signs and symptoms (1) that those individuals attribute to a situation or stimulus—or what could be termed "implicit stimulus response stereotypy"—and (2) that those individuals attribute to themselves—or what could be termed "implicit individual response stereotypy" (Cacioppo, 1983). We subsequently identified general principles governing the appraisals of individuals confronted with the signs and symptoms of disease (Cacioppo, Andersen, Turnquist, & Petty, 1986a; Cacioppo, Andersen, Turnquist, & Tassinary, in press). These principles, which are summarized in Table I, portray psychophysiological comparison processes as being pervasive, influential, and in many cases biased to support a positive view of oneself and one's physiological condition (see Table I).

A study of 54 women who had just been diagnosed as having gynecologic cancer provided an examination of several of these principles (Cacioppo, Andersen, Turnquist, & Petty, 1986a). Patients were interviewed individually within 36 hours of their admission to the hospital by an interviewer who was blind to the experimental hypotheses. The interviews, which were conducted prior to the onset of any medical treatment, inquired about the signs and symptoms patients noticed, their perceived causes for and interpretation of these bodily changes, their desire-motivation to seek further information about or treatment for the signs and symptoms, and so forth.

The results indicated that principles derived from social psychological analyses of behavior—such as the postulates of logical and hedonic consistency—provided pointers to, if not explanations for, patient decision making and delay. For instance, we found that patients tended to generate explanations for unexpected bodily changes according to prototyped conceptions they have of daily activities and physical diseases (see, also, Bishop & Converse, 1986; Leventhal et al., 1980; Safer, Tharps, Jackson, & Leventhal, 1979). In addition, however, we found that the more innocuous the account generated initially for their signs and symptoms (e.g., normal life events, not cancer), the less their motivation to continue searching for an explanation, and the longer the delay in seeking appraisal.

Perhaps more important than the ultimate validity of the specific principles
TABLE I
PSYCHOPHYSIOLOGICAL COMPARISON PROCESSES

1. People are motivated to maintain an explicable physiological condition.
2. Symptoms are not necessarily either perceived as neutrally arousing or perceived accurately in terms of their physiological etiology.
3. The strength of the motivation to understand and evaluate the symptoms is a function of their unexpectedness, salience, personal relevance, and perceived consequences.
4. Symptom interpretation involves a comparison of the symptoms with the known consequences of salient contextual stimuli (e.g., pathogens, medication), and physiological conditions (e.g., fatigue, allergies, diseases—i.e., illness prototypes).
5. Symptom interpretation is governed in part by logical consistency. For instance, the probability of a specific illness inference is a direct function of its accessibility and an inverse function of the discrepancy between the symptoms and the illness prototype.
6. Symptom interpretation is governed in part by hedonic consistency. For instance, innocuous explanations (e.g., accounts depicting the symptoms as transient or self-correcting) more greatly diminish the individual’s motivation to obtain an explicable physiological condition to a greater degree, ceteris paribus, than do highly threatening accounts.
7. The more diffuse the symptoms, the greater the number of potential comparisons and, consequently, the greater the likelihood of erroneous interpretations of the symptoms and the more susceptible to change are these inferences.
8. If an illness prototype cannot be identified initially that is believed to have effects similar to the detected bodily changes, then the prototype that maximizes the aforementioned logical and hedonic parameters will influence subsequent attention to and production and detection of the expected symptoms.
9. If a comparison cannot be identified initially that is believed to have effects similar to the detected bodily changes, then the detected symptoms will influence the idiosyncratic physiological consequences attributed to the prototype that maximizes the aforementioned logical and hedonic parameters.

outlined in Table I, however, is the suggestion from these and related approaches (e.g., Leventhal et al.; 1980; Matthews, Siegel, Kuller, Thompson, & Varat, 1983; Mechanic, 1972; Pennebaker, 1982) that a consideration of social, psychological, and physiological factors and knowledge domains need not result in reductionism but rather can lead to new, interesting, and integrative insights into human nature.

VIII. Conclusion

We have traced the transition of "social psychophysiology" from a reductionistic search for physiological invariants to an esoteric methodological tool for purposes of validating social psychological constructs to a metatheoretical orientation wherein there is a joint and integrative consideration of the inherent
biopsychosocial nature of mentation, emotion, and behavior. We argued that physiological measures can fruitfully be conceptualized as manifestations of processes invoked as part of an organismic–environmental transaction (see, also, Donchin, 1982). Such processes may or may not be part of psychological activity, and may or may not be responsive to or influential in human association and interaction. When measures within limited contexts are identified that are related to social psychological processes or events, the nature of the relationship may or may not be monotonic. When the functional relationship within the measurement context across these various levels of representation is found, it is of use to the extent that it is possible to address issues of theoretical import by employing psychophysiological measures as a source of data about the social organism. That is, the goal is not simply to catalog the physiological manifestations of social behavior.

We also noted that inferences regarding the presence or absence of a particular antecedent or process (e.g., arousal) based on a particular target physiological response (e.g., SCRs) can be misleading unless one also considers (1) the nature of the relationship between the psychological process or event of interest and the physiological response being measured (e.g., negatively evocative stimuli have often been found also to heighten SCR), (2) the likelihood of other factors within the measurement context eliciting the observed physiological response (e.g., SCR activity is heightened when individuals become startled, alerted, conflicted, ecstatic, warm, etc.), and (3) the likelihood that the antecedent of interest leads to something other than the target physiological response (e.g., mildly evocative negative stimuli may heighten activity over the brow region while failing to alter EDA).

Furthermore, although the assignment of psychological meaning to a physiological response does not depend logically on knowledge of the physiological mechanism underlying the response, the physiological basis of the responses of interest are often well articulated and can contribute to psychometric and social psychological inquiries by its: (1) intimation or stimulation of theory and operationalizations; (2) discrimination of signal from artifact; (3) provision for safety of the individuals involved; (4) stipulations for the acquisition and analysis of digital arrays and descriptive parameters that are reliable and valid representations of the physiological events of interest; and (5) guidance of feasible inferences based on physiological data.

Illustrative research was reviewed demonstrating the use of facial EMG to help track the means by which the social world impinges on individual action and experience in studies ranging from self-referent processing to self-disclosure to communication and persuasion. However, given the inherent resistance of established disciplines to new paradigms (e.g., because in the service of parsimony and disconfirmability, theories within a discipline often make no clear predictions regarding new domains) the growth of systematic research on the relationships between social processes and psychophysiological data is necessary but not suf-
sufficient to foster our considering the organism as well as the individual when studying social processes and behavior. Ultimately, therefore, the prospects for a social psychophysiological approach to human nature depend on its ability to uncover and explain new and interesting phenomena. Promising signs were reviewed that just such a circumstance might be developing.

Finally, it was noted that the social and political zeitgeists have been more influential in social psychology than in many other sciences, understandably, as Jones (1985) argues, because many of the phenomena of interest and in dire need of explanation are played out in the social and political arena (e.g., Latane & Darley, 1970; Milgram, 1963). The recent realization that the leading causes of disability and death in Western civilization have substantial social and behavioral components, and the emergence of interest and research on the social and behavioral factors related to public health, are therefore significant. These developments have stimulated interest among social psychologists not only in physiological concepts and techniques, but also in questions regarding which, when, and how physiological mechanisms moderate the effect of social stimuli on individual action, experience, and health. The long tradition of basic research and theory within social psychology is serving this emerging zeitgeist well, as social psychological principles are providing an important legacy for health as well as for psychophysiological research.

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References


SOCIAL PSYCHOPHYSIOLOGY: A NEW LOOK


