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Chapter Five

The Psychophysiological Perspective on the Social Mind

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Introduction

In 1888, Fere reported that it is possible to measure bodily concomitants of mental activities by attaching two electrodes to a person's hand and measuring changes in electrical resistance. A century later, technological advances have made it possible to track the activity of the autonomic nervous system while people pursue their regular daily activities. We can peer into the waking brain of healthy individuals using functional imaging and measure activity of small groups of neurons with intracranial recording while patients undergo surgery. We have several techniques that can selectively modify activity of neural circuits and influence the levels of specific neurotransmitters. We can identify the location of neural circuits within millimeters and trace changes in electrical brain activity with millisecond precision. Equally breathtaking is the evolution of the ease and quality of data processing. Computers with huge storage capacity and fast processors have become as much a staple in this research as the electrode. Sophisticated analytic tools allow for accurate representation and analysis of even the most complex psychophysiological signals.

Clearly, modern psychophysiology offers an exciting set of tools for probing the relationship between psychological and physiological processes in humans. But how do we use these tools to our best advantage? How do we properly make the inference from a change in skin conductance or a blot of color on a brain scan to a psychological process? More important, are these tools really useful for a social psychologist? Can they reveal something that cannot be captured with other means? Can they help us advance social psychological

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theory? The goal of this chapter is to answer these questions, and show that when these tools are used with caution and understanding, they can reveal new phenomena, spur theoretical advances, and contribute to the continuing development of social psychology.

We start with a brief review of the history of the psychophysiological approaches to social psychology. We suggest that many problems plaguing early research were due to technical limitations, insufficient knowledge about the body, and incorrect assumptions about the relationships between social psychological constructs and physiological signals. We discuss improvements in these areas, focusing on the key issue of inferring the psychological significance from physiological signals. We point out that while modern psychophysiology makes no pretense to be able to describe social behavior as a list of physiological correlates of psychological events, it is nevertheless possible to draw strong inferences from psychophysiological data. Next, we focus on the question of the utility of a psychophysiological approach for social psychology. We argue that many important empirical organizations are obscured by a restricted focus on a social or a biological level of analysis alone, but are apparent through a multi-level analysis that considers a joint operation of social and biological factors. Finally, we discuss several examples of psychophysiology findings that shed light on theoretical debates in social psychology.

Before we start, let us acknowledge a few limitations and add a few clarifications. The psychophysiological approach to social psychology represents a vast literature. As a result, in the limited space of this chapter we are unable to cover such key topics as arousal, facial expression, emotional regulation, health, interpersonal processes, psychosomatics, stress, and many others. We also do not discuss many important moderating variables such as age, gender, and individual differences. Fortunately, there are many excellent recent reviews of these topics (see Adler & Matthews, 1994; Blascovich & Tomaka, 1996; Davison & Pennebaker, 1996; Gardner, Gabriel, & Diekman, in press; Levenson & Ruef, 1997; Uchino, Cacioppo, & Kiecolt-Glaser, 1996). Similarly, we do not discuss many important types of psychophysiological measures such as cardiovascular responses, electroencephalography, and many others. Again, we refer the reader to recent reviews (Blascovich, in press; Cacioppo, Tassinary, & Berntson, in press). The psychophysiological approach to social psychology has been used to investigate the physiological consequences of social variables as well as a way to make inferences about mental processes underlying social behavior. The focus of our chapter is biased somewhat toward the latter approach. Finally, we would like to clarify that we use the word "psychophysiology" to refer to investigations focusing on both the autonomic and central nervous system, although the latter focus has earned a separate term of "neuroscience."

Inferring the Psychological Significance of Physiological Signals: From Early Enthusiasm to Cautious Optimism

Early observations

The notion that social psychological processes can be inferred from physiological responses dates at least as far back as the third century BC, when the Greek physician Erasistratos used his observation of an irregular heartbeat in a young man when his attractive stepmother visited to infer that lovesickness, not a physical illness, was the cause of the young man's malady (Mesulam & Perry, 1972). Two millennia later, the potential value of the psychophysiological data was recognized by McDougall (1908/1928) in the first social psychology textbook, who discussed the importance of biological influences (primarily instincts) on interpersonal interaction.

Empirical investigations of social psychological questions using psychophysiological data were not systematically pursued until the 1920s. Understandably, the initial studies were concerned primarily with establishing physiological correlates. For example, Riddle (1925) examined the correlation between deception and respiratory rhythms of people bluffing during a poker game. Smith (1936) investigated the usefulness of skin resistance for studying social influence by monitoring response of individuals confronted with the information that their peers' attitudes were discrepant from their own. Rankin and Campbell (1955) showed that Caucasian subjects showed a larger electrodermal response when an African American, rather than Caucasian, experimenter adjusted electrodes on their arms, a response that was interpreted as indication of prejudice.

After these modest beginnings, social psychophysiology grew in ambition, scope, and popularity. Books and chapters devoted to psychophysiological approaches to social behavior were published (Leiderman & Shapiro, 1964; Shapiro & Crider, 1969) and researchers began to hail the alleged objectivity and bias-free nature of psychophysiological measures.

But the enthusiasm was never universal. As a field, social psychology was always ambivalent toward biological measures and levels of analysis. Initially, biological factors were equated with innate causes such as instincts – an anathema to those who believed social psychology should focus on situational determinants. Thus, in 1924, Floyd Allport, author of an influential social psychology textbook, argued that it is more important to study how people construe events than to reduce social processes to physiological variables. Gordon Allport (1947) agreed, emphasizing verbal reports as a primary way to study social psychological processes. Other critics dismissed psychophysiological measures as limited to crude energetic aspects of behavior or relegated them to an inferior status of "last resort" measures – useful only if one has to investigate responses over which subjects have no control (Dawes & Smith, 1985). In an ironic reversal of physiological reductionism, some argued that bodily manifestations are "epiphenomena" of social processes (McGuire, 1985). The critical attitudes were bolstered in the late 1960s and early 1970s, when many psychophysiological studies of social processes proved disappointing. Among the findings were weak associations between self-reports and autonomic measurements, low correlations among various autonomic measures, and poor replicability across laboratories. In retrospect what these studies showed was that the mappings between social psychological processes and physiological events were less straightforward than initially believed (Cacioppo & Petty, 1983). Nevertheless, a number of investigators surmised that physiological approaches were irrelevant or unreliable indices (e.g. Barlow, 1988) and all chapters on social processes and biology were dropped from the *Handbook of Social Psychology*.

Contemporary perspectives

The criticisms did not stop the growth of the psychophysiological approach. Indeed, since 1986 more than 200 studies incorporating physiological variables have appeared in mainstream social psychological journals, and chapters discussing the interplay of biological and social processes can now be found in various handbooks in the field (e.g. Blascovich, in press; Cacioppo, Berntson, & Crites, 1996; Davison & Pennebaker, 1996). Two important reasons are behind this growth. First, researchers realized that the problem with the early research was not the biological level of analysis, but the assumptions and inferences drawn when formulating hypotheses, designing experiments, or interpreting psychophysiological data. This led to refinements in measurements and inference. Second, advances in neuroscientific techniques made increasingly possible investigations of the neural basis of social phenomena in normal populations, leading to the emergence of the field of social neuroscience. In the next few paragraphs we will discuss these developments.

Methodological and conceptual refinements A number of early problems were attributable to technical or methodological limitations and have fallen as the field progressed. For example, the replicability of psychophysiological measurements was fostered by the establishment of standards by the Society for Psychophysiological Research (see Cacioppo, Tassinary, & Berntson, in press). Other early problems were linked to insufficient physiological knowledge or simplistic assumptions about the operation of physiological processes. For example, many early studies treated arousal as a generalized nonspecific activation that equally affects autonomic, muscular, and central activity. Hence, depending on the paradigm, arousal was assessed with a wide array of physiological measures, some designed to reflect central activation (electroencephalography) and others designed to reflect various aspects of peripheral activation (heart rate, skin conductance, etc.). This, of course, led to conflicting findings and conceptual confusion. With additional research and theoretical development, however, sturdier, more intricate bridges were built spanning activational and behavioral processes (see Berntson, Cacioppo, & Quigley, 1991; Cacioppo, Berntson, & Crites, 1996).

Other important developments occurred in psychophysiological inference. Early psychophysiology was guided by the assumption of isomorphism between the psychological and physiological domain (Sarter, Berntson, & Cacioppo, 1996). Thus, it was believed that most psychological phenomena have a straightforward one-to-one correspondence to physiological systems and processes. This assumption led to two problems. First, researchers rarely tested if such an assumption is empirically true. Second, researchers believed that isomorphism is necessary for a psychophysiological measure to be useful.

Initially, once a physiological response that differentiated the presence versus absence of a psychological operation was identified, it was then assumed to be an invariant index of the presence or absence of a psychological event across various situations and paradigms. However, without testing the assumption of invariance, interpreting physiological data in this manner risks the error of affirming the consequent (Cacioppo & Tassinary, 1990). For example, the observation that lying is associated with a cardiovascular and skin conductance response (SCR) was initially thought to justify using these measures as an indicator of lying. Others who found that anxiety increased skin conductance response (SCR), then used SCR as an indicator of anxiety across individuals, situations, and paradigms. The same form of interpretation was evident in neuropsychology, where the observation that damage to a brain area leads to a deficit in a psychological function was interpreted as evidence that the brain area is uniquely identified with the function.[1]

Today, researchers are more likely to perform multiple tests before declaring an isomorphic relationship between a psychological and a physiological element. For example, before researchers in neuroscience attribute a psychological function to a brain circuit, they look for convergence of evidence from a variety of top-down and bottom-up approaches. As Sarter et al. (1996) have argued, evidence that a change in the psychological domain leads to a change in the physiological domain (e.g. performance of a psychological function leads to an activation of a circuit) is especially convincing when accompanied by evidence that a change in the physiological domain leads to a change in the psychological domain (e.g. lesion of a circuit results in a psychological deficit).[2]

Similarly, today, researchers are more likely to carefully delineate conditions under which a psychophysiological relationship holds and consider other reasons why a physiological response may occur (i.e. the base rate problem) before declaring that a physiological response can be used to "index" a psychological function (Cacioppo, Tassinary, & Berntson, in press). This can be illustrated with an example from research on the relationship between the facial EMG activity and emotion. Several research studies demonstrated that unpleasant imagery and stimuli lead to enhanced EMG activity over the brow region (e.g. Cacioppo, Petty, Losch, & Kim, 1986). Such a relationship allows facial EMG to be used to test specific experimental hypotheses using hypothetico-deductive logic, as discussed below. Note, however, that by itself such research does not demonstrate that EMG activity over the brow region *indexes* emotion. This is because increases in EMG activity over the brow region can occur for other reasons as well. The base rate problem, however, can be addressed empirically. To do that, Cacioppo, Martzke, & Petty (1988) first defined different forms of EMG responses over the brow region, and then examined the relation of these forms to the psychological state of their participants. Specifically, in their study, participants were interviewed about themselves while recordings of EMG activity were made. Afterwards, the participants watched a videotape of specific segments of the interview and were asked to describe what they had been thinking and feeling during each. Results indicated that specific forms of EMG responses over the brow region were predictive of the valence of participants' feelings during the interview, suggesting that inferential limitations attributable to high base rates can be lessened if the responses of interest are well defined. It is important to note, however, that even when such relations are established, it is not clear whether they generalize to other experimental contexts. Said more generally, the experimental context is as important to consider when interpreting the psychological significance of a physiological signal as it is when interpreting the psychological meaning of verbal responses or reaction time data.

In the preceding section we argued that contemporary researchers realize that the existence of isomorphic psychophysiological relationships cannot be assumed, but rather needs to be empirically verified. As we suggested at the end of that section, the correspondence between most psychological and physiological elements is context dependent. That is, depending on the context, the same neural circuit may participate in a different function and the same autonomic response may be elicited by a different psychological state. Similarly, depending on the context, the same psychological function may be performed by different circuits and affect a variety of psychological responses (see Farah, 1994; Sarter et al., 1996 for discussion of these issues). This observation raises a critical question. Do we need to test the nature of psychophysiological correspondence in every imaginable context before we are able to interpret a physiological measure? The answer, of course, is no. What this observation points out, however, is the critical role of theory in relating psychological and physiological events. As noted above, if different predictions can be derived from two psychological theories, the hypothetico-deductive logic of the experimental design allows strong inferences to be drawn even when the physiological measure is context dependent (Cacioppo & Tassinary, 1990; Platt, 1964).

As long as the researcher is sensitive to these limitations, and considers the base rate of the physiological event of interest, mapping the relationship between psychological and physiological events even within a single paradigm can offer valuable insights. This point can be illustrated with the following study that used skin conductance responses (SCR) to examine the question of knowledge without awareness. Tranel, Fowles, and Damasio (1985) were interested in whether patients who, as result of injury or disease, lost the ability to recognize faces, somehow retained an implicit ability to perform this discrimination. To test this hypothesis, the authors needed an implicit measure that varied as a function of facial recognition. However, the authors were aware that skin conductance responses can occur spontaneously and that – like reaction time measures – the psychological interpretation of skin conductance responses depends on the experimental context in which it was observed. Thus, they first ran a study demonstrating that in normal subjects the presentation of familiar faces evoked larger skin conductance responses than did the presentation of unfamiliar faces. The authors then used the same stimuli and procedures to study patients with prosopagnosia (inability to recognize faces). The results showed that prosopagnosic patients showed larger skin conductance responses to familiar faces than to unfamiliar faces, despite the absence of any conscious awareness of this distinction. That is, the psychophysiological measure provided early evidence of knowledge without awareness. Note that the importance of this work does not depend on skin conductance response being an invariant index of the recognition – it certainly is not. For example, studies on the orienting reaction have found enhanced SCR to novel stimuli (Lynn, 1966).

In conclusion, the time when biological levels of analyses were seen as dealing with innate or invariant characteristics has long passed. Accordingly, psychophysiology should not be thought of as providing a list of physiological invariants with which to index psychological constructs, but rather as a field of knowledge rich in theory and methods that may help innovative scholars test social psychological hypotheses.[3] Importantly, the issues raised in this section are not unique to psychophysiological measures. In fact, self-report and chronometric measures would all have to be abandoned if they were held to the requirement that they must map psychological operations in a one-to-one manner across individuals and contexts. The power of traditional social and cognitive measures comes from our knowledge of their strengths and limitations and from our understanding of their meaning within our paradigms. It behooves one to think of psychophysiological measures similarly.

Neuroscience tools enter social psychology Another reason for the current excitement about the psychophysiological approach to social psychology are the advances in neuroscience. For decades, studies of the neural basis of behavior were limited primarily to animal models, postmortem examinations, and observations of patients with brain damage. Recent years, however, brought enormous advances in brain imaging, electrophysiological recording, and neurochemical techniques. These tools are now regularly used to explore elementary cognitive processes in normal populations (Gazzaniga, 1994). These advances were not missed by social psychologists and increasingly subtle social phenomena also began to succumb to neuroscientific inquiry. Such interdisciplinary research led to the emergence of social neuroscience, a discipline that explicitly concerns itself with the study of the relationship between neural and social processes (Cacioppo & Berntson, 1992).

Towards a Multi-level Analysis of Social Phenomena

In the preceding section we discussed the advances in psychophysiological measurement and inference as well as the emergence of new tools for studying the neural basis of social behavior. But the excitement behind the psychophysiological approach to social psychology extends beyond methodological refinements or the addition of a brain scanner and neurochemistry lab to the psychophysiologist's toolbox. Perhaps the most important reason behind this excitement is the growing realization that a comprehensive account of social behavior calls for going beyond the single level of analysis and requires joint attention to factors from both the biological and social levels.[4] This point might be easier to appreciate after considering three general principles from Cacioppo and Berntson's (1992) doctrine of multi-level analysis.

The principle of multiple determinism specifies that a target event at one level of organization may have multiple antecedents within or across levels of organization. For example, consider the multiple factors that contribute to drug abuse. On the micro-level, researchers identified the contribution of individual differences in the susceptibility of the endogenous opiod receptor system, while on the macro-level researchers point to the role of social variables such as socialization and peer pressure. Our understanding of drug abuse is incomplete if either perspective is excluded.[5]

The principle of nonadditive determinism specifies that properties of the collective whole are not always predictable from the properties of the parts. Said differently, some empirical regularities will not be detectable until one looks at the data across levels of organization. Consider an illustrative study by Haber and Barchas (1983). These investigators were interested in the effects of amphetamine on primate behavior. The behavior of nonhuman primates was examined following the administration of amphetamine or placebo. No clear differences emerged between these conditions until each primate's position in the social hierarchy was considered. When this social factor was taken into account, amphetamines were found to increase dominant behavior in primates high in the social hierarchy and to increase submissive behavior in primates low in the social hierarchy. The import-ance of this study derives from its demonstration of how the effects of physiological changes on social behavior can appear unreliable until the analysis is extended across levels of organization.

A strictly physiological (or social) analysis, regardless of the sophistication of the measurement technology, may not have unraveled the orderly relationship that existed.

Finally, the principle of reciprocal determinism specifies that there can be mutual influences between microscopic (e.g. biological) and macroscopic (e.g. social) factors. For example, as is well known, the level of testosterone in nonhuman male primates can promote sexual behavior. Less well known, however, is the fact that the availability of receptive females influences the level of testosterone in nonhuman primates (Bernstien, Gordon, & Rose, 1983). Within social psychology, research has demonstrated that exposure to violent and erotic materials influences the level of physiological arousal in males, and that the level of physiological arousal has a reciprocal influence on perceptions of and tendencies toward sex and aggression (Zillman, 1989). A comprehensive account of these phenomena cannot be achieved by social psychologists if biological levels of organization are considered irrelevant or outside their purview.

Considering multiple levels of analysis not only can ensure more comprehensive explanations of existing social phenomena, but can also reveal new empirical domains previously thought not to be subject to social influences. It can challenge existing theories in the neurosciences and physiology, resulting in inclusion of social variables. It can even lead to theoretical revolutions. For instance, immune functions were once considered only to reflect physiological responses to pathogens and tissue damage. It is now clear that social psychological variables are among the most powerful determinants of the expression of immune reactions (for reviews see Kennedy, Glaser, & Kiecolt-Glaser, 1990; Uchino, Cacioppo, & Kiecolt-Glaser, 1996).

Changing notions of the mind

The previous section emphasized a growing recognition of the value of looking at both the body and the mind in advancing psychological research. These developments, of course, did not happen in a theoretical vacuum. The notion of multi-level analysis fits the present *Zeitgeist* and coincides with the fading of two important assumptions about the mind.

The first fading notion is the traditional computer metaphor representing the mind as a "hardware-independent" software that can "run" on anything – neurons, silicon chips, or even wooden parts (Block, 1995). While the computer metaphor nicely clarified the benefits of analyzing psychological processes on a level of function, it misleadingly suggested a complete independence of the hardware and software levels. This meant that nothing useful about the organization of the mind can be learned from studying the organization of the brain, and, conversely, that nothing useful about the brain can be learned from the mind.

Another fading notion is the conception of the mind as a "general-purpose" mechanism that is limitlessly shapeable by environmental conditions and able to process all mental content with equal ease. The assumption of no biological constraints clashes with animal and human research showing the effects of preparedness and specialization for many psychological processes (Hirshfeld & Gelman, 1994; Seligman, 1970). It also conflicts with what we know about the powerful role of natural selection that shaped the design of the brain for millions of years (Cosmides & Tooby, 1995; Rozin & Schull, 1988).

How Can Psychophysiology Contribute to Social Psychology?

In the preceding sections we have suggested that, when used properly, the theory and methods of psychophysiology allow strong inferences about psychological processes. We have also argued that psychophysiological inquiry can foster comprehensive accounts of cognition, emotion, and behavior. In this section, we illustrate how social psychological theories can benefit from a psychophysiological approach. Specifically, we show that the psychophysiological research can (a) contribute to discovery of new phenomena and (b) help us decide between competing theories of existing phenomena. We draw our examples from two popular domains of research: social cognition and emotion. First, focusing on social cognition, we show how psychophysiology played a crucial role in discovery of implicit memory and then discuss how recent psychophysiological findings could contribute to the debate about differences between social and non-social cognition. We then turn to the topic of emotion and show how psychophysiology has contributed to the debate about the relation between affect and cognition, inspired a change in our understanding of the relation between positive and negative affect, and offered a new look at the role of emotions in reasoning.[6]

Social cognition

Implicit and explicit memory A classic example of the influence of psychophysiology on theories in cognitive and social psychology comes from neuropsychological research on implicit memory. Until the mid 1950s, psychologists thought of long-term memory as a single, general mechanism responsible for storage of all types of information. This started to change with the now-famous neurological patient H.M.. In an attempt to treat epilepsy, H.M. underwent a bilateral resection of the medial portion of the temporal lobes, including the hippocampus and mammiliary bodies (Scoville & Milner, 1957). Although the surgery reduced H.M.'s epileptic seizures, the patient also appeared to have lost the ability to remember new information. Interestingly, further investigations determined that H.M.'s anterograde amnesia was not as complete as originally thought. In fact, H.M. showed a surprising ability to acquire new skills in the absence of any explicit recollection of learning those skills. This finding spurred research in cognitive psychology resulting in development of multi-memory models. These models distinguish between episodic memory, which enables people to retrieve specific events from the past, and semantic memory, which enables people to act on a knowledge without requiring a recollection of a specific event. Further refinements led to the concepts of explicit memory and implicit memory (see Squire, 1992 for a review). The theoretical changes sparked by H.M. and other neurological cases soon found their way into social psychology, inspiring a wave of research on implicit memory for social information and contributing to the current interest in automaticity (e.g. Bargh, 1996; Greenwald & Banaji, 1995).

What is social about social cognition? Psychophysiological findings can also bear directly on existing theoretical controversies in social psychology. Consider the debate on whether mental processes dealing with social objects are different from mental processes dealing with non-social objects.

According to Ostrom (1984) social psychologists take three positions on the question "what is social about social cognition." The *fundamentalists* claim that the same cognitive capacities and processing mechanisms are available regardless of whether the stimuli involve social or non-social objects. The proponents of the *building-block* view say that the processes involved in dealing with social events build upon simpler and conceptually more fundamental processes involved in dealing with non-social events. For example, principles of non-social cognition such as classical conditioning and categorization need to be supplemented with variables such as self-relevance or personal goals. Finally, the *realists* oppose the building-block view, arguing that mental processes involved in dealing with non-social objects derive from processes designed to deal with social objects. Thus, social cognition represents the general case in the study of cognitive processes, whereas research with non-social objects represents a special case in which the parameters on the social dimension are set to zero.

Interestingly, Ostrom (1984, p. 23) noted that although "the question of social versus non-social cognition has implications for many different research areas, not enough data are yet available to determine whether different processes are involved in the two." We suggest that recent psychophysiological research on face perception and mental state inference offers relevant evidence.

A successful social interaction requires an ability to remember new faces, recognize familiar faces, and correctly interpret facial expressions.[7] Are faces processed just like other complex objects? Evidence suggests that at least some aspect of face perception involves unique processes. Such a conclusion is suggested by findings suggesting the existence of face-specific neurons in the temporal lobe (Perrett, Rolls, & Caan, 1982) and findings on dissociations between face and object recognition (Bruce & Young, 1986). As mentioned above, prosopagnosic patients lose the ability to recognize people based on their faces, yet they are able to recognize comparably complex non-facial stimuli.

The possibility that processing of some kinds of social information may be unique extends beyond perceptual stimuli like faces to reasoning about mental states such as intentions, beliefs, and desires – an ability that is long considered to be a marker of social cognition (Heider, 1958; Ostrom, 1984). In recent years researchers began noticing that some brain injuries compromise people's ability to make inferences about others' mental states. For example, patients with damage to the orbitofrontal cortex show selective deficits on advanced theory of mind tests (Stone, Baron-Cohen, & Knight, 1998). Neuroimaging data with normal populations provide complementary findings. For instance, Baron-Cohen, Ring, Moriarty, Schmitz, Costa, & Plaisted (1994) found that answering questions about mental state terms led to increased activation in orbitofrontal regions compared to answering questions about terms related to body parts. Interestingly, some developmental disorders are characterized by a selective impairment or selective sparing in the ability to make mental state inferences. A case in point are children with autism who have difficulty with false belief tasks and tasks requiring understanding of social interaction, but who perform well on tasks requiring understanding of non-mental representations and interactions with physical objects (Baron-Cohen, Leslie, & Firth, 1985). In contrast, individuals with Williams or Down Syndrome perform relatively well on theory-of-mind tasks but are impaired on

other, less social tasks (Karmiloff-Smith, Klima, Bellugi, Grant, & Baron-Cohen, 1995).

What do these data tell about the relation between social and non-social cognition? They do not fit predictions from the realist or the fundamentalist model, emphasizing the generality of social or non-social cognition, respectively. According to these positions, we should not observe a relative impairment or advantage, or differences in the pattern of neural activation, while processing social versus non-social information (assuming task demands have been equated). The alternative "building-block" model assumes that social cognition derives from non-social cognition. The model is certainly correct when we consider basic perceptual and conceptual processes. However, the strong form of the model has trouble accounting for observations that the processing of social information can be relatively spared compared to processing of non-social information. In other words, it seems that processing of at least certain kinds of social information is not derivative from mechanisms involved in processing of complex non-social information. We hasten to clarify that the above data do *not* imply the existence of a physically separate, dedicated circuit for dealing with "social" information in general, or all face-related or mental-state related information in particular. We simply suggest that processing of certain kinds of social information may represent a unique combination of patterns across neural substrates.[8]

Human emotions

Another topic in social psychology that has benefited from progress in psychophysiology is emotion. The dialogue between psychological and physiological investigators began with James (1894) and continues to this day (e.g. Damasio, 1994; LeDoux, 1995; Panksepp, 1998). In this section, we limit discussion to three issues that have received quite a bit of attention in the social psychological community: the relation between affect and cognition, the relation between positive and negative affect, and the role of emotions in decision making.

Relation between cognition and emotion In 1980 Zajonc argued for primacy and independence of affective processing. His argument has been criticized on conceptual grounds by researchers suggesting that regular cognitive mechanisms are fully sufficient to explain processing of affective stimuli (e.g. Lazarus, 1984). The empirical basis of Zajonc's argument was also criticized. For example, as evidence that some affective responses involve minimal cognitive participation, Zajonc cited the increase in positive affect as a result of repeated, unreinforced exposures to stimuli (the mere-exposure effect). Some researchers argued that the mere-exposure effect can be explained without any reference to affective change (e.g. Mandler, Nakamura, & Van Zandt, 1987).

In the years since 1980, psychophysiological evidence has shed new light on the emotion–cognition debate. Consistent with the assumptions of affective primacy, animal studies suggest the existence of a pathway that projects a coarse representation of a stimulus from the visual thalamus directly to the amygdala. When necessary, this pathway allows for a generation of a quick affective response based on an analysis of primitive stimulus features, before a more complex analysis is completed (LeDoux, 1995).

Consistent with the assumption of affect independence, recent animal and human studies suggest that emotional and cognitive processing rely on the integrity of partially different neural mechanisms. For example, in monkeys, damage to the amygdala affects emotional behavior but not memory, while damage to the hippocampal formation affects memory but not emotional behavior (Zola-Morgan, Squire, Alvarez-Royo, & Clower, 1991). In human studies, patients with damaged amygdala show impairments in emotional conditioning, but are able to acquire declarative knowledge about reinforcement contingencies, while patients with damaged hippocampus show impairments in declarative learning, but are able to acquire emotionally conditioned responses (Bechara, Tranel, Damasio, & Adolphs, 1995). The human findings are not limited to cases where researchers had to rely on naturally occurring damages to neural circuits. For example, neuroimaging studies with normal populations show selective activation of the amygdala during acquisition of conditioned responses (e.g. Morris, Oehman, & Dolan, 1998). Finally, the existence of a unique evaluative mechanism is consistent with the recent studies using event-related potentials. For instance, Crites and Cacioppo (1996) reported that affective categorizations were characterized by a right-lateralized late positive event-related brain potential, whereas non-affective categorizations were more symmetrical – a finding consistent with the importance of the right hemisphere in emotion (Tucker & Frederick, 1989).

Psychophysiological data also shed light on the mechanisms underlying the effects of mere-exposure. As noted above, some researchers argue that the mere-exposure effect can be fully explained by cognitive mechanisms. According to such an account, repeated exposure first leads to an increase in perceptual fluency (processing ease) of the stimulus. Participants then (mis)attribute the enhanced fluency to liking, or any other salient dimension, just like they have been shown to (mis)attribute fluency to features like fame, loudness, or clarity (Bornstein & D'Agostino, 1994; Klinger & Greenwald, 1994; see also Mandler et al., 1987 for a related account based on the notion of "non-specific" activation). Thus, according to these accounts, liking for the mere-exposed stimulus is not genuine, but an artifact of the judgment task. However, Winkielman and Cacioppo (1998) argued that the involvement of perceptual fluency mechanisms does not necessarily imply the absence of genuine affect. If so, these authors reasoned, increasing perceptual fluency should not only lead to increases in liking judgment, but also to increases in electromyographic (EMG) activity over the cheek region – an indicator of positive affect. In a series of studies using various manipulations of processing ease (e.g. stimulus degradation, presentation duration) Winkielman & Cacioppo found that easy-to-process stimuli generated stronger responses over the cheek region than hard-to-process ones, consistent with the posited increase in positive affect. The above findings are consistent with demonstrations that mere-exposed stimuli generate stronger EMG responses over the cheek region than novel stimuli (Harmon-Jones and Allen, 1996).[9] Interestingly, both Winkielman and Cacioppo (1998) and Harmon-Jones and Allen (1996) studies observed the growth of positive responses to initially neutral stimuli, not a decrease in negative responses, thus suggesting that the mere-exposure effect cannot be fully explained by the extinction of neophobia (Panksepp, 1998; Zajonc, 1998).

Relation between positive and negative affect Psychophysiological evidence has also contributed to our understanding of affect organization. Past research has traditionally been guided by the notion that the qualitative features of affect could be represented along a single evaluative (pleasant/unpleasant) continuum (e.g. Osgood, Suci, & Tannenbaum, 1957; Thrustone, 1931). Such a conception considers approach–avoidance behavior, positive–negative mood, and favorable–unfavorable feelings as bipolar opposites, analogous to the physical construct of hot and cold temperatures. Although overt affective expressions may indeed tend toward bipolarity, Cacioppo, Gardner, & Berntson (1997) proposed in their bivariate model of evaluative space that the mechanisms underlying the experience and processing of positive and negative affect are partially independent and asymmetrical. Important to the emergence of the bivariate model were psychophysiological data suggesting the existence of partially separate systems involved in the processing of appetitive and defensive information (see review by Cacioppo, Gardner, & Berntson, in press). Another important foundation for this model was research on conflict behavior in rodents (Miller, 1959). This research provided one of the earliest demonstrations of positive/negative asymmetry by noting that the slope for the avoidance gradient was steeper than the slope for the approach gradient (see Cacioppo & Berntson, 1994 for discussion).

The bivariate model of evaluative space helps understand a variety of sociopsychological findings. It sheds new light on attitudinal ambivalence by specifying mechanisms subserving the coactivation of positive and negative affect toward the same stimulus (e.g. Katz, Wackenhut, & Hass, 1986; Gardner & Cacioppo, 1995), and also by predicting an asymmetry in the topography of attitude ambivalence (Cacioppo, Gardner, & Berntson, 1997). The model also helps explain the independence of positive and negative mood in daily ratings by allowing for a differential dynamic of systems responsible for regulation of positive and negative moods (e.g. Diener & Emmons, 1984). Finally, the model accounts for observations that processing of positive and negative information are not mirror images of each other, but are characterized by different activation functions. Specifically, when dealing with neutral stimuli, the organism shows a default tendency for positive behaviors – an operating characteristic referred to as "positivity offset." For example, given little information people expect happy events across a variety of life domains (Taylor, 1991) and tend to form positive impressions of unknown others (Peeters & Czapinski, 1990). However, as the amount of external information increases, the effects of the positivity offset give way to the effects of a second operating characteristic posited in the bivariate model of evaluative space – the negativity bias. The negativity bias refers to the organism's tendency to respond more strongly to the increase in the amount of negative information than to the comparable increase in the amount of positive information. For example, in impression formation, negative features weigh more heavily on the overall impression than do positive features (Skowronski & Carlston, 1989). Recent findings suggest that this negativity bias emerges at relatively early stages of evaluative processing. For instance, Ito, Larsen, Smith, & Cacioppo (1998) presented positive, negative, and neutral pictures embedded within sequences of other neutral pictures and recorded event-related potentials (ERPs) in response to these pictures. In prior research, the late positive potential of the ERP has been shown to be sensitive to evaluative categorizations. Ito et al. (1998) showed that the presentation of negative pictures was associated with larger ERPs than the presentation of equally probable, equally extreme, and equally arousing positive pictures, suggesting that the negativity bias emerges even before responses to the stimuli are selected or executed.[10]

The role of emotions in reasoning Finally, recent psychophysiological evidence may suggest a revision in the traditional view that emotion is an impairment to reason – a view as old as the notion of "animal passions." Consider, for example, patients with damage to the prefrontal cortex. These individuals show only limited deficits in their ability to analyze the pros and cons of a situation, yet are reported to experience great difficulties in making everyday decisions. The decisions of these patients are often poor. For example, one patient repeatedly lost money on "promising" business deals. Moreover, these patients have problems with making decisions in a timely way. For example, one patient spent many hours deciding between two different days for his next doctor visit (Damasio, 1994).

To account for these observations, researchers suggest that one of the functions of the prefrontal cortex is to link the cognitive representations of various options with representations of the anticipated affective consequences of these options (Damasio, 1994; Tucker, Luu, & Pribram, 1995). Such a link gives the decision maker access to somatic representations of affective consequences of past decisions, thus accounting for the differences in rejection/acceptance of alternatives that past experience would deem wise or unwise. Moreover, such a link affectively prioritizes certain options, which allows the decision maker to sort more effectively through the decision tree, thus accounting for the differences in speed of decision making between normals and prefrontal patients.

In an interesting demonstration of the role of affective feedback in reasoning, Bechara, Damasio, Tranel, & Damasio (1997) asked prefrontal patients and normals to make money in a gambling game that required them to select cards from different decks. Some cards were associated with a payment while others were associated with a substantial loss. The rules of the game were complex enough to prevent the players from easily figuring out payoffs associated with each deck. Interestingly, after playing the game for a while, normals started to show anticipatory skin-conductance response to decks associated with a loss and began to avoid taking cards from these decks. The prefrontal patients, however, showed no anticipatory SCR responses to these decks and continued to take cards from them. Interestingly, these autonomic and behavioral differences emerged even though at this point of the game normals and prefrontal patients did not differ in their explicit understanding of the payoff rules. Bechara et al. (1997) interpreted these results to mean that the ability to make good decisions is at least partly dependent on intact mechanisms of affective feedback.

Conclusion

Biological approaches to social psychology have progressed enormously in recent years. Traditional tools have been improved and exciting new ones developed. Researchers have also learned to use these tools with more caution and understanding, thus advancing our ability to make strong inferences from psychophysiological data. Along with these methodological developments, social psychologists have increased their appreciation for the various biological (evolutionary, neural, hormonal) aspects of social phenomena. Today, social psychologists are more likely to realize that it is the social psychological phenomenon, not the particular measurement strategy or level of analysis, that is important in guiding research and theory in social psychology. They also realize that multi-level research can foster

comprehensive accounts of existing phenomena, contribute to the discovery of important new phenomena, and inspire theoretical advances.

Obviously, not all investigators will decide to include a biological level of analysis in their research. However, many will discover that consideration of biological factors not only enriches their understanding of basic social psychological processes, but also allows them to better understand the implications of their research for problems of mental and physical health. It would be a shame if social psychologists did not use the best tools available to do that.

Notes

1 Such errors can be seen even today in popular interpretations of neuroscience findings. Once a brain area is found to be activated during the performance of a psychological function, it is then uniquely identified with the function (see Sarter, Berntson, & Cacioppo, 1996). The legacy of phrenology is long-lived and unfortunate as evidenced by the occasional dismissals of entire modern cognitive neuroscience as the "new phrenology."

2 Fortunately, modern neuroscience offers several bottom-up approaches that complement top-down approaches. Researchers can capitalize on naturally occurring disorders and traumas and can manipulate specific neural circuitry by means of selective lesions, activation by electrical stimulation or inactivation by cooling, pharmacological stimulations and blockades, etc.

3 Similarly, it is not a problem that concepts in the physiological domain do not correspond neatly to concepts in the psychological domain (Fodor, 1975). It is still possible to interpret psychophysiological measures in well-constructed psychological designs (Cacioppo & Berntson, 1992).

4 We wish to emphasize the difference between multi-level analysis and reductionism. Multi-level analysis is grounded in the belief that each level provides a unique way of looking at a phenomenon and reveals organizations obscured on other levels. Reductionism implies that one level of analysis is ultimately superior and all phenomena should be explained in its terms (Fodor, 1975).

5 A corollary to the principle of multiple determinism is that the mapping between elements across levels of organization becomes more complex as the number of intervening levels of organization increases. The implication is that the likelihood of erroneous mappings increases as one jumps over levels of organizations.

6 For additional examples and arguments see Klein and Kihlstrom (1998).

7 Recent research underscores the importance of the ability to interpret facial expressions in social interaction. Adolphs, Tranel, and Damasio (1998) asked normal subjects and subjects with amygdala damage for judgments of trustworthiness and approachability of several target individuals. The targets were presented in verbal descriptions and in facial portraits. When relying on the descriptions, participants with amygdala damage rated the targets similarly to controls. However, when relying on portraits, the subjects with amygdala damage rated the untrustworthy and unapproachable targets much less negatively than controls.

8 Recent evidence suggests that uniqueness of social cognition might be partly anchored in a "living versus non-living" distinction. For example, some patients selectively lose ability to recognize animals and plants while preserving the ability to recognize inanimate objects, such as tools (e.g. Caramazzo & Shelton, 1998). Interestingly, Heider (1958) anticipated this possibility by emphasizing the fundamental difference between perception of self-initiated action, and action driven by external forces. Additional research is obviously needed.

9 It is also relevant that in self-report studies subjects rate the perceptually fluent stimuli and the mere-exposed stimuli as more likable, but not as more dislikable, regardless of a question focus (Reber, Winkielman, & Schwarz, 1998; Seamon, McKenna, & Binder, 1998).

10 Such asymmetries in evaluative processing make evolutionary sense. Positivity-offset guarantees that an organism facing neutral or unfamiliar stimuli would be weakly motivated to approach and explore – after, of course, an initial neophobic response is habituated. On the other hand, a negativity bias guarantees that an organism shows caution when dealing with threatening stimuli. Such tendencies make good survival sense, since it is usually more difficult to reverse the consequence of an assault than an opportunity not pursued (Cacioppo, Gardner, & Berntson, in press). Incidentally, humans are not the only species to exhibit behavioral asymmetries in the domain of gains and losses (Stephens & Krebs, 1986).

References

Adler, N., & Matthews, K. (1994). Health psychology: Why do some people get sick and some stay well? *Annual Review of Psychology, 45*, 229–259.

Adolphs, R., Tranel, D., & Damasio, A. R. (1998). The human amygdala in social judgment. *Nature, 393*, 470–474.

Allport, F. H. (1924). *Social Psychology*. Boston: Houghton Mifflin.

Allport, G. W. (1947). Scientific models and human morals. *Psychological Review, 54*, 182–192.

Bargh, J. A. (1996). Automaticity in social psychology. In E. T. Higgins & A. W. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 169–183). New York: Guilford Press.

Barlow, D. H. (1988). *Anxiety disorders: the nature and treatment of anxiety and panic*. New York: Guilford Press.

Baron-Cohen, S., Leslie, A., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21*, 37–46.

Baron-Cohen, S., Ring, H., Moriarty, J., Schmitz, B., Costa, D., & Plaisted, K. (1994). Recognition of mental state terms: Clinical findings in children with autism and functional neuroimaging study of normal adults. *British Journal of Psychiatry, 165*, 640–649.

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science, 275*, 1293–1295.

Bechara, A., Tranel, D., Damasio, H., & Adolphs, R. (1995). Double dissociation of conditioning and declarative knowledge relative to the amygdala and hippocampus in humans. *Science, 269*, 115–118.

Bernstien, I. S., Gordon, T. P., & Rose, R. M. (1983). The interaction of hormones, behavior, and social context in non-human primates. In B. B. Svare (Ed.), *Hormones and aggressive behavior* (pp. 535–561). New York: Plenum Press.

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

Blascovich, J. (in press). Social psychophysiological methods. In C. M. Judd & H. Reis (Eds.), *Advanced research methods in social psychology*. Cambridge, UK: Cambridge University Press.

Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. In M. Zanna (Ed.), *Advances in experimental social psychology* Vol. 28 (pp. 1–51). New York: Academic Press.

Block, N. (1995). The mind as the software of the brain. In E. E. Smith, & D. N. Osherson (Eds.), *Thinking*. 2nd. edn., Vol. 3 (pp. 377–425). Cambridge, MA: MIT Press.

Bornstein, R. F., & D'Agostino, P. R. (1994). The attribution and discounting of perceptual fluency: Preliminary tests of a perceptual fluency/attributional model of the mere exposure effect. *Social Cognition, 12*, 103–128.

Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology, 77*, 305–327.

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

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

Cacioppo, J. T., & Petty, R. (1983). *Social psychophysiology*. New York: Guilford Press.

Cacioppo, J. T., & Tassinary, L. G. (1990). Inferring psychological significance from physiological signals. *American Psychologist, 45*, 16–18.

Cacioppo, J. T., Berntson, G. G., & Crites, S. L. (1996). Social neuroscience: Principles of psychophysiological arousal and response. In E. T. Higgins & A. W. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 72–101). New York: Guilford Press.

Cacioppo, J. T., Crites, S. L., & Gardner, W. L. (1996). Attitudes to the right: Evaluative processing is associated with lateralized late positive event-related brain potential. *Personality and Social Psychology Bulletin, 22*, 1205–1219.

Cacioppo, J. T., Gardner, W., & Berntson, G. G. (1997). Beyond bipolar conceptualizations and measures: The case of attitudes and evaluative space. *Personality and Social Psychology Review, 1*, 3–25.

Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (in press). The affect system: Form follows function. *Journal of Personality and Social Psychology*.

Cacioppo, J. T., Martzke, J. S., & Petty, R. E. (1988). Specific forms of facial EMG response index emotions during an interview: From Darwin to the continuous flow hypothesis of affect-laden information processing. *Journal of Social and Personality Psychology, 54*, 592–604.

Cacioppo, J. T., Tassinary, L. G., & Berntson, G. G. (in press). Psychophysiological sciences. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology*. New York: Cambridge University Press.

Cacioppo, J. T., Petty, R. E., Losch, M. E., & Kim, H. S. (1986). Electromyographic activity over facial muscle regions can differentiate the valence and intensity of affective reactions. *Journal of Personality and Social Psychology, 50*, 260–268.

Caramazzo, A., & Shelton, J. R. (1998). Domain-specific knowledge systems in the brain: The animate–inanimate distinction. *Journal of Cognitive Neuroscience, 10*, 1–34.

Cosmides, L., & Tooby, J. (1995). From function to structure: The role of evolutionary biology and computational theories in cognitive neuroscience. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 1199–1210). Cambridge, MA: MIT Press.

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

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

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

Davison, K., & Pennebaker, J. W. (1996). Social psychosomatics. In E. T. Higgins & A. Kruglansky (Eds.), *Social psychology: Handbook of basic principles* (pp. 102–130). New York: Guilford Press.

Dawes, R. M., & Smith, T. L. (1985). Attitude and opinion measurement. In G. A. Lindzey (Ed.), *Handbook of social psychology*. 3rd. edn., Vol. 1 (pp. 509–566). New York: Random House.

Diener, E., & Emmons, R. A. (1984). The independence of positive and negative affect. *Journal of Personality and Social Psychology, 47*, 1105–1117.

Farah, M. J. (1994). Neuropsychological inference with an interactive brain: A critique of the "locality" assumption. *Brain and Behavioral Sciences, 17*, 43–104.

Fere, C. (1888/1976). Notes on change in electrical resistance under the effect of sensory stimulation and emotion. *Comptes rendues des seances de al societe de biologie, 5*, 217–219.

Fodor, J. A. (1975). *The language of thought*. New York: Crowell.

Gardner, W. L., & Cacioppo, J. T. (1995). Multi-gallon blood donors: Why do they give? *Transfusion, 35*, 795–798.

Gardner, W. L., Gabriel, S., & Diekman, A. B. (in press). Interpersonal Processes. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology*. New York: Cambridge University Press.
Gazzaniga, M. S. (Ed.) (1994). *The cognitive neurosciences*. Cambridge, MA: MIT Press.
Greenwald, A. G., & Banaji, M. R. (1995). Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Psychological Review, 102*, 4–27.
Haber, S. N., & Barchas, P. R. (1983). The regulatory effect of social rank on behavior after amphetamine administration. In P. R. Barchas (Ed.), *Social hierarchies: Essays toward a sociophysiological perspective* (pp. 119–132). Westport, CT: Greenwood Press.
Harmon-Jones, E., & Allen, J. J. B. (1996). Anterior EEG asymmetry and facial EMG as evidence that affect is involved in the mere exposure effect. *Psychophysiology, 33*, 544 (abstract).
Heider, F. (1958). *The psychology of interpersonal relations*. New York: Wiley.
Hirschfeld, L. A., & Gelman, S. A. (Eds.) (1994). *Mapping the mind: Domain specificity in cognition and culture*. New York: Cambridge University Press.
Ito, T. A., Larsen, J. T., Smith, N. K., & Cacioppo, J. T. (1998). Negative information weighs more heavily on the brain: The negativity bias in evaluative categorizations. *Journal of Personality and Social Psychology, 75*, 887–900.
James, W. (1894). The physical basis of emotion. *Psychological Review, 1*, 516–529.
Karmiloff-Smith, A., Klima, E., Bellugi, U., Grant, J., & Baron-Cohen, S. (1995). Is there a social module? Language, face processing and theory of mind in individuals with William's syndrome. *Journal of Cognitive Neuroscience, 7*, 196–208.
Katz, I., Wackenhut, J., & Hass, R. G. (1986). Racial ambivalence, value duality and behavior. In J. F. Dovidio & S. L. Gaetner (Eds.), *Prejudice, discrimination, and racism* (pp. 35–59). New York: Academic Press.
Kennedy, S., Glaser, R., & Kiecolt-Glaser, J. K. (1990). Psychoneuroimmunology. In J. T. Cacioppo & L. G. Tassinary (Eds.), *Principles of psychophysiology: Physical, social and inferential elements* (pp. 177–192). New York: Cambridge University Press.
Klein, S. B. & Kihlstrom, J. F. (1998). On bridging the gap between social-personality psychology and neuropsychology. *Personality and Social Psychology Review, 2*, 228–242.
Klinger, M. R., & Greenwald, A. G. (1994). Preferences need no inferences?: The cognitive basis of unconscious mere exposure effects. In P. M. Niedenthal & S. Kitayama (Eds.), *The heart's eye* (pp. 67–85). San Diego: Academic Press.
Lazarus, R. S. (1984). On primacy of cognition. *American Psychologist, 39*, 124–129.
LeDoux, J. E. (1995). Emotions: Clues from the brain. *Annual Review of Psychology, 46*, 209–235.
Leiderman, P. H. & Shapiro, D. (Eds.) (1964). *Psychobiological approaches to social behavior*. Stanford, CA: Stanford University Press.
Levenson, R. W., & Ruef, A. M. (1997). Physiological aspects of emotional knowledge and rapport. In W. J. Ickes (Ed.), *Emphatic accuracy* (pp. 44–72). New York: Guilford Press.
Lynn, R. (1966). *Attention, arousal and the orienting reaction*. Oxford, UK: Pergamon Press.
McDougall, W. (1908/1928). *An introduction to social psychology*. Boston: John W. Luce.
McGuire, W. J. (1985). Attitudes and attitude change. In G. Lindzey & E. Aronson (Eds.), *The handbook of social psychology* 3rd edn. (pp. 000–000). Reading, MA: Addison-Wesley.
Mandler, G., Nakamura, Y., & Van Zandt, B. J. (1987). Nonspecific effects of exposure on stimuli that cannot be recognized. *Journal of Experimental Psychology Learning, Memory, and Cognition, 13*, 646–648.
Mesulam, M. M., & Perry, J. (1972). The diagnosis of lovesickness: Experimental psychophysiology without polygraph. *Psychophysiology, 9*, 546–551.
Miller, N. E. (1959). Liberalization of basic S–R concepts: Extensions to conflict behavior, motivation and social learning. In S. Koch (Ed.), *Psychology: A study of a science, study 1* (pp. 198–292). New York: McGraw Hill.
Morris, J. S., Oehman, A., & Dolan, R. J. (1998). Conscious and unconscious emotional learning in the human amygdala. *Nature, 393*, 467–470.
Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. (1957). *The measurement of meaning*. Urbana, IL: University of Illinois Press.

Ostrom, T. M. (1984). The sovereignty of social cognition. In R. S. Wyer & T. K. Srull (Eds.), *Handbook of social cognition* Vol. 1 (pp. 1–38). Hillsdale, NJ: Lawrence Erlbaum Associates.
Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. New York: Oxford University Press.
Peeters, G., & Czapinski, J. (1990). Positive–negative asymmetry in evaluations: The distinction between affective and informational negativity effects. In W. Stroebe & M. Hewstone (Eds.), *European review of social psychology* Vol. 1 (pp. 33–60). New York: Wiley.
Perrett, D. I., Rolls, E. T., & Caan, W. (1982). Visual neurons responsive to faces in the monkey temporal cortex. *Experimental Brain Research, 47*, 329–342.
Platt, J. R. (1964). Strong inference. *Science, 146*, 347–353.
Rankin, R. E., & Campbell, D. T. (1955). Galvanic skin response to negro and white experimenters. *Journal of Abnormal and Social Psychology, 51*, 30–33.
Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency of affective judgments. *Psychological Science, 9*, 45–48.
Riddle, E. M. (1925). Aggressive behavior in a small social group. *Archives of Psychology, 78*.
Rozin, P., & Schull, J. (1988). The adaptive–evolutionary point of view in experimental psychology. In R. C. Atkinson, R. J. Herrnstein, G. Lindzey, & R. D. Luce (Eds.), *Stevens' handbook of experimental psychology*, Vol. 1: *Perception and motivation*; Vol 2: *Learning and cognition* (pp. 503–546). New York: Wiley.
Sarter, M., Berntson, G. G., & Cacioppo, J. T. (1996). Brain imaging and cognitive neuroscience: Toward strong inference in attributing function to structure. *American Psychologist, 51*, 13–21.
Scoville, W. B., & Milner, B. (1957). Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery, & Psychiatry, 20*, 11–21.
Seamon, J., McKenna, P. A., & Binder, N. (1998). The mere exposure effect is differentially sensitive to different judgment tasks. *Consciousness and Cognition: An International Journal, 7*, 85–102.
Seligman, M. E. P. (1970). On the generality of the laws of learning. *Psychological Review, 74*, 406–418.
Shapiro, D., & Crider, A. (1969). Psychophysiological approaches to social psychology. In G. A. Lindzey (Ed.), *Handbook of social psychology*. 2nd. edn., Vol. 3 (pp. 1–49). Reading, MA: Addison-Wesley.
Skowronski, J. J., & Carlston, D. E. (1989). Negativity and extremity biases in impression formation: A review of explanations. *Psychological Bulletin, 105*, 131–142.
Smith, C. E. (1936). A study of autonomic excitation resulting from the interaction of individual opinion and group opinion. *Journal of Abnormal Psychology, 30*, 138–164.
Squire, L. R. (1992). Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans. *Psychological Review, 99*, 195–231.
Stephens, D. W., & Krebs, J. R. (1986). *Foraging theory*. Princeton, NJ: Princeton University Press.
Stone, V. E., Baron-Cohen, S., & Knight, R. T. (1998). Frontal lobe contributions to theory of mind. *Journal of Cognitive Neuroscience, 10*, 640–656.
Taylor, S. E. (1991). Asymmetrical effects of positive and negative events: The mobilization–minimization hypothesis. *Psychological Bulletin, 110*, 67–85.
Thrustone, L. L. (1931). The measurement of attitudes. *Journal of Abnormal Psychology, 26*, 249–269.
Tranel, D., Fowles, D.C., & Damasio, A. R. (1985). Electrodermal discrimination of familiar and unfamiliar faces: A methodology. *Psychophysiology, 22*, 403–408.
Tucker, D. M., & Fredrick, S. L. (1989). Emotion and brain lateralization. In H. Wagner & A. Manstead (Eds.), *Handbook of social psychophysiology* (pp. 27–70). Chichester, UK: Wiley & Sons.
Tucker, D. M., Luu, P. , & Pribram, K. H. (1995). Social and emotional self-regulation. In J. Grafman & K. J. Holyoak (Eds.), *Structure and function of the human prefrontal cortex* Vol. 769 (pp. 213–239). New York: New York Academy of Sciences.
Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K. (1996). The relationship between social support and health: A review with emphasis on underlying psychophysiological processes. *Psychological Bulletin, 119*, 488–531.

Winkielman, P., & Cacioppo, J. T. (1998). Affective consequences of perceptual fluency: Evidence from facial EMG. Unpublished manuscript, Ohio State University.
Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist, 35*, 117–123.
Zajonc, R. B. (1998). Emotions. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology*. 4th. edn. (pp. 591–632). Boston: McGraw-Hill.
Zillman, D. (1989). Aggression and sex: Independent and joint operations. In H. Wagner & A. Manstead (Eds.), *Handbook of social psychophysiology* (pp. 229–260). New York: Wiley.
Zola-Morgan, S., Squire, L.R., Alvarez-Royo, P., & Clower, R. P. (1991). Independence of memory functions and emotional behavior: Separate contributions of the hippocampal formation and the amygdala. *Hippocampus, 1*, 207–220.

PART II

Cognition