

Parsing Affective Space: Perspectives From Neuropsychology and Psychophysiology

Richard J. Davidson

This article reviews selective behavioral, psychophysiological, and neuropsychological research bearing on how affective space should be parsed. Neither facial expression nor autonomic nervous system activity is found to provide unique markers for particular discrete emotions. The dimensions of approach and withdrawal are introduced as fundamental systems relevant to differentiating affective space. The role of frontal and anterior temporal asymmetries in mediating approach- and withdrawal-related emotion is considered. Individual differences in tonic anterior activation asymmetry are present and are relatively stable over time. Such differences are associated with an individual's propensity to display different types of emotion, mood, and psychopathology. The conceptual and methodological implications of this perspective are considered.

The purpose of this brief article is to review theory and data derived mostly from neuropsychological and psychophysiological analyses that bear on the issue of how affective space should be parsed. Included within this inquiry is how emotions are organized and differentiated from one another and the nature of the relations among the various subcomponents that compose emotions. Within this context I consider such issues as whether emotion is best understood as categorical or dimensional, the relation between facial expressions of emotion and emotional states, and psychophysiological differentiation among emotions. Space constraints preclude an exhaustive treatment of these topics. Studies are cited for illustrative purposes with an emphasis on recent research from my laboratory.¹ My principal goal is to build a case for the importance of the approach versus withdrawal dimension

for emotional states and traits and to underscore salient issues for future research in this area.

How Do Emotions Differ From One Another?

Many classification schemes for distinguishing among emotions have been proposed. Some schemes emphasize dimensions of emotional experience such as valence (i.e., positive or negative hedonic tone) and arousal (the continuum from sleepy to highly energized; e.g., Heller, 1993; Russell, 1980; Watson & Tellegen, 1985), whereas others emphasize discrete categories such as happiness, anger, fear, and so forth (e.g., Ekman, 1992; Izard, 1977). Some theoretical treatments of this topic place a premium on elementary (e.g., Ortony, Clore, & Collins, 1988; Scherer, 1984) or more global (e.g., Johnson-Laird & Oatley, 1992; Stein & Trabasso, 1992) cognitive appraisals, whereas others base their classification scheme on specific, circumscribed brain circuits (e.g., Panksepp, 1982). The lack of consensus on classification reflects an even more basic source of disagreement concerning the phenomena to be explained. Just how is an emotional state of mind to be distinguished from a nonemotional state?

The preparation of and research described in this article were supported by Research Scientist Development Award MH00875 and Grants MH40747 and MH43454 from the National Institute of Mental Health and by a grant from the John D. and Catherine T. MacArthur Foundation.

I wish to thank the graduate students and staff of my laboratory for their invaluable help and support during many phases of this research. I also wish to thank Joan C. Borod, Don M. Tucker, and Dawn Bowers for their insightful comments on an earlier draft of this article.

Correspondence concerning this article should be addressed to Richard J. Davidson, Department of Psychology, University of Wisconsin, 1202 West Johnson Street, Madison, Wisconsin 53706.

¹ Readers wishing more complete treatments of these issues are urged to consult several recent reviews of different aspects of this literature. Data on facial differentiation among emotions are reviewed by Camras, Holland, and Patterson (in press); data on autonomic differentiation among emotions are reviewed by Cacioppo, Klein, Bernstein, and Hatfield (in press); and data on cerebral psychophysiological differentiation among emotions are reviewed by Davidson and Tomarken (1989).

What are the special properties of mental events and behavior uniquely associated with emotion? My purpose in raising these questions is not to provide answers, for they lie at the very core of this emerging domain of research. Rather, my objective is to underscore important themes in current and future research on this topic. Although tentative proposals are offered for these questions, consensus on these topics must await the accumulation of a considerable corpus of new research findings.

Differentiation on the Basis of Facial Behavior

In this section, I focus on two characteristics that have been frequently used as the basis for distinguishing among emotions. The first is facial expression, and the second is autonomic nervous system activity. Ekman (1992) underscored the importance of these characteristics as his first two defining features of basic emotions. Expressive behavior and autonomic nervous system activity have also figured importantly as defining characteristics of emotion throughout its brief history of scientific study. Indeed, William James (1884) considered the perception of such changes to be the emotion. The claim that different emotions have distinctive, universal expressive signals is based largely on the seminal studies of Ekman (e.g., Ekman, 1973) and others (e.g., Izard, 1971), in which it has been shown that observers choose the appropriate facial expression when asked to pick the one that displays a particular emotion. Other studies have found that when subjects are told a story that depicts a universal theme (e.g., loss) and are asked to choose a facial expression that portrays the emotion most likely experienced by the story's protagonist, subjects throughout the world choose the correctly matching facial expression (e.g., sadness) significantly more often than would be expected by chance. In yet another paradigm, subjects are asked to show how their face would appear if they were the protagonist in an emotion episode. Ekman (1972, 1973) has reported that New Guineans pose expressions that are judged moderately accurately by college students in the United States. These studies establish that subjects choose certain facial expressions of emotion to represent particular emotion categories and that such patterns of association are indeed universal. What such studies do not address, however, is whether the spontaneous experience of these emotions are invariably accompanied by the occurrence of the predicted facial expression. Although Ekman (1972) has studied the spontaneous display of broad

categories of positive and negative affective expressions in the United States and Japan, virtually nothing is known about the differential incidence of displaying specific discrete facial expressions in contexts in which those emotions are reported. We also know precisely little about whether different modalities of emotion elicitors (e.g., imagery and emotional film clips) are equally likely to produce facial expressions of emotion. A number of studies have suggested that emotion evoked via imagery, despite its high intensity as revealed in self-report, is less likely than other procedures to produce overt facial displays (e.g., Ekman, Levenson, & Friesen, 1983; see review by Cacioppo, Klein, Bernston, & Hatfield, in press).

Still other experiments imply that emotions differ in the probability of becoming expressed on the face. In a recent study, Tomarken and Davidson (1993) unobtrusively videotaped subjects' facial behavior while they viewed short emotional film clips designed to elicit happiness, disgust, and fear. The film clips were carefully selected on the basis of extensive prior ratings from several hundred subjects. We chose two fear and two disgust clips for comparison that were matched on self-reported intensity of the target emotion ($M = 6.30$ and 5.39 on disgust for the two disgust clips; $M = 6.44$ and 5.40 for the two fear clips, on 9-point scales). Thus, for each emotion, there was one high and one moderate intensity clip. The intensities of the nontarget emotions reported in response to these clips was also matched. For the disgust clips, the emotion reported most intensely after disgust was fear; similarly, for the fear clips, disgust was the second most intense emotion reported. The mean fear rating for the disgust clips was 3.31, whereas the mean disgust rating for the fear films was 3.10. In addition, the variance of the ratings in response to the disgust and fear film clips was matched. A total of 86 subjects were exposed to these clips in counterbalanced order. Subjects viewed the clips alone in a darkened room while physiology was recorded. The facial behavior was scored from the videotapes with Ekman and Friesen's (1984) EM-FACS system. This system is designed to code the facial actions that constitute emotional expressions and allows for the derivation of the frequency and duration of specific discrete expressions. We tabulated the percentage of subjects showing facial signs of disgust in response to the disgust clips and facial signs of fear in response to the fear clips. Sixty-two percent of the subjects showed at least one disgust expression in response to either of the two disgust film

clips. The mean number of disgust expressions displayed by subjects (who had at least one expression) to the disgust clips was 2.58, with a range from 1 to 8 expressions. In response to the fear clips, not a single subject showed a facial expression of fear or questionable fear according to the EM-FACS criteria. If we used just the most common element of the facial prototype of fear, eye widening, 8.5% of subjects showed this action unit (either alone or in combination with any other action unit or units) in response to the fear clips. If we adopted the most inclusive possible facial criteria and determined the percentage of subjects who showed any action unit (either alone or in combination with any others) that is part of the fear prototype (i.e., eye widening, lips pulled back, and eyebrows raised), a total of 18% displayed such behavior. It is important to underscore the fact that subjects reported experiencing fear as intensely in response to the fear clips as they reported experiencing disgust in response to the disgust clips. Thus, according to the self-report criteria, they were experiencing the relevant target emotion in each case. However, the facial responses to these stimuli differed dramatically. One objection that might be raised about this evidence is that film clips may simply be incapable of eliciting genuine fear. Even if they become intensely absorbed in the film clip, subjects know that they are in a laboratory and that they are not vulnerable to physical harm. A number of theorists have proposed that threat of bodily harm is a universal antecedent event that elicits fear (e.g., Lazarus, 1991). Although the fear clips we selected were saturated with this theme, there is a fundamental difference between observing others exposed to this threat and being exposed to the threat oneself.

To address this issue, we performed a second study with people who had small-animal phobias as subjects (Tomarken & Davidson, 1993). Such persons report intense fear of their phobic object. In the context of an exposure-treatment protocol, we exposed subjects (who met the criteria for simple phobia of the revised third edition of the *Diagnostic and Statistical Manual of Mental Disorders [DSM-III-R]*; American Psychiatric Association, 1987) to their phobic object (either a live boa constrictor or a live tarantula) while their facial behavior was again videotaped unobtrusively. All of our phobic subjects in this context reported feeling threatened with imminent physical harm. Here again, despite their self-reports of intense fear, we rarely observed facial signs of fear. However, we did see a large percentage of subjects display facial signs of disgust in response to the phobic stimuli. Thus, in

both a normal and a clinical sample, we found that when subjects are exposed to stimuli that they rate as eliciting moderately to extremely intense fear, few facial signs of fear are observed. The majority of subjects do show facial signs of disgust, however, in response to appropriate stimuli of comparable intensity.

Another objection that might be raised about the type of evidence described is that it was derived from adults who might have been socialized to mask their expressions of fear, even in situations in which they believed they were not being observed. Such masking may become progressively more automatic over the course of development. If the relative paucity of fear expressions in our adult subjects was due to such masking, we would expect to find these expressions in more abundance among young infants exposed to fear-producing events. However, studies of infants exposed to experimental manipulations designed to induce fear have found that facial signs of fear are seldom produced (e.g., Hiatt, Campos, & Emde, 1979; see reviews by Camras, 1992; Camras, Holland, & Patterson, in press). However, other nonfacial behavioral and physiological indexes obtained from the infants suggested that they were indeed frightened by the experimental manipulations.

Yet another concern that might be raised about this corpus of evidence is that the intensity of the elicited fear in these experimental situations was insufficiently intense and that with more intense stimulation a differentiated facial expression of fear might be produced. In fact, some evidence exists that has been interpreted to suggest that, at low intensity levels, only bivalent discrimination (i.e., positive versus negative) in the face is achieved. Higher intensities of elicited emotion might be required to produce differentiation among negative emotions (see review by Cacioppo et al., in press).

There are at least two different interpretations of such data. One interpretation holds that different effector systems have different gain requirements such that some systems require more intense input to produce a differentiated response. In this view, the pattern of efferent neural activity to the face may reflect a differentiated fear pattern, but differentiation may not become expressed in muscle activity patterns because of a relative insensitivity of this effector system to low intensity input. A second interpretation holds that the very nature of the efferent pattern of neural activity to the effector will vary with intensity. If this latter view is found to be the more correct alternative, it raises

important questions about whether low and high intensity variants of what is putatively the same emotion should appropriately be considered members of the same category.

Just as there are questions concerning the isomorphism between facial expression and discrete negative emotions, equally troubling questions can be raised about the positive emotions. As Ekman (1992) noted, it appears as if there is only one basic form of positive facial expression that denotes the felt experience of positive emotion. However, on the basis of nonfacial indexes (behavioral, subjective, and physiological) it appears as if there are multiple forms of positive affect (e.g., Davidson, Ekman, Saron, Senulis, & Friesen, 1990). For example, we have proposed that there are approach and nonapproach forms of positive affect (Davidson et al., 1990; Davidson, 1992), each of which may be associated with distinct patterns of central nervous system activity (see next section). Contentment and amusement may represent positive affective states that contain no approach component. Unambiguous approaching and happiness is often observed when 10-month old infants are approached by their smiling mothers. Infants in this situation typically exhibit overt signs of approach behavior, such as reaching toward their mother. Moreover, they show a distinctive shift in brain activity toward increased left frontal activation (Fox & Davidson, 1988). When adults are induced to experience contentment and amusement, they show no reliable shifts in frontal brain activity from baseline, despite reporting moderately intense levels of these nonapproach forms of positive affect (Davidson et al., 1990).

The examples I have introduced imply that the package linking spontaneous facial expression to other indices that reflect emotion is not as tidy as discrete emotion theories propose. Thus, categorical schemes for parsing the emotion domain that are based on prototypical facial expressions will not necessarily reflect the distinctions honored by other behavioral and biological measures.

Differentiation on the Basis of Autonomic Nervous System Patterning

Recently, autonomic nervous system patterning has been proposed as another way in which emotions can be differentiated from one another. Although the notion that emotions are associated with distinctive patterns of autonomic activity fell out of favor following the early research of Schachter and Singer

(1962), who argued that all emotions were associated with undifferentiated autonomic arousal, it is now back in vogue, in large measure as a function of the influential series of studies of Levenson, Ekman, and their colleagues (e.g., Ekman et al., 1983; Levenson, Carstensen, Friesen, & Ekman, 1991; Levenson, Ekman, & Friesen, 1990; see review in Levenson, 1992). These investigators have examined several different autonomic measures during emotion produced through different methods of elicitation.

The largest corpus of evidence gathered by Levenson, Ekman, and colleagues is derived from their directed facial action (DFA) task. Using very explicit muscle-by-muscle instructions, this task requires subjects to pose different configurations of facial muscle activity that are derived from previous studies of the prototypical facial signs of different discrete emotions. Remarkably, in several different studies, Levenson (1992) reported that the DFA procedure produces reliable changes in autonomic measures that differentiate among different expressive patterns. The most reliable differences have been found for heart rate: The production of disgust faces decreased heart rate relative to other emotions. Fear and anger have been differentiated on the basis of skin temperature, with the latter showing higher temperature than the former. Whatever else this unusual procedure might do, it generates components of an emotional response that are stripped from their usual action accompaniments. Moreover, there is considerable variability across emotion in the difficulty and effort required to produce the various emotional expressions.

Emotion has also been generated in the laboratory through the generation of imagery associated with previous emotional episodes. An exemplary study of this kind was recently reported by Sinha, Lovallo, and Parsons (1992). Sinha et al. used elaborate procedures for generating imagery scripts that were designed to elicit instances of relatively pure emotion (fear, anger, sadness, and joy) on the basis of recall of recent emotional episodes. Sophisticated measures of cardiovascular reactivity were used to examine differentiated response patterning within the cardiovascular system during the generation of emotional imagery. Anger and fear were differentiated on the basis of diastolic blood pressure and peripheral vascular resistance. Sadness and joy were quite similar on most measures, with the exception of diastolic blood pressure; sadness produced a modest increase, whereas joy was associated with a slight decrease. Although these findings are quite provocative, it should be noted that, similar to the DFA,

action tendencies during emotional imagery are necessarily constrained, possibly increasing the consistency of the observed autonomic patterns.

The primary role of autonomic changes that accompany emotion is to provide support for action. As Levenson, Ekman, and Friesen (1990) noted, autonomic changes associated with different discrete emotions "produce patterns of activity that will support the behavioral adaptations and associated motor programs that are most likely for that emotion" (p. 379). Levenson et al. (1990) asked but did not answer the question of whether the same emotion accompanied by different action tendencies is likely to be associated with an invariant or differing pattern of autonomic activity. When these emotions occur spontaneously, they are often accompanied by widely varying patterns of action. On the basis of the likelihood that the same emotion is associated with different action tendencies in different contexts or individuals, corresponding differences in the autonomic changes that support these actions can be expected.

I have already introduced the distinction between approach and nonapproach forms of happiness. These forms of positive affect are associated with different patterns of central nervous system activity (see Davidson et al., 1990) and may be accompanied by different autonomic patterns, though the requisite evidence has not yet been gathered for the latter claim. Other emotions too have a variable set of action tendencies with which they are associated. For example, fear can be associated with both fleeing and freezing, and anger is sometimes associated with approach movements (i.e., attack) and sometimes with withdrawal tendencies. The autonomic supports for the different forms of these emotions should differ considerably. For example, cardiovascular mobilization should be greater during fleeing than during freezing. Other research has identified different central neurochemical substrates for different components of fear behavior in monkeys (e.g., Kalin & Shelton, 1989), and it is likely that the autonomic concomitants also differ.

What is required is to firmly address this question in a research program in which action tendencies and emotion are independently manipulated while various physiological measures are recorded. At least for the emotions of happiness, fear, and anger, different patterns of approach and withdrawal action tendencies may occur.² Why one particular pattern will occur in any given instance of the emotion is probably a complex function of situational and person factors. However, in an experimental context, these tendencies can

be explicitly manipulated and their effects on different physiological systems characterized.

As might be expected from this brief discussion, when the empirical evidence on autonomic correlates of emotion is carefully scrutinized, there is a clear lack of consistency across studies, and the evidence does not support the idea that different discrete emotions have unique and invariant autonomic signatures. Cacioppo et al. (in press) reviewed all studies that have compared two or more emotions elicited by any procedure and assessed two or more autonomic responses. They concluded that little consistency is present in the literature. Moreover, they made the important point that the autonomic changes that do occur are clearly not necessary for the appearance of discrete emotional states because there are abundant examples of differentiated emotion occurring in the absence of such autonomic differentiation.

Approach Versus Withdrawal as the Fundamental Emotion-Relevant Dimension

In the preceding section, I questioned the utility and theoretical basis of differentiating among emotions on the basis of both facial expression and autonomic physiology. This analysis should not be construed as denying in any way the crucial relevance and importance of these response systems for emotion. Rather, my sole intent was to raise questions about the isomorphism between patterns of facial and autonomic activity and specific discrete emotions. In this section, I wish to underscore the importance of approach and withdrawal processes to emotion. Here again I do not imply that specific emotions are isomorphically associated with approach and withdrawal behavior. Rather, I illustrate the utility of examining approach and withdrawal components of emotion and, in the following section, indicate their application to the study of individual differences and psychopathology.

In a recent article (Davidson, 1992), I treated extensively the role of approach and withdrawal systems

² I do not wish to imply that the pairing between emotion and action tendency is completely arbitrary. It is likely that such pairing is actually quite constrained. In fact, attempts to pair certain action tendencies with incompatible emotions will likely result in a failure to produce either the action or the emotion. I have proposed (Davidson, 1992) that the nature of the action-emotion coupling is probably biologically constrained in a fashion similar to that observed in the literature on biological preparedness and learning (e.g., Seligman & Hager, 1972).

in emotion; here I only briefly summarize these issues. Organisms approach and withdraw at every level of phylogeny in which behavior itself is present. To approach or to withdraw is the fundamental adaptive decision in situations or conditions that have recurred during our evolutionary past (Tooby & Cosmides, 1990). In very primitive organisms with simple nervous systems, rudimentary forms of approach and withdrawal behavior occur in the absence of any emotion because the neural supports for emotion are not present. Thus, over the course of evolution, approach and withdrawal action tendencies emerged prior to the appearance of emotions to solve simple adaptive problems in primitive species (see Schneirla, 1959, for review; and Kinsbourne, 1978, for a related perspective). As the nature of adaptive problems became more complex and coordination among perceptual, cognitive, and action systems was required, emotions evolved and became associated with already established approach and withdrawal action systems. Elsewhere (Davidson, 1992), I have proposed that the integration among these various subcomponents in emotion required a convergence zone (Damasio, 1989) in the brain to bind together information from widely distributed networks. The frontal region is a likely site for an emotion convergence zone in light of its functional characteristics and its inputs and outputs (see, e.g., Fuster, 1989; Nauta, 1971).

It is now known that the primate frontal cortex is a highly differentiated structure with several distinct subregions. The orbital prefrontal cortical areas (Brodmann's areas 13 and 14) have the most significant input from subcortical sites in which emotional processing is known to occur. In particular, specific amygdaloid nuclei project to the lateral orbital prefrontal cortex. The basal nucleus of the amygdala projects to this prefrontal region (Amaral, Price, Pitkänen, & Carmichael, 1992), indicating that the prefrontal region receives already processed input from the amygdala because most sensory input arrives at the lateral nucleus. In general, the prefrontal region reciprocates with connections to the basal nucleus and other amygdaloid nuclei. Within the different subregions of the prefrontal area, there are intrinsic connections (Barbas & Pandya, 1991) so that orbital and dorsolateral regions are interconnected. Moreover, the prefrontal region has anatomical reciprocity with the medial parietal cortex (see Goldman-Rakic, 1987, for review). As a function of these anatomical arrangements, the prefrontal cortex communicates with both posterior perceptual processing regions and with subcortical structures that directly

participate in the emotional biasing of sensory input. The amygdalofugal projections provide the prefrontal region with information about emotional processing, and the prefrontal region can in turn influence the amygdala to bias the emotional processing of sensory input.

Within the frontal region, a growing corpus of evidence suggests that approach- and withdrawal-related systems are localized in different cerebral hemispheres, with the left frontal region implicated in approach-related emotional behavior and the right frontal region in withdrawal-related emotional behavior. There is considerable evolutionary logic in separating these functions to different geographical regions in the brain. Hemispheric specialization is perhaps the most effective geographic separation that has been achieved in vertebrate nervous system evolution. Such geographic separation likely minimizes competitive interaction between these systems. Moreover, recent evidence of hemispheric specialization in a number of different species (e.g., Denenberg, 1984) consistently confirms the direction of the effects found in humans and indicates that lateralization for approach-and-withdrawal emotion may be more robust across phylogeny than may be lateralization.

Many studies have appeared in which emotions likely to be associated with approach or withdrawal are experimentally aroused while electrophysiological measures of regional brain activity are obtained. These studies were recently reviewed by Davidson and Tomarken (1989). Using electrophysiological measures as the dependent variable, at least five independent laboratories have reported that certain types of negative affect (e.g., disgust and fear) produce greater relative right-sided frontal activation than do positive affects of comparable intensity (e.g., Ahern & Schwartz, 1985; Davidson et al., 1990; Dawson, Klinger, Panagiotides, Spieker, & Frey, 1992; Fox, 1991; Tucker, Stenslie, Roth, & Shearer, 1981).³ Most

³ The precise nature of the circuit implicated by these electrophysiological findings is not at all clear in extant research and would take me too far afield to address in this article. It is likely that the scalp EEG data mostly reflect activity from the lateral convexity of the cortex and thus do not directly depict orbital frontal function. It is possible that the intrinsic connections between these different subregions of the prefrontal cortex are not of the straightforward excitatory sort but may be inhibitory as suggested by Tucker (1993) and by recent research in which positron emission tomography was used to examine cerebral blood flow in these regions (Drevets et al., 1992).

important, converging evidence using a variety of other behavioral and physiological measures has also appeared (see Heller, 1990, for a recent review). In addition, studies of patients with unilateral anterior lesions are also generally consistent with this formulation (e.g., Robinson, Kubos, Starr, Rao, & Price, 1984; Starkstein & Robinson, 1991). However, not all lesion studies have produced strongly confirmatory evidence (e.g., Borod, Koff, Lorch, & Nicholas, 1986; Gainotti, 1989; House, Dennis, Warlow, Hawton, & Molyneux, 1990), and a number of studies in which facial asymmetries have been used as a proxy for cortical activation asymmetries have obtained results inconsistent with the approach versus withdrawal hypothesis (see meta-analysis by Skinner & Mullen, 1991, and reviews by Borod, 1992, 1993). In a recent article (Davidson, 1993), I reviewed the conceptual and methodological complications associated with this area of research and illustrated how such problems could account for the inconsistencies in the literature. For example, in many of the facial asymmetry studies, subjects knew they were being videotaped and so were likely to mask or voluntarily control their expressions. In other studies, an experimenter was present along with the subject while they were exposed to affective stimuli. The presence of an experimenter has been demonstrated to exert substantial influence on facial expressive behavior (Ekman, 1972). In Borod's (1993) review of the facial asymmetry studies in normal adults, she located 47 studies in the literature. According to her review, only 7 of these 47 studies were conducted in a way that would minimize the operation of display rules (subject alone and camera or observer concealed). Thus, it is important in future research to collect additional data in ways that maximize spontaneous expressive behavior.

Many other conceptual and methodological problems were identified in this literature in my review (Davidson, 1993). The principal problems noted were the failure to distinguish between the perception and production of emotion, the failure to carefully distinguish between spontaneous and more controlled or posed facial expressions, and the assumption that lesions in particular cortical regions were sufficient to produce an alteration of emotion or mood. With respect to this latter issue, we (e.g., Davidson & Tomarken, 1989) have suggested that alterations in anterior activation asymmetry, whether naturally occurring or lesion-induced, create a diathesis that changes the probability of experiencing particular types of emotions, given the requisite elicitor (such as a stressful life

event). According to this diathesis-stress formulation, it would be expected that individuals with left frontal lesions could be found who present no depressive symptoms. In fact, some investigators have reported such findings (e.g., House et al., 1990). House et al. found no significant difference in incidence of depression among patients with left compared with right anterior lesions.

House et al.'s (1990) data are clearly inconsistent with those from Robinson's group (e.g., Robinson et al., 1984). One likely source of the disparity between the findings of these two research groups is the nature of populations from which the patients were drawn. Robinson and his co-workers have tested mostly lower to lower middle class individuals from the Baltimore area. Most of these patients were exposed to very stressful conditions as a function of their neurological handicap. The patients evaluated by House et al. were well-cared for by either their families (66%) or by residential care (14%). Only a small minority were living alone. Thus, these patients were likely buffered from many of stresses of daily living presumably experienced by the patients in the Robinson studies. Thus, whereas patients evaluated by each of these groups had the hypothesized neurological diathesis for depression (left anterior lesion), they differed in the degree to which they were exposed to stress. It is clear that future studies of this type must pay special attention to the social setting of the patients.

More specific tests of our hypothesis would be studies in which individuals with unilateral lesions are exposed to specific types of affect elicitors and in which careful measures of spontaneous expressive behavior are obtained. Upon exposure to a sadness-eliciting event, we would expect a subject with a left frontal lesion to be more vulnerable to the experience of sadness than normal control subjects or subjects with lesions in the other hemisphere. Although admittedly a very simple distinction, and clearly one that is not intended to capture the full range and richness of different emotions, the distinction between approach and withdrawal components of emotion turns out to be quite useful and helps to establish important theoretical ties between neuropsychological and other approaches to emotion and affective style. These issues are considered in the next section.

Affective Style and Approach Versus Withdrawal Systems

I and my colleagues have proposed and now observed in many different studies that individuals differ

in the relative activation of the frontal region of the two cerebral hemispheres and that these differences among people in asymmetric anterior activation are relatively stable over time (Tomarken, Davidson, Wheeler, & Kinney, 1992). In the cognitive literature on hemispheric specialization, it has been observed that individual differences in measures thought to reflect posterior hemispheric activation are associated with differences in verbal and spatial cognitive task performance in the direction expected on the basis of the known specialization of the posterior cortical regions for these types of tasks (see Hellige, 1990, and Levy, 1983, for reviews). Similarly, in the affective domain, we (Davidson & Tomarken, 1989) have proposed that individual differences in anterior asymmetric activation should be associated with differences in dispositional (i.e., tonic or consistent) mood and vulnerability to certain positive and negative emotions, given the requisite elicitor. We have referred to these differences in mood and emotional reactivity collectively as *affective style*. Specifically, we have suggested that subjects with increased right-sided anterior activation will show increased vulnerability to emotions, moods, and psychopathology associated with withdrawal. Such individuals should be more vulnerable to the emotions of fear and disgust, should show more dispositional negative affect, and should show increased vulnerability to anxiety disorders that include a strong withdrawal component, such as phobias. In a number of studies, we have consistently found that the experimental arousal of disgust and fear is associated with an accentuation of right-sided frontal activation as compared with either a nonemotional baseline or a positive emotional state (e.g., Davidson et al., 1990). Moreover, in three separate studies, we found that individuals with tonically elevated right-sided frontal activation reported more intense levels of fear and disgust in response to short film clips designed to elicit these emotions than did subjects who showed left-sided activation (Tomarken, Davidson, & Henriques, 1990; Wheeler, Davidson, & Tomarken, 1993). Among people with a phobia about social interaction, the anticipation of making a public speech is associated with pronounced right anterior activation (Davidson, Marshall, Tomarken, Straus, & Henriques, 1993).

Individuals with decreased activation in the left anterior region should be more vulnerable to those emotional states and traits, such as depression, that are associated with deficits in approach-related activation. The phenomenology and symptomatology of depression specifically includes references to approach-

related deficits (see Depue & Iacono, 1989, for a review). For example, psychomotor retardation and loss of interest and pleasure are all symptoms that can logically be expected to follow from deficits in the activation of an approach system. Moreover, factor analytic studies of mood in depressed and normal subjects indicate that the most pronounced difference between these groups is not an increase in negative affect among depressives but a decrease in positive affect in this group (Watson, Clark, & Carey, 1988; see also Jaeger, Borod, & Peselow, 1986). In a very insightful article published prior to any firm data on this issue, Paul Meehl (1975) hypothesized that an individual difference of major importance to the development of psychopathology was the capacity to experience pleasure in response to life's opportunities. Individuals with a deficit in this hedonic capacity were hypothesized to be at risk for certain types of depressive disorders. Meehl stated that "clinicians and theoreticians ought to consider seriously the possibility that not only are some persons born with more cerebral 'joy-juice' than others but also that this variable is fraught with clinical consequences" (Meehl, 1975, p. 299). We have proposed that underactivation in the left anterior region is the aberrant hedonic parameter for which Meehl was seeking. In comparisons of baseline levels of frontal activation in depressed and normal control subjects, we have consistently found that depressed subjects (those with *DSM-III-R* diagnoses of major depression as well as dysphoric students who were selected on the basis of high scores on a depression inventory) show decreased activation in the left frontal region (Henriques & Davidson, 1990, 1991; Schaffer, Davidson, & Saron, 1983). We have also found that toddlers who have a temperamental style characterized by reluctance to approach novel and unfamiliar people and objects show decreased left frontal activation compared with their uninhibited counterparts (Davidson, Finman, Straus, & Kagan, 1993). Most recently, we have found that the administration of diazepam, a benzodiazepine that increases approach-related behavior in novel and unfamiliar situations, also increased left-sided frontal activation in rhesus monkeys (Davidson, Kalin, & Shelton, 1992).

Within the positive affect category, we have distinguished between approach and nonapproach forms of happiness. In response to short film clips that depict amusing positive events, subjects report increases in the intensity of happiness and amusement and also show facial signs of felt happiness (Duchenne smiles). However, these positive affect states rarely include an

approach component. Contrast this with a situation in which a 10-month-old infant sees his or her mother approaching and smiling. In addition to showing a Duchenne smile, the vast majority of infants of this age show unambiguous and frank signs of approach behavior, for example, reaching out toward the mother. We have observed different patterns of brain activity in these situations. During the approach form of positive affect, we found increases in left frontal activation above baseline (Fox & Davidson, 1987, 1988), whereas in the nonapproach form (as obtained in the film clip example), anterior asymmetry did not differ significantly from that found at baseline (Davidson et al., 1990). Thus, there seem to be two positive-affect states, both of which are associated with the same pattern of facial expressive behavior. However, behaviorally, these states differ, and they also differ in patterns of frontal brain activity.⁴

We believe, although we do not yet have the requisite data, that a similar distinction can be made between approach and nonapproach forms of anger. When anger is elicited within the first year of life it is typically associated with a strong approach component. For example, one of the most reliable procedures for the experimental elicitation of anger in the first year of life is the moderate restraint procedure (Stenberg, Campos, & Emde, 1983). In this procedure, the infant is placed on its back while its wrists are held to the ground. Infants will typically struggle against this restraint (presumably to overcome a goal blockage) and will show facial signs of anger. During this procedure, when facial signs of anger are present in the absence of crying, infants show left frontal activation (Fox & Davidson, 1988). We have not yet directly compared the experimental arousal of approach and nonapproach forms of anger in the laboratory. We are currently performing such a study by comparing brain activity during the experimental arousal of anger in subjects who habitually express their anger and in those who habitually withdraw from anger-producing situations. Only through such a comparison, or by experimentally manipulating these different forms of anger, will a more definitive answer emerge.

It is my hope that this discussion underscores the salience of the approach and withdrawal dimensions for understanding the structure of different emotions. As I tried to illustrate, for at least some emotions (e.g., anger and happiness), the magnitude of engagement of the approach and withdrawal systems is not fixed but varies with the context and across different individuals. Certain emotions may have a high probability of being

associated with either approach or withdrawal (e.g., disgust), although one may imagine scenarios in which the opposite action tendencies may be associated with even these emotions. It is clear that approach and withdrawal are dimensions that are basic to emotion, appear throughout many levels of phylogeny, emerge early in ontogeny, and are mediated by separate brain systems found in all vertebrate species.

This analysis should not be taken as inconsistent with a focus on discrete emotions. The fact that certain forms of anger and happiness both include an approach component does not imply that they are the same emotion. They may share certain important neural substrates in common, but it seems clear that they also must differ in important respects. The dimensional perspective I have articulated should be regarded as complementary to the discrete emotions perspective. These models simply address different levels of a complex process. If physiology and expressive behavior vary within emotion families, then what remains invariant across different instantiations of the same discrete emotion? In accordance with the theoretical position articulated by Stein and Trabasso (1992), the invariance is carried in the higher order goal with which the emotion is associated. Thus, for example, Stein and Trabasso argued that fear always is associated with "the desire to prevent the onset of an aversive state or the desire to prevent the loss of a valuable goal" (Stein & Trabasso, 1992, p. 233). According to their analysis, each emotion has its own unique higher order goal, which is necessary for the experience of that emotion. A similar emphasis on higher order goals is implicit in the analysis of basic emotions proposed by Johnson-Laird and Oatley (1992). Given that different discrete emotions are associated with different higher order goals and given that these goals represent the

⁴ It must be acknowledged that the comparison described here is entirely retrospective and is based on different groups of subjects. What is needed in future research is a within-subjects comparison in which approach and nonapproach forms of positive affect are elicited in the laboratory. It might be quite difficult to produce such emotional behavior in adults, although infants readily show positive affect accompanied by frank signs of approach, such as reaching toward their mother. However, it is clear that adults do experience such positive approach-related emotion in daily life. Consider the behavior of individuals who are waiting for loved ones at the airport. Once the person for whom they are waiting is sighted, many individuals will move toward and reach out to this person. Devising a laboratory situation to harness this behavior remains an unfulfilled challenge.

invariant core of the emotion, I would expect there to be central states that subserve these mental events. However, it is likely that the neural networks that subserve these core goals will be constituted in cortical sites that participate in the generation of other, non-emotional beliefs and desires. Thus, the patterns of neural activity that might reflect the core invariance within emotion families and that differentiate among different emotion families will likely be found in those brain regions—such as the dorsolateral frontal cortex—that are not specifically implicated in the emotion generation process but participate in the integration of basic cognitive and emotional operations associated with belief and desire states.

Summary and Conclusions

In this article, I have considered how emotions differ from one another, and I have illustrated some of the problems associated with the reliance on two traditional criteria—facial expressions and autonomic nervous system physiology—that have been invoked to designate and differentiate among categorical emotions. Although both facial expressions and autonomic physiology are viewed as integral and important components of the affect package, questions were raised about the isomorphism between discrete emotional states and their presumed unique facial and autonomic signatures. I proposed that approach and withdrawal systems are important components of affective space and illustrated their relevance to emotional states and traits. Asymmetries in anterior cortical activation were shown to be associated with approach- and withdrawal-related affective processes, with greater left-sided activation associated with approach emotions and greater right-sided activation associated with withdrawal emotions. The application of these concepts to individual differences in normal and pathological affect was also illustrated.

One challenge for future research in this area is to understand the relation between the dimensions of affective space described in this article and the categorical emotions that are accurately conveyed on the face and reported in emotional experience. A second challenge is to delineate precisely what neural circuit mediates the types of affective states and traits described in this article. It will undoubtedly include both orbital and dorsolateral components of the prefrontal cortex, the anterior temporal cortex, the posterior association cortex connected to these anterior cortical regions (see Goldman-Rakic, 1987; Heller, 1993), and subcortical sites that project to and receive reciprocal projections

from these anterior cortical areas, most notably the amygdala. Ideally, such studies should include both scalp electrophysiological methods and other brain imaging procedures that can provide better spatial resolution so that relations between electrophysiological signs of activation recorded from frontal scalp regions and other measures of activation (e.g., regional cerebral blood flow) in orbital and ventral frontal subareas that are not directly reflected in scalp brain electrical activity can be examined.

References

- Ahern, G. L., & Schwartz, G. E. (1985). Differential lateralization for positive and negative emotion in the human brain: EEG spectral analysis. *Neuropsychologia*, *23*, 745–756.
- Amaral, D. G., Price, J. L., Pitkänen, A., & Carmichael, S. T. (1992). Anatomical organization of the primate amygdaloid complex. In J. P. Aggleton (Ed.), *The amygdala: Neurobiological aspects of emotion, memory and mental dysfunction* (pp. 1–66). New York: Wiley-Liss.
- American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders* (3rd ed., rev.). Washington, DC: Author.
- Barbas, H., & Pandya, D. N. (1991). Patterns of connections of the prefrontal cortex in the rhesus monkey associated with cortical architecture. In H. S. Levin, H. M. Eisenberg, & A. L. Benton (Eds.), *Frontal lobe function and dysfunction* (pp. 35–58). New York: Oxford University Press.
- Borod, J. C. (1992). Interhemispheric and intrahemispheric control of emotion: A focus on unilateral brain damage. *Journal of Consulting and Clinical Psychology*, *60*, 339–348.
- Borod, J. C. (1993). Cerebral mechanisms underlying facial, prosodic, and lexical emotional expression: A review of neuropsychological studies and methodological issues. *Neuropsychology*, *7*, 427–432.
- Borod, J. C., Koff, E., Lorch, M., & Nicholas, M. (1986). The expression and perception of facial emotion in brain-damaged patients. *Neuropsychologia*, *24*, 169–180.
- Cacioppo, J. T., Klein, D. J., Bernston, G. G., & Hatfield, E. (in press). The psychophysiology of emotion. In M. Lewis & J. Haviland (Eds.), *Handbook of emotions*. New York: Guilford Press.
- Camras, L. A. (1992). Expressive development and basic emotions. *Cognition and Emotion*, *6*, 269–283.
- Camras, L. A., Holland, E. A., & Patterson, M. J. (in press). Facial expression. In M. Lewis & J. Haviland (Eds.), *Handbook of emotions*. New York: Guilford Press.
- Damasio, A. R. (1989). The brain binds entities and events by multiregional activation from convergence zones. *Neural Computation*, *1*, 123–132.
- Davidson, R. J. (1992). Prolegomenon to the structure of

- emotion: Gleanings from neuropsychology. *Cognition and Emotion*, 6, 245–268.
- Davidson, R. J. (1993). Cerebral asymmetry and emotion: Conceptual and methodological conundrums. *Cognition and Emotion*, 7, 115–138.
- Davidson, R. J., Ekman, P., Saron, C., Senulis, J., & Friesen, W. V. (1990). Approach/withdrawal and cerebral asymmetry: Emotional expression and brain physiology, I. *Journal of Personality and Social Psychology*, 58, 330–341.
- Davidson, R. J., Finman, R., Straus, A., & Kagan, J. (1993). *Patterns of frontal asymmetry differentiate between wary and outgoing children*. Manuscript submitted for publication.
- Davidson, R. J., Kalin, N. H., & Shelton, S. E. (1992). Lateralized effects of diazepam on frontal brain electrical asymmetries in rhesus monkeys. *Biological Psychiatry*, 32, 438–451.
- Davidson, R. J., Marshall, J., Tomarken, A. J., Straus, A., & Henriques, J. B. (1993). *While a phobic waits: Brain electrical patterning in social phobics during anticipation of making a public speech*. Manuscript in preparation.
- Davidson, R. J., & Tomarken, A. J. (1989). Laterality and emotion: An electrophysiological approach. In F. Boller & J. Grafman (Eds.), *Handbook of neuropsychology* (Vol. 3, pp. 419–441). Amsterdam: Elsevier.
- Dawson, G., Klinger, L. G., Panagiotides, H., Spieker, S., & Frey, K. (1992). Infants of mothers with depressive symptoms: Electroencephalographic and behavioral findings related to attachment status. *Developmental and Psychopathology*, 4, 67–80.
- Denenberg, V. H. (1984). Behavioral asymmetry. In N. Geschwind & A. M. Galaburda (Eds.), *Cerebral dominance: The biological foundations* (pp. 114–133). Cambridge, MA: Harvard University Press.
- Depue, R. A., & Iacono, W. G. (1989). Neurobehavioral aspects of affective disorders. *Annual Review of Psychology*, 40, 457–492.
- Drevets, W. C., Videen, T. O., Price, J. L., Preskorn, S. H., Carmichael, S. T., & Raichle, M. E. (1992). A functional anatomical study of unipolar depression. *Journal of Neuroscience*, 12, 3628–3641.
- Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska Symposium on Motivation* (Vol. 19, pp. 207–283). Lincoln: University of Nebraska Press.
- Ekman, P. (1973). Cross-cultural studies of facial expression. In P. Ekman (Ed.), *Darwin and facial expression: A century of research in review* (pp. 169–222). San Diego, CA: Academic Press.
- Ekman, P. (1992). An argument for basic emotions. *Cognition and Emotion*, 6, 169–200.
- Ekman, P., & Friesen, W. V. (1984). *Emotion Facial Action Coding System (EM-FACS)*. San Francisco: University of California.
- Ekman, P., Levenson, R. W., & Friesen, W. V. (1983). Autonomic nervous system activity distinguishes among emotions. *Science*, 221, 1208–1210.
- Fox, N. A. (1991). If it's not left, it's right. *American Psychologist*, 46, 863–872.
- Fox, N. A., & Davidson, R. J. (1987). Electroencephalogram asymmetry in response to the approach of a stranger and maternal separation in 10-month-old infants. *Developmental Psychology*, 23, 233–240.
- Fox, N. A., & Davidson, R. J. (1988). Patterns of brain electrical activity during facial signs of emotion in 10-month-old infants. *Developmental Psychology*, 24, 230–236.
- Fuster, J. M. (1989). *The prefrontal cortex* (2nd ed.). New York: Raven Press.
- Gainotti, G. (1989). Disorders of emotions and affect in patients with unilateral brain damage. In F. Boller & J. Grafman (Eds.), *Handbook of neuropsychology* (Vol. 3, pp. 345–361). New York: Elsevier Science.
- Goldman-Rakic, P. S. (1987). Circuitry of primate prefrontal cortex and regulation of behavior by representational memory. In V. B. Mountcastle (Ed.), *Handbook of physiology* (Vol. 5, pp. 373–417). Bethesda, MD: American Physiological Society.
- Heller, W. (1990). The neuropsychology of emotion: Developmental patterns and implications for psychopathology. In N. L. Stein, B. Leventhal, & T. Trabasso (Eds.), *Psychological and biological approaches to emotion* (pp. 167–211). Hillsdale, NJ: Erlbaum.
- Heller, W. (1993). Neuropsychological mechanisms of individual differences in emotion, personality, and arousal. *Neuropsychology*, 7, 476–489.
- Hellige, J. B. (1990). Hemispheric asymmetry. *Annual Review of Psychology*, 41, 55–80.
- Henriques, J. B., & Davidson, R. J. (1990). Regional brain electrical asymmetries discriminate between previously depressed subjects and healthy controls. *Journal of Abnormal Psychology*, 99, 22–31.
- Henriques, J. B., & Davidson, R. J. (1991). Left frontal hypoactivation in depression. *Journal of Abnormal Psychology*, 100, 535–545.
- Hiatt, S., Campos, J. J., & Emde, R. (1979). Facial patterning and infant emotional expression: Happiness, surprise and fear. *Child Development*, 50, 1020–1035.
- House, A., Dennis, M., Warlow, C., Hawton, K., & Molyneux, A. (1990). Mood disorders after stroke and their relation to lesion location. *Brain*, 113, 1113–1129.
- Izard, C. E. (1971). *The face of emotion*. New York: Appleton-Century-Crofts.
- Izard, C. E. (1977). *Human emotions*. New York: Plenum Press.
- Jaeger, J., Borod, J. C., & Peselow, E. (1986). Facial expression of positive and negative emotions in patients with unipolar depression. *Journal of Affective Disorders*, 11, 43–50.
- James, W. (1884). What is an emotion? *Mind*, 9, 188–205.
- Johnson-Laird, P. N., & Oatley, K. (1992). Basic emotions,

- rationality and folk theory. *Cognition and Emotion*, 6, 201–223.
- Kalin, N. H., & Shelton, S. E. (1989). Defensive behaviors in infant rhesus monkeys: Environmental cues and neurochemical regulation. *Science*, 243, 1718–1721.
- Kinsbourne, M. (1978). Biological determinants of functional bisymmetry and asymmetry. In M. Kinsbourne (Ed.), *Asymmetrical function of the brain* (pp. 3–13). New York: Cambridge University Press.
- Lazarus, R. S. (1991). *Emotion and adaptation*. New York: Oxford University Press.
- Levenson, R. W. (1992). Autonomic nervous system patterning in emotion. *Psychological Science*, 3, 23–27.
- Levenson, R. W., Carstensen, L. L., Friesen, W. V., & Ekman, P. (1991). Emotion, physiology and expression in old age. *Psychology and Aging*, 6, 28–35.
- Levenson, R. W., Ekman, P., & Friesen, W. V. (1990). Voluntary facial action generates emotion-specific autonomic nervous system activity. *Psychophysiology*, 27, 363–384.
- Levy, J. (1983). Individual differences in cerebral hemisphere asymmetry: Theoretical issues and experimental considerations. In J. B. Hellige (Ed.), *Cerebral hemisphere asymmetry: Method, theory and application* (pp. 465–515). New York: Praeger.
- Meehl, P. E. (1975). Hedonic capacity: Some conjectures. *Bulletin of the Menninger Clinic*, 39, 295–307.
- Nauta, W. J. H. (1971). The problem of the frontal lobe—A reinterpretation. *Journal of Psychiatric Research*, 8, 167–187.
- Ortony, A., Clore, G. L., & Collins, A. (1988). *The cognitive structure of emotions*. New York: Cambridge University Press.
- Panksepp, J. (1982). Toward a general psychobiological theory of emotions. *The Behavioral and Brain Sciences*, 5, 407–467.
- Robinson, R. G., Kubos, K. L., Starr, L. B., Rao, K., & Price, T. R. (1984). Mood disorders in stroke patients: Importance of location of lesion. *Brain*, 107, 81–93.
- Russell, J. A. (1980). A circumplex model of emotion. *Journal of Personality and Social Psychology*, 39, 1161–1178.
- Schachter, S., & Singer, J. E. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review*, 69, 379–399.
- Schaffer, C. E., Davidson, R. J., & Saron, C. (1983). Frontal and parietal electroencephalogram asymmetry in depressed and nondepressed subjects. *Biological Psychiatry*, 18, 753–762.
- Scherer, K. R. (1984). On the nature and function of emotion: A component process approach. In K. R. Scherer & P. Ekman (Eds.), *Approaches to emotion* (pp. 293–318). Hillsdale, NJ: Erlbaum.
- Schneirla, T. C. (1959). An evolutionary and developmental theory of biphasic processes underlying approach and withdrawal. In M. R. Jones (Ed.), *Nebraska Symposium on Motivation* (Vol. 6, pp. 1–42). Lincoln: University of Nebraska Press.
- Seligman, M. E. P., & Hager, J. E. (1972). *Biological boundaries of learning*. New York: Appleton-Century-Crofts.
- Sinha, R., Lovallo, W. R., & Parsons, O. A. (1992). Cardiovascular differentiation of emotions. *Psychosomatic Medicine*, 54, 422–435.
- Skinner, M., & Mullen, B. (1991). Facial asymmetry in emotional expression: A meta-analysis of research. *British Journal of Social Psychology*, 30, 113–124.
- Starkstein, S. E., & Robinson, R. G. (1991). The role of the frontal lobes in affective disorder following stroke. In H. S. Levin, H. M. Eisenberg, & A. L. Benton (Eds.), *Frontal lobe function and dysfunction* (pp. 288–303). New York: Oxford University Press.
- Stein, N. L., & Trabasso, T. (1992). The organization of emotional experience: Creating links among emotion, thinking, language, and intentional action. *Cognition and Emotion*, 6, 225–244.
- Stenberg, C., Campos, J. J., & Emde, R. (1983). The facial expression of anger in seven-month-old infants. *Child Development*, 54, 178–184.
- Tomarken, A. J., & Davidson, R. J. (1993). *Fear and the face: Differential accessibility of fear and disgust to the face*. Manuscript in preparation.
- Tomarken, A. J., Davidson, R. J., & Henriques, J. B. (1990). Resting frontal brain asymmetry predicts affective responses to films. *Journal of Personality and Social Psychology*, 59, 791–801.
- Tomarken, A. J., Davidson, R. J., Wheeler, R. E., & Kinney, L. (1992). Psychometric properties of resting anterior EEG asymmetry: Temporal stability and internal consistency. *Psychophysiology*, 29, 576–592.
- Tooby, J., & Cosmides, L. (1990). The past explains the present: Emotional adaptations and the structure of ancestral environments. *Ethology and Sociobiology*, 11, 375–424.
- Tucker, D. M. (1993). Emotional experience and the problem of the vertical integration. *Neuropsychology*, 7, 500–509.
- Tucker, D. M., Stenslie, C. E., Roth, R. S., & Shearer, S. (1981). Right frontal lobe activating and right hemisphere performance decrement during a depressed mood. *Archives of General Psychiatry*, 38, 169–174.
- Watson, D., Clark, L. A., & Carey, G. (1988). Positive and negative affectivity and their relation to anxiety and depressive disorders. *Journal of Abnormal Psychology*, 97, 346–353.
- Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological Bulletin*, 98, 219–235.
- Wheeler, R. E., Davidson, R. J., & Tomarken, A. J. (1993). Frontal brain asymmetry and emotional reactivity: A biological substrate of affective style. *Psychophysiology*, 30, 82–89.

Received December 11, 1992

Revision received April 2, 1993

Accepted April 2, 1993 ■