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EMOTION

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ABSTRACT

We review recent trends and methodological issues in assessing and testing theories of emotion, and we review evidence that form follows function in the affect system. Physical limitations constrain behavioral expressions and incline behavioral predispositions toward a bipolar organization, but these limiting conditions appear to lose their power at the level of underlying mechanisms, where a bivalent approach may provide a more comprehensive account of the affect system.

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INTRODUCTION

Recent research on emotions is almost as vast and diverse as emotional life itself. A literature search limited to the term "emotion" using PsychInfo re-

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turned 5064 citations over the past five years, and a comparable search using Medline returned 3542. A *Handbook of Emotions* appeared (Lewis & Haviland 1993) with a second edition already in preparation, journals are now devoted almost exclusively to the topic (e.g. *Cognition and Emotion*, *Motivation and Emotion*), and numerous textbooks on the topic have surfaced. The swell of interest in emotion continues to ascribe a large role to deliberation and civil discourse. Humans have walked the surface of the earth for about 2,000,000 years, and for all but the last 2000–3000 years humans have been hunter-gatherers. We nevertheless tend to see our distant past "through a reverse telescope that compresses it: a short time as hunter-gatherers, a long time as 'civilized' people" (Ackerman 1990, p. 129). We begin by reviewing recent developments in the study of human emotions. We then consider the general features of an affect system, archaic in some respects, that can be conceived as underlying emotion.

Methodological Developments in the Study of Emotion

The study of emotion has been aided in recent years by the development of standardized stimulus materials and procedures for eliciting emotions, and this continued to be an active area of inquiry in recent years (e.g. see Davidson & Cacioppo 1992, Gerrards-Hesse et al 1994). New developments were seen in stimulus sets consisting of pictures (Lang et al 1995), films (Gross & Levenson 1995, Philippot 1993, Westermann et al 1996), sounds (Bradley et al 1994), words (Bradley et al 1997), and stories, imagery, or social interactions (Westermann et al 1996, Gerrards-Hesse et al 1994).

The measurement of emotions also remained a bustling research area. The interplay among social, cognitive, and biological processes in emotion is becoming increasingly tractable, and emotional phenomena are now fruitfully studied drawing upon theories and methodologies that require collaboration among social, cognitive, developmental, clinical, and neuroscientists. For instance, methods for stereogeometric functional brain imaging and complementary methods for mapping the temporal dynamics of neural processing have become a reality over the past two decades. Positron emission tomography (PET) (e.g. Drevets & Raichle 1995, George et al 1995, Lane et al 1997, Paradiso et al 1997) and functional magnetic resonance imaging (fMRI) (e.g. Grodd et al 1995, Maddock & Buonocore 1997, Lang et al 1998) offer considerable promise in studies of affective processes (cf Fox & Woldorff 1994, Kutas & Federmeier 1998, Sarter et al 1996).

As Kutas & Federmeier note, the temporal resolution of the fMRI is still limited by the fact that the blood flow response typically lags the actual electrical signal by one to two seconds and does not track activity on a millisecond-by-millisecond basis. The temporal resolution of PET is similarly limited. In studies in which higher temporal resolution is required, fMRI or PET studies can be complemented by other measures. Indeed, advances in tracking phasic aspects of emotion were seen in (*a*) event-related brain potential paradigms (Cacioppo et al 1994, Crites et al 1995, Gardner & Cacioppo 1998); (*b*) startle probe methods (Davis 1997, Lang 1995); (*c*) continuous self-report measures (Stayman & Aaker 1993); (*d*) retrospective verbal protocols (Cacioppo et al 1997c, Davison et al 1997, Hurlburt 1997); (*e*) nonverbal pictorial assessment techniques (Bradley & Lang 1994); (*f*) facial electromyography (Tassinary & Cacioppo 1992, Witvliet & Vrana 1995); and (*g*) observational methods of infants (Emde et al 1993) and interactants (Carroll & Russell 1997, Gottman 1993).

Laboratory studies can afford impressive control over relevant variables, an important feature when dissecting phenomena as complex and multiply determined as the emotions. The ecological and external validity of laboratory paradigms and measures can sometimes be uncertain, however. Advances in electronics and statistics have improved the feasibility and methodological sophistication of both ecological momentary assessments (e.g. Diener & Lucas 1998, Larsen 1991, Suls et al 1998) and ambulatory monitoring of affective states (e.g. Guyll & Contrada 1998, Kamarck et al 1998). These assessments introduce their own set of statistical (cf Schwartz & Stone 1998) and methodological problems (e.g. Litt et al 1998) but are noteworthy developments as they should make it possible to identify which laboratory findings generalize to the real world and to improve laboratory models of human emotions. Two additional developments that are needed are: (*a*) programmatic studies of emotion that test specific conceptual hypotheses based on both the internal validity of the laboratory and the external and ecological validity of field sampling methods and ambulatory assessments; and (*b*) greater use of experimental manipulations (e.g. an intervention program) in conjunction with field sampling methods and ambulatory assessments.

There has been no shortage of debates over methods and measures, either. Over the past couple years alone, discussions appeared on topics in a wide range: (*a*) import of linguistic analyses of emotion (e.g. Wierzbicka 1995; cf Forsyth & Eifert 1996); (*b*) the role and limits of self-reports in studies of emotion (Lazarus 1995, Reisenzein 1995, Schwarz & Strack 1998) and moods (Bagozzi 1993, Green et al 1993, Watson & Clark 1997); (*c*) the pancultural agreement in emotion judgments (Ekman 1994, Rosenberg & Ekman 1995, Russell 1994); (*d*) the methodological nuances in research on cerebral asymmetries in emotion (Davidson 1993, Hagemann et al 1998, Reid et al 1998); and (*e*) the nature and existence of basic emotions (Ekman 1992, Izard 1992, Ortony & Turner 1990, Panksepp 1992).

Individual differences in emotional disposition (Davidson 1994, Depue 1996, Gray 1994, Rosenthal 1995, Tangney et al 1995), intensity (e.g. Keltner

& Ekman 1996), and reactivity (e.g. Cacioppo et al 1992, Gilboa & Revelle 1994, Larsen et al 1996) continued to be popular areas of theory and research. Explanations of the origins of the individual differences in emotion have turned in part to studies of socioemotional development, work that now extends across the life span from infancy (e.g. Izard & Ackerman 1997, Nelson & de Haan 1997, Walker-Andrews 1997) through adolescence (Flannery et al 1994) to old age (Carstensen et al 1997, Schulz & Heckhausen 1997). Related reports of the genetic determinants of emotion (e.g. McGuire 1993, Plomin et al 1993) and the universality of emotional expressions (e.g. Averill et al 1994, Ekman & Keltner 1997, Izard 1994) were counterbalanced by studies of cultural determinants (Mesquita et al 1997, Russell 1994). As this work attests, emotion is a short label for a very broad category of experiential, behavioral, sociodevelopmental, and biological phenomena.

The Relation Between Emotion and Cognition

An assumption by rationalists dating back to the ancient Greeks has been that higher forms of human existence—mentation, rationality, foresight, and decision making—can be hijacked by the pirates of emotion. In accordance with the classic assumption that emotion wreaks havoc on human rationality, the emphasis for years in psychology has been on cognition and rationality, and on ways of diminishing the influence of subjectivity and emotion in decision making and behavior. Research with chimpanzees (*Pan troglodytes*) supported the notion that symbolic representations (e.g. arabic numerals) evolved in part to lessen the primal grip of appetitive or aversive stimuli (e.g. candies) on decision making and behavior (Boysen et al 1996). However, emotions are much more than primitive reflexes. The notion that emotions are a disruptive force in rational thought and adaptive action was shown to be a gross oversimplification (e.g. Berntson et al 1993). Although the obstacles of a civilized world still occasionally call forth blind rages, emotions are increasingly recognized for the constructive role they play in higher forms of human experience.

Consider the neurological case of Elliot reported by Damasio (1994). Elliot was a businessman who developed a brain tumor that damaged his prefrontal cortex. Although Elliot began behaving irrationally, testing of Elliot revealed that his intelligence, attention, and memory remained unaffected by his illness. Instead, Elliot had lost the ability to experience emotion; and the lack of emotional guidance rendered decision making a dangerous game of roulette.

The notion that emotion contributes not only to an intelligent but also to a fulfilling life emerged most strikingly in the work on emotional intelligence. The heightened ability to monitor one's own and others' emotions, to discriminate among them, and to use the information to guide one's thinking and action has proven to be as important a determinant of life success as traditional measures of intelligence such as IQ (Goleman 1995, Mayer & Salovey 1993).

Societal changes have also influenced the direction of research on emotions. With rising health costs threatening to ravage families and finances, attention has turned to the role of emotion in cancer progression (Andersen et al 1998, Spiegel 1997), cardiovascular disease (Brezinka & Kittel 1996, Carney et al 1995), respiratory disease (Lehrer et al 1993), infectious illness (Cohen & Rodriguez 1995, Leventhal et al 1997), and immune function (Herbert & Cohen 1993, Kiecolt-Glaser et al 1994, Sternberg 1997). A second societal trend, the dawning of the information age and advances in computer vision, robotics, and telecommunications, has placed a premium on speech and facial recognition and production software. For these programs to be realistic, they must capture the emotion in the message. This need has fueled interest in the acoustic (Murray & Arnott 1993, Pittam & Scherer 1993) and rapid facial signals of emotion (Ekman 1993, Russell & Fernandez-Dols 1997). Although these represent relatively new areas of research, the economic stakes make these likely areas of new developments.

Research over the past two decades on cognition and emotion provides further evidence for the ubiquity of emotion, with the influence of emotion extending to all aspects of cognition and behavior. Perhaps of particular note in recent years are advances in our understanding of the role of emotions in attention and perception (Niedenthal & Kitayama 1994, Zajonc 1998); memory (Bradley et al 1995, Cahill 1996, Phelps & Anderson 1997); psychological defense (Paulhus et al 1997); subjective well-being (e.g. Diener & Suh 1998, Myers 1993); attitudes and persuasion (Cacioppo et al 1992, Chen & Bargh 1998); reasoning and decision making (Forgas 1995, Schwarz & Clore 1996); the meaning of expressive displays (Hess et al 1995, Rosenberg & Ekman 1994); emotional contagion (Hatfield et al 1994, Hietanen et al 1998); interpersonal relationships (Gardner et al 1998, Reis & Patrick 1996); and political information processing (Ottati et al 1992, Way & Masters 1996).

Emotions are also physiological processes and cannot be understood fully without considering the structural and functional aspects of the physical substrates (cf LeDoux 1995). Physiological investigations not only delineate underlying mechanisms but also contribute to better psychological theories by inspiring what is possible (e.g. implicit versus explicit knowledge representations) and by placing constraints on what is plausible (e.g. forward versus backward propagation). The biological (e.g. Boiten et al 1994, Cacioppo et al 1997a, Davidson 1994, Levenson 1996), biochemical (e.g. Rubinow & Schmidt 1996), and neural substrates of emotion (e.g. Damasio 1996, Davis 1997, LeDoux 1995, Neafsey et al 1993), as well as neuropsychological aspects of emotional expressions (Borod et al 1997), continued to be important and active areas of research. For instance, Shizgal (1998), in summarizing research using electrical brain stimulation to probe emotion, stated that in contrast to cognitive (i.e. perceptual and timing) channels, “the evaluative [affective] channel operates without even a pretense of objectivity." He noted that a cool stimulus applied to the skin can be pleasant if one is overheated and unpleasant if one is hypothermic. The affective value of a stimulus, he concluded, depends in part on the prevailing physiological and ecological conditions. Shizgal's (1998) physiological research implies that the brain is organized in part as an affect system, and that the operation of the affect system is not controlled in an absolute fashion by the objective features of a stimulus.

The Relativity of Emotion

The notion that there are absolute features that trigger emotional reactions was further undercut by new evidence that relativity governs the province of emotion. Kahneman and colleagues demonstrated that pain, long a bastion of absolutism, was preferred when its duration was extended while its intensity paled (Kahneman et al 1993). Kahneman and colleagues (e.g. Kahneman 1998) offered the intriguing hypothesis that the affective representation of a complex event varied as a function of the peak experience and the experience at the end of the event (i.e. the peak-end rule).

Schwarz & Strack (1998) noted that most objective life circumstances, even when combined across a dozen domains of life, account for no more than 10% of the variance in measures of subjective well-being. Indeed, they demonstrated that the same event can increase or decrease judgments of subjective well-being depending on its use in construing one's life or its use as a standard. Specifically, Schwarz & Strack (1998) suggested that a contrast effect is likely to occur when an extreme (negative or positive) event is used as a standard against which to compare a stimulus or one's current state, whereas an assimilation effect is more likely when the extreme event is included in the transient representation of the affective event. For example, a moderately negative target stimulus (e.g. an argument with a spouse) is perceived more positively when preceded by the experience of a rare, extremely negative event (e.g. a death in the family) than when not preceded by such an event (Parducci 1995) as long as the preceding event served as a comparison standard rather than as part of the target event.

Yet other ways were discovered in which the determinants of emotion are relative. Brendl & Higgins (1995) reviewed evidence that an incentive is greater when it is compatible with a person's goal (see also Shah et al 1998). Counterfactual thinking, or comparing objective outcomes with imagined outcomes that "might have been," was shown to leave bronze medalists at the 1992 Summer Olympics apparently happier than silver medalists (Medvec et al 1995; see also Roese 1997) even though, by objective standards, an Olympic silver medal is of higher value than a bronze medal. Similarly, stories or confabulations that place an evocative event in a historical context were shown to be as important a determinant of the emotions elicited by the event as the event itself (Harvey et al 1995, Kitayama & Masuda 1995, Traue & Pennebaker 1993). In addition to the perceived valuation of a stimulus or endstate, investigators demonstrated that the rates of movement toward or away from the endstate are important determinants of emotion in and of themselves (Carver & Scheier 1990, Carver et al 1996, Hsee et al 1994).

Research concerning cognitive appraisals represented an especially active area of relativity research, complementing the research that emphasized the features of the emotional eliciting stimulus by focusing upon the relativity of the internal elicitors of the emotional experience. Indeed, more than 100 articles, various books (e.g. Lazarus 1991, Omdahl 1995), and special issues of academic journals (e.g. *Cognition and Emotion*, *Psychological Inquiry*) were devoted to the topic in recent years. The premise in cognitive appraisal theories is that the appraisal of the significance of a stimulus involves "relational meaning"—the import of an event in conjunction with the conditions present in the environment and personal goals, beliefs, and adaptational resources (Lazarus 1994). Accordingly, universal antecedents are defined in terms of appraisal dimensions rather than stimulus features (e.g. Ellsworth 1994, Frijda 1994). Roseman et al (1996) argued that appraisals of unexpectedness, situational state, motivational state, probability, control potential, problem source, and agency differentiate 17 emotions, whereas in a cross-cultural study Scherer (1997) found that fewer appraisal dimensions of the eliciting event provided a reasonably good account of the major emotion categories (e.g. joy, sadness, fear, anger, disgust, shame, and guilt) (see also Fitness & Fletcher 1993, Frijda 1993, Parkinson & Manstead 1993, Reisenzein & Hofmann 1993, Smith et al 1993). Importantly, suggestive evidence that the unfolding of cognitive appraisals were themselves influenced by subcortical neural structures long associated with emotion emerged from neuropsychological cases such as Scott et al's (1997) report of a patient with lesions of the left and right amygdala (see also Bechara et al 1995, Damasio 1994, Scherer 1993).

Cognitive appraisals may be more important for some types of emotional elicitors than others. In an illustrative line of research summarized by Ohman et al (1998), two types of emotional conditioning were identified. In one type of conditioning, the knowledge that the conditioned stimulus (CS) and unconditioned stimulus (US) are associated in time is explicit (i.e. expectancy-based learning)—that is, autonomic responses occur on the same trials on which subjects develop the expectancy that the CS is followed by the US. This learning does not require an aversive US (Hamm & Vaitl 1996), is accessible to consciousness, and modifies responses related to orienting responses (LeDoux 1995, Ohman et al 1998). In a second type of visceral conditioning, the knowledge that the CS and US are associated in time is implicit (Ohman et al 1998). This learning appears most reliably when an aversive US is combined with a fear-relevant CS (e.g. snake, angry facial display), results in an enhanced startle response and tachycardia, is relatively resistant to extinction, and, although not dependent on conscious awareness of the CS-US contingency, it modifies the perceived valence of the CS as revealed by ratings (Davey 1992, Schell et al 1991, see Ohman 1993). The hippocampus appears to be especially important in the explicit learning of emotional expectancies, whereas the amygdala appears especially important in the implicit emotional conditioning. For instance, Bechara et al (1995) found that two patients with bilateral lesions of the amygdala learned the conditioning contingencies but did not acquire conditioned skin conductance responses in aversive conditioning paradigms. Patients with bilateral hippocampal damage, in contrast, failed to learn the conditioning contingencies but acquired conditioned skin conductance responses. Together, these studies suggest that cognitive appraisals may play a more important causal role in human autonomic conditioning based on explicit than implicit knowledge (LeDoux 1995, Ohman et al 1998).

Classical conditioning has traditionally provided a valuable paradigm for studying behavioral preference in nonvertebrates and nonprimates, and more contemporaneously it has been used to examine the mechanisms underlying the learning and memory of affective associations. The evolutionary advantage is obvious; recognizing the neutral trappings of a predator as a danger signal allows organisms to avoid becoming a meal. Additional evidence for the special status accorded to motivationally significant stimuli can be found in research on orienting responses. Orienting responses to threat-related stimuli are found whether the stimuli are masked or not, whereas orienting responses to neutral stimuli are found for unmasked but not masked stimuli (Dimberg & Ohman 1996, Ohman 1993). According to Ohman's theory of the orienting response, evolution has sculpted perceptual and attentional systems to provide preferential access to those classes of stimuli with adaptive significance for organisms (Ohman et al 1998). Based on comparative data, Hunt & Campbell (1997) have further suggested that orienting responses to neutral stimuli may have evolved from earlier, more motivationally basic responses, answering the questions "Is it dangerous?" or "Is it food?" rather than the "What is it?" response posited by Pavlov.

THE AFFECT SYSTEM UNDERLYING EMOTION

Evolutionary forces do not value knowledge or truth per se but species survival. Hunt & Campbell's provocative proposition underscores the primeval importance of a system that differentiates between hostile and hospitable stimuli (1997). The human brain and body have been shaped by natural selection to perform this affective categorization and to respond accordingly. Affective categorizations and responses are so critical that organisms have rudimentary reflexes for categorizing and approaching or withdrawing from certain classes of stimuli and for providing metabolic support for these actions (Davis 1997, LeDoux 1995). These rudimentary processes are evident in humans as well, but a remarkable feature of humans is the extent to which the affective categorizations are shaped by learning and cognition (Berntson et al 1993, Kahneman et al 1998). As various authors have noted, an additional adaptive advantage is conferred to species whose individual members have the capacity to learn based on the unique environmental contingencies to which they are exposed, to represent and predict events in their environment, to manipulate and plan based on representations, and to exert some control over their attentional and cognitive resources.

Zajonc's influential paper "Preferences Need No Inferences" underscored the utility of the affect system as an object of study (1980). Evidence that the neural circuitry involved in computing the affective significance of a stimulus (i.e. evaluative processing) diverges at least in part from the circuitry involved in identification and discrimination (i.e. nonevaluative processing) was provided by Shizgal (1998) in a series of studies involving brain stimulation in rats and by Cacioppo and colleagues (Cacioppo et al 1996, Crites & Cacioppo 1996) in a series of studies of ERP topographies in humans. For instance, investigations of the spatial distribution of late positive potentials across the scalp have revealed a relatively symmetrical distribution during nonaffective categorizations, whereas the spatial distribution of the late positive potentials associated with affective categorizations were more right lateralized (Cacioppo et al 1996). This asymmetrical activation is consistent with the importance of the right hemisphere in emotion (see Tucker & Frederick 1989). Furthermore, the similarities in ERP topographies indicate that affective and nonaffective appraisals are not entirely different but rather rely on a number of common information-processing operations.

In the last chapter on emotion in the *Annual Review of Psychology*, LeDoux covered in detail some of the neural substrates of the affect system (1995). Here, therefore, we focus on the structure and operating characteristics of the affect system.

Operating Characteristics of the Affect System

Stimuli and events in the world are diverse, complex, multidimensional—in short, seemingly incomparable. Yet each perceptual system has evolved to be tuned to specific features, resulting in the expression of these stimuli on a common metric (Tooby & Cosmides 1990). Seemingly incomparable stimuli and events can also be conceived as being expressed on common *motivational* metrics (Cacioppo & Berntson 1994, Lang 1995, Shizgal 1998). As Ohman et al note, "Evolution has primed organisms to be responsive to stimuli that more or less directly are related to the overall task of promoting one's genes to prosper in subsequent generations. . .. Stimuli of these types are embedded within emotional systems that help regulate behavior within critical functional domain" (Ohman et al 1998).

Information is lost in translating a multidimensional representation of a stimulus onto a common motivational metric (i.e. a currency function). However, as Shizgal states, "the information lost due to the collapsing of multiple dimensions is essential for identifying the stimulus and distinguishing it from others. . ..The circuitry that computes instantaneous utility must diverge from the perceptual circuitry subserving identification and discrimination" (Shizgal 1998). As noted above, there is now considerable evidence for differences in the circuitry in affective processing versus the processes of identification and discrimination.

From classical learning theory came the principle that motivational strength increases as the distance from a desired or undesired endstate decreases. Currency functions, in essence, represent the activation function for motivational strength. Perceptual activation functions tend to be negatively accelerating, and this appears to describe the activation function for emotion as well (Boysen et al 1996, Kemp et al 1995). For example, Boysen et al (1996) demonstrated that, for chimpanzees judging the differential incentive values of candy arrays, the relative effectiveness of a given increment in payoff diminished as the base size of the payoff increased. The activation function for affective responses is thus reminiscent of microeconomic marginal utility functions.

Stages and Channels of Evaluative Processing

One distinction Shizgal (1998) made between the evaluative (affective) and perceptual channels is that the former is constructed not to return objective properties of the stimulus but to provide a subjective estimate of the current significance of these properties. How many evaluative channels are there? Most have posited one in which subjective, valent information is derived from the flow of sensation (e.g. Green et al 1993). Studies of the conceptual organization of emotion, for instance, suggest that people's knowledge about emotions is hierarchically organized and that a superordinate division is between positivity and negativity (e.g. Lang et al 1990).

One reason underlying this superordinate division in emotional knowledge may be that physical constraints restrict behavioral manifestations to bivalent actions (approach/withdrawal). Evolution favors the organism that can learn, represent, and access rapidly whether approach or withdrawal is adaptive when confronted by a stimulus. Accordingly, mental guides for one's actions in future encounters with the target stimuli—attitudes (e.g. Cacioppo & Berntson 1994), preferences (e.g. Kahneman 1998), and conceptual organizations of emotion (e.g. Ortony et al 1988)—also tend to be more expected and stable when organized in terms of a bipolar evaluative dimension (ranging from very good and not at all bad to very bad and not at all good).

Physical limitations may constrain behavioral expressions and incline behavioral guides toward bipolar (good/bad; approach/withdraw) dispositions, but these constraints do not have the same force at the level of underlying mechanism. That is, the fact that approach and withdrawal tend to be reciprocally activated behavioral manifestations does not mean that they were derived from a single bipolar evaluative channel; it only means that the outputs of all of the evaluative processors comprising the affect system are combined in order to compute preference and organize action. Various theorists have posited that the module in the affect system that computes attitudes, preferences, and actions derives input from at least two specialized evaluative channels that process information in parallel—one in which threat-related (i.e. negative) information is derived from the flow of sensation and a second in which safety and appetitive (i.e. positive) information is derived (e.g. Cacioppo et al 1998a, Gilbert 1993, Lang et al 1990, Marcus & Mackuen 1993, Watson & Clark 1992, Zautra et al 1997).

According to the model of evaluative space (Cacioppo & Berntson 1994, Cacioppo et al 1997b), the common metric governing approach/withdrawal is a single dimension at response stages but is the consequence of two intervening metrics (i.e. evaluative channels)—the activation function for positivity and the activation function for negativity—at the inaugural affective processing stages. Further, multiple modes of activation are posited to exist for the two evaluative channels: (*a*) reciprocal activation occurs when a stimulus has opposing effects on the activation of positivity and negativity; (*b*) uncoupled activation occurs when a stimulus affects only positive or only negative evaluative activation; and (*c*) nonreciprocal activation occurs when a stimulus increases (or decreases) the activation of both positivity and negativity. This model thus does not reject the reciprocal activation that is assumed in subjective reports of affect, and demanded in behavioral manifestations of affect, but rather subsumes it as one of the possible modes of activation and explores the antecedents for each mode of evaluative activation.

Evidence for the existence of multiple modes of evaluative activation has been observed across all levels of analysis (cf Cacioppo & Berntson 1994). For instance, Hoebel (1998) reviewed evidence that whereas morphine has reciprocal effects on neurochemical processes underlying approach and withdrawal behavior, food restriction alters neurochemical effects underlying approach behavior in an uncoupled fashion. At the verbal level, Goldstein & Strube (1994) demonstrated the uncoupled activation of positivity and negativity in affective reports collected from students at the beginning and end of three consecutive class periods. The intensity of positive and negative reactions on any particular day were found to be uncorrelated. Moreover, exam feedback activated positivity and negativity differently. Students who performed well on an exam showed an increase in positive affect relative to their beginning-of-class level, whereas their level of negative affect remained unchanged; and students who performed poorly showed an increase in negative affect but no change in positive affect.

Such distinctions between positive and negative affective processes have also been observed in (*a*) uplifts and hassles (Gannon et al 1992, Zautra et al 1990); (*b*) mood states (Lawton et al 1992, Zautra et al 1997); (*c*) organization of self-knowledge (e.g. Showers 1995, Showers & Kling 1996); (*d*) self-regulatory focus (e.g. Higgins 1997); (*e*) self-efficacy (Zautra et al 1997); (*f*) personality processes (Robinson-Whelen et al 1997, Rusting & Larsen 1998, Watson et al 1992); (*g*) achievement motivations (Elliot & Church 1997, Elliot & Harackiewicz 1996); (*h*) attitudes and persuasion (Cacioppo & Berntson 1994); (*i*) emotional expressivity (Gross & John 1997); (*j*) social interactions (Berry & Hansen 1996, Cacioppo et al 1997b); (*k*) affect toward political leaders (Marcus & Mackuen 1993); and (*l*) intergroup discrimination (Blanz et al 1997, Brewer 1996).

However, Green et al (1993) questioned the notion that positive and negative affect were separable on methodological grounds (see also Bagozzi 1993, Marsh 1996). Specifically, they argued that measures of affect typically rely on similarly worded scales with identical endpoints. This feature, they argued, can lead to positively correlated measurement error effectively suppressing the magnitude of the true negative correlation between positive and negative affective states. Thompson et al (1995), in contrast, suggested that methodological artifacts (e.g. carryover between unipolar positive and negative rating scales) could instead inflate the negative correlation between positive and negative rating scales, and they recommended segregating self-report measures of positive and negative affect to avoid self-presentational biases.

A recent investigation by Nelson (1998) addressed these methodological concerns and found evidence for the operation of multiple modes of evaluative activation. Nelson (1998) used a structural modeling approach to examine the structure of affect toward two different social categories—African Americans and the poor—while accounting for correlated measurement error among the observed variables. Nelson's analyses of the structure of the emotional responses toward the poor revealed substantial independence between positive and negative factors. This two-factor model was significantly better than the bipolar model even when the effects of correlated measurement error were extracted. This result is precisely what would be expected if positive and negative affect were separate dimensions at a basic level. Nelson's analyses of the structure of students' emotional responses toward African Americans, however, revealed a bipolar model to be sufficient when the effects of correlated measurement error were considered. This latter result illustrates that affect is not invariably organized in a bipolar *or* a bivariate structure but rather the structure of affective response is influenced by the mode of evaluative activation elicited by the stimulus (Cacioppo & Berntson 1994).

Methodological issues are important to consider, but assuming that the affect system consists only of a single bipolar evaluative channel can also be costly in terms of the fertile avenues of research it precludes. Brain imaging studies, for instance, have tended to contrast positive and negative states, a procedure that impedes the differentiation of the conditions in which positive and negative processes are separable. This may be unwise because, although preliminary at this juncture, some brain imaging studies suggest that different neural structures may be involved in positive and negative hedonic processes. George et al, for instance, used PET during the recall of happy, sad, or neutral memories while viewing congruent happy, sad, or neutral faces (George et al 1995). Comparisons between the sadness-minus-neutral and the happy-minus-neutral conditions revealed that, rather than reciprocal changes in blood flow to the same brain regions, a change from sad to happy affective state produced increased cerebral blood flow to distinguishable brain regions (see also Lane et al 1997).

Research on cortical asymmetry is also consistent with the notion of specialized evaluative channels for the processing of positive and negative information that are subsequently integrated in the production of an affective response (e.g. Davidson 1993, Davidson et al 1990). In a study by Sutton & Davidson, for instance, resting EEG asymmetries were compared with scores on Carver & White's Behavioral Approach System/Behavioral Inhibition System measure, a self-report instrument designed to assess individual differences in the tendency to approach or withdraw and to experience concomitant affective states (Sutton & Davidson 1997, Carver & White 1994). Consistent with the notion that positivity and negativity are separable systems differentially associated with left and right hemispheric activation, respectively, greater relative left asymmetry at midfrontal electrode sites was positively correlated with behavioral activation system scores and negatively correlated with behavioral inhibition system scores. Similarly, studies using computerized tomography to investigate the relationship between the location of stroke-related lesions and affective symptoms showed that the severity of post-stroke depression was positively related to lesion proximity to the left frontal pole but negatively related to lesion proximity to the right frontal pole (Robinson & Downhill 1995). Robinson and colleagues further observed that patients with right lateralized infarctions were more likely than their left-hemisphere–lesioned counterparts to display inappropriate cheerfulness.

The evidence for the separability of positive and negative evaluative processes becomes more controversial when one turns to the literature on the conceptual organization of moods, affect, and emotion. Among the best known research bearing on the centrality of people's net positive and negative feelings is Osgood et al's classic work on the measurement of meaning (1957). In multiple studies and cultures, evaluative bipolar word pairs (e.g. pleasant-unpleasant) were found to comprise a fundamental dimension underlying people's understanding of the world. Conceptually similar results have been found in crosscultural, multidimensional scaling studies of emotional feelings (e.g. Bradley & Lang 1994, Larsen & Diener 1992) and in crosscultural ratings of emotionally evocative pictures (e.g. Lang et al 1995). Thus, the two-dimensional representation that best represents people's conceptual organization of affect and emotion may tend to be positive/negative X active/inactive rather than positive/nonpositive X negative/non-negative. Given that psychological states such as conflict, ambivalence, and inconsistency among beliefs about an attitude object tend to be unexpected, nonharmonious, and unstable, people's conceptual organization of evaluative processes and affective states (e.g. moods) may tend toward a bipolar structure because of the operation of motives to maintain a simple and psychologically consistent representation of the world.

In sum, the common metric governing approach/withdrawal can perhaps be best conceptualized as a single dimension at response stages with the bivalent affective response the consequence of two intervening evaluative channels, one for positivity (appetition) and one for negativity (aversion). Consistent with the notion that input from these evaluative channels is combined with antagonistic effects on action dispositions and behavior, a bivalent organization of affect is more likely to be observed as one moves down the neuraxis (see Berntson et al 1993, Cacioppo et al 1998). For instance, relative to neutral states, negative states tend to potentiate startle eyeblink whereas positive states tend to inhibit it (see reviews by Filion et al 1998, Lang et al 1990) because of the modulating effects of the amygdala (Davis 1997, Lang 1995).

The value of considering the additional complexities introduced by multiple evaluative channels and modes of evaluative activation derives not only from the data it explains but also from the questions it generates and the bridges it builds across data previously thought to be separate. Research in areas of inquiry as distinct as coping in chronic pain patients (Zautra et al 1995), classroom performance and academic motivation (Elliot & Church 1997), frequency and quality of social interactions (Berry & Hansen 1996), blood and organ donation (Cacioppo & Gardner 1993), and racial prejudice (Schofield 1991) all support the wisdom of considering the two motivational systems as functionally separable.

The partial segregation of the positive and negative evaluative channels in the affect system not only confers an additional flexibility of orchestrating appetitive and aversive motivational forces via modes of evaluative activation, but also affords evolution the opportunity to sculpt distinctive activation (i.e. currency) functions for positivity and negativity. Interest in differences in the effects of positive versus negative information has grown substantially in recent years. Not only have numerous articles and several major reviews on the topic appeared (e.g. Cacioppo & Berntson 1994, Levy 1992, Peeters & Czapinski 1990, Skowronski & Carlston 1989, Taylor 1991) but two issues of the *European Journal of Social Psychology* are devoted to the topic. The extant data suggest at least two differences in these currency functions: (*a*) a positivity offset—the output of positivity is higher than the output of negativity at very low levels of affective input; and (*b*) a negativity bias—the increase in output per quantum of input is greater for negativity than positivity (see Cacioppo et al 1998).

POSITIVITY OFFSET The positivity offset is the tendency for there to be a weak positive (approach) motivational output at zero input, an intercept difference in the affective system. As a consequence of the positivity offset, the motivation to approach is stronger than the motivation to avoid at low levels of evaluative activation (e.g. at distances far from a goal). What might be the possible evolutionary significance of the positivity offset? Without a positivity offset, an organism in a neutral environment may be unmotivated to approach novel objects, stimuli, or contexts. Such organisms would learn little about novel or neutral-appearing environments and their potential value or threat. With a positivity offset, however, an organism facing neutral or unfamiliar stimuli would be weakly motivated to engage in exploratory behavior. Such a tendency may have important survival value, at least at the level of a species.

How might this evolutionarily endowed tendency manifest itself in the present day? One line of evidence may be the prevalence of "unrealistic optimism," the tendency to expect generally positive outcomes for unknown future events (Brinthaupt et al 1991, Hoorens & Buunk 1993, Pulford & Colman 1996, Regan et al 1995). A second line of evidence may be the robust "positivity bias" found in impressions of neutral, unknown, or ambiguous human and nonhuman targets (Klar & Giladi 1997, Sears 1983, Peeters 1991). Finally, research concerning the "mere exposure" effect demonstrates that affectively neutral stimuli may be evaluated positively even when presented outside of conscious awareness (Bornstein 1989, Harmon-Jones & Allan 1998). These lines of research support the existence of a positivity offset in a myriad of domains; when asked to evaluate stimuli or situations that by objective standards should be affectively neutral (e.g. the unknowable future, the "average" person, an unfamiliar Chinese idiogram), people show a consistent tendency to respond in a mildly positive fashion.

NEGATIVITY BIAS Exploratory behavior can provide useful information about an organism's environment, but exploration can also place an organism in proximity to hostile stimuli. Because it is more difficult to reverse the consequences of an injurious or fatal assault than those of an opportunity unpursued, the process of natural selection may also have resulted in the propensity to react more strongly to negative than to positive stimuli. Termed the negativity bias, this heightened sensitivity to negative information is a robust psychological phenomenon (see reviews by Cacioppo & Berntson 1994, Cacioppo et al 1997b, Peeters & Czapinski 1990, Taylor 1991).

Miller's research on rodent behavior provided some of the earliest evidence for a negativity bias through determining that the slope for the avoidance gradient was steeper than the slope for the approach gradient (Miller 1961). Forty years later, evidence supporting a negativity bias has been found in domains as varied as impression formation (e.g. Skowronski & Carlston 1989), person memory (e.g. Ybarra & Stephan 1996), blood and organ donation (e.g. Cacioppo & Gardner 1993), hiring decisions (e.g. Rowe 1989), personnel evaluations (e.g. Ganzach 1995), and voting behavior (e.g. Klein 1991, 1996). It has been found to characterize the judgments of children as well as adults (e.g. Aloise 1993, Robinson-Whelen et al 1997). Taylor summarized a wide range of evidence showing that negative events in a context evoke stronger and more rapid physiological, cognitive, emotional, and social responses than neutral or positive events (Taylor 1991; see also Westermann et al 1996). As further evidence, Ito et al (1998) have recently uncovered ERP evidence consistent with a negativity bias in the affect system.

In sum, negative emotion has been depicted previously as playing a fundamental role in calibrating psychological systems; it serves as a call for mental or behavioral adjustment. Positive emotion, in contrast, serves as a cue to stay the course or as a cue to explore the environment. This characterization may help account for evolutionary forces sculpting distinctive activation functions for positive and negative affect; the separable activation functions serve as complementary, adaptive motivational organization. Species with a positivity offset *and* a negativity bias enjoy the benefits of exploratory behavior and the self-preservative benefits of a predisposition to avoid or withdraw from threatening events. The features reviewed in this section represent only the rudimentary operations of an affect system, however. Work on the relativity of emotion shows that cognitive factors and physiological states affect the extent to which appetitive or defensive motivations are aroused, and recent work suggests that self-regulatory focus also influences approach and withdrawal gradients (Carver & Scheier 1990, Higgins 1997, Shah et al 1998). The organization of the affect system warrants further study as a reflection of our evolutionary heritage and as a continued force in the shaping of even our most civilized responses.

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