

The Affect System Has Parallel and Integrative Processing Components Form Follows Function

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ABSTRACT

The affect system has been shaped by the hammer and chisel of adaptation and natural selection such that form follows function. The characteristics of the system thus differ across the nervous system as a function of the unique constraints existent at each level. For instance, although physical limitations constrain behavioral expressions and incline behavioral predispositions toward a bipolar (good—bad, approach—withdraw) organization, these limiting conditions lose their power at the level of underlying mechanisms. According to the authors' model of evaluative space ([J. T. Cacioppo & G. G. Berntson, 1994](#); [J. T. Cacioppo, W. L. Gardner, & G. G. Berntson, 1997](#)), the common metric governing approach—withdrawal is generally a single dimension at response stages that itself is the consequence of multiple operations, such as the activation function for positivity (appetition) and the activation function for negativity (aversion), at earlier affective processing stages.

Affect in personality and social psychology has traditionally been treated as the conscious subjective aspect of an emotion considered apart from bodily changes (e.g., [Osgood, Suci, & Tannenbaum, 1957](#); [Thurstone, 1931](#)). Like the organization and processes underlying the undeniable percept that the sun circles the earth, however, the organization and processes underlying affective experiences may be far subtler than their apparent manifestations might lead one to suspect. Although rich in emotional terms ([Clore, Ortony, & Foss, 1987](#); [Frijda, Markam, Sato, & Wiers, 1995](#); [Ortony, Clore, & Foss, 1987](#); [Russell, 1978](#)), language sometimes fails to capture affective experiences—especially intense affective experiences—so metaphors become more likely vehicles for rendering these conscious states of mind ([Fainsilber & Ortony, 1987](#); [Hoffman, Waggoner, & Palermo, 1991](#); [Ortony & Fainsilber, 1989](#)).

Affective reports have also long been recognized as subject to a host of motivational influences (e.g., [Abelson et al., 1968](#); [Brehm, 1956](#)) and contextual distortions (e.g., [Fabrigar, Visser, & Browne, 1997](#); [Irvine, 1995](#); [Ostrom & Upshaw, 1968](#); [Schwarz & Strack, in press](#)) as well as being only modestly related to other aspects of affective reactions, such as physiology and behavior (e.g., [Cook & Sellitz, 1964](#); [Lang, 1971](#); [Nisbett & Wilson, 1977](#)). Furthermore, recent investigations in personality and social psychology have characterized affect as capable of being elicited quickly, effortlessly, automatically, or even unconsciously, on exposure to the stimulus (e.g., [Bargh, Chaiken, Gendler, & Pratto, 1992](#); [Pratto & John, 1991](#); see [Tesser & Martin, 1996](#)). Investigations of the structure of affective words and of self-reports of affect are, therefore, important but may be incomplete. Our goal here is to review selective evidence ranging from neural mechanisms to political behavior to explore

some of the properties and features of the system underlying affective appraisals, experiences, and actions. ¹As we will see, the structure of the affect system depends on function, which varies across the level of the nervous system (neuraxis).

The Affect System

The affect system has been sculpted by the hammer and chisel of adaptation and natural selection to differentiate hostile from hospitable stimuli and to respond accordingly. Although specific behaviors may differ depending on the stimulus and context, there is an underlying commonality to these behaviors. Affective categorizations and responses are so critical that all enduring species have rudimentary reflexes for categorizing and approaching or withdrawing from certain classes of stimuli and for providing metabolic support for these actions (e.g., [Berntson, Boysen, & Cacioppo, 1993](#); [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, Diener, & Schwarz, in press](#)). As various authors have noted, an additional adaptive advantage is conferred on species whose individual members have the capacity to learn on the basis of the unique environmental contingencies to which they are exposed, to represent and predict events in their environment, to manipulate and plan on the basis of representations, and to exert some control over their attentional and cognitive resources.

[Zajonc's \(1980\)](#) influential article, "Preferences Need No Inferences," underscored the utility of the affect system as an object of study in its own right. Such a focus is not to deny the inextricable links between affect and cognition. Affect directs attention, guides decision making, stimulates learning, and triggers behavior (e.g., [Damasio, 1994](#)). Evolutionary forces, however, do not value knowledge or truth per se but rather species survival. 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 \(in press\)](#) in a series of studies involving brain stimulation in rats and by [Cacioppo, Crites, and Gardner \(1996; Crites & Cacioppo, 1996; Gardner & Cacioppo, in press\)](#) in a series of studies of event-related brain potential (ERP) topographies in humans. For instance, investigations of the spatial distribution of late positive potentials (LPP) across the scalp have revealed a right lateralization of affective categorizations, whereas the spatial distribution of the LPP associated with nonaffective categorizations is more symmetrical ([Cacioppo et al., 1996](#)). Whether individuals performed affective or nonaffective categorizations of stimuli was manipulated by [Crites and Cacioppo \(1996\)](#), who similarly obtained a symmetrical topography of LPPs when a nonaffective categorization is performed (e.g., deciding whether a food item is a vegetable) but a right lateralized topography of LPPs with an affective categorization (e.g., deciding whether a food item is positive). This asymmetrical activation is consistent with the importance of the right hemisphere in emotion (see [Tucker, 1981](#); [Tucker & Frederick, 1989](#)). However, considerable similarities in the ERPs were observed as well, consistent with the notion that affective and nonaffective appraisals rely on a number of common information-processing operations. In the next section we examine the form of the activation functions that characterize the operation of the affect system.

Activation (Currency) Functions

Stimuli and events in the world are diverse, complex, and 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](#); see also [Ohman, Hamm, & Hugdahl, in press](#)). People have little difficulty doing cross-modal matching, in which they express variations in the intensity of a visual stimulus in terms of sound or touch. Seemingly incomparable

stimuli and events are also expressed on common valuation metrics or "currency functions" ([Shizgal, in press](#)). The perceptual systems are important not for the description they give of the environment but for the adaptive implications of the stimuli that pass through their bandwidths. As [Ohman et al. \(in press\)](#) noted,

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. Such stimuli include those related to the survival tasks ... stimuli of these types are embedded within emotional systems that help regulate behavior within critical functional domains.

An *activation function* refers to the mathematical relationship between the full range of inputs to a system and the outputs obtained from that system. The activation functions for hedonic inputs can be thought of as currency functions. Information is lost in the translation of a multidimensional representation of a stimulus onto a currency function. As [Shizgal \(in press\)](#) noted,

One cannot recover the temperature, sweetness, or texture of a gustatory stimulus from a currency value representing its instantaneous utility. However, the information lost due to the collapsing of multiple dimensions is essential for identifying the stimulus and distinguishing it from others. Thus, the circuitry that computes instantaneous utility must diverge from the perceptual circuitry subserving identification and discrimination.

Indeed, it is features such as these that make it useful to think of the affect system as an entity intimately related to yet distinguishable from the cognitive system.

Perceptual activation functions tend to be negatively accelerating, and currency functions appear to be negatively accelerating as well ([Boysen, Berntson, Hannan, & Cacioppo, 1996](#) ; [Kemp, Lea, & Fussell, 1995](#)). [Boysen et al. \(1996\)](#) , for instance, tested chimpanzees (*Pan troglodytes*) with training in counting and numerical skills. The chimps performed a reverse contingency task in which they selected between two appetitive stimuli, represented either as arrays of different amounts of candies or, more symbolically, by two Arabic numerals. Performance on the task was highly sensitive not to the objective value (e.g., number of candies) of the array stimuli but to the numerical disparity between the arrays. However, the chimps did not appear to be making absolute disparity judgments. Instead, the effects of disparity were qualified by the overall size of the stimulus arrays, with a given disparity yielding smaller effects with larger overall array sizes. That is, the chimpanzees' judgments of the differential incentive values of the stimuli were reminiscent of microeconomic marginal utility functions in which the relative effectiveness of a given increment in payoff diminishes as the base size of the payoff increases. This suggests that the currency functions for the affect system may best be depicted as negatively accelerating when characterizing their full range of activation. Linear functions are reasonable approximations when dealing with more restricted ranges of activation, such as that observed in psychological laboratories in response to pictures ([Ito, Cacioppo, & Lang, 1998](#)).

Stages of Evaluative Processing

One distinction between the evaluative channels of the affect system and the perceptual channels of the perceptual system 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 ([Cacioppo & Gardner, 1999](#) ; [Shizgal, in press](#) ; [Zajonc, 1980](#)). ²How many evaluative channels are there in the affect system? Most researchers have posited one in which subjective, valent information is derived from the flow of sensation (e.g., [D. P. Green, Salovey, & Truax, 1999](#) ; [Russell & Carroll, 1999](#) ; [Russell & Feldman Barrett, 1999](#)). Research on the conceptual organization of emotion is consistent with the notion that

people's knowledge about emotions is hierarchically organized and that a superordinate division is between positivity and negativity (e.g., [Russell, 1983](#) ; [Russell & Mehrabian, 1977](#) ; see [Tesser & Martin, 1996](#) ; [Watson & Tellegen, 1985](#)).

Physical constraints generally restrict behavioral manifestations to bivalent actions (approach—withdrawal). It is true that one can stay motionless or circle a stimulus at a constant distance. Evolution, however, favors the organism that can learn, represent, and access rapidly whether approach or withdrawal is adaptive when confronted by a stimulus. There is also a behavioral efficiency, a conservation of limited cognitive resources, and a reduction in physiological stress that is served by mental representations of general and enduring net action predispositions toward classes of stimuli ([Blascovich et al., 1993](#) ; [Fazio, Blascovich, & Driscoll, 1992](#) ; [Lingle & Ostrom, 1981](#)). Accordingly, mental guides for one's actions in future encounters with the target stimuli, such as attitudes (e.g., [Cacioppo & Berntson, 1994](#) ; [Fishbein & Ajzen, 1975](#)) and preferences (e.g., [Kahneman, in press](#)), may tend to be more expected and stable when organized in terms of a bipolar evaluative dimension. Indeed, [Brehm \(1956\)](#) found individuals to amplify the positive features and diminish the negative features of a chosen alternative and to magnify the negative features and minimize the positive features of an unchosen alternative. This motivational push toward affective bipolarity was especially compelling when individuals initially regarded the alternatives to be similarly appealing. The bipolar (positive—negative) structure that comes from the spreading of alternatives represents a stable endpoint, however, not the states or processes that preceded this endpoint.

The fact that approach and withdrawal are reciprocally activated behavioral manifestations does not mean that they were derived from a single bipolar evaluative channel. Nor does the fact that positive and negative affect have antagonistic effects on approach or withdrawal behavior mean that the affective inputs are invariably reciprocally activated (e.g., see [Edwards & Ostrom, 1971](#)). They mean only that the outputs of the evaluative processors composing the affect system are combined in order to compute bivalent action tendencies and actions ([Cacioppo & Berntson, 1994](#)). Such an organization fosters function: free and swift approach to appetitive stimuli and rapid and unfettered withdrawal from aversive stimuli. This organization is patent in the neural architecture of spinal cord reflexes—the so-called final common pathway for behavior—where activation of flexor reflexes reciprocally inhibits extensor antagonists and vice versa ([Sherrington, 1906](#)). This introduces a reciprocal bias in motor outputs, but this peripheral organization does not preclude the activation of both flexors and extensors (e.g., isometric contractions) via input from rostral brain areas (e.g., through voluntary efforts). The affect system may be organized similarly, perhaps not by accident, because the affect system—constituted largely of reflexes and fixed action patterns in simple organisms—evolved to direct behavior in a way that fosters species survival.

Various theorists have posited that the theoretical 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 sensory inputs and its associations and a second in which safety and appetitive (i.e., positive) information is derived (e.g., [Cacioppo & Berntson, 1994](#) ; [Cacioppo, Gardner, & Berntson, 1997](#) ; [Gilbert, 1993](#) ; [Gray, 1994](#) ; [Lang, Bradley, & Cuthbert, 1990](#) ; [Marcus & Mackuen, 1993](#) ; [Marcus, Sullivan, Theiss-Morse, & Wood, 1995](#) ; [Watson, Wiese, Vaidya, & Tellegen, 1999](#) ; [Zautra, Potter, & Reich, 1997](#)). In an important and integrative article, [Lang et al. \(1990\)](#) summarized the behavioral evidence for distinguishing between approach and withdrawal reflexes or behaviors, with negatively valent behaviors organized in terms of an "aversive" or "defensive motivational system" and positively valent behaviors organized in terms of an "appetitive motivational system" ([Konorski, 1967](#) ; [Masterson & Crawford, 1982](#) ; [Miller, 1961](#) ; [Schneirla, 1959](#)). Lang and colleagues (e.g., [Lang et al., 1990](#) ; [Lang, Bradley, & Cuthbert, 1992](#)) have incorporated appetitive and aversive motivational systems into a theory of emotion:

It is proposed that two motive systems exist in the brain—appetitive and aversive—accounting for the primacy of the valence dimension. Arousal is not viewed as having a separate substrate, but rather, as reflecting variations in the activation (metabolic and neural) of either or both systems. ([Lang, 1995](#), p. 374)

Individuals approach, acquire, or ingest certain classes of stimuli and withdraw from, avoid, or reject others. Many behaviors that do not fall at these extremes can nevertheless be placed along an approach—withdrawal continuum. Because behavior is often constrained by the mutual exclusivity of the various options, Lang and colleagues posited that appetitive and aversive motivational systems were uniformly reciprocally activated. That is, emotions are viewed by [Lang et al. \(1990, 1992\)](#) as evolving from simple action tendencies that directly reflect activation of aversive or appetitive systems.³ The appetitive and aversive motivational systems are reducible to a single valence (good—bad) dimension in Lang's theory because these motivational systems were assumed explicitly to be reciprocally activated. Given that [Lang et al. \(1990, 1992\)](#) were focused on defensive reflexes, where reciprocal activation is the rule, Lang's formulation serves as a principal example of form following function. Startle reflex modulation does indeed seem to be organized in a bipolar structure, reflecting the net reciprocal activation at this level of the aversive and appetitive motivational systems ([Lang, 1995](#)).

When thinking about the human affect system as a whole, no single structure appears to apply; rather, the shape of the affective system appears to reflect the goal of the affective processing at any given level. According to our model of evaluative space ([Cacioppo & Berntson, 1994](#) ; [Cacioppo et al., 1997](#)), when the appetitive and aversive features of stimuli are being determined, these rapid, critical evaluations can occur at least in part in parallel, and the potential affective space can be depicted as being at least bivariate. The form of these early stages of information processing, which involves subcortical and cortical circuits (see *Neural Substrates*, below), is functionally adaptive in that it fosters the extraction and evaluation of hedonic inputs. The greater the appetitive inputs the greater the activation of positivity (appetitive motivational force), whereas the greater the aversive inputs the greater the activation of negativity (aversive motivational force).⁴ The world and life experiences are complex, so a given stimulus can have very different effects on different individuals (or the same individual in different circumstances), and a given stimulus can have similar or different effects on the activation of positivity and the activation of negativity. Stimuli that activate neither positivity nor negativity elicit indifference, whereas stimuli that strongly activate both positivity and negativity elicit intense ambivalence. A two-dimensional representation of the activation of positivity and negativity, therefore, may provide a more comprehensive formulation for depicting these operations. This two-dimensional space, which is depicted as the bottom plane in [Figure 1](#), is termed the *evaluative plane or space*.

Given that the affect system evolved to guide behavior, information processed by the affect system does not stop with its registration on the evaluative space. Instead, the antagonistic effects of the activation of positivity and negativity are integrated into a net affective predisposition or action, which can be represented as an overlying bipolar response surface (see [Figure 1](#)).⁵

Modes of Evaluative Activation

Our questioning of the assumption that the motivational systems (i.e., evaluative channels) are invariably reciprocally activated derives from the notion of evolutionary economy. Two evaluative channels (i.e., positivity and negativity, relating to the appetitive and aversive motivational systems, respectively) can be construed as having three activational states each: decreasing activation, no change in activation, and increasing activation. If the positive and negative evaluative channels are orchestrated such that they are always reciprocally activated, the dynamic range of the affect system as a whole is

enhanced, but the two evaluative channels still have only three activation states: increased positivity—decreased negativity, no change, and decreased positivity—increased negativity. Separable evaluative channels would not need to have evolved if their actions were always reciprocally organized, because a single evaluative channel ranging from positivity to negativity would have sufficed. Why, then, might appetitive and aversive motivational systems have evolved as orchestrated but distinguishable assemblages? If the mode of activation of these two evaluative channels varies, the combinations of evaluative input from these two channels expands from three to nine, with a consequent expansion of response properties (e.g., directional stability, dynamic range, and response lability; see [Cacioppo & Berntson, 1994](#), Table 1). This leads to the concept of multiple *modes of evaluative activation* underlying behavioral predispositions and actions: (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. ⁶

The bivariate evaluative space presented in [Figure 1](#) accommodates all possible combinations of positive and negative affective activation: The reciprocal mode of evaluative activation is represented as one diagonal vector that ranges from maximal positivity—minimal negativity to maximal negativity—minimal positivity, the nonreciprocal mode of evaluative activation is represented as the alternate diagonal that ranges from minimal positivity and negativity to maximal positivity and negativity, and the uncoupled modes of evaluative activation are represented as vectors lying along the axes. The family of vectors parallel to those above represents the general categories, or modes, of evaluative activation expressed from varying starting points within the two-dimensional plane depicted in evaluative space. As noted above, low activation of both positivity and negativity by a stimulus reflects neutrality or indifference, whereas high activation of positivity and negativity reflects ambivalence. Note that although indifference and ambivalence represent two very different affective substrates, their mapping onto the overlying surface yields similarly middling (e.g., neither approach nor avoidance) responses. Thus, knowledge of the position of a response on the overlying bipolar affective surface does not provide definitive information about underlying processes or mechanisms. This is one of the reasons that knowledge of an individual's net affective predisposition is not sufficient to understand fully the state of the affect system.

In reciprocal evaluative activation, changes in behavioral predispositions and behavior are fueled consistently by the changes in the positive and negative evaluative processes underlying these endpoints. For instance, an individual's preference for or behavior toward a stimulus would become more positive if the stimulus evokes positive evaluative processes and diminishes negative evaluative processes. Variations in the magnitude of their reciprocal activation, although affecting the magnitude of the change in preference, would not be expected to alter the basic direction of the change. Of course, positive and negative evaluative processes could be reciprocally activated with the negativity evoked by a stimulus increasing and the positivity evoked by the stimulus decreasing rather than vice versa. In contrast, nonreciprocal modes (coactivation or coinhibition) have an inherently variable or unstable effect on the *direction* of behavioral predispositions or behavior while the range of response is constrained. In coactivation, for instance, both positive and negative evaluative processing are increasing; however, changes in the activation of positivity and negativity have functionally opposite effects on the consequent predisposition or approach—withdrawal behavior. Minor variations in the magnitude of the relative activation of positivity or negativity, therefore, can lead to a more positive predisposition, a more negative predisposition, or no manifest change in predisposition toward the stimulus, depending on which evaluative substrate dominates. The directional instability of ambivalent attitudes, for instance, has been noted (e.g., [Katz, Wackenhut, & Hass, 1986](#)) and is explicable as a formal property of the coactivation of opposing evaluative activation functions.

Note, too, that this conceptualization of the affect system does not reject the bipolar conceptualization

but rather subsumes it in two ways: (a) as the reciprocal diagonal and the family of vectors parallel to this diagonal within the evaluative space and (b) as the net response predisposition represented by the overlying surface (see [Figure 1](#)). One of the unique implications of this framework is that the question should be not whether positive and negative affective processes are reciprocally activated but rather under what conditions are they reciprocally, nonreciprocally, or independently activated.

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 \(in press\)](#) reviewed evidence that food restriction alters neurochemical effects underlying approach behavior in an uncoupled fashion, whereas morphine has reciprocal effects on neurochemical processes underlying approach and withdrawal behavior. The separable activation of positivity and negativity at the verbal level is evident in a study by [Goldstein and Strube \(1994\)](#) in which self-reported positive and negative affect were collected from students at the beginning and end of three consecutive class periods. Although a bipolar model would predict reciprocal activation of positive and negative affect, as evidenced by negative within-subject correlations between the intensity of positive and negative reactions on a particular day, the reactions were in fact uncorrelated. Moreover, exam feedback activated positivity and negativity differently. Students who scored above the mean on the exam showed an increase in positive affect relative to their beginning-of-class level, whereas their level of negative affect remained unchanged within the class period. Similarly, students who scored below the mean on the exam showed an increase in negative affect but no change in positive affect within the class period. Distinctions between positive and negative affective processes have also been observed in uplifts and hassles ([Gannon, Vaux, Rhodes, & Luchetta, 1992](#); [Zautra, Reich, & Gurnaccia, 1990](#)), mood states ([Lawton, Kleban, Dean, Rajagopal, & Parmelee, 1992](#); [Watson & Tellegen, 1985](#); [Zautra, Potter, & Reich, 1997](#)), organization of self-knowledge (e.g., [Showers, 1995](#); [Showers & Kling, 1996](#)), self-regulatory focus (e.g., [Higgins, 1997](#)), self-efficacy ([Zautra, Hoffman, & Reich, 1997](#)), personality processes ([Depue, 1996](#); [Diener & Lucas, in press](#); [Robinson-Whelen, Kim, MacCallum, & Kiecolt-Glaser, 1997](#); [Rusting & Larsen, 1998](#); [Watson, Clark, McIntyre, & Hamaker, 1992](#)), achievement motivations ([Elliot & Church, 1997](#); [Elliot & Harackiewicz, 1996](#)), organ donations ([Cacioppo & Gardner, 1993](#)), emotional expressivity ([Gross & John, 1997](#)), interpersonal relationships ([Berry & Hansen, 1996](#); [Cacioppo et al., 1997](#)), affect toward political leaders ([Marcus & Mackuen, 1993](#)), and intergroup discrimination ([Blanz, Mummendey, & Otten, 1997](#); [Brewer, 1996](#); [Mummendey, 1994](#)).

[Watson and Clark \(1991, 1992; Watson & Tellegen, 1985\)](#) proposed that positive and negative affect were separate dimensions and that negative affect can be represented at two distinct structural levels.⁷ At the higher level of abstraction, a general negative factor accounts for shared variance across the negative affects, whereas at the lower level of abstraction the negative affects (e.g., fear, hostility, sadness, and guilt) are distinct and exhibit unique variance. Much of the research on Watson and Clark's proposed two-factor structure of affective space has centered on methodological or statistical issues. [D. P. Green, Goldman, and Salovey \(1993; D. P. Green & Citrin, 1994\)](#), for instance, questioned the notion that positive and negative affect were separable on methodological grounds (see also [Bagozzi, 1993; Marsh, 1996; Suh, Diener, & Fujita, 1996; Watson & Clark, 1997](#)). Specifically, they argued that measures of affect typically rely on similarly worded scales with identical endpoints. This feature, they argued, leads to a similarity in responses to the positive and negative scale items (i.e., positively correlated measurement error), which would suppress the magnitude of the true negative correlation between positive and negative affective states. In an interesting analysis of data on the public perceptions of Hispanics, [D. P. Green and Citrin \(1994\)](#) demonstrated that nonrandom measurement error in survey questions (e.g., error attributable to the common format and response options) can diminish the correlation between positively and negatively valenced statements.⁸

A recent investigation by [Nelson \(in press\)](#) addressed the methodological concerns of D. P. Green and

colleagues and found evidence for the operation of multiple modes of evaluative activation. Nelson 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 non-poor students' 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 one would expect if positive and negative affect were separate dimensions at the most abstract level, as posited by [Watson and Clark \(1991, 1992\)](#). Nelson's analyses of the structure of the 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 as a subjective state or response disposition does not invariably manifest in a bipolar or a bivariate structure but rather its manifest structure is influenced by the mode of evaluative activation elicited by the stimulus ([Cacioppo & Berntson, 1994](#)). That is, conceptualizations of positivity and negativity as the opposite endpoints of a single bipolar evaluative channel do not provide a comprehensive account.

Although [Nelson's \(in press\)](#) demonstration is notable for its theoretical import, we are not suggesting that the nonreciprocal modes of evaluative activation are common. To the contrary, the clearest guides to behavior are provided when a stimulus elicits reciprocal activation ([Cacioppo et al., 1997](#)). The most salient structural feature of predispositions to respond that are stored in memory—for instance, for simple and familiar stimuli toward which one has acted previously (e.g., [Brehm, 1956](#))—is therefore likely to be bipolarity. Consider the International Affective Picture System ([IAPS; Lang, Bradley, & Cuthbert, 1995](#)), a set of several hundred photographs that have been scaled in terms of their valence, arousal, and dominance. Included among these pictures are items people are likely to encounter in everyday life, such as cute dogs, delectable foods, dirty dishes, and scenes with trash. We recently scaled these pictures using unipolar positivity, negativity, and ambivalence ratings and bipolar valence, dominance, and arousal ratings ([Ito, Cacioppo, & Lang, 1998](#)). The vast majority of these pictures were characterized by reciprocal activation, and the set as a whole elicited reciprocal activation. Moreover, when participant rather than picture was used as the unit of analysis, individuals generally showed reciprocal activation.⁹ This is to be expected ([Cacioppo et al., 1997](#); see also [D. P. Green et al., 1999](#); [Russell & Carroll, 1999](#)). The best tests of theories are crucial tests, however. If reciprocal activation were the only mode of evaluative activation, then one should never find evidence of nonreciprocal or uncoupled activation. This is why studies ranging from [Brehm \(1956\)](#) to [Nelson \(in press\)](#), why the emergence of any stimulus in the IAPS that appeared to elicit nonreciprocal activation ([Ito, Cacioppo, & Lang, 1998](#)), and why affective states such as bittersweetness and ambivalence, are so informative.

In sum, if the activation of positive and negative evaluative processes were inevitably reciprocally coupled, then detailing separable positive and negative evaluative channels would not enhance prediction of the resulting affective responses. However, theory and research from areas ranging from the conceptual organization of emotion through sociopolitical issues to unconditioned responses indicate that positive and negative evaluative processes have some nonoverlapping operating components (e.g., functional independence), are opposing in their effects on attitudes or behavior, and are capable of being differentially activated. There is evidence that reciprocal modes of evaluative activation are more likely to manifest postdecisionally (see [Cacioppo et al., 1997](#)), at high levels of emotional (particularly negative) intensity ([Zautra, Potter, & Reich, 1997](#)), and as one moves down the level of the neuraxis ([Berntson et al., 1993](#); [Ito & Cacioppo, in press](#)), but additional research is needed on the factors governing the mode of evaluative activation. Even though these questions remain, the concept of modes of evaluative activation appears to be useful in thinking about the operation and structure of the affect system.

Neural Substrates

The extant neurophysiological data cannot resolve the nature and structure of the affect system. Research on the neural substrates of emotion, however, can contribute to social psychological theory and research by inspiring new concepts and relationships, providing supportive or nonsupportive evidence on predicted structural relations, and adding realistic constraints to theoretical conjectures ([Cacioppo & Berntson, 1992](#)). All thoughts, motives, affects, and actions are organized and orchestrated by the central nervous system (CNS). Although the complexity of the CNS may at times seem bewildering, central neural substrates evidence general principles of organization that are common features across distinct systems and mechanism. These principles offer a framework for understanding not only spinal reflexes and somatic motor actions but also psychological and behavioral processes. As mentioned above, one general principle of neural organization is the reciprocal innervation of opponent effector systems ([Sherrington, 1906](#)). This is based on the spinal organization of reflex controls of antagonistic flexor and extensor muscles, by which activation of one effector system was accompanied by inhibition of the other, opposing system. The neural circuitry underlying spinal somatomotor control now is fairly well clarified, including the specific motoneuron pools and the interneuronal pathways underlying the reciprocal innervation. Although derived from the study of spinal reflexes, the principle of reciprocal innervation is recognized to be a far more pervasive feature of central neural systems ([Sherrington, 1906](#) ; for a synopsis, see [Berntson et al., 1993](#)).

The functional organization of the somatomotor system may be instructive in considering the central substrates of affective systems and approach—avoidance reactions in general. Flexors (e.g., biceps) and extensors (e.g., triceps) have directly opposing actions, and the joint outcome of these actions can yield varying degrees of either flexion or extension of the forearm, but not both. That is, the output of this opponent system is bipolar, varying along a continuum from extreme flexion to extreme extension, as constrained by the musculoskeletal structure of the arm. In the organization of simple reflexes, such as the flexor (pain) withdrawal reflex, reciprocal innervation of the flexor and extensor motoneurons can be highly adaptive. The pain stimulus that triggers flexor contraction synergistically inhibits extensor activity and promotes flexor withdrawal.

Despite the pattern of reciprocal innervation of antagonistic motor neuron pools at the reflex level, the neural organization of flexor—extensor control cannot be viewed along a simple bipolar continuum. Rostral motor systems exert potent descending control not only over reciprocally organized spinal reflex circuits but also directly on lower motor neurons. Moreover, rostral motor systems controlling extensors and flexors have separate cortical representations (see classic work by [Asanuma, 1975](#)). Rostral systems are able to inhibit or override reciprocal spinal organizations and can coactivate both extensor and flexor lower motoneuron pools. This is important in postural support reactions, balance, and dynamic motor adjustments. It also provides the neurological substrate for volitional increases in tension in both biceps and triceps muscles (e.g., in stiffening the arm) and for the ability to inhibit basic flexor withdrawal reflexes (e.g., in suppression of pain withdrawal in the cold pressor test). These phenomena document central bivariate control of flexors and extensors despite the fact that this bivariate central control is physically constrained into bipolar manifestations.

Although the pattern of reciprocal inhibition does tend to promote a bipolar output, the fundamental bipolar nature of forearm flexion and extension arises from the physical constraints of the musculoskeletal system, not from central motor substrates. This poses an important caveat for conceptualizations of central affective networks. Although there may be interactions among positive and negative affective systems, the fact that conceptual organizations of emotion and behavioral outputs tend toward a bipolar structure does not imply that central mechanisms adhere to the same structure. Indeed, emerging data on central substrates for positive and negative affect suggest the existence of at least partially distinct neural mechanisms.

Early work on the neural systems mediating reward and aversion revealed that reinforcing and punishing

effects could be induced by stimulation of differentiated brain areas ([Delgado, Roberts, & Miller, 1958](#) ; [Olds & Milner, 1954](#)). This work spearheaded efforts to elucidate the neural and neurochemical substrates of hedonic processes. Recent studies have focused on the role of the mesolimbic dopamine pathway in reward ([Wise, 1996](#)) and on the amygdala as a substrate for aversion ([Davis, 1992b](#) ; [LeDoux, 1992](#)).

The mesolimbic dopamine pathway originates in the ventral tegmental area of the midbrain and projects to the nucleus accumbens. Activation of this system has been shown to function as a reward, and animals will perform an arbitrary operant in order to self-administer stimulation of this pathway ([Wise, 1996](#)). Like natural rewards, this stimulation triggers release of dopamine in the nucleus accumbens, which appears to contribute importantly to reward ([Hoebel, Hernandez, Mark, & Pothos, 1992](#)). Similarly, administration of addictive drugs, such as cocaine, induces dopamine release in the nucleus accumbens, and blockade of dopamine receptors in this area has been reported to attenuate the rewarding effects of addictive drugs as well as natural rewards (Hoebel et al., 1991; [Wise, 1996](#)). Moreover, animals will self-administer dopamine receptor agonists into the nucleus accumbens, as well as drugs that release endogenous dopamine. These and other findings have led to the view that the mesolimbic dopamine pathway is a crucial central substrate for reward. Although invasive studies are obviously precluded in humans, indirect findings are in accord with this view. Drugs that potentiate dopamine activity, such as amphetamine and cocaine, can be highly euphoric and can enhance natural rewards, whereas agents that block dopamine action have been reported to attenuate reward ([Wise, 1996](#)).

In contrast, the amygdala has been implicated in negative affect ([Adolphs, Tranel, Damasio, & Damasio, 1995](#) ; [Davis, 1992a, 1992b](#) ; [LeDoux, 1992](#)). Aversive reactions and punishment effects can be evoked by stimulation of the amygdala ([Halgren, 1982](#)). Although somewhat similar results can be obtained by stimulation of central pain transmission pathways, the effects of amygdalar stimulation do not appear to reflect pain per se. The amygdala is not part of the primary pain projection system, and lesions of this structure do not eliminate simple unconditioned responses to pain stimuli ([LeDoux, 1992](#)). Rather, lesions appear to selectively attenuate affective reactions to aversive stimuli, particularly responses to conditioned aversive stimuli ([Davis, 1992a](#) ; [Killcross, Robbins, & Everitt, 1997](#) ; [LeDoux, 1992](#)). Consistent with inferences derived from animal research, brain imaging studies in humans have revealed activation of the amygdala in response to negative affective stimuli ([Irwin et al., 1996](#)) and during aversive conditioning ([Diedrich et al., 1997](#)). Moreover, fear and other negative emotions in humans have been reported frequently with amygdaloid stimulation or abnormal epileptic activity ([Cendes et al., 1994](#) ; [Halgren, 1982](#)). The difference is not absolute, however, as specific amygdalar circuits may also play some role in positive affect.

The focus on the amygdala and nucleus accumbens does not adequately reflect the complexity and multiplicity of central evaluative substrates. ¹⁰The nucleus accumbens and the amygdala represent critical nodal points in affective mechanisms, but reward and aversion can be evoked by stimulation of widely distributed, but differentiated, central systems. These systems defined by stimulation and lesion methods closely correspond to relevant substrates identified during naturally induced affective states by metabolic or gene markers that reflect neural activation ([Gomita, Moriyama, Ichimaru, & Araki, 1988](#) ; [Sandner et al., 1993](#) ; [Yeomans, 1990](#)). Despite partial overlap and interaction among these systems, positive and negative affective reactions appear to be associated with separable neural circuits. Even in overlapping areas that can yield both self-stimulation and escape behavior, the rewarding and aversive consequences of stimulation appear to be mediated by distinct neural populations ([Anderson, Diotte, & Miliaressis, 1995](#) ; [Bielajew & Shizgal, 1980](#)), indicating a simple algebraic summation of independent contributions ([Anderson et al., 1995](#)).

Dissociation between stimulation-induced approach and escape reactions have also been reported with drug administration. Morphine, for example, has been shown to elevate stimulation thresholds for escape behavior without altering self-stimulation ([Carr, Bonnet, & Simon, 1982](#) ; [Ichitani & Iwasaki, 1986](#)). Similarly, the benzodiazepine receptor agonist diazepam was found to reduce the punishing effects of foot shock on operant performance, again without altering self-stimulation ([Gomita & Ueki, 1981](#)). Moreover, the rewarding effects of opiates are disrupted by lesions of the nucleus accumbens, whereas the aversive effects of cocaine withdrawal are unaltered; in contrast, lesions of the amygdala attenuate the aversive effects of withdrawal without attenuating the rewarding effects of opiate administration ([Kelsey & Arnold, 1994](#)). These findings reveal that central mechanisms for reward and aversion can be independently manipulated, again indicating a fundamental dissociability of brain systems subserving positive and negative affect.

Although we have considered some findings on the amygdala and nucleus accumbens, this discussion is not about particular brain structures but about the fundamental separability of positive and negative substrates. Central systems for positive and negative affect are vast and complex ([Berridge, 1996](#)). Studies on both decerebrate humans and animals reveal basic, stereotyped orofacial intake-rejection reflexes to positive and aversive tastes (for a review see [Berridge, 1996](#) ; [Berridge & Pecina, 1995](#)). Higher systems, such as the amygdala and nucleus accumbens, appear to play a more important role in appetitive aspects of food intake and in acquired taste aversions ([Berridge, 1996](#) ; [Roldan & Bures, 1994](#) ; [Schafe & Bernstein, 1996](#)). Even at the most basic level of organization, however, intake-rejection reflexes are not organized reciprocally. Experimental manipulations at the level of the brain stem can selectively potentiate intake responses without altering aversive-rejection responses ([Berridge & Pecina, 1995](#)). Moreover, these basic reflexes are sensitive to distinct taste qualities. Intake responses are selectively potentiated with sucrose, whereas rejection responses are preferentially enhanced with quinine. When a combined solution of sucrose and quinine is presented, one does not see an attenuation of both intake and rejection in rats. Quite the contrary: Both reflexes are potentiated, and one sees an alternation of vigorous, opposing orofacial patterns ([Berridge & Grill, 1984](#)). Rostral neural systems likely add considerable flexibility in food intake patterns, and multiple substrates may be involved in distinct aspects of food intake. Despite the fact that differential patterns of neural activity may underlie different aspects of food intake—or different affective states, for that matter—there remains a basic commonality in the approach—avoidance systems. A neutral stimulus (conditioned stimulus [CS], e.g., Pavlov's bell) paired with an unconditioned stimulus (US, e.g., food powder) can yield a new association such that the CS comes to evoke conditioned responses (CRs) such as approach, salivation, and so on, similar to those of the US (i.e., unconditioned responses [URs]). In this case of food, the basic US—UR relation appears to be intrinsically organized at brain stem levels, whereas the CS—CR link requires higher neural mechanisms. Nevertheless, they operate on a common appetitive substrate, as evidenced by the fact that degrading the US—UR relation (e.g., by adding a foul taste to the food) results in an associated degradation of a previously established CS—CR link (see [MacIntosh, 1983](#)).

Although they are separable, central systems for positive and negative affect do appear to interact naturally, in accord with the principle of reciprocal innervation. Noncontingent stimulation of "reward" sites in the hypothalamus, for example, appears to generally facilitate approach behaviors while suppressing escape or withdrawal responses. Conversely, stimulation of "aversive" systems is associated with an enhancement of escape reactions generally and inhibition of approach responses ([Stellar, Brooks, & Mills, 1979](#)). Moreover, as is the case for extensor and flexor activity, behavioral constraints may further bias toward bipolar manifestations of affective processes. By the use of experimental paradigms that permit concurrent expression of positive and negative affective processes, the studies outlined above reveal that central affective systems can be independently manipulated. Although overt affective expression may tend toward bipolarity, a bivariate model of central affective processes is necessary to accommodate these results.

Distinctions Between the Currency Functions for Positivity and Negativity

The effects of the activation of positivity and negativity are not mirror opposites. Active forms of coping, such as problem solving, influence positive affective states more than negative affective states in chronic pain patients ([Zautra, Burleson, et al., 1995](#) ; [Zautra, Reich, & Newsom, 1995](#)). Classroom performance motivated by the desire for mastery or for social approval (approach motivations), in contrast to a fear of failure (avoidance motivation), is associated with better grades and more durable intrinsic motivation ([Elliot & Church, 1997](#)). In research on social interactions, positive and negative affectivity have each been related to the number of social interactions in which individuals engage and the amount of time spent engaged in social contact, but positive (and not negative) affectivity has predicted the pleasantness of the social interactions, whereas negative affectivity has predicted the frequency of relatively superficial dyadic same-sex interactions ([Berry & Hansen, 1996](#)). On the basis of research suggesting that positive and negative interracial attitudes and behaviors were related to different factors, [Schofield \(1991\)](#) reasoned that practices designed to increase positive interaction among Black and White students may not substantially decrease negative interaction. Schofield's hypothesis is provocative because it suggests that theory and research on promoting positive interracial affect and behaviors may not have the intended reciprocal effect on negative interracial affect and behaviors. Similarly, investigators have been perplexed by why so few people who feel positively about donor behaviors are themselves donors ([Sarason, Sarason, Pierce, Shearin, & Sayers, 1991](#) ; [Sarason et al., 1993](#)). Part of the answer may lie in the findings that the positive and negative evaluative processes underlying donor attitudes and behaviors are separable and that the negative substrate represents a powerful impediment ([Parisi & Katz, 1986](#) ; see [Cacioppo & Gardner, 1993](#) ; [Gardner & Cacioppo, 1995](#)).

Evolution can genetically endow only limited fixed adaptive responses relative to the potential range of circumstances an organism could encounter. Therefore, there is an evolutionary pressure to maximize flexibility. The partial segregation of the positive and negative evaluative channels in the affect system confers the additional flexibility of orchestrating appetitive and aversive motivational forces via modes of evaluative activation, which in turn affords greater flexibility for learned dispositions. It also affords evolution the opportunity to sculpt distinctive activation (i.e., currency) functions for positivity and negativity. Interest in differences in the impact of positive versus negative information has grown substantially in recent years. Numerous articles and several major reviews on the topic have appeared (e.g., [Cacioppo & Berntson, 1994](#) ; [Levy, 1992](#) ; [Peeters & Czapinski, 1990](#) ; [Skowronski & Carlston, 1989](#) ; [Taylor, 1991](#)), and the two final issues of the *European Journal of Social Psychology* in 1990 were devoted to the topic. Of particular interest here is the research on affective asymmetries (e.g., appetitive vs. aversive stimuli) rather than cognitive asymmetries (e.g., presence vs. absence of a feature) in positive and negative information processing ([McGuire & McGuire, 1996](#)). 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 for positivity.

Positivity offset.

The *positivity offset* is the tendency for there to be a weak positive (approach) motivational output at zero input. In other words, the level of positive output is higher at the intercept than is the level of negative output. As a consequence of the positivity offset, the motivation to approach is stronger than the motivation to avoid at very low levels of evaluative activation. 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. The neophobic response to foreign stimuli that characterizes most species permits an initial period of observation. With no negative outcomes, this exposure allows the initial neophobic response to habituate, thereby allowing

exploratory behavior to manifest. In the absence of such a motivation to explore, organisms would learn little about novel or neutral-appearing environments and their potential reward value. With a positivity offset, however, an organism facing neutral or unfamiliar stimuli would be weakly motivated to approach and, with the quick habituation of the initial fear response, to engage in exploratory behavior. Such a pairing of initial neophobic and subsequent exploratory tendencies may have important survival value, at least at the level of a species. A positivity offset also fosters social cohesion even in the absence of other information about conspecifics.

If this reasoning is correct, one might expect such a tendency to manifest itself in the human cognitive system in several ways. First, individuals may exhibit relatively positive rather than neutral expectations for unknown future events. Several recent studies have found this to be the case. [Pulford and Colman \(1996\)](#) found that people overestimated the likelihood that they would experience positive and negative outcomes in the coming week, with this overestimation being greater for positive than for negative outcomes. [Hoorens and Buunk \(1993\)](#) found that people attributed lower health risks to themselves than to others. [Brinthaupt, Moreland, and Levine \(1991\)](#) found that students interested in joining campus groups expected membership to lead to more rewards and fewer costs for them than others (for whom expected rewards and costs were more equally distributed). Diener and colleagues have reported extensive evidence demonstrating that the normative human experience seems to involve a state of mildly positive affect (e.g., [Diener & Diener, 1996](#)). Finally, [Regan, Snyder, and Kassin \(1995\)](#) reported two experiments in which individuals held more positive expectations about their own futures than those of an aggregate of same-sex peers or other individual social objects. As Regan et al. noted: "Indeed, most of us remain firmly encased in the solipsistic belief that negative life events or outcomes are less likely to happen to us than to others and that positive events are more likely to happen to us than to others" (p. 1073).

In addition to imparting an optimistic glow to future expectations, the positivity offset should also sway attitude and impression *formation*. Indeed, a robust "positivity bias" in impression formation is evident in the literature ([Adams-Weber, 1979](#) ; [Benjafield, 1985](#) ; [Kaplan, 1973](#) ; [Klar & Giladi, 1997](#) ; [Sears, 1983](#)). [Boucher and Osgood \(1969\)](#) first documented the tendency to form positive impressions of unknown others, christening it the *Pollyanna bias*; they asserted that this bias reflected unrealistically optimistic assumptions about human nature. This tendency toward generosity in our evaluations of others has been attributed variously to impression management on the part of the research participant ([Bruner & Tagiuri, 1954](#)), the manifestation of the "golden section" ratio in the use of positive versus negative descriptors ([Benjafield, 1985](#)), the attributional implications of the behaviors used (e.g., neutral descriptors implying a lack of negative features; [Jones & Davis, 1965](#)), and the "bonus" attraction that results from an individual's fundamental similarity with any conspecific ([Byrne, 1971](#) ; [Sears, 1983](#)). Although all of these processes have been shown to affect the magnitude of the positivity bias, none of them has been shown to erase it completely. [Gardner \(1996\)](#) hypothesized that the robust "positivity bias" in impression formation reflected the more general positivity offset in the evaluative system. In four studies, Gardner found evidence of a positivity offset in impression formation that was not limited by the social desirability concerns of the participants, by the type of neutral behaviors used, or by the similarity between target and participant. Indeed, the positivity offset was observed not only in impressions of human targets but also with impressions of novel fish and insects. The positivity offset demonstrated in this work, then, could not have been a result of the neutral behaviors implying the absence of negative attributes. Neither could it have merely reflected the process of similarity leading to attraction, as [Sears's \(1983\)](#) "person positivity bonus" would have predicted. Instead, the positivity offset appeared to be a more general operating characteristic of the affect system. We turn next to what we believe to be another general operating characteristic of the affect system: the negativity bias.

Negativity bias.

Human taste buds respond to sweet, salty, sour, and bitter stimuli. Most can detect sweetness in approximately 1 part in 200, saltiness in 1 part in 400, sourness in 1 in 130,000, and bitterness in 1 in 2,000,000. From the perspective of the affect system, a given amount of a negative or threat-related gustatory stimulus (e.g., most poisons taste bitter) activates a stronger affective response than the same amount of a positive (e.g., sweet) gustatory stimulus. This may be more than an epicurean curiosity; it may represent differences in the currency functions for positive and negative affects that is so pervasive it has been termed the *negativity bias* (see reviews by [Cacioppo & Berntson, 1994](#) ; [Cacioppo et al., 1997](#) ; [Peeters & Czapinski, 1990](#) ; [Skowronski & Carlston, 1989](#) ; [Taylor, 1991](#)). Among the earliest evidence for a negativity bias is [Miller's \(1959\)](#) study, in which he determined that the slope for the avoidance gradient in his rodent research on conflict behavior was steeper than the slope for the approach gradient. [Skowronski and Carlston \(1989\)](#) reviewed research on impression formation and found support for a negativity bias in impression formation, and [Cacioppo and Gardner \(1993\)](#) found evidence for the negativity bias in their review of research on attitudes toward blood and organ donations. Recent work has also found evidence of a negativity bias in individuals of various ages and in nonlaboratory settings (e.g., [Aloise, 1993](#) ; [Robinson-Whelen et al., 1997](#)). [Aloise \(1993\)](#) , for instance, asked children in grades 3—5 and college students how many behaviors they require before attributing positive or negative traits to other people. Regardless of age, individuals tended to require fewer behaviors to infer negative than positive traits. [Walden \(1993\)](#) examined reactions of children (ages 27—95 months) to an ambiguous stimulus that had not been described or had been described as fearful, neutral, or positive. Negative expectations had a stronger impact on the children's behavior than positive expectations, and this effect was magnified in younger children. The negativity bias can also be seen in the assessments of utility by accounting for what has been called *loss aversion* ([Kahneman & Tversky, 1984](#)). Observing that losses loom larger than gains, [Kahneman and Tversky \(1984\)](#) argued that the value function relating negative events to subjective value has a steeper slope than the one relating positive events to subjective value.

[Klein \(1991\)](#) observed a negativity bias in the political domain as well. More than 3,000 respondents rated presidential candidates on several personality traits in national election surveys from 1984 to 1988. Results revealed that negative personality characteristics were more predictive of overall evaluations and voting behavior than were positive traits. These results were replicated by [Klein \(1996\)](#) in a study of the voters' impressions of Bill Clinton and George Bush in the 1992 presidential election. [Taylor \(1991\)](#) 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 (see also [Cacioppo, Berntson, Larsen, & Poehlmann, in press](#) ; [Westermann, Spies, Stahl, & Hesse, 1996](#)).

Several factors have been identified as accounting for the fact that negative information receives more weight than positive information does. A dominant explanation in the impression formation literature rests on the differential diagnosticity of negative versus positive behaviors ([Reeder & Brewer, 1979](#) ; [Skowronski & Carlston, 1989](#)). In short, this theory argues that impressions depend on the diagnosticity of a given behavior in exemplifying a trait category (e.g., honest, athletic). The diagnosticity of a behavior is determined by both the valence of the behavior and the applicability of the behavior to either a morality or an ability domain. In morality-relevant domains, when people are judging others for their honesty or kindness, negative behaviors provide a higher level of diagnosticity, because moral individuals are necessarily constrained from exhibiting immoral acts (e.g., an honest person never cheats), but immoral individuals are free to display either moral or immoral behavior. Ability-relevant domains, in which judgments concern athleticism or intelligence, are restricted in the reverse fashion. Individuals high in ability can exhibit behavior either high or low in ability (e.g., even Tiger Woods may have a bad game now and then), but low-ability individuals cannot exhibit high-ability behaviors; positive behaviors should thus be weighted more heavily in ability-relevant impressions.

To the extent that much of the impression literature has investigated morality-relevant domains, it is

difficult to unravel whether evidence of a negativity bias results from an operating feature of the affective system or reflects attributional analyses of behavioral diagnosticity. However, [Gardner \(1996\)](#) found evidence of a negativity bias even when only ability-relevant behaviors were presented in an impression task. Furthermore, [Ganzach \(1995\)](#) found that greater weight was given to negative attributes than to positive attributes in an analysis of three real-world data sets of performance evaluation, and [Rowe \(1989\)](#) observed conceptually similar results in employment decisions. Given that performance and employment decisions represent judgments of ability, it appears that explanations of the negativity bias that rest on diagnosticity calculations alone cannot fully account for the empirical evidence.

Furthermore, evidence for the negativity bias (as well as for the positivity offset) has been found in paradigms in which diagnosticity and morality—competence are irrelevant. [Miller's \(1959\)](#) studies of learning in rats is a case in point. In humans, [Ito, Cacioppo, and Lang \(1998\)](#) measured the positive and negative feelings evoked by 472 slides selected to represent the full affective space captured by the IAPS ([Lang et al., 1995](#)). Arousal ratings were used to index the intensity of the affective stimulus (they were plotted on the abscissa), and the unipolar positivity and unipolar negativity ratings were used to index the magnitude of the affective response (they were plotted on the ordinate). Analyses revealed that the intercept was significantly higher for ratings of positive than for negative stimuli (i.e., a positivity offset). Results also revealed that the slope of the regression line for the ratings of the negative stimuli was significantly steeper than that of the regression line for the ratings of the positive stimuli (i.e., the negativity bias). That is, positive stimuli have a greater effect on affect than negative stimuli do at comparably low levels of activation, but the opposite is the case at comparably high levels of activation. A conceptually similar pattern of results was reported by [Wojciszke, Brycz, and Borkenau \(1993\)](#), who investigated reactions to moderately or extremely positive and negative behaviors of fictitious targets.

Evidence for the negativity bias has also been found in studies of electrocortical potentials, as well. We have developed a paradigm using ERPs to investigate evaluative processes independent of behavioral responses ([Cacioppo et al., 1996](#); [Crites & Cacioppo, 1996](#)). In an illustrative study, [Cacioppo et al. \(1996\)](#) recorded ERPs as participants were exposed to series of positive, neutral, and negative stimuli (e.g., trait words). To maximize the likelihood that participants were categorizing the stimuli along evaluative dimensions, the stimuli were presented within sequences of six, and participants were asked to count silently the number of positive (or negative, counterbalanced) stimuli that appeared in each sequence. The majority of the stimuli within each sequence were drawn from a single evaluative category (e.g., all positive or all negative). In some sequences, for instance, all six stimuli were drawn from this same evaluative category, but in others one of the six stimuli was drawn from the other evaluative category (e.g., a positive food embedded within a sequence of negative foods). This made it possible to record the ERPs associated with the appraisal of evaluatively consistent and evaluatively inconsistent target stimuli. Cacioppo et al. found a larger amplitude LPP (a P300-like component) with a mean latency of approximately 650 ms to evaluatively inconsistent stimuli (e.g., a negative stimulus embedded in a sequence of positive stimuli) than to evaluatively consistent stimuli (e.g., a positive stimulus embedded in a sequence of positive stimuli). This LPP enhancement was found regardless of whether the evaluatively inconsistent stimulus was positive or negative. Subsequent studies demonstrated that the LPP amplitudes associated with evaluative processes are maximal over central—parietal regions, vary as a function of the degree of evaluative inconsistency (e.g., LPP amplitudes are larger to extremely negative stimuli than to moderately negative stimuli embedded in a sequence of positive stimuli), and vary more as a function of evaluative categorizations than response selection or execution ([Cacioppo, Crites, Gardner, & Berntson, 1994](#); [Crites, Cacioppo, Gardner, & Berntson, 1995](#)).

In Study 1, [Crites et al. \(1995\)](#) presented positive, neutral, and negative stimuli in series of predominantly positive stimuli, whereas in Study 2 they presented positive, neutral, and negative stimuli

in series of predominantly negative stimuli. A re-examination of data from Crites et al. revealed larger LPP amplitudes to negative stimuli embedded in a series of positive stimuli ($M = 8.93 \mu\text{V}$) as compared to positive stimuli embedded in a series of negative stimuli ($M = 6.70 \mu\text{V}$). [Ito, Larsen, Smith, and Cacioppo \(1998\)](#) explicitly tested whether the negativity bias operates at the evaluative categorization stage in two experiments using ERPs. The LPP, which is differentially sensitive to the evaluative categorization but not the response output stage ([Cacioppo et al., 1994](#); [Crites et al., 1995](#); [Gardner & Cacioppo, in press](#)), was recorded to positive, negative, and neutral pictures embedded within sequences of other neutral pictures. Results confirmed that (a) the evaluative categorization of positive or negative stimuli in sequences of neutral stimuli was associated with larger amplitude late positive brain potentials over central—parietal regions and (b) the evaluative categorization of negative stimuli was associated with a larger amplitude LPP than was the evaluative categorization of equally probable, equally evaluatively extreme, and equally arousing positive stimuli. Because the degree of evaluative consistency and inconsistency was equivalent for positive and negative targets in these studies, the larger LPPs evoked by negative than positive stimuli is consistent with the notion that the currency function for negativity is steeper than the currency function for positivity.

In sum, exploratory behavior can provide useful information about an organism's environment, and the positivity offset fosters such behavior. 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 not pursued, the process of natural selection may have resulted in distinguishable motivational organizations for positivity and negativity with the propensity to react more strongly to proximate negative events than to positive or neutral events. 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. 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, whereas positive emotion serves as a cue to stay the course. These characterizations may also help account for evolutionary forces sculpting separable substrates and distinctive currency functions for positive and negative affect.

The focus of our model is more on the architecture and operating characteristics of the affect system than on the antecedent conditions for arousing positive or negative affect. Like the phenomenon of color perception, however, affect is not an invariant property of the stimulus but a product of neural transformations of the stimulus input within an array of contextual information. Work on the relativity of emotion, for instance, has demonstrated that cognitive factors and physiological states can influence the extent to which appetitive or defensive motivations are aroused (see [Cacioppo & Gardner, 1999](#)). [Brendl and Higgins \(1995\)](#), for example, provided evidence that an incentive is greater when it is compatible with a person's self-regulatory focus and goal (see also [Shah, Higgins, & Friedman, 1998](#)). These models complement the present by identifying factors that influence the degree to which appetitive or defensive motivations are aroused.

Conclusion

When asked to define poetry, A. E. Houseman said "I could no more define poetry than a terrier can a rat, but I thought we both recognized the object by the symptoms which it provokes in us" ([Ackerman, 1990](#), p. 295). The same might be said about affect. It is understandable, therefore, why the structure of affect has tended to be defined in terms of the symptoms it provokes (i.e., the words used to describe these feelings; [D. P. Green et al., 1999](#); [Russell & Feldman Barrett, 1999](#); [Watson et al., 1999](#)). We have also suggested that this approach, although important, may paint an incomplete picture of the affect system. As research on automatic emotional processing has so nicely shown, it is important to go beyond the traditional boundaries of conscious mental states in theories of the affect system.

The prior literature on the structure of affect and moods has tended both to focus on people's verbal reports of feeling states and to cast the question as whether positive and negative feelings are organized in a bipolar or bivariate structure (e.g., [Russell & Carroll, 1999](#)). We do not believe this approach to be productive any longer, and we have suggested several revisions.

First, we have suggested that the structure of verbally expressed moods and feelings is important to understand as a psychological phenomenon but that we should not confuse this with the task of understanding the form and function of the underlying affect system. What are needed are psychological models of the affect system that do not merely speculate about mediating psychological processes but that instead specify them in detailed, empirically meaningful ways. Additionally, these models and specifications would not rely solely on self-report evidence of psychological processes but would be based also on more rigorous experimental techniques—including approaches from the cognitive sciences and the neurosciences—for uncovering mediating mechanisms.

Second, and relatedly, the stimuli and scales that are used in studies can bias the results that are obtained. [R. F. Green and Goldfried \(1965\)](#) long ago noted that when affect is defined as consciously accessible elemental feelings of pleasure and activation, and the experimental stimuli and scales are selected to differ in terms of valence and arousal, it is not surprising to find evidence that affect is organized in terms of valence and arousal. [Watson et al. \(1999\)](#) noted that high negative affectivity is marked by more terms (*distressed, fearful, hostile, jittery, nervous, and scornful*) than low negative affect (*calm, at rest, placid, and relaxed*). Terms such as *quiet, hushed, reposed, peaceful, tranquil, undisturbed, and serene* appear not to have been among the experimental stimuli, however. It is unclear whether the relative dearth of linguistic markers at the lower end of the continua is a function of the stimulus set(s) used in these studies or a reflection of the structure of affective experience.

Third, the issue may be not either—or but under what conditions and at what stage of affective processing are positivity and negativity organized in a bipolar versus bivariate (or even more complex) fashion. Physical limitations constrain behavioral expressions and incline behavioral guides toward bipolar (good—bad; approach—withdraw) dispositions while cognitive economies incline conceptual organizations toward a similar structure. These endpoints do not imply that the form of the underlying processes is similarly structured, however. We have suggested that the common metric governing approach—withdrawal is generally bipolar at response stages but that this response organization is the consequence of two intervening metrics: the activation function for positivity (appetition) and the activation function for negativity (aversion), at an earlier stage of affective processing. A two-dimensional representation of the activation of positivity and negativity may therefore provide a more comprehensive formulation for depicting the affective processes that predispose and culminate in an affective (e.g., approach—withdrawal) predisposition or response. This net action tendency can then be represented as an overlying bipolar response surface (see [Figure 1](#)). Inherent in this framework is the concept of modes of evaluative activation, which accommodates all possible combinations of positive and negative evaluative activation. Thus, in this conceptualization of the affect system the bipolar conceptualization is subsumed in two ways: (a) as the reciprocal diagonal and the family of vectors parallel to this diagonal in evaluative space and (b) as the overlying surface representing the net predisposition to respond.

[D. P. Green et al. \(1999\)](#) noted that biases that are due to random and nonrandom measurement error can mask bipolar structure in mood ratings. This is an important point for investigators to recognize in studies of affective ratings. There are other rating biases that also should be considered, of course. [Thompson, Zanna, and Griffin \(1995\)](#), for instance, highlighted biases that can make affective ratings appear more rather than less bipolar than they actually are. It is important, though, that demonstrations that bipolarity in affective ratings can be masked by methodological biases do not logically imply that affective processes or experiences are necessarily organized in a bipolar fashion. D. P. Green et al.

acknowledged this point but appear to argue that pleasant and unpleasant states are best understood using a bipolar framework, because in most circumstances these feelings are experienced inversely. What is true in most circumstances is not necessarily the most important or relevant data from a theoretical perspective. Experimental social psychologists have long recognized the importance of artificial environments to obtain theoretical insights. Most of the data to date, for instance, still favor the view that self-perception and cognitive dissonance theories can account for changes that follow attitude-discrepant behaviors. But this theoretical question was essentially resolved in a single study by [Fazio, Zanna, and Cooper \(1977\)](#), who showed that neither theory could account entirely for their results but instead that each theory had a unique domain of application. Physicists, too, have long recognized the need to create quite artificial circumstances—events that are so infrequent as to not be observable in the normal course of daily events—to test theories about the structure (nature, elements) and forces underlying physical phenomena. One therefore does not need the majority of studies to yield results inconsistent with bipolarity to question the adequacy of a bipolar model of affect. Even were deviations from bipolarity to be fleeting (but see lingering states of ambivalence), it would not mean they were unimportant. Cognitive dissonance, for instance, is typically a rather fleeting state, but its short- and long-term consequences can be rather dramatic. Thus, we agree that bipolarity may frequently describe people's affective ratings, but we disagree that this means that the structure of the affect system can be captured comprehensively or parsimoniously by bipolarity.

One might question the utility of placing all "pleasant" goal states into one positive category and all "unpleasant" goal states into one negative category. We would agree that there is substantial value in retaining categorical conceptualizations of emotion (e.g., happy, sad, fear, anger, disgust). We would further contend, however, that there is substantial and unique insight to be gained by the present framework. As [Marr \(1982\)](#) noted, different data representations render certain mental operations simple and others complex. The literature on emotion is replete with examples of the utility of both categorical (i.e., discrete) and dimensional perspectives, and there is precedence for such an approach in other sciences (e.g., particle vs. wave theories of light). The issue, therefore, may be not whether all pleasant states should be placed into one positive category and all unpleasant states into a negative category but what new or unique insights, understandings, and testable hypotheses are obtained by such a conceptualization.

Indeed, the value of considering the additional complexities introduced by multiple evaluative channels and modes of evaluative activation derives in large part from the data it explains, the questions it generates, and the bridges it builds across empirical literatures previously thought to be separate. Data from the neurosciences to the social sciences suggest the separability of positive and negative affective processes. Self-report and ERP data suggest distinctive currency functions for positivity and negativity. These currency functions represent multifarious appetitive and aversive inputs, respectively, along common metrics. Research using multiple operationalizations suggests a positivity offset and a negativity bias in these currency functions. There is also evidence that reciprocal modes of evaluative activation are more likely to manifest postdecisionally (see [Cacioppo et al., 1997](#)), at high levels of emotional (particularly negative) intensity ([Zautra, Potter, & Reich, 1997](#)), and as one moves down the level of the neuraxis ([Berntson et al., 1993](#)), but additional research is needed on the factors governing the modes of evaluative activation. The greater likelihood of reciprocal relations between positivity and negativity as one moves from the determination of the appetitive and aversive qualities of a stimulus to action in response to the stimulus is consistent with the physical constraints that generally restrict behavioral manifestations to bivalent actions and the role of the somatic and autonomic nervous system in carrying out the results of appraisals to achieve these actions. This formulation may also provide a useful heuristic for investigating individual differences in motivational orientation. For instance, the magnitude of the positivity offset and negativity bias may be expected to differ across individuals. Research to explore the stability and predictive utility of these parameters, as well as their relation to affective disorders, may therefore be worthwhile.

We previously used temperature (hot and cold) to illustrate the activation functions that would be expected from entities at the opposite ends of a whole bipolar dimension ([Cacioppo et al., 1997](#)). Note that we were not speaking of people's perceptions of temperature but rather the physics of temperature. Cold is the absence of heat. The structure of people's perceptions of temperature are considerably more complicated, as is apparent when one feels both feverish and chilly. Thus, studies of people's perceptions of temperature (e.g., see [Russell & Carroll, 1999](#)) may tell us more about the nonbipolarity of people's perceptions of temperature than of how complex data from a bipolar dimension may look.

Finally, and perhaps most important, most of the research on the structure of affect has relied on correlational procedures. Theory and research on the structure of affect could benefit considerably from a greater reliance on experimental methods. For example, we have manipulated the extent of positive and negative information about an object as one means of determining the activation functions for positivity and for negativity ([Gardner, 1996](#)). Similarly, [Edwards and Ostrom \(1971\)](#) used an experimental approach in their study of the limitations of bipolarity. To the extent that bipolar, circumplex, and evaluative space conceptualizations make the same predictions, distinguishing between them is moot. To the extent that they make different predictions, a focused experimental test of these predictions is best. For instance, the model of evaluative space offered the novel prediction that ambivalence is asymmetrical in that not only is ambivalence perceived to be more negative than positive but also that negative components are weighted more heavily than positive components. Experimental tests supported this hypothesis ([Cacioppo et al., 1997](#)). It is important that experimental methods do not bias the answer about the structure of affect one way or another; they simply eliminate some of the biases (e.g., subject-selection artifacts) that can be introduced when relying on correlational methods, and they allow more sharply focused empirical tests among theories.

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1

Discussion of the factors that lead to more or less activation of the affect system is beyond the scope of this article (but see [Brendl & Higgins, 1995](#), or [Cacioppo & Gardner, 1999](#), for a review).

2

This distinction has long been recognized in social psychology and has served, for instance, as a rationale for social comparison processes ([Festinger, 1954](#)).

3

[Lang et al. \(1990, 1992\)](#) acknowledged that there are many emotions but posited that these discrete emotions are organized by their motivational determinants and can be construed as ordered along strategic dimensions of valence and arousal.

4

The term *positivity* is used here to refer to an abstract entity that includes appetitive motivational substrates, processes, and outputs, whereas the term *negativity* is used to refer to the abstract entity including aversive motivational substrates, processes, and outputs. In our formulation, positivity (and negativity) can range from inactive to fully activated (cf. [Konorski, 1967](#) ; [Lang et al., 1990](#) ; [Masterson & Crawford, 1982](#) ; [Miller, 1961](#) ; [Schneirla, 1959](#)). Thus, our use of these terms differs from that of Watson and colleagues. For instance, high levels of positivity and negativity yield ambivalence in our formulation, whereas high positive affectivity and negative affectivity in [Watson and Tellegen's \(1985\)](#) formulation are characterized by arousal, astonishment, and surprise. This is due to differences in the conceptualizations of positivity and negativity.

5

The positivity \times negativity plane depicted in [Figure 1](#) represents the status in what we have termed *evaluative space* because it describes the level of activation of the underlying positive and negative inputs to a bivalent affective response. The resulting behavioral predisposition to approach or withdraw can be represented in terms of an overlying surface. It is possible to derive this overlying surface for all combinations of positivity and negativity. The exact shape of the attitudinal surface is dependent on the form of the activation functions, the relative value of the weighting coefficients, and the scaling of the axes (see [Cacioppo & Berntson, 1994](#)). For purposes of approximation, the currency functions for positivity and negativity were designated as negatively accelerating, with the exponent for negativity being larger than the exponent for positivity and the intercept being larger for positivity than for negativity ([Cacioppo & Berntson, 1994](#) ; [Cacioppo et al., 1997](#)).

6

It is important to note that the activation of positivity and negativity is assumed generally to have antagonistic effects on behavior regardless of mode. *Modes of evaluative activation* refer not to whether positivity, for instance, fosters approach and negativity fosters withdrawal but to the level (e.g., increase, no change, decrease) of positivity and negativity elicited by an event or stimulus. Note, too, that the model does not specify why positivity or negativity is activated but rather it specifies the form of their activation, the modes and effects of their activation, and so forth (see [Cacioppo et al., 1997](#)).

7

Watson and colleagues (e.g., [Watson & Clark, 1991](#)) conceptualized these two dimensions as bipolar rather than as unipolar (cf. [Cacioppo & Berntson, 1994](#)). [Watson et al. \(1999\)](#) recently revised their formulation such that there is now agreement between their model and ours on this feature.

8

In a related program of research, [Thompson et al. \(1995\)](#) suggested that methodological artifacts (e.g., carryover between unipolar positive and negative rating scales) could inflate the negative correlation between positive and negative rating scales. They recommended segregating self-report measures of

positive and negative affect to avoid self-presentational biases.

9

These results were generally replicated when using a structural modeling approach to analyze these data (P. Salovey, personal communication, October 23, 1998).

10

The precise role of these structures in reward processes has yet to be fully explicated. Stressors, for example, have also been found to trigger dopamine (DA) release from the nucleus accumbens ([Salamone, Cousins, & Snyder, 1997](#)). This may be consistent with the role of DA in reward, as aversive contexts motivate behavior and set the stage for reinforcement of responses that lead to escape or otherwise reduce the aversive context. Current models emphasize the role of the mesolimbic DA system in incentive motivation and the link to behavioral action ([Salamone et al., 1997](#) ; [Wickelgren, 1997](#)). This view is also consistent with recent data on drug addiction. Many drugs of abuse, such as cocaine, amphetamine, and morphine, are potent releasers of DA in the nucleus accumbens and can be highly euphoric. Drug consequences such as euphoria, however, may be of secondary importance in addiction. Drug addicts are often driven more by the desire for a drug, even though they report minimal pleasure on drug delivery ([Berridge & Robinson, 1995](#) ; [Wickelgren, 1997](#)). These latter phenomena are in keeping with the potential role of the nucleus accumbens in incentive dispositions and associated attentional and cognitive biases toward drug-related stimuli and actions.

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Figure 1. Illustrative bivariate evaluative space and its associated affective response surface. This surface represents the net predisposition of an individual toward (+) or away (–) from the target stimulus. This net predisposition is expressed in relative units, and the axis dimensions are in relative units of activation. The point on the surface overlying the left axis intersection represents a maximally positive predisposition, and the point on the surface overlying the right axis intersection represents a maximally negative predisposition. Each of the points overlying the dashed diagonal extending from the back to the front axis intersections represent the same middling predisposition. Thus, the nonreciprocal diagonal on the evaluative plane—which represents different evaluative processes (e.g., neutrality to ambivalence)—yields the same middling expression on the affective response surface. Dashed lines (including the coactivity diagonal) represent isocontours on the evaluative plane, which depict many-to-one mappings between the affective response surface and the underlying evaluative space. These isocontours are illustrative rather than exhaustive. From "Relationship Between Attitudes and Evaluative Space: A Critical Review, With Emphasis On the Separability of Positive and Negative Substrates," by J. T. Cacioppo and G. G. Berntson, 1994, *Psychological Bulletin*, 115, p. 412. Copyright 1994 by the American Psychological Association.

