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The Affect System

What Lurks below the Surface of Feelings?

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ABSTRACT

The structure of affective space has been debated for more than fifty years. According to the model of evaluative space (Cacioppo & Berntson, 1994; Cacioppo, Gardner, & Berntson, 1997), the common metric governing approach/withdrawal is generally a single bipolar 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. Accordingly, affective space can be bipolar or bivariate depending on specific circumstances. We further extend the model by reviewing evidence for coactivated emotional states and component processes underlying affect, emotion, and feeling. Two different event-related brain components that reflect implicit affective processing provide specific information on the general location and timing of component affective processing.

Not long ago, the camera was a metaphor for memory, the computer for the brain. Memory, however, does not activate a stored depiction of the event but rather reconstructs the event (Loftus, 1979; Roediger & McDermott, 2000). Contrary to the doctrine of rationality, the inferences drawn from facts (e.g., syllogisms) are not coldly calculated conditional probabilities but a calculus shaped in part by wishful thinking (McGuire, 1981). People do not weigh evidence objectively but generally exercise a confirmatory bias. For example, disagreeing parties who receive mixed messages containing evidence for and against each party's position tend to polarize rather than moderate their attitudes (Lord, Ross, & Lepper, 1979). The metaphors of the camera and the computer failed because they are based on the notion that the brain is a passive, dispassionate recorder and processor of information rather than a builder of meaning in ways sculpted by experience, personal and ancestral.

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One way in which this operates is well known. Sense organs filter most of the information available in a given environment, with the brains of different species receiving quite different types and bandwidths of the available information. Visual light is only a small part of the electromagnetic spectrum (400–700 nanometers/millimicrons), with changes across this spectrum perceived as changes in color. The visual perception of the bumblebee, in contrast, does not include the relatively long wavelengths that we see as red, but extends into the region of ultraviolet light below 400 nm into aspects of the environment that are invisible to humans. Moreover, the fusion flicker rate is much faster for bees than humans, so that a movie depiction of a moving object that appears in motion to humans may appear as a series of still images to bees.

Our evolutionary heritage sculpts ongoing perceptions, thoughts, feelings, and actions in a deeper sense as well. Close or occlude your left eye, fixate on the X, and note the presence of the target O. Now move your eye closer or further away from the screen while maintaining fixation on the X. Although the O should disappear at some distance (about 12 inches), the horizontal line is perceptually continuous. The continuity of the horizontal line is a visual construction.

==**X**==========**O**==========

Nowhere should the brain's construction of mental contents based on personal and ancestral experiences be more evident than in feelings and emotion. Traditionally, however, the scientific study of affect and emotion has centered on discrete feeling states. Among the important contributions of the cognitive revolution was the realization that conscious experiences provide a glimpse of only a small subset of the cognitive structures and operations that needed to be explored and understood. Many cognitive (and affective) processes occur unconsciously, with only selected outcomes reaching awareness (Bargh, 2001; Cacioppo, Priester, & Berntson, 1993; Kihlstrom, 1987) yet, as LeDoux (2000) noted, emotion researchers have generally regarded the end products that have reached awareness or behavioral displays as the most appropriate evidence for the study of emotion. In this chapter, we regard feelings and emotions as a subset of the operations of an affect system, whose structure and operating characteristics have been shaped by evolutionary forces to produce generally adaptive behaviors across a very wide range of circumstances.[1]

[1] We are not suggesting that evolutionary forces are the *only* influences that produce adaptive behaviors.

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NATURAL SELECTION ACTS ON OUTCOMES

In *Expression of Emotions in Man and Animals*, Charles Darwin (1872) articulated three principles in which behavioral expressions reflected a combination of adaptive movements, communicative signals, and general activation. Darwin's principles of serviceable associated habits, antithesis, and actions due to the constitution of the nervous system reflect a more general tenet: that for an animal to survive it must be able to discriminate hostile from hospitable events, to adjust behavior (its own and that of others) accordingly, and to marshal the requisite energy to support the necessary behavioral adjustments. The ability to differentiate between hostile and hospitable stimuli and to respond accordingly is so critical that all animals have rudimentary reflexes for categorizing and approaching or withdrawing from certain classes of stimuli and for communicating to others. Evaluative discriminations are performed in simple organisms by hard-wired stimulus-response connections or fixed action patterns. Human infants are also endowed with a finite set of hard-wired evaluative discriminations (e.g., retreat from nociceptive stimuli, startle response to sudden intense noise). A remarkable feature of humans is the extent to which the evaluative discrimination of stimuli is shaped by learning, cognition, and appraisal processes (Berntson, Boysen, & Cacioppo, 1993; Scherer, this volume). Although only a subset of these evaluative discriminations have been called emotions, and an even smaller subset feelings, the full set of mechanisms involved in evaluative information processing can be thought of as constituent parts of an integrated, heterarchically organized affect system.

Physical constraints generally restrict behavioral manifestations to bipolar (approach/withdrawal) actions. Although one can stay motionless or circle a stimulus at a constant distance, evolution favors the organism that can learn, represent, and access rapidly whether approach or withdrawal is adaptive when confronted by a stimulus. If the affect system evolved to guide behavior toward hospitable and away from hostile stimuli, a valuable consequence of affective processing would be a component of the mental representation that specifies whether stimuli from a given category are harmful or beneficial, likable or dislikable, safe or dangerous, good or bad. Consistent with this reasoning, there is 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). Moreover, mental guides for one's actions in future encounters with the target stimuli such as attitudes and preferences are more expected and stable when organized in terms of a bipolar evaluative dimension (e.g., Cacioppo & Berntson, 1994; Fishbein & Ajzen, 1975; Heider, 1946). Almost half a century ago, Brehm (1956) found that individuals, following a selection between two alternatives, spread the appeal of these alternatives by some

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combination of amplifying the positive features of the chosen alternative, diminishing the negative features of the chosen alternative, magnifying the negative features of the unchosen alternative, and minimizing the positive features of an unchosen alternative. This motivational push toward affective bipolarity was especially strong when subjects 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.

With the scientific study of affect and emotion centered on discrete feeling states and behavior, and with the steady state of these feelings in terms of a single evaluative (hostile-hospitable) dimension, measures and theories were developed built around the valence dimension (e.g., Osgood, Suci, & Tannenbaum, 1956; Russell & Carroll, 1999). Studies of the conceptual organization of affect and emotion, for instance, indicate that people conceptually organize feelings and emotions in terms of a circular order around the perimeter of the space defined by a bipolar valence dimension and an orthogonal dimension labeled activation (i.e., a circumplex; Russell, 1980). Using multidimensional scaling of similarity ratings, Russell and other researchers have recovered the circumplex from similarity judgments of emotion-related words in several cultures around the world and from children's similarity judgments of facial expressions (cf. Russell & Carroll, 1999). Thus, the circumplex is viewed not only as a description of the end products of the affect system, but also of people's moment-by-moment affective experiences (cf. Watson & Tellegen, 1985).

There is an understandable appeal to settling for steady-state feelings and behaviors as the appropriate data to model in the area of emotions. After all, these phenomena beckon to be explained. A lesson learned from the cognitive sciences, however, is that the structure and activation of the processes underlying mental contents are not revealed by study of the mental contents alone, that most cognitive and affective processes occur unconsciously, with only selected outcomes reaching awareness (LeDoux, 2000).

Neal Miller (1959, 1961) recognized early that approach and withdrawal are behavioral manifestations that can come from distinguishable motivational substrates. His conflict theory was enriched by conceptualizing approach and withdrawal separately, investigating their unique antecedents and consequences, and examining the psychological constraints that led typically to the reciprocal activation of approach and withdrawal tendencies. Building on this early work and the work of Lang and colleagues (Lang, Bradley, & Cuthbert, 1990), we have proposed a model of the affect system in which the underlying motivational substrates for the processing of appetitive and aversive information are partially separable, characterized by distinct activation functions for positivity and negativity (which refer to the general underlying motivational systems), and coupled through

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multiple modes of evaluative activation (Cacioppo & Berntson, 1994, 1999; Cacioppo, Gardner, & Berntson, 1997, 1999; Ito & Cacioppo, 1998; Larsen, McGraw, & Cacioppo, 2001). Briefly, a stimulus may vary in terms of the strength of positive evaluative activation (i.e., positivity) and the strength of negative evaluative activation (i.e., negativity) it evokes (see Figure 14.1). The model further posits that positive and negative evaluative processes are distinguishable (stochastically and functionally independent); are characterized by distinct activation functions (e.g., positivity offset and negativity bias principles); are related differentially to ambivalence (corollary of ambivalence asymmetries); have distinguishable antecedents (heteroscedacity principle); and tend to gravitate from a bivariate toward a bipolar structure when the underlying beliefs are the target of deliberation or a guide for behavior (principle of motivational certainty) (Cacioppo et al., 1997).

Positivity and negativity, represented as a bivariate plane in Figure 14.1, represent two broad systems underlying emotion, feelings, and behavior. Although specific emotions and behaviors may differ depending on the stimulus, context, and organismic state, there is an underlying commonality among appetitive affects and behaviors and among aversive affects and behaviors (Diener, 1999). Thus, in the evaluative space model, discrete emotions are conceptualized as constituent elements within two general categories of affective processes.[2] The activation of positivity and negativity, which generally have antagonistic effects on behavior, are combined to produce a response predisposition (see *z*-axis in Figure 14.1). In a bipolar model, the effects of appetitive and aversive motivation are assumed not only to have antagonistic effects but also to be reciprocally activated (Lang et al., 1990). The evaluative space model does not reject reciprocal activation, but rather subsumes it as one of the three possible modes of activation and explores the antecedents for each mode of evaluative activation. One of the unique predictions made by the evaluative space model, therefore, is that positivity and negativity can be coactivated. In the savanna, for example, animals must come to the water to drink even though their predators come there to hunt. The organism that can process such appetitive and aversive cues in parallel is better able to approach or withdraw from environmental stimuli swiftly than one that can only sample such conflicting cues in serial. Thus, coactivation of positivity and negativity fosters vigilance and directional flexibility in responding.

[2] Discrete and dimensional approaches to affect and emotion have been pitted against one another as if they were necessarily competing formulations. In the present formulation, negative discrete emotions are viewed as elements (e.g., analogous to stars) that constitute a broader organization (i.e., negativity dimension, analogous to a galaxy), and positive discrete emotions are viewed as a different set of elements that constitute a second broad organization (i.e., positivity dimension).

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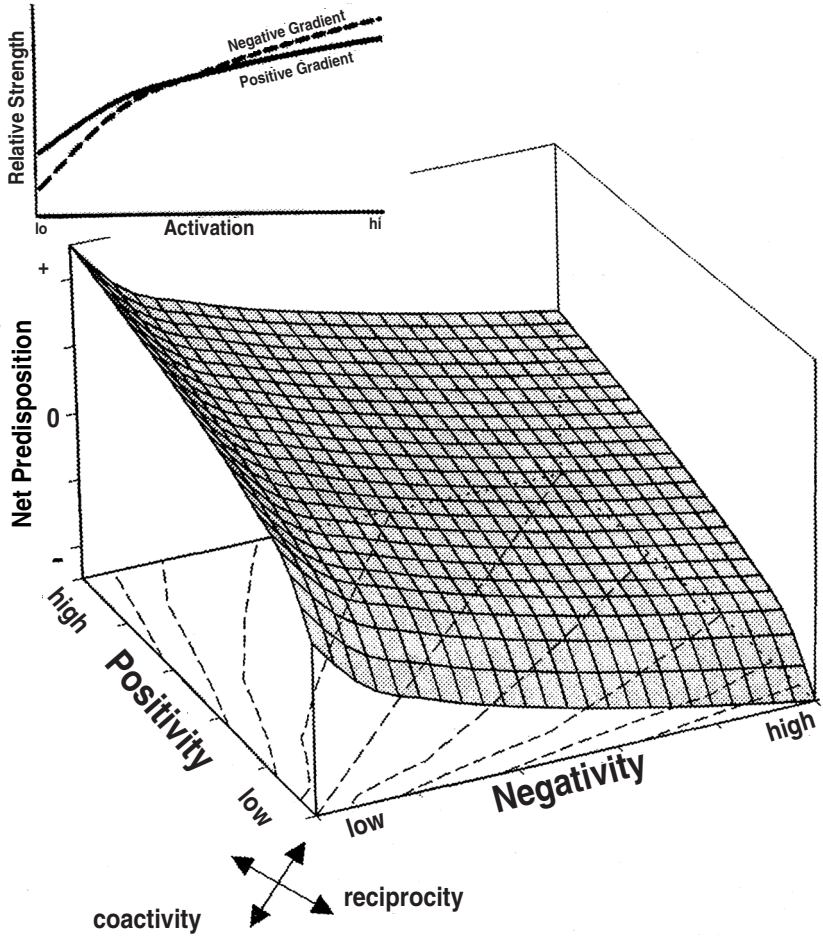


FIGURE 14.1. Illustrative bivariate evaluative space and its associated affective response surface. This surface represents the net predisposition of an individual toward (+) or away from (−) the target stimulus. This net predisposition is expressed in relative units and the axis dimensions are in relative 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 represents the same middling predisposition. Thus, the nonreciprocal diagonal on the evaluative plane – which represents different evaluative processes (e.g., neutral 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. *Figure Inset:* the activation functions depicted separately for positivity and negativity. Adapted from J. T. Cacippo and G. G. Berntson (1994), "Relationship between Attitudes and Evaluative Space," a critical review, with emphasis on the separability of positive and negative substrates. *Psychological Bulletin, 115*, 401–423.

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The affect system, according to the evaluative space model, evolved to guide an organism toward hospitable and away from hostile events. The evaluative space model, therefore, also predicts that coactivation is a tense, unexpected, disharmonious state. Coactivation can be advantageous in specific circumstances because, given the antagonistic effects of positivity and negativity, the dynamic range and lability of responses is minimized and directional flexibility is maximized (see Cacioppo & Berntson, 1994, Table 1). Moreover, coactivation may foster faster responses to unexpected movements. Finally, because it is unpleasant, coactivation motivates either a retreat from the eliciting stimulus or circumstance, or a resolution of the evaluative ambiguity. Consistent with this reasoning, ambivalence has been associated with evaluative instability (e.g., Bargh, Chaiken, Govender, & Pratto, 1992; Hass, Katz, Rizzo, Bailey, & Eisenstadt, 1991).

Larsen et al. (2001) conducted three field studies to examine whether coactivation of positivity and negativity is reflected in the self-reports of feelings (e.g., happiness and sadness, bittersweet). Larsen et al. found that individuals were more likely to report feeling both happy and sad immediately after watching the film *Life Is Beautiful* (Study 1), moving out of their college dormitories (Study 2), and graduating from college (Study 3) than in more typical situations (e.g., a typical day on campus). In addition to including standard emotion items such as *happy* and *sad*, in Study 3 Larsen et al. included a more intriguing emotion: *bittersweet*. The term "bittersweet" implies a commingling of positive and negative feelings and is therefore difficult to place in the circumplex and other bipolar frameworks. Yet its inclusion in the lexicon suggests that it can sometimes characterize individuals' feelings. Consistent with this possibility, graduates were not only more likely to report feeling both happy and sad than nongraduates, they also reported feeling more bittersweet than nongraduates. In sum, Larsen et al. replicated the typical finding that happiness and sadness are largely mutually exclusive in routine, steady-state conditions, but demonstrated that these two seemingly opposite emotions can co-occur under certain circumstances.

Additional research has shown that mixed feelings can occur not only in situations as rich as those studied by Larsen et al. (2001), but in situations as simple as a game of chance. In a laboratory experiment with a gambling task, Larsen, McGraw, Mellers, & Cacioppo (in press) presented participants with fifty-fifty chances to win one of two amounts (e.g., seven or eleven dollars) or lose one of two amounts. On winning trials, participants were more likely to feel both good *and* bad about winning the smaller outcome (i.e., a *disappointing win*) than the larger. Even though winning felt good, missing an opportunity to win an even larger amount felt bad. Similarly, participants were more likely to report mixed feelings after they lost the smaller of two amounts (i.e., *relieving losses*) rather than the larger. Thus, losing felt bad even as avoiding a larger loss felt good.

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One possibility is that the spotlight of attention focuses on the pleasant and unpleasant aspects of ambivalent situations in turn rather than in parallel. Though attention is limited (e.g., Kahneman, 1973), it can be directed to at least two channels of information (Spelke, Hirst, & Neisser, 1976). De Gelder and Vroomen (2000), for example, found that people can integrate congruent and incongruent emotional cues from the face and tone of voice in judging a target's emotion. Such data notwithstanding, self-report data may ultimately be unable to rule out the possibility that people attend to and experience positive and negative inputs in serial. It is worth noting that the evaluative space model is concerned with coactivation of underlying mechanisms more so than the resulting experience of mixed feelings. Toward that end, priming effects demonstrate that concepts can be coactivated even when one or the other falls outside the spotlight of attention (e.g., Macrae, Milne, & Bodenhausen, 1994).

Although a great deal more work needs to be done, the brain appears to have the capacities posited by the evaluative space model. One of the core predictions of the evaluative space model is that appetitive and aversive information are processed separately at the earliest stages of hedonic information processing and are combined to produce a more integrated guidance in the form of a predisposition to respond positively or negatively. Regions have been identified in animal studies that appear to be preferentially involved in appetitive information processing (e.g., nucleus accumbens, ventral pallidum, paraventricular nucleus); others in aversive information processing (e.g., central amygdala, bed nucleus stria terminalis); and others in both (hypothalamus, anterior cingulate) (see Berridge, this volume; Panksepp, this volume; Damasio, this volume). In a recent functional magnetic resonance imaging (fMRI) study by O'Doherty, Kringelbach, Rolls, Hornak, and Andrews (2001), participants performed a gambling task while in a scanner. An increase in the activity of the lateral orbitofrontal (OFC) was related to the participants' receipt of punishment, and the opposite pattern was recorded in the medial OFC. (Damage to the OFC is associated with impairments in social and emotional behavior.) O'Doherty et al. (2001) concluded that the conceptual representation of reward and punishment may be processed in distinct subregions of the OFC, with the magnitude of activation varying as a function of the magnitude of the reward or punishment. Kawasaki et al. (2001) recorded from single cells in the ventromedial prefrontal region of epileptic patients. They reported cellular firing within 120 ms of stimulus presentation, with different cells firing when pleasant and unpleasant stimuli were presented. These results add to the increasing evidence that the processing of appetitive and aversive information is separable at early stages of information processing.

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AFFECTIVE ASYMMETRIES

Affective asymmetries, like cognitive heuristics, constitute an important domain in which the brain creates representations biased by personal and ancestral experiences rather than fastidious depictions of external events. Consider the following empirical results: (1) when people rate someone they do not know, they rate the person on the positive side of the scale's neutral point (Anderson, 1981); (2) when triadic structures are used to depict relationships among oneself (*p*), another person (*o*), and a topic (*x*), people prefer a positive to a negative link (attraction) between oneself and the other (Heider, 1958) whether or not there is balance or agreement – and attraction information is processed more quickly than is agreement or balance information (Cacioppo & Petty, 1981); (3) retrospective voting studies suggest that incumbents are retained if the economy (i.e., the personal resources of the voters) is prospering but are discarded if it is not, with the incumbents being hurt more by deteriorating economic conditions than they are helped by improving economic conditions (Kieweit & Rivers, 1984); and (4) people may be risk-aversive on gains and risk-seeking on losses, although the effects of losses tend to be greater than the effects of gains (Kahneman & Tversky, 1979). These affective asymmetries, which have been puzzling because they are inconsistent in terms of whether positive or negative information is weighted more, are readily explained within the evaluative space model.

Specifically, the separation of appetitive from aversive information processing at early stages before formulating a plan or predisposition to respond made it possible for natural selection to shape distinct activation functions for positivity and negativity (Cacioppo et al., 1997, 1999). We have hypothesized that the activation functions for appetitive (approach) and aversive (withdrawal) affects are both negatively accelerating but differ in activation threshold (higher for positivity than negativity) and gain (higher for negativity than positivity) (see inset, Figure 14.1). These differences in activation functions prescribe two affective asymmetries: (1) a *positivity offset* – the positive system responds more strongly than the negative system at low levels of activation; and (2) a *negativity bias* – as activation increases, the negative system responds more strongly than the positive system. Further, though these features are posited to reflect the default mode of the affect system, the effects of appetitive and aversion stimuli on hedonic activation also depend in part on the affective context in which a stimulus appears. The function of this feature of the affect system is similar to the adaptation seen in various receptor mechanisms: to maximize sensitivity to small variations in stimulation within an ecological niche while accommodating wide variations in levels and ranges of stimulation across ecological niches. This feature is reminiscent of Weber's

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law: the just-perceptible increment of a stimulus is a constant fraction of the stimulus.

The affective asymmetries described above are consistent with these posited activation functions. The positive asymmetries described by Anderson (1981) and Heider (1958), for instance, emerge in conditions of low affective activation. The rating of unknown people as positive may be based in part on the diagnosticity of neutral information or morality/competence of the behaviors ("Don engages in normal behavior so he is probably OK"; cf. Skorwonski & Carlston, 1989), but it is more difficult to explain the attraction effect in research on cognitive balance in those terms. Moreover, using a procedure developed by Gardner (1995), we examined whether diagnosticity was the critical feature by having participants rate either a hypothetical person (toward whom participants generally felt positive even without any information), an (imaginary) "aguaphore" fish (toward which participants generally felt neutral without any information), and an (imaginary) "entophore" insect (toward which participants generally felt negative without any information) (Cacioppo, Gardner, & Berntson, 1997). Participants rated each after either receiving no additional information or neutral and nondiagnostic information (e.g., the person is susceptible to the laws of gravity; the entophore has six legs). Results indicated that the person, the aguaphore fish, and the entophore insect were each rated slightly more positively after deliberation about neutral and nondiagnostic information.

In contrast, the negative asymmetries such as the effects of economic progress versus economic decline on electoral support for incumbents (Ansolabeher, Iyengar, & Simon, 1990; see also Holbrook, Krosnick, Cacioppo, Visser, & Gardner, 2001) and the relative effects of gains versus losses (Kahneman & Tversky, 1979) are found in conditions of high affective activation. These are just the circumstances in which the affect system should modulate information processing differently, ceteris paribus producing a greater weighting of negative than positive information (see Figure 14.1). 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); and has been found to characterize the judgments of children as well as adults (e.g., Aloise, 1993; Robinson-Whelen et al., 1997). Taylor (1991) summarizes 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.

Ito, Cacioppo, and Lang (1998a) measured the positive and negative feelings evoked by 472 slides selected to represent the full affective space captured by the International Affective Picture System (IAPS; Lang et al.,

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1995). Arousal ratings were used to index the intensity of the affective stimulus (which were plotted on the abscissa), and the unipolar positivity and unipolar negativity ratings were used to index the magnitude of the affective response (which were plotted on the ordinate). Analyses revealed that the intercept was significantly higher for ratings of positive than negative stimuli (i.e., a positivity offset). Results also revealed the slope of the regression line for the ratings of the negative stimuli was significantly steeper than the regression line for the ratings of the positive stimuli (i.e., the negativity bias). Stated more simply, positive stimuli have a greater impact than negative stimuli at comparably low levels of activation, but the opposite is the case at equally high levels of activation.

To assess the generalizability of this effect across stimulus items, Ito, Larsen, Smith, and Cacioppo (1998b) replicated the regression analyses using 620 verbs (e.g., act), nouns (e.g., lion), adverbs (e.g., leisurely), and adjectives (e.g., quiet) from the Affective Norms for English Words (ANEW; CSEA, 1998), and we have subsequently conducted a similar analysis on the 555 trait adjectives from Anderson (1965). As predicted by the evaluative space model, evidence for a positivity offset was found, in that the most neutral positive words were judged slightly but significantly more extreme than the most neutral negative words, and evidence for a negativity bias was found such that the slope of the evaluatively negative words was steeper than the slope of the evaluatively positive words. The human mind treats hedonic information differently when constructing a representation of the world; doing so, at least in the long run, has adaptive advantage over depicting reality objectively and weighting affective information symmetrically.

EARLY AFFECTIVE PROCESSING: EVIDENCE FROM EVENT-RELATED BRAIN POTENTIALS

The extant evidence for affective asymmetries has relied on verbal or behavioral responses. Even the evidence of greater interference in the Stroop task when negative than positive words are presented relies on latency differences in overt response (Pratto & John, 1991). Walter Cannon (1929) long ago suggested that the sympathetic nervous system responds in a fight-or-flight fashion to negative events in order to promote survival. The evidence for the negativity bias based on affective ratings could reflect operations fairly late in information processing. Ito, Larsen, Smith, and Cacioppo (1998b) therefore used event-related brain potentials (ERPs) to test the prediction that affective asymmetries such as the negativity bias emerge early in the processing of appetitive and aversive information, prior to response selection or execution. We used a paradigm developed by Cacioppo, Crites, Berntson, and Coles (1994) to study evaluative categorizations. The experimental task requires the classification of stimuli

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in terms of their evaluative significance, such as counting the number of positive (or negative) pictures in a short series. A late positive potential that peaks around 550 msec has been identified that is more sensitive to evaluative categorization than response stages (Cacioppo, Crites, Gardner, & Berntson, 1994; Crites, Cacioppo, Gardner, & Berntson, 1995). Ito et al. (1998b) recorded ERPs to positive, negative, and neutral pictures embedded within sequences of other neutral pictures. Results showed: (1) as in prior research, positive or negative stimuli in sequences of neutral stimuli were associated with larger amplitude late positive brain potentials over centroparietal regions that peaked at approximately 550 msec; and (2) the negative stimuli were associated with a larger amplitude late positive potential than was the evaluative categorization of equally probable, equally evaluatively extreme, and equally arousing positive stimuli. These results provide support for the hypothesis that the negativity bias in affective processing occurs early.

In a follow-up, Ito and Cacioppo (2000) used the online measurement of categorization processes provided by ERPs to assess the implicit and explicit categorization of stimuli along evaluative (positive, negative) and nonevaluative (people, no-people) dimensions. Participants were exposed to stimuli that simultaneously varied along both dimensions but were explicitly instructed to categorize along only one of them. As in our prior research, the late positive potential was sensitive to participants' explicit categorization task. However, the late positive potential also revealed implicit categorization along the non-task relevant dimension – for instance, it was larger to a positive/negative picture in a series of negative/positive pictures even when the participants were engaged in a nonevaluative task (counting the number of pictures that depicted humans). More interestingly, clear evidence of an implicit negativity bias was also found, suggesting that, ceteris paribus, negative stimuli spontaneously receive greater processing than positive stimuli. Moreover, the explicit task of categorizing stimuli along a nonevaluative dimension neither diminished nor delayed the late positive potential to variations in the evaluative dimension.[3] We interpreted these results as evidence for the operation of adaptively beneficial implicit categorization processes, triggered by significant proximal stimuli, serving broad, cross-situational goals (Ito & Cacioppo, 2000; see also Collani, Jacobsen, & Schroger, 2001).

The ERP waveform can be represented as a small number of orthogonal underlying components – components that could be measured by examining the covariance between time points in the ERP waveform: those

[3] There are limitations to this finding, viz., as hypothesized for low levels of hedonic activation (see Figure 14.1, inset), the negativity bias and implicit categorization effects are not found when using mildly evocative experimental stimuli such as words ("pleasant," "unpleasant") (Cacioppo, Crites, & Gardner, 1996; Crites & Cacioppo, 1996).

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which exhibit large intercorrelations are defined as a component (cf. Coles, Donchin, & Porges, 1986). Component loadings index the relationship between amplitude and time (thereby revealing temporal information about the operation of separable implicit processes), and the scalp region over which the component is maximal may help constrain the nature of each implicit process (e.g., occipital region would suggest altered attention or visual processing, centroparietal region would suggest associative processing) (Fabiani, Gratton, & Coles, 2000).

Smith et al. (2001) manipulated the valence of the target stimuli (positive, negative, or neutral) and the probability of the stimuli (frequent vs. rare) in two studies. In each study, principal components analysis confirmed that the P1 amplitude to all frequent stimuli and to rare negative stimuli were larger than P1 amplitude to rare positive stimuli. This component was maximal over the occipital region and peaked at about 140 msec – in the same range of time in which the earliest endogenous attentional components appear. Moreover, this component was only modestly correlated with the LPP, which again was maximal at about 550 msec over the centroparietal areas. Given that the P1 component of the ERP is a proximal index of attention allocation to valenced stimuli, these results suggest an extremely rapid (< 120 ms) differentiation of positive and negative stimuli manifesting as a negativity bias in attention allocation.

Two sources of evidence suggest that the superior colliculus, posterior pulvinar nucleus, and amygdala pathway may underlie the P1 negativity bias. First, patients with striate cortex lesions show preserved abilities to localize and discriminate visual stimuli that are not consciously perceived (blindsight), suggesting that a neural tract involving the superior colliculus and posterior pulvinar nucleus can subserve gross visual discrimination in the absence of visual awareness. Second, neuroimaging studies have revealed correlations between increased blood flow to amygdala, superior colliculus, and pulvinar in response to masked ("unseen") emotional stimuli (e.g., Morris, Öhman, & Dolan, 1999). Thus, while the striate cortex visual pathway affords high resolution visual processing, the superior colliculus and pulvinar pathway afford relatively fast low resolution visual processing that can guide (motivate) attention without intention or awareness (see Winston & Dolan, this volume; Öhman & Wiens, this volume). Such an affective asymmetry serves to guide attentional and cognitive resources to potential threats in the environment even before they can be consciously registered.

COMPONENTS ACROSS LEVELS OF THE NEURAXIS

Although we have depicted positivity, negativity, and the derived affective response predisposition as general processes in Figure 14.1, these results point to another organizing principle of the affect system: these

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components of the affect system are represented at multiple levels of the brain and nervous system within a heterarchical structure, with distinguishable levels and components that are highly interactive (Berntson et al., 1993; Berntson & Cacioppo, in press). This structure is consistent with Ekman's (this volume) distinction between automatic scanning devices and more deliberative emotional processing; Öhman's (Öhman & Wiens, this volume) distinction between prepared and learned affective responses; and Damasio's (this volume) observation that emotion involves neural components at multiple levels of the neuraxis organized heterarchically beginning in the brainstem and ending in the cortex (Berntson, Cacioppo, & Sarter, in press).

The nineteenth-century neurologist John Hughlings Jackson emphasized the hierarchical structure of the brain, and the re-representation of functions at multiple levels within this neural hierarchy (Jackson, 1884). The notion was that information is processed at multiple levels of organization within the nervous system. Primitive protective responses to aversive stimuli are organized at the level of the spinal cord, as is apparent in flexor (pain) withdrawal reflexes that can be seen even after spinal transection. These primitive protective reactions are expanded and embellished at higher levels of the nervous system (see Berntson et al., 1993). The evolutionary development of higher neural systems, such as the limbic system, endowed organisms with an expanded behavioral repertoire, including escape reactions, aggressive responses, and even the ability to anticipate and avoid aversive encounters. Evolution not only endowed us with primitive, lower-level adaptive reactions, but it sculpted the awesome information-processing capacities of the highest levels of the brain. Thus, neurobehavioral mechanisms are not localized to a single level of organization within the brain, but are represented at multiple levels of the nervous system. At progressively higher levels of organization, there is a general expansion in the range and relational complexity of contextual controls and in the breadth and flexibility of discriminative and adaptive responses (Berntson et al., 1993). But, although higher-level systems confer greater behavioral variability and adaptive flexibility, they do not replace lower neurobehavioral mechanisms.

Adaptive flexibility of higher-level systems has costs, given the finite information-processing capacity of neural circuits. Greater flexibility implies a less rigid relationship between inputs and outputs, a greater range of information that must be processed, and a slower serial-like mode of processing. Consequently, the evolutionary layering of higher-processing levels onto lower substrates has adaptive advantage, in that lower and more efficient processing levels may continue to be utilized, and may be sufficient in some circumstances. For example, pain withdrawal reflexes, mediated by inherent spinal circuits, can manifest in rapid protective responses to pain stimuli. However, ascending pain pathways also convey

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information to higher levels of the neuraxis that subserve integrative aspects of affective, cognitive, and behavioral reactions such as fear, anxiety, avoidance, and/or aggression. Reflex responses provide a rapid, low-level response, but they are not immutable, as higher neurobehavioral processes can come to suppress or bypass pain withdrawal reflexes (e.g., self-injecting insulin or recovering a billfold from a fire). These organizational features are not limited to somatic systems, but apply to the autonomic nervous system as well (Berntson et al., 1998).

Although we have emphasized the features at the extremes, there is a continuum of neuraxial organization relevant to evaluative processing. We have discussed, for instance, how negative pictures could capture visual attention quickly, an effect we found to manifest in the P140 component of the ERP. Öhman and Mineka (2001) review evidence that people automatically devote more attention to negative (fearful) information than to positive information. Although fast and automatic, this component process can nevertheless be modulated by context. Smith, Larsen, Chartrand, and Cacioppo (2001), for instance, primed participants with positive and negative information, and measured the amount of attention they allocated to each, using both event-related brain potentials (Experiment 1) and a Stroop color-naming task (Experiment 2). Results showed that the attention bias to negative information was attenuated when positive constructs were made accessible.

CONCLUSION

Negative emotion has previously been depicted as playing a fundamental role in calibrating psychological systems; it serves as a call for mental or behavioral adjustment and problem solving, to perform convergent thinking. Positive emotion, in contrast, serves as a cue to stay the course or to explore the environment, to perform divergent thinking (see review by Cacioppo & Gardner, 1999). The separable activation functions provide a 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, scrutinize, and withdraw from threatening events. These features represent only the rudimentary operations of an affect system, however. A heterarchical organization of the neural components constituting the affect system provides a rich repertoire of processing operations that vary in their speed, contextual control, and behavioral flexibility. 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, its operating characteristics, and its outputs

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(e.g., affective asymmetries) warrant further study as a reflection of our evolutionary heritage and as a continued force in shaping the mind's construction of the world.

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