The Affect System: Architecture and Operating Characteristics

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Abstract

The affect system refers to the functional components involved in appetitive and aversive information processing. We review evidence suggesting that affect is not a unitary faculty but rather is composed of a number of distinct processes. Physical limitations constrain behavioral expressions and incline behavioral predispositions toward a bipolar (good-bad, approach-withdraw) organization, but this organization appears to be the consequence of multiple operations, including the activation of positivity (appetition) and the activation of negativity (aversion), at earlier affective-processing stages. The partial segregation of positive and negative affective processing afforded evolution the opportunity to sculpt distinctive activation functions for these affective components and allows their coactivation. Coactivation, in turn, cultivates the exploration of novel environments and the pursuit of seemingly hospitable events while fostering vigilance for and rapid retreats from hostile developments.

Keywords

affect; emotion; ambivalence; attitudes; preferences

Bill Bryson, a middle-aged author, spent the summer hiking the Appalachian Trail with a friend, Stephen Katz. The task proved far more difficult than either had imagined. In the end, simply surviving the effort was an achievement. Bryson's reaction to leaving the trail reflected the culmination of a summer full of emotion:

> "So do you feel bad about leaving the trail?" Katz asked after a time.
>
> I thought for a moment, unsure. I had come to realize that I didn't have any feelings toward the [Appalachian Trail] that weren't confused and contradictory. I was weary on the trail, but still strangely in its thrall; found the endless slog tedious but irresistible; grew tired of the boundless woods but admired their boundlessness; enjoyed the escape from civilization and ached for its comforts. I wanted to quit and to do this forever, sleep in a bed and in a tent, see what was over the next hill and never see a hill again. All of this all at once, every moment, on the trail or off. "I don't know," I said. (Bryson, 1998, pp. 270–271)

The positive features of the experience—the boundless woods, the escape from civilization—left Bryson wanting for more, whereas the negative features—the tedium and discomforts—left him wanting no more. The fact that the positive and negative features of the trail had opposing effects on his will and behavior is captured by many theories of emotion, but the fact that these seemingly contradictory effects could be felt simultaneously is not accommodated as easily, nor is Bryson's meager verbal response to such distinct and seemingly incompatible feelings. These facts are captured, however, by recent theoretical developments that have emerged from research on the distinct processes and operating characteristics comprising the affect system. Our purpose here is to review some of these developments.

THE AFFECT SYSTEM

The affect system refers to the components of the nervous system (conceptual and neurophysiological) involved in appetitive (positive) and aversive (negative) information processing.[2] The affect system works hand in glove with the cognitive system to appraise the significance of stimuli and to execute appropriate actions. It directs attention, guides decision making, stimulates learning, and triggers behavior. The neurological case of Elliot, reported by Damasio (1994), is illustrative. Elliot was a businessman who developed a brain tumor that damaged his prefrontal cortex. He began behaving irrationally following the damage to the prefrontal cortex by the brain tumor and the subsequent surgery. Tests revealed that although his intelligence, attention, and memory were unaffected, Elliot had lost the ability to experience emotion—and without emotion, there were no affective responses to foster learning or decision making.

What happens to appetitive and aversive information prior to selection of a response? How could Bryson simultaneously feel so attracted to and repulsed by the Appalachian Trail? Traditionally, appetitive and aversive inputs were conceptualized as having direct, opposing effects on response predisposition, the representation of which was the simple difference in the strength of the appetitive and aversive inputs (Thurstone, 1931). Functionally, the affect system can be thought of as a differential amplifier, sensitive to the difference in positive and negative inputs, not to their absolute levels. In this conceptualization, appeti-

tive and aversive inputs are processed as one channel of information, and the activations of positivity and negativity are reciprocally related. Increasing one is equivalent to decreasing the other; activating positivity is equivalent to deactivating negativity.

Affect is typically treated as the conscious subjective aspect of an emotion and the public expression of feeling. Human language is one of the primary means for communicating mental contents and for expressing feelings. Investigations of words that describe feelings, it is reasoned, may therefore shed light on the orderly arrangement of the parts of affect. Such studies suggest that emotional terms form a circumplex (circular) structure that can be divided by two axes, one representing the quality, or valence, of a response and a second representing its intensity (see review by Larsen & Diener, 1992). The identity of the emotion depends on the valence dimension, with words depicting pleasant emotions (e.g., *joy, proud, affection*) falling on one side of this dimension, and words depicting unpleasant emotions (e.g., *anxiety, anger, sad*) falling on the other. Although there are differences between feelings of fear and anger and between feelings of joy and pride, there is a greater commonality to feelings and behaviors that have the same valence than to feelings and behaviors that have different valences.[3] Feelings such as those expressed by Bryson about the Appalachian Trail, however, are difficult to capture fully along a bipolar valence continuum.

Recent studies have characterized affect as capable of being elicited quickly, effortlessly, automatically, or even unconsciously upon exposure to the stimulus (Tesser & Martin, 1996). Investigations of the structure of affective words and of self-reports of affect, although important, may therefore be incomplete. The affect system has evolved to discriminate hostile from hospitable events and to decide quickly whether approach or withdrawal is adaptive. Accordingly, mental guides for one's actions in future encounters with a target—attitudes, preferences, and conceptual organizations of emotion—tend to be stable and harmonious when organized in terms of a bipolar evaluative continuum. This does not mean that these cognitive representations derive from a single bipolar evaluative processor; it only means that the outputs of the evaluative processors that make up the affect system are combined to compute preference and organize action toward or away from the evocative stimulus. Recent developments in disparate areas of research have begun to call into question whether a single evaluative processor is sufficient. Various theorists have posited that the module in the affect system that computes attitudes, preferences, and actions receives input from at least two specialized evaluative channels that process information in parallel—one in which threat-related (i.e., negative) information is derived and a second in which safety and appetitive (i.e., positive) information is derived (see review by Cacioppo, Gardner, & Berntson, 1999).

POSITIVE AND NEGATIVE AFFECTIVE-PROCESSING COMPONENTS

The need for separate positive and negative information processing modules is well documented by the literature on learning and motivation, which is replete with examples of asymmetrical effects of positive and negative stimuli (Mackintosh, 1974). Rewarding and punishing stimuli, for example, do not invariably yield symmetrically opposing effects on behavioral dispositions. Contrary to a simple bipolar conceptualization, approach-avoidance tendencies arising from concurrent reinforcement and punishment of a given response do not necessarily yield null or neutral dispositions. Rather, they can induce potent conflicts, as evidenced by stress reactions and behavioral vacillation (Miller, 1959). Furthermore, "punishment" by electric shock of a previously positively reinforced response can either strengthen or suppress that ongoing behavior (Fowler & Miller, 1963).

Even in cases in which positive and negative stimuli have opposing effects on learning and performance, the underlying mechanisms appear to be distinct. For example, the effects of sodium amytal, an anesthesia, on approach-avoidance tendencies appear to be relatively selective for the avoidance component, and benzodiazepine receptor agonists, which have anti-anxiety effects, appear to preferentially weaken the suppressive effects of an aversive conditioned stimulus without altering responding for positive reinforcers. Even when punishment of a behavior established by positive reinforcement results in suppression of this behavior, the punishment does not necessarily weaken the approach disposition or result in unlearning of the response, as the behavior may again emerge (without further reinforcement) when the punishment is withdrawn (Mackintosh, 1974).

These findings are difficult to reconcile with a simple bipolar model of affect, as the behavioral consequences of positive and negative inputs are not uniformly symmetrical, and may be observed concurrently. A two-dimensional representation of the activation of positivity and negativity together with an overlying surface (depict-

ing the net affective disposition) may therefore provide a more comprehensive formulation. This three-dimensional space, called the evaluative space model (ESM), is depicted in Figure 1.

In the ESM, the net predisposition is portrayed as the consequence of two intervening evaluative processors, each of which has its own activation function. An activation function is a quantitative depiction of the output of a processor for zero to maximal levels of input. The ESM posits that the activation function for each of these processors is negatively accelerating. Multiple modes of activation are also posited (Cacioppo & Berntson, 1994). Reciprocal activation occurs when a given stimulus increases positivity and decreases negativity, or vice versa. This is the mode that is assumed to operate in bipolar models of the affect system and is the mode that characterizes reflex behavior (Lang, Bradley, & Cuthbert, 1990). Other modes of evaluative activation are also posited by the model, however. For instance, the conflicting feelings Bryson expressed about the Appalachian Trail are the predictable consequence of coactivated positivity and negativity, and his meager verbal response to Katz's question captures the poor behavioral guidance such an affective state provides. If the affect system evolved to guide action in a sometimes hostile, sometimes hospitable world, the intense coactivation of positivity and negativity would not be expected to be a pleasant or stable state for the system. Although unstable, coactivation cultivates the exploration of novel environments and the pursuit of seemingly hospitable events while fostering vigilance for and rapid retreats from hostile developments.

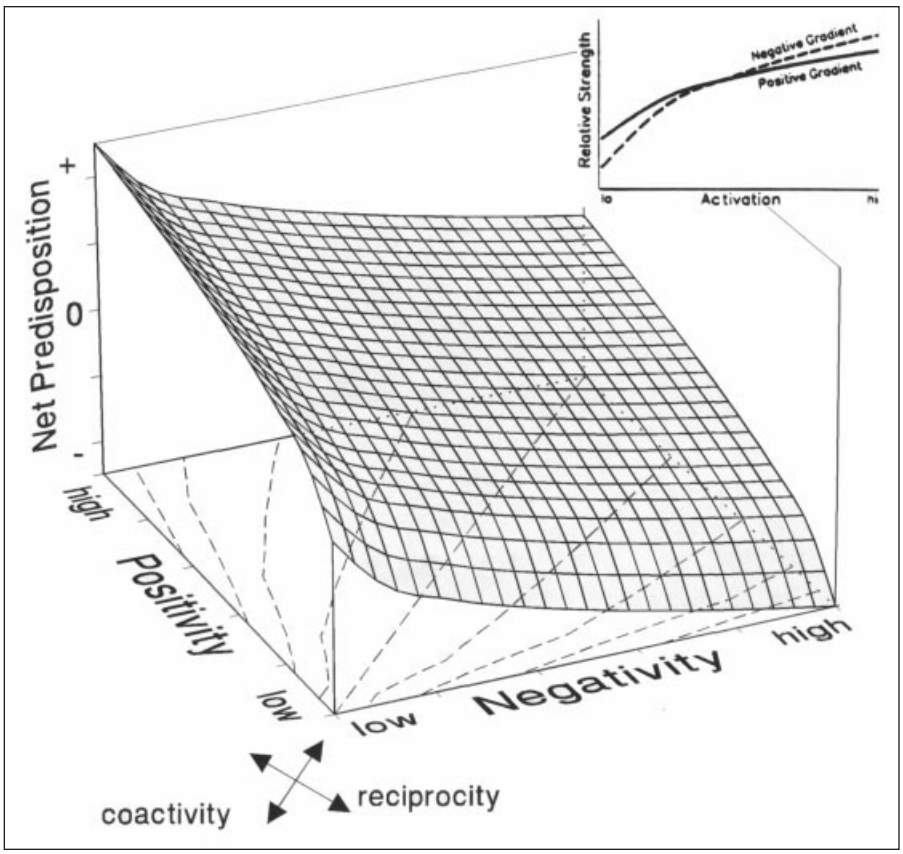

Fig. 1. The evaluative space model (ESM). The ESM posits that two separable affective processors are activated by appetitive (positive) and aversive (negative) information, respectively. All combinations of positive and negative activation are possible through multiple modes of evaluative activation, so a two-dimensional plane is required to depict these processor states. The distinctive activation functions for positivity and negativity are highlighted in the inset. The outputs of these processors are combined to produce a net predisposition of an individual toward (+) or away from (–) the target stimulus. This net predisposition is represented by the overlying surface. Copyright © 1999 by the American Psychological Association. Reprinted with permission from Cacioppo, J.T., Gardner, W.L., & Berntson, G.G. (1999). The affect system has parallel and integrative processing components: Form follows function. *Journal of Personality and Social Psychology, 76*, 839–855.

The partial segregation of the positive and negative evaluative channels in the affect system also afforded evolution the opportunity to sculpt distinctive activation functions for positivity and negativity. The extant data suggest at least two differences between the functions (see the inset in Fig. 1): The function for positivity is higher than the function for negativity at zero input (i.e., there is a positivity offset), and the function for negativity rises more quickly than the function for positivity (i.e., there is a negativity bias). Early support for these differences is evident in the literature stimulated by Miller's (1959) theory of conflict.

The positivity offset means there is a tendency for a weak positive (approach) motivational output at zero input. The evidence for a positivity offset is fairly broad—ranging from affective judgments of pictorial stimuli and impressions of neutral, unknown, or ambiguous human and nonhuman stimuli to the tendency to expect generally positive outcomes for unknown future events (Cacioppo et al., 1999). As a consequence of the positivity offset, the motivation to approach is stronger than the motivation to avoid at low levels of evaluative activation (e.g., at distances far from a goal). What might be the

possible evolutionary significance of the positivity offset? Without a positivity offset, an organism in a neutral environment may be unmotivated to approach novel stimuli. Such an organism would learn little about novel or neutral-appearing environments and their potential value or threat. With a positivity offset, however, an organism facing neutral or unfamiliar stimuli would be weakly motivated to engage in exploratory behavior following the habituation of an initial fear response to something new and unfamiliar. Such a tendency may have important survival value, at least for a species, if not the individual.

Exploratory behavior can provide useful information about an organism's environment, but exploration can also place an organism in harm's way. Because it is more difficult to reverse the consequences of an injurious or fatal assault than an opportunity unpursued, the process of natural selection may also have sculpted a propensity to react more strongly to negative than positive stimuli. Termed the negativity bias, this heightened sensitivity to negative information is a reliable psychological phenomenon. Taylor (1991) summarized a wide range of evidence showing that negative events evoke stronger and more rapid physiological, cognitive, emotional, and social responses than neutral or positive events, and there is event-related potential (ERP)[4] evidence consistent with a negativity bias emerging early (within hundreds of milliseconds) in affective processing (Ito, Larsen, Smith, & Cacioppo, 1998).

In sum, affect has traditionally been treated as the conscious subjective aspect of an emotion. As such, it represents the output of a set of information processing operations. There is a voluminous literature on the effects of affective states and their causes and concomitants, but recent developments have drawn attention to the affect system as an object of study in its own right. Contemporary research suggests that the affect system is not a unitary faculty but rather is composed of a number of distinct processes. Research on the architecture and operating characteristics of the affect system is still relatively recent, and additions and revisions to the story outlined in this review are inevitable. The concept of modes of evaluative activation is novel, and what determines the various modes needs to be better understood. Individual differences in operating characteristics almost certainly exist, and research on such differences should help illuminate affective processes and disorders. Research on neural substrates should help further refine understanding of the architectural components and processes of the affect system. It is this type of multilevel integrative research that should progressively clarify the nature of affect and affect-laden information processing.

Recommended Reading

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Notes

1. Address correspondence to John T. Cacioppo, Department of Psychology, The University of Chicago, 5848 S. University Ave., Chicago, IL 60637; e-mail: cacioppo@uchicago.edu.

2. The recent emergence of the field of affective neuroscience speaks to the level of activity and vitality of research on the neurophysiological components of the affect system. Given space limitations, however, our focus here is on the conceptual components of the system. Readers interested in the former might see recent reviews by Davidson and Irwin (1999) or Cacioppo, Gardner, and Berntson (1999).

3. There are distinctions among the feelings of joy, pride, and affection and among the feelings of anxiety, anger, and sadness, but pleasant feelings tend to co-occur and unpleasant feelings tend to co-occur. As Diener (1999) noted, "There is a glue that holds together certain of the discrete emotions. The explanation of the co-occurrence of emotions and moods has the potential of shedding light on the most fundamental nature of affect" (p. 803). Diener (1999) recently called for a more careful examination of the affect system, and what part of this system a particular set of measures is likely to reflect.

4. The ERP is the brain's electrical signature of the occurrence of a discrete event. The event is usually a stimulus (e.g., a tone, word, or picture), and specific features of the ERP are thought to reflect information processing activity (e.g., the categorization of a tone as high or low or the categorization of a trait descriptor as good or bad).

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