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Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho



Review article

The current status of research on the structure of evaluative space[☆]

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ARTICLE INFO

Article history:

Received 20 February 2009

Accepted 10 March 2010

Available online xxx

Keywords:

Positivity
Negativity
Depression
Ambivalence

ABSTRACT

The structure of evaluative space shapes emotional life and must be capable of an astonishing range of emotional experience and expression. In this article, we outline the current status of research on the Evaluative Space Model (ESM; Cacioppo et al., 1997, 1999), which proposes that behavioral predispositions (e.g., approach, withdrawal) are the ultimate output of the affect system, which is defined by operating characteristics that differ for positivity and negativity, and across levels of the nervous system. First, we summarize the tenets of the model, as well as counterarguments raised by other theorists. To address these counterarguments, we discuss the postulates of affective oscillation and calibration, two features of the affect system proposed to underlie the durability and adaptability of affect. Finally, we consider the implications of disorder in the structure of evaluative space for the comprehension and treatment of depression and anxiety.

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[☆] Preparation of this article was supported by a grant from the National Institute of Mental Health (Grant No. P50 MH52384-01A1).

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Our emotional world is composed of an interconnected web of people, objects, and events that each carry potentially critical information for not only our ability to survive, but also thrive. The complex and dynamic nature of this emotional world, combined with the survival value inherent in many of the stimuli encountered in its reaches, demands the capability of responding both quickly

and flexibly when determining whether a stimulus is hostile, hospitable, or has features of both. The affect system has evolved to efficiently and effectively promote adaptive responses to stimuli, and to produce an astonishing range of emotional experience and expression. Discriminating hostile from hospitable stimuli is so fundamental to and important for mammalian survival that this behavioral organization can be found at multiple levels of the neuraxis, ranging from the spinal cord to the neocortex (Berntson et al., 1993; Berntson and Cacioppo, 2008), and can happen quickly, efficiently, and without awareness (Wilson and Bar-Anan, 2008). However, although the primary function of the affect system is to discriminate bad from good, harmful from helpful, aversive from appetitive, it does not follow that the structure of the affect system is necessarily constrained to a bipolar configuration. Rather, the complexity and flexibility of observable emotional responses suggest that the underlying structure of the affect system is capable of nuanced and adaptive processing. The model of evaluative space (ESM; Cacioppo and Berntson, 1994; Cacioppo et al., 1997, 1999) proposes that bipolar behavioral predispositions are influenced by the affect system, but the affect system is not constrained to a bipolar processing continuum.

In the current paper we review the basic principles of the ESM, as well as emerging evidence supporting them and counterarguments that have been raised against the ESM by other researchers. We then discuss the principles of affective calibration and affective oscillation, the support for each, and their functional utility for understanding emotional responses. Finally, we consider the utility of the ESM for understanding and studying clinical disorders, particularly major depression and generalized anxiety.

1. Historical perspectives on the structure of evaluative space

Historically, the pleasure–displeasure continuum was considered to be a fundamental dimension of emotion (Wundt, 1921/1924); a parallel bipolar dimension, that of evaluation, was proposed to underlie meaning in general (Osgood et al., 1957), such that a reduction in negativity was equivalent to an increase in positivity. In other words, feeling “less bad” following a traumatic event, such as the loss of a loved one, was considered functionally equivalent to feeling “more good.” One of the first researchers to challenge this assumption was Norman Bradburn (1969), who in his analysis of survey data raised the possibility that positive and negative affect were separable. Counterarguments from other theorists, however, ranged from the fact that people were reporting on different periods of their life during which their emotions were bipolar (thus, positive and negative affect were never co-experienced or independent within a single individual) to the possibility that the apparent separability was simply a measurement artifact. Although the idea that positive and negative affect were separable clearly had many strong opponents, evidence for the separability of appetition and aversion continued to accrue and some version of separability was featured in many dominant theories of emotion – notably, this is especially true for neurally mechanistic theories (i.e., those that explicitly propose specific neural mechanisms underlying emotional processes). Gray (1982) suggested that two separable neural systems subserved behavioral appetition and aversion, with the *behavioral activation system* primarily composed of mesolimbic dopaminergic projections from the ventral tegmentum to the ventral striatum (including the nucleus accumbens) and the *behavioral inhibition system* including the amygdala and septohippocampal system (SHS; see McNaughton and Gray, 2000 for an update of this model). Lang and his colleagues (Lang, 1995) have proposed that emotions are action dispositions that are driven by two opponent motivational systems, namely the appetitive and aversive systems,

housed in subcortical regions of the brain. Lang and colleagues’ theory of motivational priming (1995) suggests that activation of each of these systems primes associations, representations, and actions that are consistent with the active system. Both Gray (1982; McNaughton and Gray, 2000) and Lang’s (1995) theories, however, are explicit in positing that appetition and aversion are reciprocally activated, which means that emotions continue to be conceptualized along a bipolar valence dimension (i.e., ranging from very negative to very positive). In other words, feeling “less bad” is equivalent to feeling “more good,” regardless of the underlying structure of evaluative space proposed by these different models.

2. The Evaluative Space Model

Affect refers to feelings beyond those of the traditional five senses, with an emphasis on the experience of emotions and variations in hedonic tone.¹ Accordingly, the scientific study of human affect and emotion has tended to emphasize reportable feeling states. Studies of the conceptual organization of affect and emotion indicate that people represent 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; e.g., see Russell and Carroll, 1999). Alternatively, Watson and Tellegen (1985) have proposed a model that combines valence and activation to create two orthogonal dimensions of positive activation (PA) and negative activation (NA), each of which represents highly activated emotions, such as excitement (PA) and distress (NA). Although PA and NA are thought to be largely independent, Watson and Tellegen’s model is also founded on the assumption of a basic bipolar valence dimension containing the negatively correlated endpoints of happiness and sadness (Watson and Tellegen, 1999). Although there is an appeal to studying feelings to understand affect, this approach often fails to consider the mechanisms underlying our mental contents and ignores the fact that most cognitive processes occur outside of direct awareness (Nisbett and Wilson, 1977; Wilson and Bar-Anan, 2008). Over millions of years of evolution, efficient and manifold mechanisms have evolved for differentiating hostile from hospitable stimuli and for organizing adaptive responses to these stimuli. These are critically important functions for the evolution of mammals, and the integrated set of mechanisms that serve these functions can be thought of as an “affect system.” It is this affect system – its architecture and operating characteristics – that is the focus of the ESM (Cacioppo and Berntson, 1994, 1999; Cacioppo et al., 1997, 1999).

Emotional life is incredibly varied. Current research in the field of emotion continues to debate the number of core or basic emotions that we experience (e.g., Ekman et al., 1972), as well as their structure in affective space, and particularly along the emotion circumplex (e.g., Watson et al., 1999; Russell and Carroll, 1999). Both the basic emotions approach and the dimensional approach to the study of affect have their strengths and weaknesses, in that each focuses on one aspect of emotional processes often by ignoring or disregarding others. For example, the basic emotions approach explores the cultural and situational specificity and generalizability of emotional experience and expression to better understand the evolutionary history and, ultimately, the functional roles that emotions serve. The basic emotions approach, however, tends to overlook the global underlying mechanisms of emotional processes in favor of a focus on specific antecedents, consequents, and (often

¹ Throughout the current paper affect refers to generalized evaluations of positivity and negativity, whereas emotion refers both to discrete emotions (e.g., anger, disgust, happiness) and the study of responses to environmentally relevant objects and events more globally. Feelings are reportable emotional experiences, and moods are durable feeling states.

facial) correlates of a small set of emotions, such as happiness, sadness, anger, disgust, fear, and surprise. In other words, theories of basic emotions emphasize the trees over the forest. Similarly, dimensional approaches emphasize the fundamental underlying components of emotional experience, whether valence and arousal (e.g., Russell and Carroll, 1999), PA and NA (Watson et al., 1999), appetite and aversion (Lang, 1995), behavioral activation and behavioral inhibition (Gray, 1982), or some other conceptualization, without regard to the discrete states that form the building blocks of our emotional life. Theories of dimensional emotion processes often cannot see the trees for the forest.

Both of the discrete emotion and dimensional approaches clearly have merit. More importantly, both approaches provide complementary information and limiting conditions for the understanding of emotion and affect. As indicated above, we suggest that the relationship between discrete emotions and the structure of evaluative space is analogous to that between trees and forests. Although trees are the fundamental building blocks of forests, it can be difficult to delineate individual trees, to separate one from the next, or to determine the contributions of a single unit to the whole. Rather, individual trees are part of a vast ecosystem that contains internal organizations critical to their creation and continued existence. In the current paper, we focus on the forests of emotional experience, at times overlooking the trees. This is not to suggest that a discrete emotion conceptualization of the affect system is in any way unimportant or uninformative. Indeed, discrete emotions have received much of the focus of emotion research since the time of Darwin (1872). Instead, we suggest that studying the forests of emotional experience will shed light on the underlying structure of the affect system, ultimately contributing to a better understanding of the guiding principles of affective processes and their consequences for both adaptive and dysregulated behavior.

Although behavior may be constrained to a single bipolar dimension defined by the opposing movements of approach and withdrawal, the mechanisms underlying the affect system must be capable of an astonishing range of emotional experience and expression. In addition, constraints on the output of any system do not necessarily require that the internal mechanisms conform to the same structure. In other words, the affect system may very well have an underlying structure that allows for great flexibility of responses. The ESM (Cacioppo et al., 1997, 1999) proposes that behavioral predispositions are the ultimate output of the affect system, which is defined by separable systems for processing positivity and negativity, each characterized by unique operating characteristics. The ESM does not contest the circumplex as a stable endpoint of the conceptual organization of affect and emotion, nor does it question the existence of core emotions. The ESM does, however, dispute the assumption that the circumplex structure fully captures the functional dimensions of the affect system. The ESM is not a theory of what elicits affective states or emotions. Rather, it is a theory of the mechanisms that underlie affect, and how these mechanisms are engaged in theoretically predicted circumstances. We begin by describing the primary dimensions of evaluative space and summarizing evidence for the support of a multidimensional approach to the study of affect and emotion.

It is worth noting at the outset that the ESM assumes that positive affect is linked with appetitive motivation and negative affect with aversive motivation, such that high positivity will more often than not lead to motivation to approach and high negativity will lead to motivation to avoid. Certain emotions appear to violate this assumption – in particular, anger is an approach-oriented negative emotion (Carver and Harmon-Jones, 2009). We argue that although under specific circumstances anger may result in approach-oriented behavior, the underlying motivation may remain defensive. In some situations, one must approach the target to eliminate the threat. Such behavior is exhibited in more mun-

dane circumstances as well – for example, writing a nasty review of a rival's manuscript may be an aggressive, approach-oriented behavior, but the underlying motivation may be to prevent publication. Thus, although the proximal behavior appears to be appetitive or approach-oriented, the distal motivation is defensive. Consistent with this perspective, the startle reflex is potentiated when individuals view angry faces (Springer et al., 2007), suggesting that viewing angry faces may induce a defensive motivation under certain circumstances. Similarly, we may be required to perform avoidant or withdrawal-oriented behaviors in order to pursue a goal, as in the early days of courtship, when over-eagerness may be viewed as desperation. Waiting three days to call after a first date is clearly an avoidant behavior with, often, an appetitive motivation. The proximal behavior is avoidant, the distal motivation is appetitive. Therefore, the ESM equates positivity with appetitive motivation and negativity with aversive motivation.

3. The structure of evaluative space is bivariate: positivity and negativity are separable

Positivity and negativity represent two systems that underlie emotion and affect. Although moods, subjective feelings, and discrete emotions vary widely across contexts, cultures, and individuals, when considered in terms of their behavioral profiles two clusters of emotional experiences emerge: positive (pleasant, appetitive) and negative (unpleasant, aversive) states (Cacioppo et al., 2000). The *level of organization* postulate suggests that although there are distinctions among both positive and negative emotions, positive emotions are more similar to each other than they are to negative emotions, and vice versa (see Table 1 for descriptions of all postulates discussed herein). This organization is suggestive of two underlying dimensions of the affect system: one focused on processing appetitive stimuli, such as food and cooperative conspecifics, and a second on aversive stimuli, such as predators. Thus, the ESM argues that the dimensions of positivity and negativity are at least partially functionally separable, in that they are not equivalent in their constitution, operations, or consequences (*functional separability* postulate). In this respect, we agree with researchers who suggest that appetite and aversion are two distinct dimensions (e.g., Lang, 1995; Gray, 1982). What separates the ESM from these theories is that we explicitly argue that these dimensions are not necessarily reciprocally or equally activated. The combined outputs of the appetitive and aversive systems produce a behavioral predisposition to either approach or avoid the stimulus (*evaluative activation* postulate), where the behavioral effects of positive affect (i.e., approach) are generally in opposition to those of negative affect (i.e., avoidance; *antagonistic effects* postulate). Although some of these calculations may be straightforward, such as avoiding a potentially harmful stimulus (e.g., snake, angry person), others require more complicated algorithms. For example, animals must come to water sources to drink even though this exposes them to predators. The ability to simultaneously hold two opposing motivations, to approach the water and avoid being eaten, is clearly adaptive and requires nuanced and flexible evaluative processes. The affect system performs such calculations to ultimately determine behavior toward or away from a stimulus.

3.1. Behavioral evidence for the separability of positivity and negativity

Much research over the past 20 years supports the separability of positivity and negativity in emotional responses, both in self-reports of mood and in responses to emotional events in the laboratory. Warr et al. (1983) found that although positive affect was correlated with the number of self-reported positive life events

Table 1
A brief description of the ESM postulates. Note that this is an incomplete list; readers interested in the full breadth of the model should turn to Cacioppo et al. (in press).

Postulate	Definition	Additional detail
Level of organization	There are distinctions among both positive and negative emotions, but positive emotions are more similar to each other than they are to negative emotions, and vice versa	A single valence continuum does not capture the structure and operating characteristics of affect system
Functional separability	Positivity and negativity are not equivalent in their constitution, operations, or consequences	There is a superordinate dimensional structure representing appetitive predispositions, positive affects, and emotions, as well as a superordinate dimensional structure representing defensive predispositions, negative affects, and emotions
Energetic efficiency	Behavior in future encounters with target stimuli will tend to be more expected and stable when organized in terms of a bipolar evaluative dimension	Behavioral and cognitive efficiency and a reduction in stress is served by mental representations of general action predispositions toward classes of stimuli
Evaluative activation	Affect is a joint function of positively and negatively valent activation functions	
Antagonistic effects	Directional response effects of positive affect (approach) are generally opposite to those of negative affect (avoidance)	
Modes of evaluative activation	Positivity and negativity can be reciprocally activated, independently activated, or co-activated	At high levels of coactivation (which minimizes the dynamic range, reduces response lability, and maximizes directional flexibility), energy expenditure is taxing over long periods of time; eliciting circumstances tend to be avoided
Parallel evaluative processing	The ability to achieve coactivation of positivity and negativity by attending to positive and negative features of a stimulus simultaneously (e.g., bittersweet, disappointing wins)	
Oscillation (or low-pass filtering)	The ability to achieve coactivation of positivity and negativity by oscillating between positive and negative stimuli with sufficient speed that results in the sustained activation of positivity and negativity	Even though there can be an oscillation between positive and negative activation, if the speed of presentation is faster than the low-pass filter cutoff, the activation of each cannot follow the speed of the oscillations and coactivation (ambivalence) results
Distinct activation functions	The partial segregation of the positive and negative evaluative channels allows for distinct activation functions for positivity and negativity	
Positivity offset	The offset (intercept) for the positive activation function is higher than that of the negative activation function	Motivation to approach is stronger than the motivation to withdraw at very low levels of evaluative activation; this promotes exploratory behavior – without a positivity offset, a person in a neutral environment is unlikely to approach novel stimuli
Negativity bias	The gain for the negative activation function is higher than that of the positive activation function	Motivation to withdraw is stronger than the motivation to approach at very high levels of evaluative activation; it is more difficult to overcome a fatal assault than to return to an opportunity unpursued
Recalibration	The activation functions for positivity and negativity are capable of the same kind of recalibrations based on salient contextual and accessible stimuli as is seen in receptor mechanisms	Both sensitivity to small variations among stimuli and a dynamic range suitable to detect a wide array of affective stimuli are preserved
Affective dispositions	There are measurable individual differences in the positivity offset and negativity bias	These individual differences have a biological basis
Heterarchical organization	There is a continuum of neuraxial organization that extends throughout the central nervous system in a heterarchical structure, ranging from the frontal lobes to the spinal cord	Rostral, in contrast to caudal, neurobehavioral organizations are slower, more serial-like; susceptible to more contextual control; potentiate greater response flexibility; and manifest multiple modes of appetitive and aversive activation

over a 6-month period and negative affect was correlated with the number of negative events, positive and negative affect were not correlated, consistent with the notion that positivity and negativity may not be reciprocally activated. Diener and Iran-Nejad (1986) found that self-reported mood also showed some independence of positivity and negativity, such that when one type of affect is present at a relatively low level, the level of the opposing type can range anywhere from low to high without affecting the original affect. In other words, a strongly positive event (e.g., getting a manuscript accepted in a top journal) that occurs on a day characterized by a mild level of negative mood (e.g., getting up on the wrong side of bed) may selectively increase positive mood while a mild negative mood state persists. In the laboratory, Brehm and Miron (2006) provided evidence for this independence of emotional states, such that a negative event (e.g., losing a lottery) experienced after a positive event (e.g., receipt of a candy bar) did not eliminate the initial emotional response (i.e., happiness).

Therefore, a change in one affect (positivity, negativity) does not necessarily influence pre-existing emotional states.

3.2. Neural evidence for the separability of positivity and negativity

The structure of neural systems itself provides some preliminary evidence for the potential for a separation of appetitive and aversive information processing. The literature generally supports the conclusion that reward and punishment circuitry remain at least partially independent, with reward involving the nucleus accumbens (and the ventral striatum more broadly) and punishment implicating aspects of the insula, amygdala, and bed nucleus striata terminalis. As mentioned previously, Gray's neurally mechanistic theory of motivation (1982; McNaughton and Gray, 2000; see also Canli, 2006 for an excellent review of this model) proposes that two separable neural systems subservise behavioral appetition and

aversion: the behavioral activation system (BAS), which mediates responses to rewarding and non-punishing stimuli, and the behavioral inhibition system (BIS), which is activated only under conditions of conflict when goals are incompatible (e.g., when dangerous stimuli need to be approached). Gray (1982; McNaughton and Gray, 2000) clearly relates individual differences in BAS and BIS function to different emotional disorders, namely those of impulsivity (or addiction) and anxiety, respectively. Although many aspects of this theory remain up for debate, the central conceptualization of different neural systems underlying particular behavioral dispositions is well-supported.

O'Doherty and his colleagues have taken a complementary approach to understanding the neural correlates of emotional processes, focusing on reward and punishment as potentially separable systems. Using functional magnetic resonance imaging (fMRI) and a multitude of affective stimuli (e.g., faces, odors, gambles, tastes), O'Doherty and his colleagues (O'Doherty et al., 2001, 2002, 2003; Gottfried et al., 2002) have reported that different subregions of the orbitofrontal cortex (OFC) are involved in reward and punishment processing, with monetary reward – as well as appetitive and pleasant odors, smells, and faces – activating medial OFC and monetary punishment – as well as aversive and unpleasant odors, smells, and faces – activating lateral OFC (although other studies have failed to find this dissociation; cf. Elliott et al., 2003; Breiter et al., 2001). Furthermore, even within a single neural structure (e.g., the striatum), losses and gains may be represented in spatially distinct regions. Seymour et al. (2007) found that although prediction errors for losses and gains both activated the ventral striatum, the activation peaks for gains and losses were spatially distinct, with anterior regions of the striatum responding to gains and posterior regions to losses. Importantly, this spatial selectivity mirrors the relationship between the anterior–posterior dimension of the striatum and valence (i.e., reward–punishment) observed in rats (Reynolds and Berridge, 2001). An additional dimension of functional separability within the striatum/nucleus accumbens is the selective involvement of dopamine (DA) and acetylcholine (ACh) in positivity and negativity, respectively (Hoebel et al., 2007).

Other support for the separability of neural systems for negativity and positivity comes from a meta-analysis of neuroimaging studies of emotion conducted by Wager et al. (2003), which showed clear differences in brain activation as a function of valence. Wager et al. (2003) found that more peaks of activation were reported in the cerebellum and insula for negative than positive stimuli, but that more peaks of activation were reported in the basal ganglia (including the ventral striatum) for positive than negative stimuli. These results are consistent with animal work on the separability of reward and punishment neural circuitry (cf. Reynolds and Berridge, 2001, 2002). Importantly, as activation increased for both negative and positive stimuli in all of these areas, activation patterns did not reflect a bipolar function of valence. In other words, a bipolar structure of emotion might indicate that positive and negative affect are opposite outputs of a single neural generator such that one neural system may account for the experience of both affects, with increased activation corresponding to, for example, increased positive and decreased negative affect, and decreased activation corresponding to decreased positive and increased negative affect (i.e., reciprocal activation). The extant neural data do not support this conclusion.

A final source of neural evidence for the separability of reward and punishment is that of the apparent specialization of neurotransmitters and their receptor densities. Hariri et al. (2002) have repeatedly shown that polymorphisms of the serotonin reuptake gene (5HTT) are associated with differences in amygdala reactivity to emotional (and particularly negative – both fearful and angry) faces, such that individuals with a short allele show increased amygdala reactivity. The same polymorphism is also associated

with individual differences in neuroticism and anxiety disorders (Gonda et al., 2008; Gunther et al., 2007), and recent studies suggest that the short allele affects not only amygdala reactivity, but also functional connectivity between the amygdala and regions of the ventromedial prefrontal cortex (particularly the subgenual anterior cingulate cortex [ACC]). Serotonin itself has long been linked to depressive mood, and the projections of the serotonergic system extend from the raphe nucleus to neural regions associated with negativity (as well as Gray's behavioral inhibition system), including the amygdala and areas of prefrontal cortex, ultimately projecting broadly throughout the cortex. Dopamine, however, has long been linked to reward and even addiction. Animals will electrically self-stimulate dopaminergic pathways (Olds, 1958a,b), and dopamine reuptake is decreased following the administration of cocaine, resulting in an accumulation of dopamine in the synaptic cleft (Ritz et al., 1987; Hoebel et al., 1999). Contrary to the serotonergic pathway leading from the amygdala to the prefrontal cortex (PFC), the dopaminergic pathway extends from regions of the mid-brain including the ventral tegmentum to the nucleus accumbens. Furthermore, there are high concentrations of dopamine receptors (D1, D2) in the ventral striatum, a structure clearly implicated in reward-related behaviors such as wanting and liking (Berridge, 1996). Thus, the serotonin system appears to be relatively selective for responding (and controlling responses) to negative, aversive stimuli, whereas the dopaminergic system is selective for responding to positive, appetitive stimuli.

4. The separability of positivity and negativity allows for multiple modes of activation

Previous models of emotion have proposed multiple underlying dimensions (e.g., Lang, 1995; Gray, 1982; Watson and Tellegen, 1999). None of these models, however, have questioned the assumption that positivity and negativity are reciprocally activated, meaning that increasing one necessarily decreases the other. The ESM suggests that, although reciprocal activation may be the most common mode of the affect system and may result in more stable behavior over time (*energetic efficiency* postulate), it is not the only mode of activation (see Fig. 1). Because positivity and negativity are functionally separable and partially independent, increasing one is not assumed to have a direct effect on the other (*modes of evaluative activation* postulate). Consider a typical political campaign, in which the average voter may possess a few pieces of

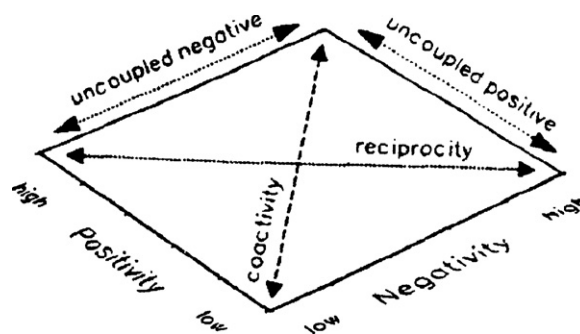


Fig. 1. The bivariate evaluative plane. The left axis represents the level of excitatory activation of positive evaluative processes (labeled positivity), and the right axis represents the level of excitatory activation of negative evaluative processes (labeled negativity). Along each axis, the level of activity increases with movement away from the front axis intersection. The dotted diagonal extending from the left to the right axis intersections represents the diagonal of reciprocal control (labeled reciprocity). The dashed diagonal extending from the back to the front axis intersections depicts the diagonal of nonreciprocal control (labeled coactivity). The arrows alongside the axes represent uncoupled changes in positive or in negative evaluative processing. These diagonals and axes, and vectors parallel to them, illustrate the major modes of evaluative activation.

positive information about her favored candidate. The revelation that the candidate's views on a particular issue (e.g., abortion) are more moderate or even in opposition to the voter's own position will likely have an effect on the voter's feelings toward the candidate. Traditional models of affect would suggest that the voter's feelings will not only become *more negative*, but also *less positive* (i.e., reciprocal activation), perhaps resulting in a change in voting behavior. The ESM, however, suggests that an increase in negativity is not necessarily accompanied by a decrease in positivity. Thus, positivity may be maintained even as negativity increases, resulting in coactivation (i.e., objective ambivalence). Reciprocal activation and coactivation are two possible modes of activation proposed by the ESM. Independent activation by either the positivity or negativity system is also possible. Returning to our voter, the discovery that her original information about the candidate was unfounded may affect her positivity toward the candidate, but will likely not increase (or decrease) her negativity.

4.1. Coactivation

Thus, the ESM proposes that the separability of positivity and negativity at initial levels of processing allows for multiple relationships between the two, characterized as different modes of activation. One hallmark of this proposed feature of the affect system is that it provides a theoretical base for the experience of objective ambivalence. If positivity and negativity can be co-activated rather than simply reciprocally related, under specific theoretically derived circumstances an individual may feel both positive and negative, resulting in a conflict between approach and avoidant behaviors. Consider the case of a gazelle that must approach the water to drink even though its fiercest predator often hunts in that proximity. Coactivation of positivity and negativity may promote approach behavior while maintaining vigilance for a potentially harmful encounter. The conflict between approach and avoidance may result in a high energy state in which resources can be quickly utilized for escape, if necessary. And ultimately, the animal that can simultaneously experience positive and negative affect will have an evolutionary advantage over one that must process serially.

A more mundane example of the utility of coactivation concerns a voter who possesses both positive and negative information about a candidate, and thus faces a difficult decision – to cast her vote for the candidate or a rival. The ESM proposes that situations in which positivity and negativity are co-activated are generally rare and highly arousing, as they provide indeterminant guidance for behavior (Fig. 2). The ability to weigh and simultaneously experience positivity and negativity, however, allows for a flexibility of responding that is critical for adapting to changing environments and need states. Even though objective ambivalence (i.e., the simultaneous experience of positivity and negativity) may be unpleasant, it is arguably critical for human survival.

These examples of coactivation all concern situations in which an individual is simultaneously attending to positive and negative features of a single stimulus or event, which is a form of achieving coactivation that results from *parallel evaluative processing*. A second form of achieving coactivation results from *oscillation*, or the ability to fluctuate between positive and negative stimuli with sufficient speed to produce a sustained activation of both. Russell and Carroll (1999) have long argued that happiness and sadness, which they conceptualize as being opposite ends on a bipolar continuum, cannot occur simultaneously; rather, that individuals may simply oscillate between these two states. In other words, ambivalence is just oscillation between positivity and negativity, happiness and sadness – the two affects do not actually co-occur. We argue that oscillation may simply be a second mechanism for achieving coacti-

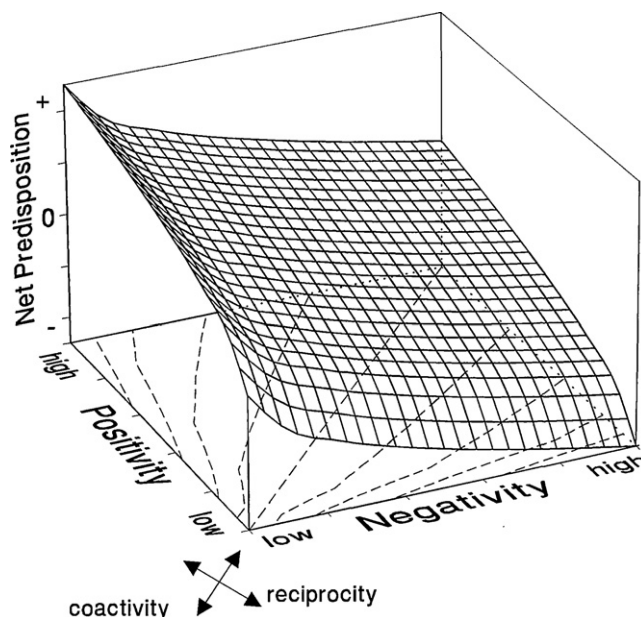


Fig. 2. Illustrative bivariate evaluative space and its associated affective response surface. This surface represents the net predisposition of an individual toward (+) or away from (–) the target stimulus. This net predisposition is expressed in relative units and the axis dimensions are in relative 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 ambivalent) – 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. Adapted from Cacioppo and Berntson (1994).

vation. Affect is “sticky.” A mood or emotional state, once obtained, can be difficult to reverse (Brehm and Miron, 2006; Diener and Iran-Nejad, 1986). When oscillating quickly enough between positivity and negativity, both affects may be activated for an extended period of time, resulting in the experience of a blurred but stable state of coactivation or subjective ambivalence. In other words, if an individual is oscillating between two emotional states at a rate fast enough that the subjective experience is that of ambivalence, the product of oscillation is conceptually identical to that of simultaneous experience. Fast oscillation between happiness and sadness may function much as a low-pass filter, such that high frequency activity (i.e., that of the individual states of positivity and negativity) is removed, leaving behind only the blurred product of the two.

5. Evidence for the coactivation of positivity and negativity

5.1. Behavioral evidence

Larsen et al. (2001) showed that individuals report experiencing subjective ambivalence (i.e., coactivation of positivity and negativity) in specific, theoretically predicted, but atypical situations, such as on the day of their graduation from college. On a normal, average day on campus, however, emotional states conformed to a bipolar configuration, as participants reported some happiness or some sadness, but little to no coactivation of the two. This study is critical for illustrating our position on the structure of evaluative space. The ESM proposes that a bipolar structure of affect provides a stable and efficient guide for how to deal with the world, and

thus this is an organization that dominates our emotional experience under normal circumstances, and toward which we tend to gravitate.

The experience of ambivalence in ecologically valid situations is strong evidence for the coactivation of positivity and negativity. Such field settings, however, often sacrifice experimental control for psychological impact. Larsen et al. (2004) elicited ambivalence in the laboratory environment via a unique set of gamble outcomes in which winning (or losing) the lesser of two amounts (e.g., \$5 instead of \$10) reliably produced simultaneous happiness and sadness. Disappointing wins (and relieving losses) have proven to be a useful tool for studying the experience of ambivalence in the laboratory, and have been used to validate the *evaluative space grid* (ESG), a new measure of affect that directly follows from the theoretical predictions of the ESM (Larsen et al., 2009).

Finally, we have recently found evidence for the role of oscillation in the experience of objective ambivalence (Norris et al., in preparation). Participants viewed pairs of emotional images taken from the International Affective Picture System (IAPS; Lang et al., 1999) that oscillated at either 0.2 Hz or 2 Hz for a duration of 10 s. Participants reported feeling ambivalent following oscillating pairs that included one pleasant picture (e.g., happy couple) and one unpleasant picture (e.g., car accident). Importantly, no ambivalence was reported when participants viewed pairs of matched valence pictures (i.e., two pleasant, two neutral, two unpleasant pictures). In sum, oscillation between two stimuli of opposing valence elicits objective ambivalence much as single stimuli that elicit both positive and negative affect (e.g., a disappointing win) elicit objective ambivalence.

5.2. Neural evidence

Grabenhorst et al. (2007) used fMRI to show that the brain represents not only the overall affective value of a stimulus but also the independent contributions of positivity and negativity to that overall evaluation. Specifically, a complex odor mixture composed of pleasant and unpleasant components elicited activation in both regions associated with representing odor pleasantness (medial OFC) and those representing odor unpleasantness (dorsal ACC, mid OFC). The brain is thus capable of simultaneously representing the positive and negative hedonic value of a complex stimulus, and this ability may contribute to affective decision making.

Grabenhorst et al. (2007) focused on the coactivation of separable neural circuits associated with positivity and negativity (i.e., pleasant and unpleasant odors) that contribute to the overall evaluation of a complex and objectively ambivalent affective stimulus (i.e., an odor mixture). In other words, Grabenhorst and colleagues examined patterns of neural activation in neural networks involved in processing positivity and negativity in response to stimuli that were both positive and negative, or objectively ambivalent. Taking a complementary approach, Cunningham et al. (2003, 2004) examined the neural substrates of objective ambivalence by correlating patterns of brain activation with individuals' ambivalent responses to stimuli. Specifically, participants rated famous names as "good" and/or "bad" on separate scales. Objective ambivalence was calculated from these ratings (Priester and Petty, 1996) and used to predict brain activation. Cunningham et al. (2003) reported that greater ambivalence was associated with increased activation of the right ventrolateral prefrontal cortex (vlPFC; see Cunningham et al., 2004 for a replication). Cunningham et al. (2003) also found this area of vlPFC to be more active when participants made an evaluative (good/bad) versus non-evaluative (past/present) judgment, suggesting that the vlPFC may be critical for evaluative processes. Although these findings do not directly address the separable neural systems that underlie positivity and negativity and

their coactivation during objective ambivalence, they do suggest that objective ambivalence recruits neural areas involved in evaluation, perhaps to reduce the behavioral indeterminacy associated with the coactivation of positivity and negativity.

In sum, the experience of objective ambivalence, or the coactivation of positivity and negativity, is supported by both behavioral and neural data. Behavioral results suggest that although affect may be constrained to a reciprocal organization under most normal circumstances (i.e., increased positivity is associated with decreased negativity), ambivalence does occur in highly evocative, complex emotional situations (e.g., on graduation day; Larsen et al., 2001) and in well-controlled laboratory paradigms (Larsen et al., 2004). Occam's razor, or the law of parsimony, states that "All other things being equal, the simplest solution is the best." Larsen and his colleagues have conclusively demonstrated that, although reciprocal activation may represent the simplest relationship between positivity and negativity, it is not the only possible pattern of activation, and that positivity and negativity can be co-activated under specific, theoretically predicted circumstances. Thus, parsimony is not satisfied by any model of the affect system that posits that positivity and negativity are always reciprocally activated. Furthermore, the relative independence of neural systems for positivity and negativity, their coactivation during the experience of objective ambivalence, and the specificity of function observed by neurotransmitters (e.g., serotonin, dopamine) are supportive of the separability of positivity and negativity, at least at initial underlying levels of processing. The ESM, therefore, provides a more comprehensive approach to understanding the structure of evaluative space.

6. Heterarchical organization across the neuraxis allows for multiple representations

The ESM suggests that affective processes are multiply represented in the brain and spinal cord, but function differently across levels of the neuraxis (i.e., the central nervous system; *heterarchical organization* postulate). Having studied stroke patients who lost the functionality of large areas of cortex yet remained capable of performing fundamental activities (e.g., eating, talking, moving), Jackson (1897) was perhaps the first researcher to clearly articulate the view that functions critical for human survival may be represented in multiple neural structures. The ESM argues that, as differentiating good from bad, appetitive from aversive, helpful from harmful, are critical functions, evaluative processes are instantiated at multiple levels of the neuraxis. The spinal cord produces perhaps the most primitive and gross reflexive response to a stimulus, which is constrained to an approach/withdrawal configuration and specific to inherently noxious stimuli – but is also fast and efficient. At this level of the neuraxis, flexor and extensor muscles are reciprocally coupled, mechanically, so that a limb movement can only be an extension or a flexion (Berntson and Cacioppo, 2003). Even at this level, however, the basic spinal motorneuron circuits are separate and distinct, and hence can be subject to independent, reciprocal, or coactive control. Although there are interneuronal links which tend to promote reciprocal activity (e.g., crossed extension reflex), both flexor and extensor muscles can be simultaneously contracted. In this case, the mechanical bipolar constraints of limb movement belie the greater underlying complexity of neuromuscular systems. At higher levels of the neuraxis, responses become even more flexible, providing the organism with an increasingly sensitive and context-dependent behavioral repertoire (Berntson et al., 1993). Because of the greater information processing capacities and the broader range of output resources, rostral regions of the brain often produce slower, more serial-like response dispositions, and may

implement behavioral output by modulating lower-level reflexes or by direct control of lower motor neurons via descending influences.

The multiple levels of representation of approach and avoidance behaviors allow for different modes of activation to be dominant or prevail depending on the level of representation (Berntson and Cacioppo, 2008; Berntson et al., 2009). At particularly low levels of organization, such as spinal reflexes, responses may be constrained to be reciprocally activated (e.g., flexion/extension responses to painful stimulation such as heat). These low level responses, however, can be overridden via involvement of top-down mechanisms triggered by complex contextual and interpersonal cues (e.g., in the need to walk through fire to save a child). In other words, muscular reflexes may be constrained to a mode of reciprocal activation to provide immediate, automatic, behaviorally rigid responses to stimuli of clear valence and import (e.g., fire and food); whereas higher levels of the neuraxis have the ability to override these dominant responses to produce adaptive, flexible responses that consider the current environment and context.

7. Asymmetries in positivity and negativity

We have argued that the independence of positivity and negativity allows for multiple modes of activation, such that increasing one does not necessarily affect the other, a feature of the affect system that also allows for the coactivation of both positivity and negativity (i.e., the experience of ambivalence). In addition, separable systems for the processing of positivity and negativity allow for differences in how appetitive and aversive stimuli are processed. The ESM suggests that positivity and negativity may be characterized by distinctive activation functions, where an activation function is the relationship between input to a system and output from that system (postulate of *distinct activation functions*). Imagine two audio speakers that are controlled by different volume controls. The speakers can be set so that a one-unit increase in input (i.e., one notch on the volume knob) results in the same change in output (i.e., the same increase in decibels), resulting in symmetry in the speakers' activation functions. The affect system, however, may not be well-served by symmetry in activation functions for positivity and negativity. Rather, as aversive stimuli have arguably stronger implications for survival than do equally appetitive stimuli (e.g., avoiding a predator is more critical than pursuing a mate), the affect system may have evolved to be vigilant for and to produce rapid and strong responses to aversive and potentially harmful stimuli. In other words, a one-unit increase in volume produces a different decibel output for our two hypothetical speakers, such that increasing negativity has a stronger impact than does increasing positivity. This asymmetry is termed the *negativity bias* (see Fig. 3, Table 1).

Positivity, however, promotes exploration and curiosity, behaviors that contribute to knowledge about the world around us and, ultimately, to the resources we obtain. Thus, in the absence of stimulus input to the affect system, the default response may be approach-oriented. Turning again to our speaker metaphor, when the volume on our pair of speakers is turned off, one speaker may continue to produce a low-level output or “hum.” The affect system may have evolved such that in the absence of stimulus input to the system, positivity is stronger than negativity, producing a *positivity offset* (Fig. 3, Table 1) that results in a tendency to approach and explore novel (but neutral) environments.

In sum, the ESM proposes two asymmetries in the activation functions for positivity and negativity: a *negativity bias*, such that strongly aversive stimuli elicit stronger responses than do appetitive, all else being equal; and a *positivity offset*, such that when input to the affect system is absent or minimal, positivity outweighs negativity.

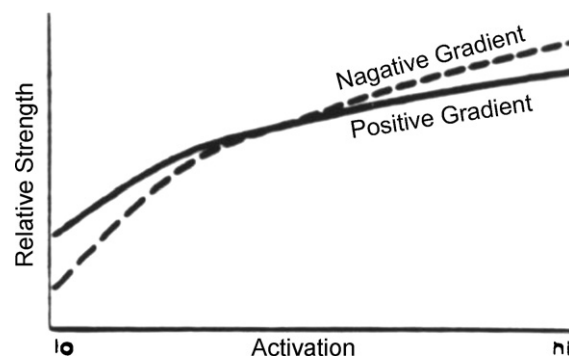


Fig. 3. Activation functions for positive and negative dimensions of affective processing; the x-axis represents affective input, whereas the y-axis represents output of the system. The ESM proposes that there are two asymmetries in affective processing: the positivity offset is the result of greater positive than negative affect at low levels of emotional input; the negativity bias is the result of stronger responses to negative than to equally extreme positive input. Adapted from Cacioppo and Berntson (1994).

8. Evidence for the negativity bias and positivity offset

8.1. Negativity bias

Negativity bias is readily apparent at the lowest level of neural organization. Flexor withdrawal reflexes are the first to emerge developmentally, the first to re-emerge after spinal cord injuries, and the most powerful of spinal reflexes (see Berntson and Cacioppo, 2008). In the past 20 years, multiple review articles have provided strong support for the existence of a negativity bias in emotional responses. Taylor (1991) argued that negative events evoke stronger physiological, cognitive, emotional, and social responses than do neutral or positive events, and that this mobilization of the organism is often followed by a minimization phase, in which the impact of the event is minimized or even erased. Cacioppo et al. (2000) performed a meta-analysis of studies examining physiological responses during experienced emotion states and found that negative emotions did indeed elicit stronger and more reliable physiological responses than did positive emotions. Other reviews have focused on the contributions of the diagnosticity and salience (Baumeister et al., 2001) and the contagion (Rozin and Royzman, 2001) of negative stimuli, such that the presence of a negative entity (e.g., a cockroach) can ruin an otherwise positive entity (e.g., a delicious dinner). Few of these reviews, however, delve into the level of underlying mechanism, and few theories regarding the structure of the affect system can account for a negativity bias.

Kahneman and Tversky (1984) explored the differential impact of positivity and negativity in their studies on framing, showing that losses and gains have different effects on risk-seeking behavior (i.e., individuals are risk averse in the domain of gains and risk seeking in the domain of losses), that a negative frame has a stronger effect on behavior than a positive frame (e.g., “200 of 600 infected people will die” versus “400 of 600 infected people may live”), and that losses loom larger than gains (e.g., a loss of \$100 has a stronger effect on behavior than does a gain of the same amount). Pratto and John (1991) found that negative words (e.g., murder and cancer) elicited stronger Stroop interference than did neutral or positive words, suggesting that the meaning of negative words is automatically processed. Hansen and Hansen (1988; see also Öhman et al., 2001a,b) showed that angry faces “pop out” of a display of distracters, whereas happy faces take longer to be detected and require a more effortful search. Crawford and Cacioppo (2002) found that individuals are better able to implicitly learn a relationship between negative affect and

spatial location than between positive affect and spatial location, suggesting that there is an advantage to learning where to look for danger. In sum, both basic processes, such as attentional capture and implicit learning, and more conscious, deliberate judgments involved in decision making are subject to a bias toward negativity.

Psychophysiological data support a negativity bias in emotional reactivity. James (1884; see also Friedman, *this issue*) first proposed that peripheral psychophysiological responses precede rather than follow a change in emotional state, giving rise to the prediction that distinct emotions (e.g., anger, fear, sadness, happiness, and disgust) ought to be differentiated by unique physiological signatures. In a recent meta-analysis, Cacioppo et al. (2000) found that, although strong support for the psychophysiological differentiation of distinct emotions is ultimately lacking, negative and positive emotional states are distinguished by both facial and visceral responses (with the exception of skin conductance and cutaneous blood flow), such that negative states elicit stronger responses than do positive. Furthermore, negative emotions were generally associated with stronger responses of the autonomic nervous system (ANS) than were positive emotions. Interestingly, we recently found that even though skin conductance does not typically distinguish between positive and negative affective states, as it is a measure of arousal and not of valence, individuals high in neuroticism exhibited marginally stronger skin conductance reactivity to unpleasant than pleasant pictures (Norris et al., 2007). This finding is consistent with a negativity bias in physiological responding for some individuals – we return to a discussion of individual differences below.

Researchers have begun to use other measures, such as event-related brain potentials (ERPs) and functional magnetic resonance imaging (fMRI) to further investigate the mechanisms underlying the negativity bias. Using ERPs, Ito et al. (1998) found evidence for a negativity bias in the evaluative categorization stage of processing (i.e., deciding a stimulus is good or bad), as indexed by the late positive potential (LPP), a positive-going component maximal over central midline sites at approximately 500 ms post-stimulus onset that is sensitive to context violations. Ito et al. (1998) not only reported a larger LPP to context-inconsistent visual scenes (e.g., an emotionally evocative target picture presented in the context of many neutral pictures), but also found that the LPP was larger to unpleasant than to equally frequent, arousing, and extreme pleasant target pictures. Furthermore, Ito and Cacioppo (2000) showed that the LPP is also sensitive to implicit categorization, such that even when participants categorized stimuli on a non-evaluative dimension (e.g., people/no people), a negativity bias emerged in the LPP. These findings indicate that even when processed indirectly, negativity has a stronger effect on neural responses than does positivity.

Additional ERP research has shown that the negativity bias emerges at even earlier stages of processing than the relatively late LPP. Smith et al. (2003, 2006) focused on early attentional components of the ERP, and found evidence for a negativity bias in the P1, a positive-going component maximal over occipital sites at about 120 ms post-stimulus onset. The P1 is larger to contextually primed stimuli, as well as to negative visual stimuli, suggesting that aversive stimuli may be “chronically primed,” a finding consistent with research on selective attention to aversive or threatening stimuli (e.g., Bradley et al., 2003). It is worth noting that the negativity bias in the P1 can be eliminated, but only by making positive stimuli more accessible (i.e., attention to positivity can be increased, but attention to negativity cannot be decreased; Smith et al., 2006). Carretié et al. (2001b) found that the P200, another attention-related ERP component, had higher amplitudes and shorter latencies for negative than positive stimuli. The P200 negativity bias was replicated and extended in a subsequent

paper, in which Carretié et al. (2001a) argue that an expectancy bias toward negative stimuli (i.e., pre-stimulus onset, a larger frontal N280 is observed for cues indicating a subsequent negative target) gives way to an initial, rapid and brief “early” attentional response to negative stimuli (i.e., post-stimulus P200), which is followed by a slower but longer “late” attentional response to positive stimuli (i.e., post-stimulus P340; see also Carretié et al., 2004). Importantly, the purpose of these responses is thought to differ, with the earlier bias toward negativity focused on rapid motor action, and the later bias toward positivity aimed at deeper levels of processing. Furthermore, source localization analyses of the two ERP components exhibiting a negativity bias in attention revealed possible neural substrates, with the anterior cingulate cortex (ACC; BA 32) implicated in expectancy-related effects and the visual association cortex implicated in the early attentional bias toward negative stimuli.

Source localization analyses of electrocortical activity collected from the scalp, however, are an indirect index of neural correlates. Using fMRI as a more direct index of neural activity, we have recently conducted multiple studies examining the neural correlates of the negativity bias. Participants viewed pleasant and unpleasant pictures that were matched on both psychological (e.g., extremity and arousal) and physical (e.g., spatial frequency, color, and complexity) dimensions while full brain volumes were acquired. In three studies, individuals showed greater activation of the right visual association cortex (e.g., BA 19, extending to BA 39) to unpleasant than to equally extreme and arousing pleasant pictures (Norris and Cacioppo, *in preparation*). Importantly, when auditory stimuli were used in lieu of pictures, neural activation indicating a negativity bias moved from visual association cortex to auditory association cortex (e.g., BA 22), suggesting both that (a) the negativity bias generalizes to other modalities, and (b) emerges at the same level of processing regardless of stimulus type. In addition, one study also revealed a negativity bias in neural activity in the ACC, consistent with source localization results from Carretié et al. (2001a,b, 2004). Other studies using PET (Fredrikson et al., 1993; Kosslyn et al., 1996) and fMRI (Mourão-Miranda et al., 2003) have produced similar results. In sum, evidence from both source-localized ERPs (Carretié et al., 2001a,b, 2004) and from fMRI (Norris and Cacioppo, *in preparation*) is consistent with a negativity bias in early stages of attention. It remains to be seen how this early attentional bias toward negativity produces the broad mobilization of behavior observed toward aversive and potentially harmful stimuli.

Finally, Cunningham et al. (2008) have shown a negativity bias in amygdala activation to stimuli that contain both positivity and negativity. Cunningham and his colleagues asked participants to either (a) indicate their attitude toward a famous person using a 4-point valence scale ranging from *very negative* to *very positive*, (b) focus on their positive responses to that individual and respond on a 4-point positivity scale ranging from *not at all positive* to *very positive*, or (c) focus on their negative responses to that individual and respond on a 4-point negativity scale ranging from *not at all negative* to *very negative*. Results indicated that although the amygdala was activated when participants made overall attitude judgments of both positive and negative stimuli, amygdala activation was also affected by motivational frame. When asked to focus on negativity or positivity, amygdala activation was strongest to negative and positive stimuli, respectively. A negativity bias was observed, however, in that the amygdala was still responsive to negative stimuli even when participants were focusing on their positive feelings. Given recent theories that the amygdala responds to motivationally relevant stimuli (Norris et al., 2004; Cunningham et al., 2008; Sander et al., 2003) and ERP findings supporting the implicit processing of negativity (Ito and Cacioppo, 2000), this pattern of findings suggests that negative

stimuli remain significant even when an individual is focused elsewhere.

8.2. Positivity offset

As with the negativity bias, a positivity offset can be seen at the level of spinal reflexes. Although flexor withdrawal reflexes predominate at higher stimulus intensities, lower level stimuli predominantly trigger extensor, approach, and engagement responses (see *Berntson and Cacioppo, 2008*). As with the negativity bias, many findings in the field of social psychology provide some evidence for a similar positivity offset, or the tendency for positivity to outweigh negativity when little information (or input to the affect system) is available. *Zajonc (1968)* showed that under conditions of mere exposure – when a stimulus has simply been observed more frequently, all else remaining equal – exposure increases liking of a stimulus (e.g., Chinese ideographs, nonsense words). *Zajonc (1968)* also showed that positive words (e.g., good, happy, and clean) are used more frequently than their negative counterparts (e.g., bad, sad, and dirty; see also research on the *Pollyanna hypothesis, Boucher and Osgood, 1969*). The person perception literature has repeatedly shown that individuals express mild liking of unknown others. Originally termed the person-positivity bias (*Sears, 1983*), this robust finding has recently been extended to targets that are not human, including fish and insects (*Cacioppo et al., 1997*). Furthermore, research on egotistic optimism has shown that individuals predict that they will experience more positive than negative outcomes in the upcoming week (*Pulford and Colman, 1996*), attribute lower health risks to themselves than others (*Hoorens and Buunk, 1993*), and expect that joining an extracurricular group will have more rewards than costs for themselves than for others (*Brinthaup et al., 1991*). Returning to studies on loss aversion (*Kahneman and Tversky, 1984*), *Harinck et al. (2007)* recently showed that although losses do loom larger than gains for larger outcomes (e.g., losing €150 versus finding €150), gains loom larger than losses for smaller outcomes (e.g., finding €0.10 versus losing €0.10). These results are consistent with the operation of both a positivity offset at relatively low levels of affective input and a negativity bias at relatively high levels of affective input.²

In sum, research on emotional responses from many different perspectives is consistent with the functioning of a positivity offset, such that under conditions in which little to no affective information is available (e.g., when encountering a novel stimulus or person, making predictions about our own uncertain futures, or responding to a mild and un consequential gain or loss), positivity outweighs negativity. Indeed, *Diener and Diener (1996)* have argued that the normative human experience involves a basal level of positive affect. Emerging research and theory suggests that a subjective well-being “set point” may (a) be set for most individuals such that the default emotional state is slightly positive (e.g., *Diener and Diener, 1996*), and (b) function such that following aversive events the set point is re-attained more quickly than expected (e.g., *Gilbert et al., 1998*). This well-being “set point” may function much like a weight set point, such that although differences across individuals exist, it is relatively difficult to maintain a state beyond a range immediately surrounding one’s individual set point.

² Note that the ESM is agnostic regarding the definitive levels of intensity (or input to the affect system) required to produce a positivity offset versus negativity bias. Given the flexibility of the affect system to adjust to different environments, these intensity thresholds may change to accommodate different ranges of input. Thus, a positivity offset is expected to emerge at relatively low intensity levels within a context, whereas the negativity bias is expected to emerge at relatively high intensity levels with the same context.

8.3. Calibration of the affect system

To maintain flexibility in multiple contexts and ecological niches, the affect system may have evolved to function in ways similar to the visual system, such that affective processes may adapt to differing emotional contexts much as the eye adapts to contexts differing in brightness. When entering a darkened room from a bright summer day the pupil must adjust (i.e., dilate) to the new environment in order to remain sensitive to small changes in light. This adjustment is performed automatically, and allows us to catch enough light to sustain vision; but also comes at a cost, as image quality is sacrificed. We argue that the affect system may perform the same kind of calibration as a function of different emotional contexts (see *Kahneman, 1999* for a similar argument; *recalibration* postulate). Specifically, the negativity bias will ensure that an individual remains vigilant for aversive stimuli and the positivity offset will provide some basis for exploration and curiosity, regardless of the emotional context, whether the environment is safe and familiar or dangerous and unknown.

One possible mechanism by which the affect system may calibrate is that of contrast, or the effects of preceding or surrounding stimuli on our interpretation of a target stimulus. Returning to the visual analogy, *Hong and Shevell (2008)* have studied the neural correlates of chromatic contrast, by which a single color swatch appears to change its hue depending on its surroundings. *Sandusky and Parducci (1965)* found that neutral odors were rated as more pleasant when they followed unpleasant versus pleasant odors, suggesting that a neutral stimulus is rendered either pleasing or displeasing depending on the effects of a preceding stimulus. *Parducci (1968)* also found evidence for an affective contrast effect in the moral realm, as participants rated the act of poisoning a neighbor’s dog more objectionable when it was preceded by more despicable acts (e.g., the murder of a parent) versus less despicable acts (e.g., stealing towels from a hotel). The fact that both our basic sensory processes like color vision and odor perception and our moral decisions can be affected by arguably irrelevant contextual stimuli is a strong argument for the importance of contrast in multiple domains.

Although many researchers have argued that affective contrast may be a result of a response bias, such that participants feel required to use the entire span of a rating scale, recent findings argue against this. *Larsen and Norris (2009)* found that moderately pleasant stimuli elicit stronger decreases in EMG activity over *corrugator supercilii* when included in a set with mildly pleasant stimuli than in a set with extremely pleasant stimuli. In other words, when presented alongside less positive images, moderately positive images become more rewarding and pleasant, but when presented in the context of extremely positive images, those same pictures become less rewarding and more neutral. *Reynolds and Berridge (2008)* found in rats that context (i.e., stressful versus preferred home environments) can affect the function of the nucleus accumbens, tuning the neural structure to generate more defensive or appetitive behaviors. Finally, *Foti and Hajcak (2008)* used contextual sentences to manipulate participants’ perceptions of emotional images (e.g., a picture of a car accident accompanied by the statement “The set was dressed for the next scene of filming”). *Foti and Hajcak (2008)* found that contextual sentences manipulated emotional responses, reflected in both self-reports and ERPs. Emotional processes are clearly very sensitive to context; we simply argue that the affect system has evolved to take context into consideration.

9. Individual differences in the negativity bias and positivity offset

The Evaluative Space Model suggests that asymmetries in the activation functions for positivity and negativity have evolved

over time to provide certain adaptive advantages, such that the positivity offset promotes exploration and discovery whereas the negativity bias provides vigilance for aversive and potentially harmful stimuli. As these asymmetries are thought to be adaptive, most individuals should exhibit evidence of both a negativity bias and positivity offset. However, as variance is the engine of evolution, individual differences in the magnitude of the negativity bias and positivity offset should exist, be stable over time, generalize across different types of stimuli, and predict behavior (*affective dispositions* postulate, Table 1). The summary of literature providing support for the functioning of a negativity bias and positivity offset reveals that these asymmetries do affect emotional judgments toward a broad variety of stimuli under diverse conditions. Yet, little research has directly examined individual differences in these proposed operating characteristics of the affect system.

Ito and Cacioppo (2005) measured individuals' responses to emotional pictures and found strong support for both a negativity bias and positivity offset at the normative level in their sample. Furthermore, the magnitude of both features differed across individuals, was normally distributed in the sample, and was stable over about 2 weeks. Importantly, both the negativity bias and positivity offset predicted judgments on an unrelated impression formation task, such that individuals with higher positivity offsets made more positive judgments about an unknown other when given only neutral information (e.g., "Sam was exposed to sunlight"), and individuals with higher negativity biases made more negative judgments about the target when provided with negative behavioral information (e.g., "Sam stole vegetables from his neighbor's garden"). In a recent replication and extension of this work, we have found that not only do individual differences in the negativity bias and positivity offset exist, but they also generalize across different modalities (e.g., visual, auditory) and types of stimuli (e.g., pictures, words), are relatively stable over a 1-year period, and predict implicit learning of relationships between affect and space (Norris et al., in preparation). Specifically, participants are exposed to a correlation between affect (e.g., pictures ranging from neutral to very unpleasant or from neutral to very pleasant) and spatial location, such that unpleasant images tend to appear toward the top of the computer screen ($r = .5$) or, in a separate version of the task, pleasant images tend to appear toward the right of the screen ($r = .5$). Results consistently show that participants are better at learning the relationship between negativity and space than that between positivity and space (Crawford and Cacioppo, 2002), and individual differences in both the negativity bias and the positivity offset predict implicit learning on this task (Norris et al., in preparation). Finally, individual differences in the negativity bias predicted patterns of neural activation to affective stimuli, such that individuals with a higher negativity bias show even greater activation of association cortices (visual for pictures, auditory for sounds) to unpleasant than to pleasant pictures (Norris and Cacioppo, in preparation). The observed relationship between neural activation and individual differences in the negativity bias provides strong evidence for the conclusion that the negativity bias is driven at least in part by greater attention to unpleasant stimuli than to pleasant stimuli, at least at early stages of processing. In sum, individual differences in the negativity bias and positivity offset may have far-reaching consequences for how we learn about and respond to stimuli in the environment.

10. Implications for understanding affective disorders

One consequence of variance in emotional processes across individuals is that studying individual differences may clarify the key processes that bring about the expression of symptoms of affective disorders (i.e., pervasive sadness and anhedonia). Individual

differences in the features of affective processing that are postulated by the ESM, such as the positivity offset and negativity bias and the independent contributions of positivity and negativity to emotional states, may shed light on the mechanisms by which emotion processes become disordered. Although we argue that both the positivity offset and negativity bias are adaptive, research has made it clear that individuals differ in the magnitude of these asymmetries. Such individual differences in the positivity offset and negativity bias may predict whether an individual is prone to experience depression or anxiety. A similar argument has been made by Watson et al. (1988), who have suggested that although both depression and anxiety are characterized by increased negative affect, they can be distinguished by the addition of decreased positive affect in depression. The ESM differs from earlier perspectives in that it describes multiple features of affective processes that may affect mental health, including the calibration process, the independence of positivity and negativity, the "stickiness" of affect, and both the negativity bias and positivity offset. In addition, the ESM suggests that affective disorders may be characterized by dysregulation at specific levels of the neuraxis, and that the levels affected may differ across individuals. We now turn to detailed discussion of a select set of these hypotheses.

First, the ESM suggests that positivity and negativity are functionally separable at initial stages of processing. Unlike many models of emotion which assume that positivity/happiness and negativity/sadness are opposite ends of a single bipolar continuum, the ESM allows for independent contributions of positivity and negativity to emotional states and to approach/avoidance behavior. Research by Davidson and his colleagues (cf. 2004) has supported this conclusion, as they have long shown that positive and negative affect are associated with differential patterns of electrocortical activity over the prefrontal cortex, suggesting that positivity and negativity may rely on separable neural systems and may differentially contribute to the development of affective disorders. Individuals who exhibit greater relative left frontal electroencephalographic (EEG) activity tend to experience more positive affect in their lives (Tomarken et al., 1992), respond with more extreme positive affect following a positive mood induction (Wheeler et al., 1993), and have greater behavioral activation system (BAS) sensitivity (Sutton and Davidson, 1997). In comparison, individuals who exhibit greater relative right frontal EEG activity experience more negative affect, respond to a negative mood induction with more negative affect, and report greater BIS sensitivity. In addition, patients diagnosed with major depressive disorder (MDD) show relatively less left than right prefrontal EEG activity. Finally, prefrontal EEG asymmetry is predictive of pharmacological treatment response (Bruder et al., 2001) and covaries with genetic risk for depression (Smit et al., 2007), suggesting that resting prefrontal asymmetry reflects a stable diathesis (i.e., endophenotype) for the development of depression (Allen et al., 2004).

Although the motivational processes of positivity and negativity often correspond to a person's approach or avoidance responses, clear dissociations are also possible (Blanchard and Blanchard, 1969, 1988; Löw et al., 2008). Recent work has suggested that frontal EEG asymmetry, for instance, appears to be more closely associated with the proximal approach/avoidance response than the distal motivational goal (i.e., appetite, aversion). Indeed, Harmon-Jones and Allen (1998) have argued that the critical variable in research on frontal EEG activity is not positivity/negativity but rather the organization of the motor system to approach or avoidance. Supporting evidence for this contention comes from a series of studies investigating the relationship between prefrontal cortical activity and anger, a negative emotion with an approach orientation (Carver and Harmon-Jones, 2009). Individuals with higher trait anger show greater left relative resting EEG activity (Harmon-Jones and Allen, 1998), individuals who are insulted in the

laboratory show greater left relative EEG activity (Harmon-Jones and Sigelman, 2001), and a direct manipulation of approach motivation (i.e., ability to cope) within an anger manipulation has shown that greater coping ability is related to greater left relative EEG activity (Harmon-Jones et al., 2003). Thus, frontal EEG asymmetry appears to more strongly reflect behavioral predispositions (i.e., approach/avoidance) than motivational organization (see Harmon-Jones et al., *this issue*). Importantly, frontal regions of the cortex include areas involved in response selection, preparation, and execution (e.g., supplementary motor area), consistent with the idea that frontal EEG asymmetry reflects the proximal behavioral orientation. The implication is that frontal EEG may be a sensitive measure of the approach/avoidance orientation of behavioral preparedness but not of the motivational processes addressed in the ESM. Regardless, research using frontal EEG has underscored the utility of studying the independence of positivity and negativity – as well as that of approach and avoidance – for understanding emotions such as anger as well as mental health disorders such as depression.

The separability of positivity and negativity contributes to the flexibility of the affect system, which allows for adaptive responses in highly variable and changing environments. The independence of positivity and negativity, however, also allows for multiple forms of dysregulation involving one or both of these systems. Heightened sensitivity to negativity may give rise to anxiety or depression, depending on positive functioning. If positivity is intact, anxiety may result; if positivity is diminished, depression may result (Watson and Tellegen, 1985). Manic states may occur when sensitivity to positivity is heightened, regardless of the function of negativity. The ESM therefore suggests that understanding the component processes that give rise to emotion is necessary for distinguishing between different forms of emotional disorders. One implication of this suggestion is that knowing how the component processes are dysregulated in depression, for example, will provide clinicians with a more focused approach to treatment. Consider two depressed individuals, one extremely dysphoric and anxious, the other characterized by decreased positivity (i.e., lack of enjoyment in activities that were previously pleasurable). If the component affective processes differ between these individuals, such that the former is characterized by heightened sensitivity to negativity and the latter by decreased sensitivity to positivity, the therapist can elect the most effective course of treatment for each. Thus, understanding the component processes of affect has implications for both diagnosis and treatment of emotional disorders.

Second, the negativity bias and positivity offset are the products of the component processes of positivity and negativity. Therefore, it is to be expected that individual differences in these asymmetries may also contribute to the development of emotional disorders. Although we argue that a negativity bias is adaptive, in that it fosters vigilance for potentially harmful events (even over the possibility of a beneficial experience, like finding food or a mate), heightened sensitivity to negativity and decreased responding to positivity might produce an overly large negativity bias that may result in behavioral paralysis. If one expects nothing but the worst at all times, the world becomes a dangerous, hostile place. The ESM, however, distinguishes between responses to extremely evocative stimuli and mildly emotional stimuli, toward which positivity is thought to be greater than negativity. A second possibility in depression is that, if positivity is decreased across the board, individuals may fail to experience a positivity offset. Importantly, as depression is a disorder with a broad range of symptoms and causes, disorders of affective processes will differ greatly across individuals. Thus, the magnitudes of both the negativity bias and the positivity offset are critical for understanding the pathology of emotional disorders.

Much research supports the hypothesis that both anxiety and depression are characterized by strong biases toward negative (and particularly threatening) information. Anxious individuals in particular tend to show greater interference to negative stimuli on the Stroop color-naming task, whether stimuli are anxiety-related (Richards et al., 1992) or threat-related (Dalgleish, 1995; Amir et al., 1996). Depressed individuals have also exhibited increased Stroop interference for negative – and particularly sad – words (Williams and Nulty, 1986). Furthermore, a recent neuroimaging study has shown that the rostral anterior cingulate cortex (ACC), a region previously implicated in cognitive interference and the Stroop interference effect more specifically (Bush et al., 2000), was more active in depressed individuals on sad than neutral Stroop trials, and activation of the rostral ACC correlated with color-naming latencies of sad words in depressed patients (Mitterschiffthaler et al., 2008). In sum, research on depressed and anxious individuals using the emotional Stroop task supports the ESM's prediction that both depression and anxiety disorders may be characterized by a larger negativity bias.

Studies using the dot probe paradigm, in which participants first see two faces (one on the left, one on the right) and then indicate the position of a dot that follows (i.e., left or right), have also revealed a bias toward negative information in anxiety and depression. High trait anxious individuals show an attention bias toward angry (and sometimes fearful; Mogg et al., 2007) faces (Mogg and Bradley, 1999; Bradley et al., 1999, 2000; Pishyar et al., 2004), this bias can be observed in 7- to 12-year olds with generalized anxiety disorder (although they also show a bias for happy faces; Waters et al., 2008) and in teenagers with high but subclinical trait anxiety levels (Telzer et al., 2008), and this bias may be more specific to social anxiety than to other forms (Mogg and Bradley, 2002). The attentional bias toward threatening faces observed in anxious individuals is accompanied by an enhanced N2pc (i.e., posterior N2, associated with attentional selection; Eimer, 1996) component of the ERP (Fox et al., 2008), as well as by increased activation of the right dorsolateral PFC (Telzer et al., 2008). Together, these findings suggest that the negativity bias in anxiety is subserved by both selective attention to and greater attention demand for threatening faces.

Additional neuroimaging studies examining threat bias in anxious individuals have implicated the amygdala, such that individuals with generalized social phobia exhibit greater activation of the amygdala to negative (i.e., fearful, angry, disgusted) than to positive (i.e., happy) faces (Phan et al., 2006), amygdala activation to fearful faces in adolescents correlates with social dimensions of anxiety, including peer rejection and humiliation (Killgore and Yurgelun-Todd, 2005), and children with anxiety disorders show greater amygdala activation to fearful faces than do normal controls (Thomas et al., 2001). These studies suggest that anxiety disorders (and social anxiety in particular) may increase the relevance of threat-relevant social stimuli, as the amygdala has been implicated in processing stimuli of biological importance (Sander et al., 2003).

Depression also biases attention toward threatening faces on the dot-probe task, such that individuals with major depressive disorder (MDD) show maintained attention to angry faces as opposed to neutral faces (Leyman et al., 2007), and this bias seems to persist even following treatment for depression (Joormann and Gotlib, 2007). Furthermore, depressed patients show greater activation of the amygdala to sad faces than do healthy controls (Neumeister et al., 2006; Fu et al., 2008), and amygdala activation to sad (Fu et al., 2004) and masked fearful (Sheline et al., 2001) faces decreases with treatment for depression. This pattern of amygdala activation can be seen in at-risk adolescents as well, suggesting that increased amygdala reactivity to negative facial expressions may reflect vulnerability for major depression (Monk et al., 2008). Finally, depressed individuals exhibit a predisposition to interpret

neutral faces as negative, and this negative interpretation bias correlates with amygdala reactivity (Dannowski et al., 2007).

Comparing the patterns of data for anxious and depressed participants, one might conclude that the attentional bias toward negative faces is similar if not identical in the two disorders, with the possible exceptions that the bias tends to be stronger for “threatening” expressions in anxiety (i.e., anger) and for sad expressions in depression. Examining effects for happy faces, however, delineates the two affective disorders. Whereas anxiety does not seem to be associated with any specific pattern of responses to happy faces, adolescents at risk for depression show decreased activation of the nucleus accumbens when viewing happy faces (Monk et al., 2008), depressed adults require higher intensity expressions to correctly identify happiness (Joormann and Gotlib, 2006), depressed adults show superior memory for sad faces and inferior memory for happy faces (Ridout et al., 2003), and depressive mood is associated with longer response times to finding a happy face in a crowd of distractors, suggesting that attention to happy facial expressions is reduced in depression (Suslow et al., 2001). In sum, although an attentional bias toward negative faces is observed in both anxiety and depression, only depressed participants also exhibit a concomitant difficulty in attending to, processing, and remembering positive faces. The ESM predicts and provides a theoretical explanation for this pattern of results, as well as imparting a framework for the study of the affective mechanisms that underlie affective disorders.

11. Future directions and remaining questions

We have here reviewed the current status of research on the structure of evaluative space. The principles of the ESM provide a road map for future investigations in multiple arenas, such as testing theories of the mechanisms underlying emotional disorders and examining the relationships between feeling states and physiological responses. The ESM's *postulate of functional separability*, which states that positivity and negativity are independent at underlying stages of processing, gives rise to a series of unique predictions regarding both healthy and dysregulated emotional processes. For example, the ESM predicts that at low levels of affective input, positivity outweighs negativity (the *positivity offset*), and at relatively high levels of affective input, negativity outweighs positivity (the *negativity bias*). An important corollary of these predictions is that a thorough understanding of emotional processes requires observation at multiple levels of input – it is not enough to look at responses to extreme stimuli. Applied to the theories of depression, the ESM might therefore suggest that depression could result from (a) strong responses to very aversive stimuli, (b) weak responses to very appetitive stimuli, (c) strong responses to mildly aversive stimuli, (d) weak responses to mildly appetitive stimuli, or (e) some combination of the above. The pattern of responding observed for an individual may be critical for treatment of the disorder, and may also shed light on the nature of comorbidities (e.g., with anxiety disorders or substance abuse).

Furthermore, the ESM has implications for psychophysiological and neuroscience research. Existing evidence supports the utility of approaching the study of basic emotional processes from a dimensional approach, as both physiological (e.g., ANS function; Cacioppo et al., 2000) and neural (cf. Wager et al., 2003) data differentiate between positive and negative affective states. Research on the positivity offset and negativity bias predicts that responses to equally extreme pleasant and unpleasant stimuli may have unequal effects on physiological reactivity. In addition, the *heterarchical organization* postulate suggests that limiting the study of emotional responses to one level of the neuraxis, such as basic reflexes (e.g., emotion-modulated startle response) or cortical activation (e.g., ERPs and fMRI), will fail to truly capture the full spectrum of reac-

tivity of the affect system. In sum, the postulates of the Evaluative Space Model have the ability to direct and guide future research on the structure of affective space, as well as its representation in the brain and body and, ultimately, its implications for affective disorders.

References

- Allen, J.J., Urry, H.L., Hitt, S.K., Coan, J.A., 2004. The stability of resting frontal electroencephalographic asymmetry in depression. *Psychophysiology* 41, 269–280.
- Amir, N., McNally, R.J., Riemann, B.C., Burns, J., 1996. Suppression of the emotional stroop effect by increased anxiety in patients with social phobia. *Behaviour Research and Therapy* 34, 945–948.
- Baumeister, R.F., Bratslavsky, E., Finkenauer, C., Vohs, K.D., 2001. Bad is stronger than good. *Review of General Psychology* 5, 323–370.
- Berntson, G.G., Boysen, S.T., Cacioppo, J.T., 1993. Neurobehavioral organization and the cardinal principle of evaluative bivalence. In: Crinella, F.M., Yu, J. (Eds.), *Brain Mechanisms: Papers in Memory of Robert Thompson*. New York Academy of Sciences, New York, NY, US, pp. 75–102.
- Berntson, G.G., Cacioppo, J.T., 2003. A contemporary perspective on multilevel analyses and social neuroscience. In: Kessel, F., Rosenfield, P.L., Anderson, N.B. (Eds.), *Expanding the Boundaries of Health and Social Science: Case Studies in Interdisciplinary Innovation*. Oxford University Press, New York, NY, US, pp. 18–40.
- Berntson, G.G., Cacioppo, J.T., 2008. The functional neuroarchitecture of evaluative processes. In: Elliot, A.J. (Ed.), *Handbook of Approach and Avoidance Motivation*. Psychology Press, New York, NY, US, pp. 307–321.
- Berntson, G.G., Norman, G.J., Cacioppo, J.T., 2009. Evaluative processes. In: Berntson, G.G., Cacioppo, J.T. (Eds.), *Handbook of Neuroscience for the Behavioral Sciences*. Wiley, Hoboken, NJ.
- Berridge, K.C., 1996. Food reward: brain substrates of wanting and liking. *Neuroscience of Biobehavior Review* 20, 1–25.
- Blanchard, D.C., Blanchard, R.J., 1988. Ethoexperimental approaches to the biology of emotion. *Annual Review of Psychology* 39, 43–68.
- Blanchard, R.J., Blanchard, D.C., 1969. Passive and active reactions to fear-eliciting stimuli. *Journal of Comparative and Physiological Psychology* 68, 129–135.
- Boucher, J., Osgood, C.E., 1969. The pollyanna hypothesis. *Journal of Verbal Learning & Verbal Behavior* 8, 1–8.
- Bradburn, N.M., 1969. *The Structure of Psychological Well-being*. Aldine, Oxford, England.
- Bradley, B.P., Mogg, K., Millar, N.H., 2000. Covert and overt orienting of attention to emotional faces in anxiety. *Cognition & Emotion* 14, 789–808.
- Bradley, B.P., Mogg, K., White, J., Groom, C., de Bono, J., 1999. Attentional bias for emotional faces in generalized anxiety disorder. *British Journal of Clinical Psychology* 38, 267–278.
- Bradley, M.M., Sabatinelli, D., Lang, P.J., Fitzsimmons, J.R., King, W., Desai, P., 2003. Activation of the visual cortex in motivated attention. *Behavioral Neuroscience* 117, 369–380.
- Brehm, J.W., Miron, A.M., 2006. Can the simultaneous experience of opposing emotions really occur? *Motivation and Emotion* 30, 13–30.
- Breiter, H.C., Aharon, I., Kahneman, D., Dale, A., Shizgal, P., 2001. Functional imaging of neural responses to expectancy and experience of monetary gains and losses. *Neuron* 30, 619–639.
- Brinthaup, T.M., Moreland, R.L., Levine, J.M., 1991. Sources of optimism among prospective group members. *Personality and Social Psychology Bulletin* 17, 36–43.
- Bruder, G.E., Stewart, J.W., Tenke, C.E., McGrath, P.J., Leite, P., Bhattacharya, N., Quitkin, F.M., 2001. Electroencephalographic and perceptual asymmetry differences between responders and nonresponders to an SSRI antidepressant. *Biological Psychiatry* 49, 416–425.
- Bush, G., Luu, P., Posner, M.I., 2000. Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences* 4, 215–222.
- Cacioppo, J.T., Berntson, G.G., 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.
- Cacioppo, J.T., Berntson, G.G., 1999. The affect system: architecture and operating characteristics. *Current Directions in Psychological Science* 8, 133–137.
- Cacioppo, J.T., Berntson, G.G., Larsen, J.T., Poehlmann, K.M., Ito, T.A., 2000. The psychophysiology of emotion. In: Lewis, R., Haviland-Jones, J.M. (Eds.), *The Handbook of Emotion*, 2nd edition. Guilford Press, New York, pp. 173–191.
- Cacioppo, J.T., Berntson, G.G., Norris, C.J., Gollan, J.K., in press. The evaluative space model: functional structure and operating characteristics of the affect system. In: Van Lange, P., Kruglanski, A., Higgins, E.T. (Eds.), *Handbook of Theories of Social Psychology*. Sage Press, Thousand Oaks, CA.
- Cacioppo, J.T., Gardner, W.L., Berntson, G.G., 1997. Beyond bipolar conceptualizations and measures: the case of attitudes and evaluative space. *Personality and Social Psychology Review* 1, 3–13.
- 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, 839–839.
- Canli, T., 2006. *Biology of Personality and Individual Differences*. Guilford Press, New York, NY, US.
- Carretié, L., Hinojosa, J.A., Martín-Loeches, M., Mercado, F., Tapia, M., 2004. Automatic attention to emotional stimuli: neural correlates. *Human Brain Mapping* 22, 290–299.

- Carretié, L., Martín-Loeches, M., Hinojosa, J.A., Mercado, F., 2001a. Emotion and attention interaction studied through event-related potentials. *Journal of Cognitive Neuroscience* 13, 1109–1128.
- Carretié, L., Mercado, F., Tapia, M., Hinojosa, J.A., 2001b. Emotion, attention and the "negativity bias," studied through event-related potentials. *International Journal of Psychophysiology* 41, 75–85.
- Carver, C.S., Harmon-Jones, E., 2009. Anger is an approach-related affect: evidence and implications. *Psychological Bulletin* 135, 183–204.
- Crawford, L.E., Cacioppo, J.T., 2002. Learning where to look for danger: integrating affective and spatial information. *Psychological Science* 13, 449–453.
- Cunningham, W.A., Johnson, M.K., Gatenby, J.C., Gore, J.C., Banaji, M.R., 2003. Neural components of social evaluation. *Journal of Personality and Social Psychology* 85, 639–649.
- Cunningham, W.A., Raye, C.L., Johnson, M.K., 2004. Implicit and explicit evaluation: fMRI correlates of valence, emotional intensity, and control in the processing of attitudes. *Journal of Cognitive Neuroscience* 16, 1717–1729.
- Cunningham, W.A., Van Bavel, J.J., Johnsen, I.R., 2008. Affective flexibility: evaluative processing goals shape amygdala activity. *Psychological Science* 19, 152–160.
- Dalgleish, T., 1995. Performance on the emotional stroop task in groups of anxious, expert, and control subjects: a comparison of computer and card presentation formats. *Cognition & Emotion* 9, 341–362.
- Dannlowski, U., Ohrmann, P., Bauer, J., Kugel, H., Arolt, V., Heindel, W., et al., 2007. Amygdala reactivity to masked negative faces is associated with automatic judgmental bias in major depression: a 3 T fMRI study. *Journal of Psychiatry & Neuroscience* 32, 423–429.
- Darwin, C., 1872. *The Expression of the Emotions in Man and Animals*. Oxford University Press, New York, NY.
- Davidson, R.J., 2004. What does the prefrontal cortex "do" in affect: perspectives on frontal EEG asymmetry research. *Biological Psychology* 67, 219–233.
- Diener, E., Diener, C., 1996. Most people are happy. *Psychological Science* 7, 181–185.
- Diener, E., Iran-Nejad, A., 1986. The relationship in experience between various types of affect. *Journal of Personality and Social Psychology* 50, 1031–1038.
- Eimer, M., 1996. The N2pc component as an indicator of attentional selectivity. *Electroencephalography & Clinical Neurophysiology* 99, 225–234.
- Ekman, P., Friesen, W.V., Ellsworth, P., 1972. *Emotion in the Human Face: Guidelines for Research and an Integration of Findings*. Pergamon Press, Oxford, England.
- Elliott, R., Newman, J.L., Longe, O.A., Deakin, J.F., 2003. Differential response patterns in the striatum and orbitofrontal cortex to financial reward in humans: a parametric functional magnetic resonance imaging study. *Journal of Neuroscience* 23, 303–307.
- Foti, D., Hajcak, G., 2008. Deconstructing reappraisal: descriptions preceding arousing pictures modulate the subsequent neural response. *Journal of Cognitive Neuroscience* 20, 977–988.
- Fox, E., Derakshan, N., Shoker, L., 2008. Trait anxiety modulates the electrophysiological indices of rapid spatial orienting towards angry faces. *Neuroreport* 19, 259–263.
- Fredrikson, M., Wik, G., Greitz, T., Eriksson, L., Stone-Elander, S., Ericson, K., Sedvall, G., 1993. Regional cerebral blood flow during experimental phobic fear. *Psychophysiology* 30, 126–130.
- Friedman, B.H., this issue. Feelings and the body: the Jamesian perspective on autonomic specificity of emotion.
- Fu, C.H.Y., Williams, S.C.R., Cleare, A.J., Brammer, M.J., Walsh, N.D., Kim, J., et al., 2004. Attenuation of the neural response to sad faces in major depression by antidepressant treatment: a prospective, event-related functional magnetic resonance imaging study. *Archives of General Psychiatry* 61, 877–889.
- Fu, C.H.Y., Williams, S.C.R., Cleare, A.J., Scott, J., Mitterschiffthaler, M.T., Walsh, N.D., et al., 2008. Neural responses to sad facial expressions in major depression following cognitive behavioral therapy. *Biological Psychiatry* 64, 505–512.
- Gilbert, D.T., Pinel, E.C., Wilson, T.D., Blumberg, S.J., Wheatley, T.P., 1998. Immune neglect: a source of durability bias in affective forecasting. *Journal of Personality and Social Psychology* 75, 617–638.
- Gonda, X., Fountoulakis, K.N., Juhasz, G., Rihmer, Z., Lazary, J., Laszik, A., Akiskal, H.S., Bagdy, G., 2008. Association of the s allele of the 5-HTTLPR with neuroticism-related traits and temperaments in a psychiatrically healthy population. *European Archives of Psychiatry: Clinical Neuroscience*.
- Gottfried, J.A., O'Doherty, J., Dolan, R.J., 2002. Appetitive and aversive olfactory learning in humans studied using event-related functional magnetic resonance imaging. *Journal of Neuroscience* 22, 10829–10837.
- Grabenhorst, F., Rolls, E.T., Margot, C., da Silva, M.A.A.P., Velazco, M.I., 2007. How pleasant and unpleasant stimuli combine in different brain regions: odor mixtures. *Journal of Neuroscience* 27, 13532–13540.
- Gray, J.A., 1982. *The Neuropsychology of Anxiety: An Enquiry into the Functions of the Septo-hippocampal System*. Clarendon Press/Oxford University Press, New York, NY, US.
- Gunther, K.C., Conner, T.S., Armeli, S., Tennen, H., Covault, J., Kranzler, H.R., 2007. Serotonin transporter gene polymorphism (5-HTTLPR) and anxiety reactivity in daily life: a daily process approach to gene-environment interaction. *Psychosomatic Medicine* 69, 762–768.
- Hansen, C.H., Hansen, R.D., 1988. Finding the face in the crowd: an anger superiority effect. *Journal of Personality and Social Psychology* 54, 917–924.
- Harinck, F., Van Dijk, E., Van Beest, I., Mersmann, P., 2007. When gains loom larger than losses: reversed loss aversion for small amounts of money. *Psychological Science* 18, 1099–1105.
- Hariri, A.R., Mattay, V.S., Tessitore, A., Kolachana, B., Fera, F., Goldman, D., Egan, M.F., Weinberger, D.R., 2002. Serotonin transporter genetic variation and the response of the human amygdala. *Science* 297, 400–403.
- Harmon-Jones, E., Allen, J.J.B., 1998. Anger and frontal brain activity: EEG asymmetry consistent with approach motivation despite negative affective valence. *Journal of Personality and Social Psychology* 74, 1310–1316.
- Harmon-Jones, E., Gable, P.A., Peterson, C.K., this issue. The role of asymmetric frontal cortical activity in emotion-related phenomena: a review and update.
- Harmon-Jones, E., Sigelman, J., 2001. State anger and prefrontal brain activity: evidence that insult-related relative left-prefrontal activation is associated with experienced anger and aggression. *Journal of Personality and Social Psychology* 80, 797–803.
- Harmon-Jones, E., Sigelman, J.D., Bohlig, A., Harmon-Jones, C., 2003. Anger, coping, and frontal cortical activity: the effect of coping potential on anger-induced left frontal activity. *Cognition & Emotion* 17, 1–24.
- Hoebel, B.G., Avena, N.M., Rada, P., 2007. Accumbens dopamine-acetylcholine balance in approach and avoidance. *Current Opinion in Pharmacology* 7, 617–627.
- Hoebel, B.G., Rada, P.V., Mark, G.P., Pothos, E.N., 1999. Neural systems for reinforcement and inhibition of behavior: relevance to eating, addiction, and depression. In: Kahneman, D., Diener, E., Schwarz, N. (Eds.), *Well-being: The Foundations of Hedonic Psychology*. Russell Sage Foundation, New York, pp. 558–572.
- Hong, S.W., Shevell, S.K., 2008. Binocular rivalry between identical retinal stimuli with an induced color difference. *Visual Neuroscience* 25, 361–364.
- Hoorens, V., Buunk, B.P., 1993. Social comparison of health risks: locus of control, the person-positivity bias, and unrealistic optimism. *Journal of Applied Social Psychology* 23, 291–302.
- Ito, T.A., Cacioppo, J.T., 2000. Electrophysiological evidence of implicit and explicit categorization processes. *Journal of Experimental Social Psychology* 36, 660–676.
- Ito, T.A., Cacioppo, J.T., 2005. Variations on a human universal: individual differences in positivity offset and negativity bias. *Cognition & Emotion* 19, 1–26.
- Ito, T.A., Larsen, J.T., Smith, N.K., Cacioppo, J.T., 1998. Negative information weighs more heavily on the brain: the negativity bias in evaluative categorizations. *Journal of Personality and Social Psychology* 75, 887–900.
- Jackson, J.H., 1897. Remarks on the relations of different divisions of the central nervous system to one another and to parts of the body. *The British Medical Journal*, 65–69.
- James, W., 1884. What is an emotion? *Mind* 9, 188–205.
- Joormann, J., Gotlib, I.H., 2006. Is this happiness I see? Biases in the identification of emotional facial expressions in depression and social phobia. *Journal of Abnormal Psychology* 115, 705–714.
- Joormann, J., Gotlib, I.H., 2007. Selective attention to emotional faces following recovery from depression. *Journal of Abnormal Psychology* 116, 80–85.
- Kahneman, D., 1999. Objective happiness. In: Kahneman, D., Diener, E., Schwarz, N. (Eds.), *Well-being: The Foundations of Hedonic Psychology*. Russell Sage Foundation, New York, NY, US, pp. 3–25.
- Kahneman, D., Tversky, A., 1984. Choices, values, and frames. *American Psychologist* 39, 341–350.
- Killgore, W.D.S., Yurgelun-Todd, D.A., 2005. Social anxiety predicts amygdala activation in adolescents viewing fearful faces. *Neuroreport* 16, 1671–1675.
- Kosslyn, S.M., Shin, L.M., Thompson, W.L., McNally, R.J., Rauch, S.L., Pitman, R.K., Alpert, N.M., 1996. Neural effects of visualizing and perceiving aversive stimuli: a PET investigation. *Neuroreport* 7, 1569–1576.
- Lang, P.J., 1995. The emotion probe: studies of motivation and attention. *American Psychologist* 50, 372–372.
- Lang, P.J., Bradley, M.M., Cuthbert, B.N., 1999. *International Affective Picture 2 System (IAPS): digitized photographs, instruction manual and affective ratings*. 3 Technical Report A-6. University of Florida, Gainesville, FL.
- Larsen, J.T., McGraw, A.P., Cacioppo, J.T., 2001. Can people feel happy and sad at the same time? *Journal of Personality and Social Psychology* 81, 684–696.
- Larsen, J.T., McGraw, A.P., Mellers, B.A., Cacioppo, J.T., 2004. The agony of victory and thrill of defeat: mixed emotional reactions to disappointing wins and relieving losses. *Psychological Science* 15, 325–330.
- Larsen, J.T., Norris, C.J., McGraw, A.P., Hawley, L.C., Cacioppo, J.T., 2009. The evaluative space grid: a single-item measure of positivity and negativity. *Cognition and Emotion* 23, 453–480.
- Larsen, J.T., Norris, J.L., 2009. A facial electromyographic investigation of affective contrast. *Psychophysiology* 46, 831–842.
- Leyman, L., De Raedt, R., Schacht, R., Koster, E.H.W., 2007. Attentional biases for angry faces in unipolar depression. *Psychological Medicine* 37, 393–402.
- Löw, A., Lang, P.J., Smith, J.C., Bradley, M.M., 2008. Both predator and prey: emotional arousal in threat and reward. *Psychological Science* 19, 865–873.
- McNaughton, N., Gray, J.A., 2000. Anxiolytic action on the behavioural inhibition system implies multiple types of arousal contribute to anxiety. *Journal of Affective Disorders. Special Issue: Arousal in Anxiety* 61, 161–1161.
- Mitterschiffthaler, M.T., Williams, S.C.R., Walsh, N.D., Cleare, A.J., Donaldson, C., Scott, J., et al., 2008. Neural basis of the emotional stroop interference effect in major depression. *Psychological Medicine* 38, 247–256.
- Mogg, K., Bradley, B.P., 1999. Some methodological issues in assessing attentional biases for threatening faces in anxiety: a replication study using a modified version of the probe detection task. *Behaviour Research and Therapy* 37, 595–604.
- Mogg, K., Bradley, B.P., 2002. Selective orienting of attention to masked threat faces in social anxiety. *Behaviour Research and Therapy* 40, 1403–1414.
- Mogg, K., Garner, M., Bradley, B.P., 2007. Anxiety and orienting of gaze to angry and fearful faces. *Biological Psychology* 76, 163–169.
- Monk, C.S., Klein, R.G., Telzer, E.H., Schroth, E.A., Mannuzza, S., Moulton, J.L., et al., 2008. Amygdala and nucleus accumbens activation to emotional facial expressions in children and adolescents at risk for major depression. *American Journal of Psychiatry* 165, 90–98.

- Mourão-Miranda, J., Volchan, E., Moll, J., de Oliveira-Souza, R., Oliveira, L., Bramati, I., Gattass, R., Pessoa, L., 2003. Contributions of stimulus valence and arousal to visual activation during emotional perception. *Neuroimage* 20, 1955–1963.
- Neumeister, A., Drevets, W.C., Belfer, I., Luckenbaugh, D.A., Henry, S., Bonne, O., et al., 2006. Effects of a α_2c -adrenoreceptor gene polymorphism on neural responses to facial expressions in depression. *Neuropsychopharmacology* 31, 1750–1756.
- Nisbett, R.E., Wilson, T.D., 1977. Telling more than we can know: verbal reports on mental processes. *Psychological Review* 84, 231–259.
- Norris, C.J., Cacioppo, J.T., in preparation. Individual Differences in Negativity Bias Predict Neural Attentional Bias to Unpleasant Stimuli. Dartmouth College, Hanover, NH.
- Norris, C.J., Chen, E.E., Zhu, D.C., Small, S.L., Cacioppo, J.T., 2004. The interaction of social and emotional processes in the brain. *Journal of Cognitive Neuroscience* 16, 1818–1829.
- Norris, C.J., Eichenold, N.M., Cacioppo, J.T., in preparation. Oscillation as a Mechanism for Objective Ambivalence: Behavioral and Neural Evidence. Dartmouth College, Hanover, NH.
- Norris, C.J., Larsen, J.T., Cacioppo, J.T., 2007. Neuroticism is associated with larger and more prolonged electrodermal responses to emotionally evocative pictures. *Psychophysiology* 44, 823–826.
- O'Doherty, J.P., Deichmann, R., Critchley, H.D., Dolan, R.J., 2002. Neural responses during anticipation of a primary taste reward. *Neuron* 33, 815–826.
- O'Doherty, J., Kringelbach, M.L., Rolls, E.T., Hornak, J., Andrews, C., 2001. Abstract reward and punishment representations in the human orbitofrontal cortex. *Nature Neuroscience* 4, 95–102.
- O'Doherty, J., Winston, J., Critchley, H., Perrett, D., Burt, D.M., Dolan, R.J., 2003. Beauty in a smile: the role of medial orbitofrontal cortex in facial attractiveness. *Neuropsychologia* 41, 147–155.
- Öhman, A., Flykt, A., Esteves, F., 2001a. Emotion drives attention: detecting the snake in the grass. *Journal of Experimental Psychology: General* 130, 466–478.
- Öhman, A., Lundqvist, D., Esteves, F., 2001b. The face in the crowd revisited: a threat advantage with schematic stimuli. *Journal of Personality and Social Psychology* 80, 381–396.
- Olds, J., 1958a. Effects of hunger and male sex hormone on self-stimulation of the brain. *Journal of Comparative Physiological Psychology* 51, 320–324.
- Olds, J., 1958b. Satiation effects in self-stimulation of the brain. *Journal of Comparative Physiological Psychology* 51, 675–678.
- Osgood, C.E., Suci, G.J., Tannenbaum, P.H., 1957. *The Measurement of Meaning*. University of Illinois Press, Oxford, England.
- Parducci, A., 1968. The relativism of absolute judgment. *Scientific American* 219, 84–90.
- Phan, K.L., Fitzgerald, D.A., Nathan, P.J., Tancer, M.E., 2006. Association between amygdala hyperactivity to harsh faces and severity of social anxiety in generalized social phobia. *Biological Psychiatry* 59, 424–429.
- Pishyar, R., Harris, L.M., Menzies, R.G., 2004. Attentional bias for words and faces in social anxiety. *Anxiety, Stress & Coping: An International Journal* 17, 23–36.
- Pratto, F., John, O.P., 1991. Automatic vigilance: the attention-grabbing power of negative social information. *Journal of Personality and Social Psychology* 61, 380–391.
- Priester, J.R., Petty, R.E., 1996. The gradual threshold model of ambivalence: relating the positive and negative bases of attitudes to subjective ambivalence. *Journal of Personality and Social Psychology* 71, 431–449.
- Pulford, B.D., Colman, A.M., 1996. Overconfidence, base rates and outcome positivity/negativity of predicted events. *British Journal of Psychology* 87, 431–445.
- Reynolds, S.M., Berridge, K.C., 2001. Fear and feeding in the nucleus accumbens shell: rostrocaudal segregation of GABA-elicited defensive behavior versus eating behavior. *Journal of Neuroscience* 21, 3261–3270.
- Reynolds, S.M., Berridge, K.C., 2002. Positive and negative motivation in nucleus accumbens shell: bivalent rostrocaudal gradients for GABA-elicited eating, taste "liking"/"disliking" reactions, place preference/avoidance, and fear. *Journal of Neuroscience* 22, 7308–7320.
- Reynolds, S.M., Berridge, K.C., 2008. Emotional environments retune the valence of appetitive versus fearful functions in nucleus accumbens. *Nature Neuroscience* 11, 423–425.
- Richards, A., French, C.C., Johnson, W., Napastek, J., 1992. Effects of mood manipulation and anxiety on performance of an emotional stroop task. *British Journal of Psychology* 83, 479–491.
- Ridout, N., Astell, A.J., Reid, I.C., Glen, T., O'Carroll, R.E., 2003. Memory bias for emotional facial expressions in major depression. *Cognition & Emotion* 17, 101–122.
- Ritz, M.C., Lamb, R.J., Goldberg, S.R., Kuhar, M.J., 1987. Cocaine receptors on dopamine transporters are related to self-administration of cocaine. *Science* 237, 1219–1223.
- Rozin, P., Royzman, E.B., 2001. Negativity bias, negativity dominance, and contagion. *Personality and Social Psychology Review* 5, 296–320.
- Russell, J.A., Carroll, J.M., 1999. On the bipolarity of positive and negative affect. *Psychological Bulletin* 125, 3–13.
- Sander, D., Grafman, J., Zalla, T., 2003. The human amygdala: an evolved system for relevance detection. *Reviews in the Neurosciences* 14, 303–316.
- Sandusky, A., Parducci, A., 1965. Pleasantness of odors as a function of the immediate stimulus context. *Psychonomic Science* 3, 321–322.
- Sears, D.O., 1983. The person-positivity bias. *Journal of Personality and Social Psychology* 44, 233–250.
- Seymour, B., Daw, N., Dayan, P., Singer, T., Dolan, R., 2007. Differential encoding of losses and gains in the human striatum. *Journal of Neuroscience* 27, 4826–4831.
- Sheline, Y.I., Barch, D.M., Donnelly, J.M., Ollinger, J.M., Snyder, A.Z., Mintun, M.A., 2001. Increased amygdala response to masked emotional faces in depressed subjects resolves with antidepressant treatment: an fMRI study. *Biological Psychiatry* 50, 651–658.
- Smit, D.J., Posthuma, D., Boomsma, D.I., De Geus, E.J., 2007. The relation between frontal EEG asymmetry and the risk for anxiety and depression. *Biological Psychology* 74, 26–33.
- Smith, N.K., Cacioppo, J.T., Larsen, J.T., Chartrand, T.L., 2003. May I have your attention, please: electrocortical responses to positive and negative stimuli. *Neuropsychologia* 41, 171–183.
- Smith, N.K., Larsen, J.T., Chartrand, T.L., Cacioppo, J.T., Katafiasz, H.A., Moran, K.E., 2006. Being bad isn't always good: affective context moderates the attention bias toward negative information. *Journal of Personality and Social Psychology* 90, 210–220.
- Springer, U.S., Rosas, A., McGettrick, J., Bowers, D., 2007. Differences in startle reactivity during the perception of angry and fearful faces. *Emotion* 7, 516–525.
- Suslow, T., Junghanns, K., Arolt, V., 2001. Detection of facial expressions of emotions in depression. *Perceptual and Motor Skills* 92, 857–868.
- Sutton, S.K., Davidson, R.J., 1997. Prefrontal brain asymmetry: a biological substrate of the behavioral approach and inhibition systems. *Psychological Science* 8, 204–210.
- Taylor, S.E., 1991. Asymmetrical effects of positive and negative events: the mobilization-minimization hypothesis. *Psychological Bulletin* 110, 67–85.
- Telzer, E.H., Mogg, K., Bradley, B.P., Mai, X., Ernst, M., Pine, D.S., et al., 2008. Relationship between trait anxiety, prefrontal cortex, and attention bias to angry faces in children and adolescents. *Biological Psychology* 79, 216–222.
- Thomas, K.M., Drevets, W.C., Dahl, R.E., Ryan, N.D., Birmaher, B., Eccard, C.H., et al., 2001. Amygdala response to fearful faces in anxious and depressed children. *Archives of General Psychiatry* 58, 1057–1063.
- Tomarken, A.J., Davidson, R.J., Wheeler, R.E., Doss, R.C., 1992. Individual differences in anterior brain asymmetry and fundamental dimensions of emotion. *Journal of Personality and Social Psychology* 62, 676–687.
- Wager, T.D., Phan, K.L., Liberzon, I., Taylor, S.F., 2003. Valence, gender, and lateralization of functional brain anatomy in emotion: a meta-analysis of findings from neuroimaging. *Neuroimage* 19, 513–531.
- Warr, P.B., Barter, J., Brownbridge, G., 1983. On the independence of positive and negative affect. *Journal of Personality and Social Psychology* 44, 644–651.
- Waters, A.M., Mogg, K., Bradley, B.P., Pine, D.S., 2008. Attentional bias for emotional faces in children with generalized anxiety disorder. *Journal of the American Academy of Child & Adolescent Psychiatry* 47, 435–442.
- Watson, D., Clark, L.A., Tellegen, A., 1988. Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology* 54, 1063–1070.
- Watson, D., Tellegen, A., 1985. Toward a consensual structure of mood. *Psychological Bulletin* 98, 219–235.
- Watson, D., Tellegen, A., 1999. Issues in the dimensional structure of affect—effects of descriptors, measurement error, and response formats: comment on Russell and Carroll (1999). *Psychological Bulletin* 125, 601–610.
- Watson, D., Wiese, D., Vaidya, J., Tellegen, A., 1999. The two general activation systems of affect: structural findings, evolutionary considerations, and psychobiological evidence. *Journal of Personality and Social Psychology* 76, 820–820.
- Wheeler, R.E., Davidson, R.J., Tomarken, A.J., 1993. Frontal brain asymmetry and emotional reactivity: a biological substrate of affective style. *Psychophysiology* 30, 82–89.
- Williams, J.M., Nulty, D.D., 1986. Construct accessibility, depression and the emotional stroop task: transient mood or stable structure? *Personality and Individual Differences* 7, 485–491.
- Wilson, T.D., Bar-Anan, Y., 2008. The unseen mind. *Science* 321, 1046–1047.
- Wundt, W., 1924. *An Introduction to Psychology* (R. Pintner, Trans.). Allen & Unwin, London (original work published 1912).
- Zajonc, R.B., 1968. Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology* 9, 1–27.