# 5 DIMENSIONAL APPROACHES TO THE STRUCTURE OF AFFECT

## A DIMENSIONAL VIEW OF AFFECT

Many emotion scientists view emotions and moods as reflections of general dimensions of experience rather than as discrete categories. The focus of this approach is often on how the world is *experienced* and much of the research in this tradition uses self-report as the primary data. An underlying assumption is that emotions are defined to a large extent by the verbal labels we use to describe them. One of the functions of a language is to provide labels for particular states and events which can be readily understood by speakers of that language. Thus, we know what people mean when they say they are 'madly in love', or that they are 'angry'. A genuine problem for science, however, is that these everyday labels often describe very broad and 'fuzzy' semantic categories that may not necessarily represent facts of nature (Russell and Feldman Barrett, 1999). In other words, while we know roughly what is meant when people say that they are sad, it is not clear if our concept of sadness actually refers to a natural biological or psychological category. Research that traces the development of emotion concepts in children, for example, has found that even very young children can discriminate between different emotions. However, it seems that the basis of this discrimination is along the dimensions of pleasure and arousal rather than the more adult categories labelled fear, anger and so on. This has led some investigators to argue that children need to *learn* these more refined categories by exposure to numerous social situations (e.g., Russell and Lemay, 2000).

In an extensive review, Russell (1991) concluded that emotion categories in the English language are similar to emotion concepts in other languages but, importantly, they are not identical. Moreover, the number of labels referring to emotion categories also varies widely from language to language. This raises the possibility that emotions may also vary widely from culture to culture. In other words, if our understanding of emotions is generated by the linguistic terms available in our culture, then our *experience* of emotions may also be determined by our language and culture. An extreme form of this view is that emotions are learned or socially constructed, rather than given to us by nature (Averill, 1980; Feldman Barrett, 2006a). This is an assumption underlying many theories that take a *dimensional* approach to the understanding of emotion.

## WHAT DO WE MEAN BY DIMENSIONS?

Many emotion scientists argue that the *human experience of emotion*, or the *feelings* associated with emotions, is the main phenomenon to be explained. This emphasis on people's feelings has led to the hypothesis that the world is experienced along broad dimensions, rather than as discrete categories of different emotions. Research on a number of different emotion components (subjective report; physiological response; neural activity) has converged on the notion that affect can be described along two broad dimensions. These have been variously called *arousal* and *valence* (Russell, 1983), *approach* and *avoidance* (Davidson, 1994b), or *positive affect (PA)* and *negative affect (NA)* (Watson and Tellegen, 1985).

A number of different terms have been used to refer to the *arousal* dimension in different theoretical accounts: *activation*, *tension*, *energy*, *activity* and so on. However, these terms are almost certainly referring to the same underlying construct. In terms of subjective experience, *arousal* or *activation* is often interpreted as the amount of energy we feel we have available. This can range from deep sleep and drowsiness, through feeling relaxed, alert, active, hyperactive, to frenetic excitement at the top end of the scale. It is often argued that these subjective feelings of activation or arousal represent a summary of our true physiological state at any given time (e.g., Russell and Feldman Barrett, 1999). Arousal rises and falls throughout the day and is dependent on a range of environmental factors such as the time of day, the weather, physical activity, intake of drugs and so on, in addition to general personality differences (Thayer, 1989, 1996). These variations are *felt* or experienced as changes in what has been called *core affect* and form an important dimension of our subjective experience of affective states (Feldman Barrett, 2006a; Russell, 1980; Russell and Feldman Barrett, 1999). This conceptualization of arousal and how it is experienced is close to the definition of mood states that we outlined in Chapter 2.

A sense of *valence* (positive versus negative) or *pleasure* has also been identified as an important dimension of affective experience. This term has been variously referred to as *hedonic tone*, *positive* and *negative affect*, *pleasant* and *unpleasant* feelings, *approach* and *avoidance*, and so on.

Extensive research has shown that the dimensions of valence and arousal appear to be universal human experiences occurring in all cultures (Osgood et al., 1975; Wierzbicka, 1995). In particular, a number of bipolar dimensions such as tense–calm, happy–sad, excited–depressed have been found in all the languages that were examined (Osgood et al., 1975). This indicates that people commonly describe their subjective experiences along a number of bipolar dimensions, and that we experience the world around us in terms of these bipolar concepts – 'I was very happy/very sad'; 'The situation was very relaxed/very tense' and so on. Subsequent theories have focused primarily on the two broad dimensions of valence (positive–negative) and arousal (relaxed–excited). These seem to be the most salient dimensions, and it has been difficult to draw a distinction between arousal and a possible third dimension of *tension*, *dominance* or *potency* (Russell, 1983). Taken together, this line of research suggests that these two dimensions do indeed represent the fundamental building blocks of our emotional experience.

A dimensional approach has also emerged from behavioural research with animals. In particular, Konorski (1967) proposed a model based on two broad types of reflexes: *preservative* and *protective*. Preservative reflexes relate to the preservation of health and well-being and include nurturing the young, ingestion of food, and sexual activities. Protective reflexes relate to survival: avoiding and withdrawing from dangers and the rejection of noxious substances (poisons etc). These are all *unconditioned responses* – we do not have to learn how to do them. An important point to remember is that Konorski emphasized that arousal or activation modulates *both* of these types of reaction.

This view was extended by Dickinson and Dearing (1979), who developed the dichotomy between preservative and protective reactions into two opposing motivational systems: *attractive* and *aversive*. The idea is that these systems can be activated by a wide range of unconditioned stimuli, and tend to oppose each other – when one is active the other is inhibited. These two motivational systems are seen as fundamental to the learning of new responses to unconditioned stimuli. Many other lines of research have supported the hypothesis that two motivational systems – attractive–aversive and approach–avoidance – exist in the brain (e.g., Davidson, 1994b; Depue and Collins, 1999; Rolls, 2005).

It is very likely that the two neurobiological systems overlap considerably with the valence dimension discovered in human research. In other words, the attractive or approach system may be involved in generating feelings of positive affect (PA), while the aversive or withdrawal system may generate feelings of negative affect (NA). It is often assumed that these two motivational systems (approach–avoidance) can account for the salience of the valence dimension in our subjective experience, and that arousal accounts for variations in the activation of both systems (Lang, 1995). The important point here is that arousal is not seen as a separate substrate in the brain, but, rather, is considered to reflect variations in the valence dimension. A brief overview of dimensional approaches to understanding emotion is presented in Box 5.1.

## CRITERIA FOR IDENTIFYING GENERAL DIMENSIONS OF AFFECT

Since emotional experience is at centre stage in most dimensional accounts it is not surprising that subjective report of feelings is a primary criterion for the dimensions approach. The notion that we experience blends of broad dimensions such as pleasant or unpleasant rather than discrete emotions seems somewhat counterintuitive because our perception of emotions as discrete categories is very powerful. Imagine a situation in which you were very angry and contrast that with one in which you were very afraid. At first it might seem that these two states felt very different. However, the evidence suggests that if you really try to describe how the two states *feel* it is difficult to get beyond descriptions of arousal and valence. The argument is that what distinguishes the two states is the *perception* and *interpretation* of the surrounding context

BOX 5.1

## A brief overview of dimensional approaches to understanding affect

One of the earliest attempts to provide a description of the fundamental dimensions of how we experience the world was put forward by Wilhelm Wundt (1874/1905). Wundt was a German scientist – a contemporary of William James – who is widely considered to be the founder of experimental psychology in Europe. He established the world's first laboratory of psychological science at the University of Leipzig in 1879.

Wundt asked people to describe their inner experiences (a method known as *introspection*), and concluded that emotional experience (feelings) could be understood by looking at three different dimensions: *valence* (positive–negative), *arousal* (calm–excited), and *tension* (tense–relaxed). Moreover, he argued that these dimensions were likely to be related to measurable physiological states of the body. Subsequent evidence confirms that valence is indeed a salient aspect of our experience of the world. For example, people find it very easy to report on how good or bad they feel, and liking or disliking something is likely to result in either approach or withdrawal, which are two important behavioural dimensions observed in even the simplest organisms (Schneirla, 1959). Likewise, it seems to be an easy task for most people to report on how arousing or intense an experience is, showing that arousal is also an important dimension of subjective experience. William James (1884, 1890/1950) also assumed that arousal represented an important dimension of the subjective experience of emotions.

Subsequent research in emotion science using self-report data has confirmed that arousal and valence are both important components of how affect is experienced (e.g., Russell, 1980; Russell and Feldman Barrett, 1999). Measures of physiological responding have also highlighted the importance of these two dimensions. A particularly useful development has been the construction of a large database of photographs by Peter Lang and his colleagues. These photographs have been rated by hundreds of people along the dimensions of valence and arousal (Bradley and Lang, 1994; Lang, 1980) and are available to emotion researchers as the *International Affective Picture System (IAPS)* (Lang et al., 2005). This standardized set of stimuli is extremely useful because the same material can be used by different laboratories, making it much easier to draw comparisons across different studies. In order to achieve normative ratings, each individual is presented with a large number of photographs one at a time and asked to rate each photograph according to (a) how pleasant or unpleasant it is, and (b) how arousing it is. People generally have no problem in separating these dimensions and subsequent research has shown that each dimension is associated with different patterns of psychophysiological response (Lang et al., 1993). Figure 5.1 shows how some images are typically organized in the two-dimensional space defined by valence and arousal. As can be seen, a photograph of a cute baby is generally rated as being highly pleasant and medium in terms of arousal, whereas an erotic image might be judged as being equally pleasant but more arousing. Likewise, a picture of a snake is generally judged as fairly arousing but also fairly unpleasant.

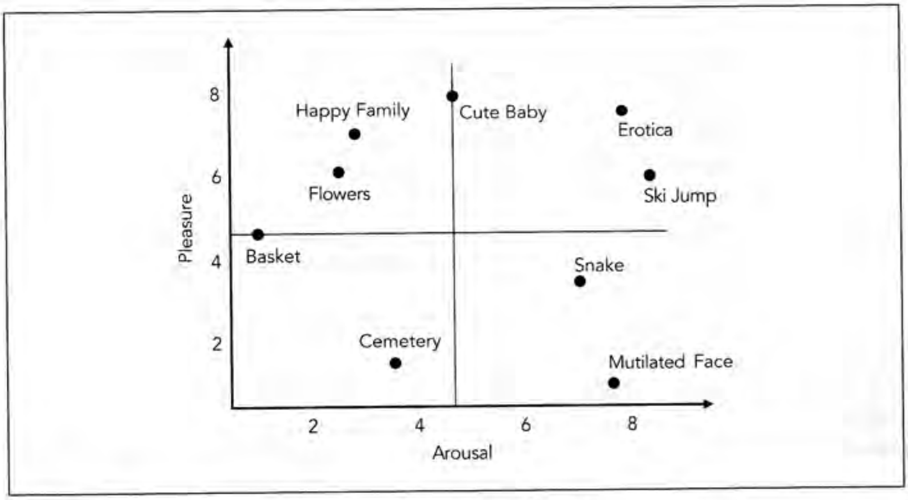


FIGURE 5.1 Typical distribution of images from the IAPS set

*Source:* Adapted from Lang (1995).

Standardized sets of affective sounds (Bradley and Lang, 1999b) and words (Bradley and Lang, 1999a) have also been developed. These have also been successfully rated along the dimensions of valence and arousal. Thus, it seems that people find it easy to judge images, sounds and words in terms of how arousing they are (most calm to most exciting) as well as how pleasant or unpleasant they are (valence).

(Feldman Barrett, 2006a; Schachter and Singer, 1962). Therefore, self-report data is an important method for identifying dimensions.

A broader criterion for the authenticity of the approach as a whole comes from evidence showing that the cognitive interpretation of general feelings is a major determinant of how emotions are categorized. Other important criteria in the identification of affective dimensions comes from research examining the physiological and neural circuits that might underlie emotional responses (Davidson, 1984; Lang, 1995; Rolls, 1999). Some key criteria to identify affective dimensions are outlined in Table 5.1.

## OVERVIEW OF EMPIRICAL EVIDENCE FOR DIMENSIONS

### Subjective report

#### *Description experience sampling measures of affective experience*

A key criterion to establish that subjective experience is based on two broad dimensions is to demonstrate that this is how people actually report their emotional experience. One method is the *Descriptive Experience Sampling* procedure (DES) (Hurlbert, 1997). This involves testing large numbers of people across different situations and asking them to report how they feel in each situation.

TABLE 5.1 Criteria for the dimensional approach to understanding emotion

| *Criteria* | *Required pattern of results* |
|---|---|
| Subjective report | Self-report studies should demonstrate that people's experience of emotion is described primarily in terms of two dimensions rather than several discrete emotions. |
| | Self-report measures between the various negative emotions should be highly intercorrelated. Likewise, correlations between reports of positive emotions should be high. |
| Physiological specificity | Physiological responses should be specific to the dimensions of valence and arousal, and responses to these dimensions should be relatively independent of each other. |
| | Physiological indicators among the negative (and positive) emotions should be correlated with each other. |
| Neural circuits | Separate neural circuits for valence and for arousal should be identified |
| Cognitive appraisals | Evidence should be found that appraisals occur for the dimensions of valence and activation or arousal to a larger extent than for other dimensions of experience. |
| | Additionally, it is important for this approach to establish that cognitive appraisal or conceptualization is necessary to explain reports of discrete emotion categories. |

Generally, people can report their experiences easily, although individual differences have been found. For example, some people tend to report their experiences in very broad, global terms whereas others characterize their experiences more along the lines of discrete emotion terms (Feldman Barrett, 2004). One student's response to the terrorist attacks of 9/11 in New York City was 'Maybe anger, confusion, fear. I just felt bad on September 11th, Really bad' (Feldman Barrett, 2006c, p. 38). Another student used more precise discrete emotion labels by saying 'My first reaction was terrible sadness ... But the second reaction was that of anger, because you can't do anything with the sadness'. At first sight, this evidence seems to go against the hypothesis that emotions are experienced along two broad dimensions. However, subsequent analysis supports the dimensional perspective in that *all* participants in eight different studies described their momentary emotional state in terms of pleasure or displeasure, while people differed widely in the use of discrete emotion terms (Feldman Barrett, 2006c). In other words, while *everyone* can easily describe the difference between a pleasant and an unpleasant feeling, there are large individual differences in the understanding and use of discrete emotions labels. This suggests that valence (pleasure and displeasure) may be a more fundamental property of affect than discrete emotion terms. It is interesting to note at this point that it is often not clear from this research whether people are reporting their subjective experience of emotions or moods, or both.

Other studies using the DES methodology have found that people report feeling some degree of affect almost all of the time (Diener et al., 1991) and that emotional experiences are almost always reported in terms of being either pleasant or unpleasant. It is, perhaps, encouraging to note that most people report that they experience positive affect (pleasant feelings) most of the time (Diener and Diener, 1996). In support of a dimensional approach, however, it is not clear that everyone experiences anger, sadness, fear and so on as qualitatively different states (e.g., Feldman Barrett, 2006b; Larsen and Cutler, 1996). For example, when people's reports of their daily emotional experiences over several weeks are analyzed, it becomes obvious that many individuals describe their experience in very broad, global terms, whereas others characterize their experiences in more discrete emotion terms (Feldman Barrett, 1998). Feldman Barrett (2004) points out that people who report their experiences in global terms often use discrete emotion labels to refer to broad affective states (pleasant versus unpleasant). She describes these people as being low on *emotional granularity*. Those who are high in emotional granularity, however, tend to use discrete emotion labels in a more precise way to capture the distinctiveness of a word's meaning. These data seem to indicate that people differ in terms of how good they are at accessing and/or describing their own internal states. A difficulty in describing differences among distinct internal states does not, of course, necessarily mean that these states do not exist.

Nevertheless, when people are asked to describe their experiences of emotion the evidence from DES techniques suggests that anger, sadness, fear etc are often not experienced as distinct and separate states. In order to get round potential problems in verbalizing experiences, a more common method of acquiring self-report data is to present people with standardized questionnaires relating to affective experience. When these data are analyzed by sophisticated statistical techniques it seems that the various discrete emotion terms can be broken down into more fundamental or primitive components relating to valence and arousal (e.g., Russell, 1980).

### *Questionnaire measures of affective experience*

A typical research methodology is to obtain self-report data about how affective states (moods and emotions) are consciously experienced. For example, people may be asked to describe their experience of emotion by selecting representative adjectives (cheerful, happy, sad, irritable etc). If emotions are experienced as discrete categories (anger, sadness, fear etc) then these data should cluster around a small number of categories with different factors for each basic emotion. However, a large body of data indicates that this is not the case. When self-reports of emotional experience are projected into geometric space by means of sophisticated statistical techniques the data almost invariably take on a *circumplex structure* as shown in Figure 5.2.

Figure 5.2 is based on Russell's model, with arousal or activation on the vertical axis and valence on the horizontal axis. Feelings are characterized in terms of pleasantness and intensity, and basic emotion categories only fall in certain regions of the circumplex (Feldman Barrett, 2006b; Russell, 1980; Russell and Feldman Barrett, 1999). These data suggest that affect is best conceptualized as variations along a number of dimensions – intensity, degree of pleasure, degree of activation – rather than in terms of discrete categories. In the case of fear, for example, being attacked by a large dog would usually be more intense and less pleasurable than the fear experienced on a

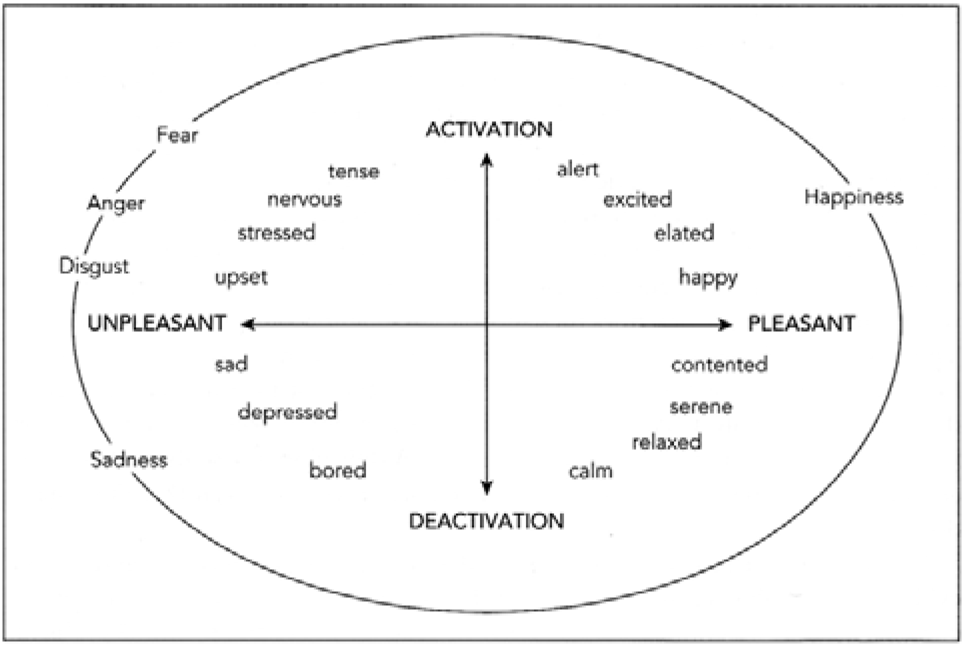


**FIGURE 5.2** A graphical representation of Russell's two-dimensional model of emotion
*Source:* Adapted from Russell (1980).

roller coaster ride. Both are instances of fear, but the two experiences can be rated along these dimensions in quite different ways. Thus, rather than there being a set of separate discrete emotions with clear boundaries between them, the idea is that each emotion can be situated as a specific point along the two dimensions of *pleasantness* and *activation* (Russell and Feldman Barrett, 1999).

Russell's (1980) circumplex model proposes two bipolar dimensions of experience with one ranging from positive to negative affect (i.e., PA to NA), and the second reflecting variations in arousal. This perspective implies that obtaining ratings along two scales – pleasant–unpleasant and active–passive – is sufficient to capture the differences between emotions. The key proposal is that every emotion can be understood as a combination or blend of these two dimensions.

An alternative view suggests that PA and NA represent separate and unrelated (*orthogonal*) dimensions of experience (Watson and Tellegen, 1985). This *independent* model views both PA and NA as distinct constructs (least to most positive, and least to most negative). At first sight, it might seem that PA and NA have to be linked in a bipolar way because it is hard to imagine someone in a state of high NA and high PA at the same time. However, empirical research has found that the bipolar relationship seems to apply only for very intense levels of emotional experience. Thus, people reporting very high levels of NA do indeed tend to report relatively low levels of PA, just as high levels of PA are associated with reports of low levels of NA (Diener and Iran-Nejad, 1986; Watson, 1988).

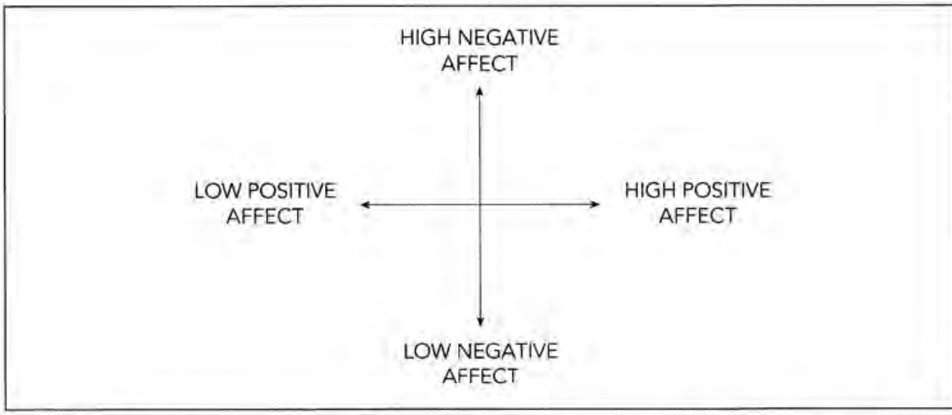


FIGURE 5.3 Two-dimensional model of emotion based on Watson and Tellegen (1985)

However, under the more typical everyday circumstances when emotional experiences are less intense, PA and NA actually seem to be strikingly independent of each other (Diener and Emmons, 1985; Watson, 1988). Thus, somebody who is experiencing a low level of NA (e.g., fairly relaxed) is not necessarily feeling happy. In fact, scores on PA can occur anywhere along the continuum. Early work found, for example, that people's self-reports of sadness and happiness are not correlated (Nowlis, 1965). Moreover, as noted by Watson and Clark (1994), PA and NA can sometimes become dissociated even under more intense conditions. For example, when we actively try to experience NA (e.g., watching a horror movie, parachute jumping, or riding on a roller coaster) this can also lead to high levels of excitement and pleasure. Further evidence for the independence of PA and NA is the fact that negative mood states are highly correlated with each other, and positive mood states are highly correlated with each other (Watson et al., 1988). Thus, people who are in an apprehensive mood are also likely to report feelings of depression, tension etc.

In contrast to Russell's model (see Figure 5.2), in which activation and valence are seen as two separate dimensions, the structural model proposed by Watson and Tellegen (1985) has two *independent* dimensions of *valence* (PA and NA). As shown in Figure 5.3, this structure suggests that affective space can best be conceptualized in terms of two separate dimensions of positive and negative affect. Thus, happiness might be represented as relatively high on PA and relatively low on NA, while excitement might be rated higher on PA but at the same level of NA.

Yet another description of affective space considers that the two critical aspects are independent dimensions of *activation*: tension vs energy (Thayer, 1989, 1996). A schematic diagram of this model is presented in Figure 5.4.

In summary then, the structures of affective space that emerge from questionnaire studies have been interpreted as:

representing two dimensions of *valence* (Watson and Tellegen, 1985);
representing two dimensions of *activation* or *energy* (Thayer, 1989); or
comprising both *valence* and *activation* (Russell, 1980).

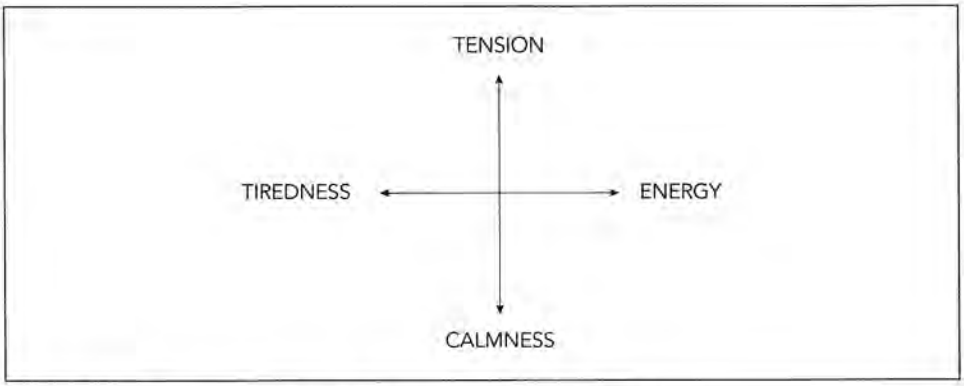


**FIGURE 5.4** Two-dimensional model of emotion based on Thayer (1989)

Do these results indicate fundamentally different structures underlying the conscious experience of affect? In spite of apparent differences, it has been argued that all of these models are actually describing the same affective space (Russell and Feldman Barrett, 1999). For example, Watson and Tellegen's (1985) notion of PA and NA implicitly involves the notion of *activation* in that both PA and NA are considered to vary in *intensity*. This seems to effectively incorporate the notion of activation or arousal into the structure. Likewise, Thayer's (1989) two activation dimensions also implicitly incorporate *valence*.

Empirical evidence using complex structural equation modelling of self-report data supports the hypothesis that all of these structures are indeed describing the same thing (Feldman Barrett and Russell, 1998; Yik et al., 1999). They reported that the pleasant–unpleasant and activated–deactivated dimensions accounted for 92% of the variance in PA and 97% of the variance in NA. Similarly, when Thayer's dimensions were examined, it was found that the pleasant–unpleasant and activated–deactivated dimensions accounted for 80% of the energy–tired dimension, and 73% of the tense–calm dimension. Thus, it seems that in spite of using different labelling these structures are actually measuring the same underlying components of subjective experience and that valence and activation are both critical dimensions of our experience (Russell and Feldman Barrett, 1999). In terms of the two criteria for self-report data outlined in Table 5.1, it is clear that the data do support both assumptions:

(a) people report their emotional experience in terms of valence and arousal, and
(b) there are high inter-correlations between self-reports of negative emotions and positive emotions.

### Physiological specificity

If dimensional models are correct, then we would expect to find fairly consistent patterns of physiological activation in relation to the dimensions of valence and arousal. In psychophysiological research it has often been argued that emotions are best understood as being organized around an underlying motivational base (Bradley and

Lang, 2000b; Lang, 1995). The idea is that the appetitive (or approach) and the aversive (or withdrawal) systems can account for the valence dimension in the expression of emotions. Most models assume that approach and withdrawal systems are mutually inhibitory so that when one is activated the other is inhibited (Dickinson and Dearing, 1979; Konorski, 1967). These models do not generally see arousal as a third system that is modulated independently of the approach and withdrawal systems. In contrast, arousal is seen as the metabolic and neural activation of either approach or withdrawal systems, or the co-activation of both together (Cacioppo and Berntson, 1994). The brain's approach and withdrawal systems are therefore considered to represent the neuroanatomical foundation of both valence and arousal effects in animals and humans. If emotions are indeed organized by the brain's motivational systems of approach and withdrawal, we might expect that the physiological responses to affective stimuli should reflect this organization. In other words, as indicated in Table 5.1, the response of physiological systems should co-vary with subjective judgments of valence and arousal. Thus, we should be able to find physiological responses that are activated by increasing levels of arousal, but not affected by valence. Likewise, increasing levels of valence should activate certain physiological responses independently of variations in arousal.

A typical methodology to assess the relationship of physiological responses to subjective reports of valence and arousal is to first require participants to evaluate a large number of stimuli such as IAPS pictures on the basis of valence and arousal. The pictorial stimuli can then be ranked from high to low for each individual on the basis of their own judgments. The next step is to examine the degree of activity in each physiological measure for each rank (collapsed across participants) in terms of valence and arousal. This strategy optimizes the possibility of detecting changes in physiology which correlate with changes in affective judgements (Bradley and Lang, 2000a; Lang et al., 1993). Research using this methodology has focused on the action of facial muscles, skin conductance and heart-rate responses, as well as electrocortical activity and the startle reflex.

### *Facial muscle action*

Several major groups of muscles in the face are important for the expression of different emotions (Ekman and Friesen, 1986; Fridlund and Izard, 1983). For example, the ***corrugator muscles*** are important for lowering and contracting the brows and this expression is a reliable indicator of distress. The ***zygomatic muscle***, in contrast, is important for the smile response and activity in this muscle indicates expressions of happiness. A clear prediction then is that if a stimulus (e.g., a picture, a word or a sound) is judged to be unpleasant then we should detect activity within the corrugator muscle, whereas if a stimulus is judged to be pleasant then activity in the zygomatic muscle is more likely. Contractions of these facial muscles can be measured by means of the electromyographic activity (EMG) detected by small electrodes placed on these muscles. As shown in Figure 5.5, significant activation of the corrugator muscle does indeed occur when a picture is rated as unpleasant. Figure 5.5(a) shows the degree

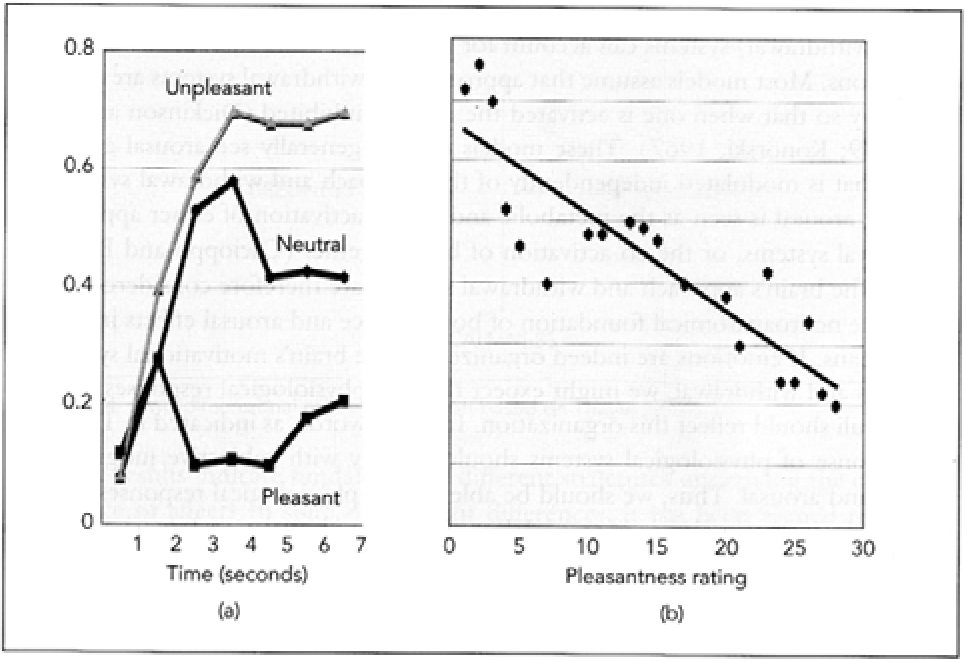


FIGURE 5.5 Patterns of facial corrugator EMG activity
(a) As a function of prior valence ratings of IAPS pictures (left panel)
(b) The correlation between an individual's ratings of pleasure with the corrugator EMG response to viewing IAPS pictures.

*Source:* Adapted from Lang et al. (1993).

of activation of the corrugator muscle when viewing pleasant, neutral and unpleasant IAPS pictures. The corrugator muscle is activated by all types of picture, but at some point there is a clear divergence based on the rated valence of the picture. For the neutral items, EMG activity is intermediary between the pleasant and unpleasant pictures. The degree of activation is increased for unpleasant pictures, whereas the degree of activation is decreased for the pleasant pictures relative to neutral pictures. Moreover, as shown in Figure 5.5(b), the negative correlation between self-reports of valence and corrugator EMG activity is very high ($r = -0.90$) (Lang et al., 1993). The degree of change in corrugator activity systematically decreases as the pleasantness ratings of the pictures increase. This supports the notion that activity of the corrugator muscle does indeed provide a good index of the *valence* of a stimulus.

As expected, the opposite pattern occurs for activity of the zygomatic muscle (smile response). As shown in Figure 5.6, there is a strong positive correlation between activity in the zygomatic muscle and self-reported ratings of valence. As the ratings of pleasantness increase the degree of activity in the zygomatic EMG also increases ($r = 0.56$) (Lang et al., 1993). It is interesting to note that there are significant gender differences in this paradigm. About 75% of women show the expected pattern compared with only 25% of men showing this pattern. A very similar data pattern has been reported (including the gender difference) when participants were asked to imagine

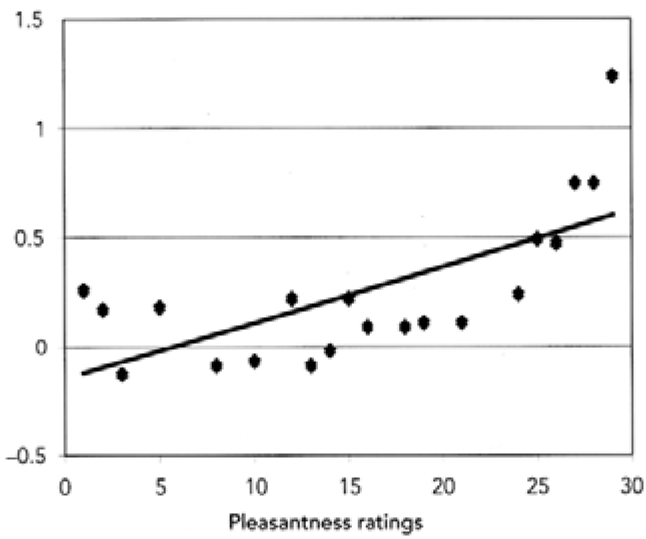


FIGURE 5.6 The correlation between individual's affective judgments of pleasure with their zygomatic EMG response when viewing IAPS pictures

*Source:* Adapted from Lang et al. (1993).

different positive and negative scenes rather than actually viewing the pictures. Once again, facial EMG responses in the zygomatic muscle increased with increasing pleasantness (Schwartz et al., 1980). It is difficult to interpret the gender difference here, but it suggests that women might be more facially expressive than men when experiencing positive and negative affect. The data shown in Figure 5.6 are collapsed across male and female participants, which explains the relatively modest correlation ($r = 0.56$).

### *Heart rate and skin conductance*

The first point to note is that there are a number of difficulties in using heart rate as an index of emotional state. Several physical factors, such as posture, height and weight, an individual's fitness level and so on, all have a significant impact on the underlying heart rate, as well as the degree of variability in heart rate. In addition to physical factors, it has also been found that heart rate varies according to different mental processes. For example, when orienting to external stimuli heart rate tends to decelerate, whereas when attempting to recall some item from memory the typical heart-rate response is one of acceleration (Lang et al., 1990). Thus, a range of both physical and psychological factors can influence the heart-rate response, making it difficult to use as an index of response to affective stimuli.

Nevertheless, when careful controls are put in place a classic heart-rate response can be observed when viewing affective pictures. When a picture is first presented the heart rate tends to slow, probably reflecting attentional orienting. The second stage

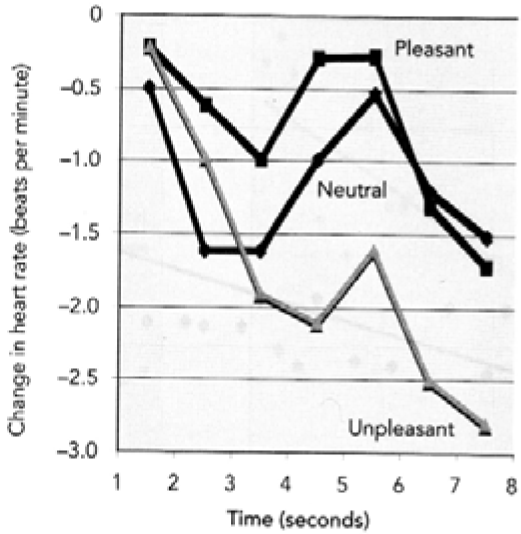


**FIGURE 5.7** Pattern of heart-rate response as a function of the prior valence ratings of IAPS pictures

*Source:* Adapted from Lang et al. (1993).

involves an acceleration of heart rate, followed a few seconds later by a secondary deceleration. As shown in Figure 5.7, the valence of the stimuli influences this standard pattern. Unpleasant stimuli produce the greatest degree of initial deceleration and acceleration, while pleasant stimuli produce greater peak acceleration (Lang et al., 1993). Correlational analysis has also shown a high positive correlation between the peak heart-rate acceleration and the individual's affective judgements of pleasure ($r = 0.76$) (Lang et al., 1993).

A more reliable measure of arousal is the *skin conductance response* (SCR). As shown in Figure 5.8(a) the degree of SCR activity tends to increase linearly as ratings of arousal increase, regardless of the degree of emotional valence. While activity does not change much over 7 seconds for neutral pictures, strong increases are observed for both pleasant and unpleasant pictures as arousal increases. In addition, as shown in Figure 5.8(b), there is a strong positive correlation ($r = 0.81$) between self-report ratings of arousal and changes in skin conductance (Lang et al., 1993).

In summary, the data measuring facial muscles, heart-rate response and skin conductance response are consistent with the hypothesis that there are specific physiological responses to the self-reported dimensions of valence and arousal. Activity in corrugator and zygomatic muscles as well as heart-rate response are all indicative of variations in the valence of stimuli. In contrast, skin conductance activity is a good index of variations in the self-reported arousal of stimuli In addition, changes in cortical activity, as measured by evoked potentials, and overall viewing time are also indicative of arousal as opposed to valence. Thus, we tend to look longer at arousing pictures, regardless of whether they are positive or negative.

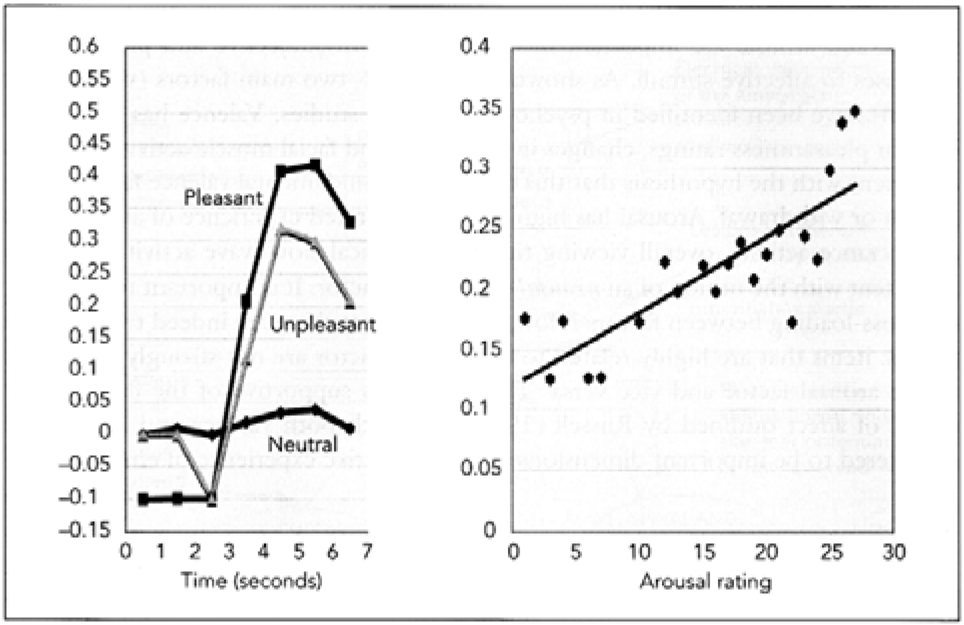


**FIGURE 5.8** Patterns of skin conductance activity

(a) As a function of prior valence and arousal ratings of IAPS pictures

(b) The correlation between individual's ratings of arousal with the changes in skin conductance response to viewing IAPS pictures

*Source:* Adapted from Lang et al. (1993).

**TABLE 5.2** Loadings of dependent measures from two factor analyses of measures of emotional picture processing

| *Measure* | *Valence* | *Arousal* |
|---|---|---|
| *From Lang et al. (1993)* | | |
| Valence ratings | 0.86 | –0.00 |
| Corrugator muscle | –0.85 | 0.19 |
| Heart rate | 0.79 | –0.14 |
| Zygomatic muscle | 0.58 | 0.29 |
| Arousal ratings | 0.15 | 0.83 |
| Interest ratings | 0.45 | 0.77 |
| Viewing time | –0.27 | 0.76 |
| Skin conductance | –0.37 | 0.74 |
| *From Cuthbert et al. (1998)* | | |
| Valence ratings | 0.89 | 0.07 |
| Corrugator muscle | –0.83 | –0.10 |
| Heart rate | 0.73 | –0.02 |
| Arousal ratings | –0.11 | 0.89 |
| Cortical slow wave | –0.06 | –0.79 |
| Skin conductance | 0.19 | 0.77 |

*Source:* Bradley and Lang (2000b).

Factor analytic studies have supported the view that the motivational variables of valence and arousal are important in organizing both subjective and physiological responses to affective stimuli. As shown in Table 5.2, two main factors (valence and arousal) have been identified in psychophysiological studies. Valence has high loadings for pleasantness ratings, changes in heart rate, and facial muscle activity, which is consistent with the hypothesis that this represents a fundamental valence factor of approach or withdrawal. Arousal has high loadings for rated experience of arousal, skin conductance activity, overall viewing time, and cortical slow wave activity, which is consistent with the notion of an *arousal* or intensity factor. It is important to note that the cross-loading between factors is low, indicating that these are indeed two separate factors: items that are highly related to the valence factor are not strongly correlated to the arousal factor and vice versa. This analysis is supportive of the dimensional model of affect outlined by Russell (1980), in which both valence and arousal are considered to be important dimensions of our subjective experience of emotions.

*Startle response*

Lang (2000) has hypothesized that the brain's *avoidance system* is activated when an organism reacts to an aversive stimulus, while activation of this system will be reduced when an appetitive stimulus is being processed. The assumption is that both of these priming effects – potentiation and reduction of response – are likely to be influenced by the overall level of activation. Measurement of the *startle response* has proved to be an easy-to-measure defensive reflex which is useful for testing this hypotheses. The startle response is a primitive defensive reflex that plays a protective role such as protection of the eye in the eye-blink reflex. It interrupts ongoing behaviour so that the potential threat can be attended to and processed (Graham, 1979). According to the *motivational priming hypothesis* (Lang, 1995), this defensive startle reflex should be faster and of greater strength when the aversive motivational system is already activated. Imagine that you are alone in a dark house late at night and are feeling nervous. A loud noise outside is likely to result in a stronger startle response than if you were relaxing with friends in the daylight.

This hypothesis was first studied in a fear conditioning experiment with rats (Brown et al., 1951). During the extinction period, when the unconditioned stimulus is no longer presented with the conditioned stimulus and the fear response to the conditioned stimulus gradually declines, the rats were startled by shots from a toy pistol. The degree of startle was measured by a stabilimeter in the floor of the cage. The animals reacted more strongly when the startle stimuli were presented during the fear-conditioned signals than during presentations of neutral stimuli. An extensive series of studies by Davis and his colleagues has shown that fear-conditioned startle is modulated by a neural circuit of which the amygdala is an important part. This circuitry is shown in Figure 5.9 (Davis, 1986; 1989; Davis et al., 1987).

In animal studies, the whole body startle response is generally measured, whereas in human studies the typical methodology is to measure just the eye-blink reflex. An eye-blink typically occurs 30 to 40 milliseconds after the onset of a stimulus and

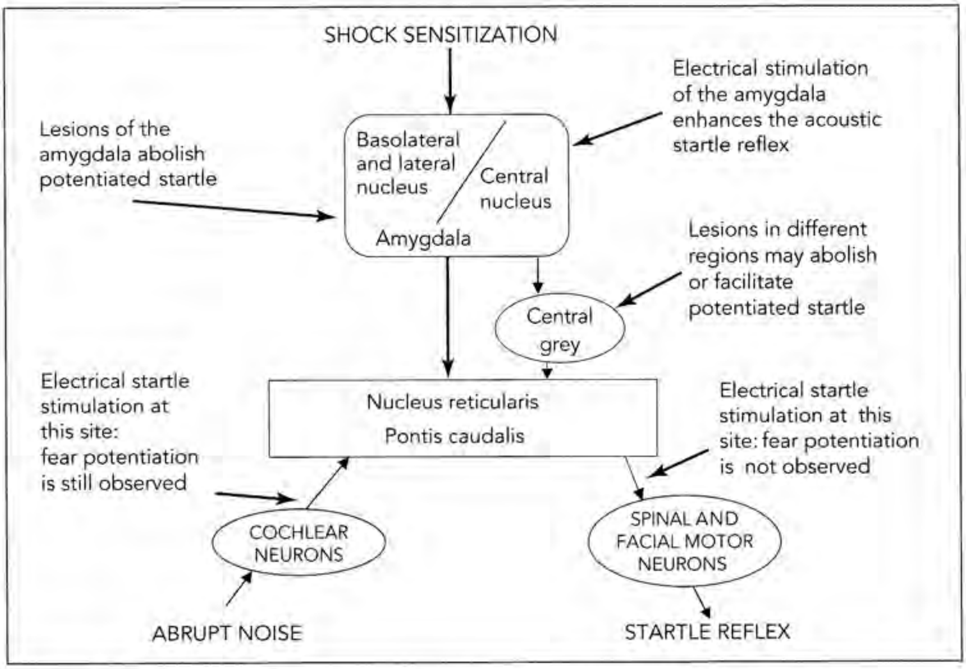


**FIGURE 5.9** The neural pathway between a startle probe input and its effector output
*Source:* Adapted from Lang (1995).

this provides a reliable index of the startle reflex. The latency and magnitude of this response can be measured by placing small electrodes just below the lower eye-lid to detect small changes in the facial muscle that surrounds the eye. The stimulus used to evoke an eye-blink response in humans is usually a 50-millisecond burst of white noise at around 95 decibels (db). This stimulus is fairly innocuous and does not interfere with ongoing tasks, but is still sufficient to induce an eye-blink reflex. Many studies have confirmed that the eye-blink response to a startle probe is enhanced during exposure to shock-conditioned stimuli relative to an unconditioned stimulus. This is a similar result to the findings of startle studies with rats (Hamm et al., 1991). This suggests that the same neural structures might be responsible for controlling startle potentiation in both rats and humans (Lang, 1995).

Lang's *motivational priming hypothesis* proposes that when an organism is processing an unpleasant scene the brain's aversive defensive system is activated and any defensive reflexes will be enhanced. However, since the aversive and appetitive systems are considered to be mutually inhibitory, it follows that when pleasant stimuli are being processed the aversive system should be suppressed, and therefore the magnitude of defensive reflexes should be diminished (Lang, 1995; Lang et al., 1990). This hypothesis has been tested directly on people viewing IAPS pictures. As expected, when viewing unpleasant pictures (e.g., snakes, pointing guns, etc) the startle response is at its strongest, whereas when viewing pleasant pictures (e.g., happy babies, attractive nudes, etc) the startle response is at its minimum (Bradley et al., 1990). Moreover, both skin conductance responses and startle potentiation are greatest when viewing unpleasant pictures that are judged to be more arousing (Cuthbert et al., 1996). In a similar way, as pleasant pictures are judged to be more arousing the degree of skin conductance responses also increases. However, a different pattern emerges for the startle potentiation effect with pleasant stimuli. Increasing ratings of arousal of these images are associated with a greater inhibition of the reflex response. The effects on startle magnitude of pleasant and unpleasant stimuli of increasing arousal rating is shown in Figure 5.10.

As can be seen in Figure 5.10, as arousal rating increases the startle magnitude increases for unpleasant stimuli but decreases for pleasant stimuli. This is exactly as predicted by the motivational priming hypothesis, which explains this pattern by assuming that negative IAPS pictures engage the brain's aversive defensive (withdrawal) system whereas positive IAPS pictures do not. Thus, on the basis of these data it seems that both valence and arousal can make independent contributions to startle modulation.

More recent research on emotion regulation, however, has suggested that startle seems to be primarily a reflection of arousal rather than valence (Dillon and LaBar, 2005). Dillon and LaBar presented their participants with a series of IAPS pictures and instructed them to enhance, maintain or suppress the intensity of whatever emotional response was elicited by the pictures. The prediction was that if arousal is critical then enhance instructions should lead to a greater magnitude of eye-blink startle relative to either maintain or suppress instructions, and this should happen for both

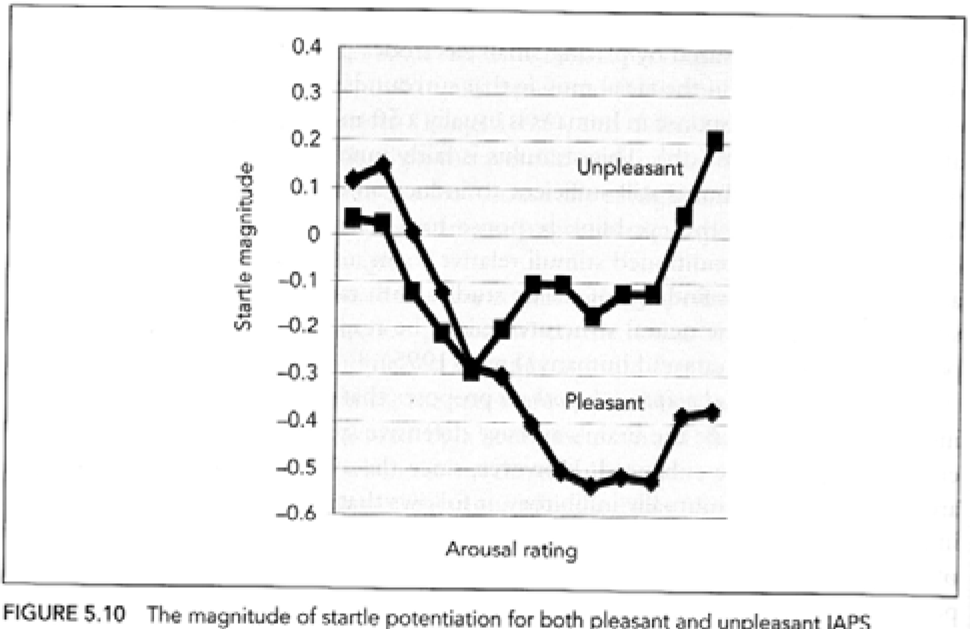


FIGURE 5.10 The magnitude of startle potentiation for both pleasant and unpleasant IAPS pictures as a function of increases in self-reported ratings of arousal

*Source:* Bradley and Lang (2000b).

positive and negative pictures. However, if valence is more important then a different pattern should emerge, based on Lang's motivational priming hypothesis. In this case, because the aversive system is activated when viewing negative pictures, enhance instructions should lead to increased startle when compared to maintain or suppress instructions. Conversely, because the aversive system is assumed to be inhibited when processing positive pictures, then enhance instructions should attenuate startle relative to maintain or suppress instructions. This is because positive affect is assumed to be highest when the emotional responses from viewing positively valenced pictures are enhanced. Dillon and LaBar's results are presented in Figure 5.11.

As can be seen in Figure 5.11, the emotion regulation instructions led to an increased startle response for enhance relative to maintain and suppress instructions. However, while the suppress instructions produced a reduced startle response compared to maintain instructions, this did not reach statistical significance. The most important finding, however, is that the general pattern of enhance > maintain > suppress was the same for both negative and positive IAPS pictures. Thus, conscious attempts to increase and decrease the emotional response to pictures had similar effects on the startle response regardless of valence. These results are inconsistent with the motivational priming hypothesis. They fit Dillon and LaBar's hypothesis that arousal may be more important than valence in modulating startle.

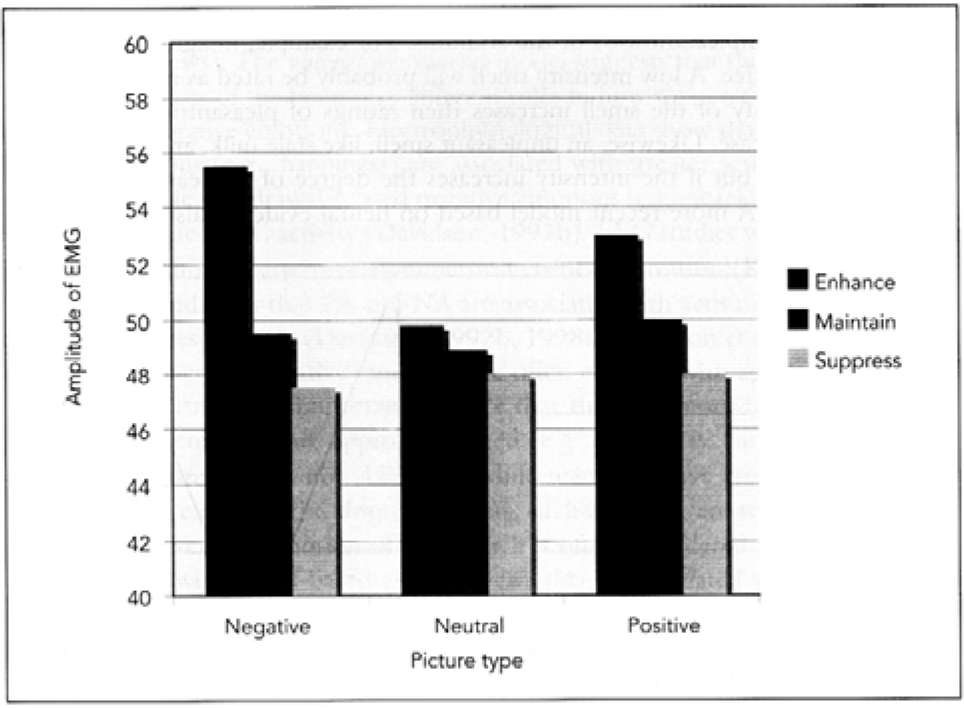


FIGURE 5.11 Eye-blink startle responses as a function of emotion regulation cues

*Source:* Adapted from Dillon and LaBar (2005).

To summarize, there is evidence that physiological measures reflect two underlying dimensions that can be termed valence and arousal. Activity in facial muscles and variations in heart rate show specific patterns of responses for the *valence* dimension, while measures of skin conductance and the startle reflex provide an index of *arousal*. Thus, based on the criteria outlined in Table 5.1, there is reasonably strong physiological evidence for a dimensional approach.

### Neural circuits

Investigation of the dimensions approach by measuring neural activity is somewhat problematic because there are essentially three different models. The overall level of neural activity could be assessed. If arousal is coded by the brain as a separate dimension from valence, as predicted by some models (Russell, 1980), then we would expect to observe some brain areas that activate in response to arousal and not to valence. The neural assessment of valence is even more complicated because it is not clear whether valence is a single bipolar dimension going from most unpleasant to most pleasant that is independent of arousal (Russell, 1980), or whether PA and NA are independent dimensions with varying levels of arousal for each (Watson and Tellegen, 1985). A diagrammatic representation of these models is outlined in Figure 5.12.

As shown in Figure 5.12(b), Watson and Tellegen's (1985) model combines valence and arousal by allowing both PA and NA to vary in intensity. This makes intuitive sense because increasing the intensity of something often does change the pleasantness (or unpleasantness) of the stimulus. For example, imagine the smell of freshly ground coffee. A low intensity smell will probably be rated as mildly pleasant, and as the intensity of the smell increases then ratings of pleasantness will almost certainly also increase. Likewise, an unpleasant smell, like stale milk, at a low intensity may be tolerable, but if the intensity increases the degree of unpleasantness is also likely to increase. A more recent model based on neural evidence also suggests that

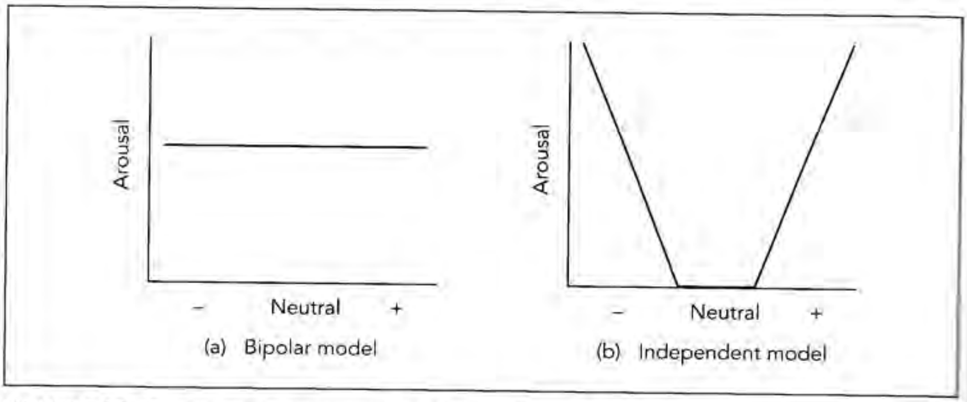


FIGURE 5.12 Diagrammatic representation of two different models of valence
(a) The bipolar model assumes that activation increases from most negative to most positive (e.g., Russell, 1980)
(b) The independent model assumes that activation increases independently for both positive and negative valences (e.g., Watson and Tellegen, 1985).

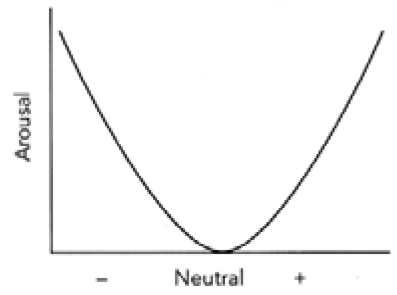


FIGURE 5.13 Winston et al.'s (2005) model relating intensity and valence
*Source:* Lewis et al. (2007).

intensity and valence may be integrated in the representation of a stimulus (Winston et al., 2005). This model suggests that valence increases from most neutral to most intense regardless of being positive or negative, which gives the U-shaped relationship shown in Figure 5.13.

### *EEG studies of the neural correlates of valence*

Richard Davidson and his colleagues have used EEG to measure cortical activity in the left and right hemispheres in order to index valence (see Davidson, 1984, 1992b, 1998a, for reviews). The *valence asymmetry* model suggests that the right and the left prefrontal cortices of the brain play different roles in how we perceive and experience positive and negative emotions. Electrophysiological data show that approach-related positive emotions (e.g., happiness) are associated with greater activation of the left-sided PFC, while withdrawal-related negative emotions (e.g., fear) are associated with greater right-sided PFC activity (Davidson, 1992b). EEG studies with monkeys have shown a very similar pattern of asymmetrical cortical activation (Kalin et al., 1998). This research indicates that PA and NA are associated with activation of the left and right cortices, respectively (Davidson, 1992b, 1998a; Davidson et al., 1990).

While positive and negative emotions are often equated with approach and withdrawal mechanisms, it is important to note that these are not identical constructs. Many positive emotions are approach-related (e.g., happiness, curiosity), but some, such as contentment, are not. Likewise, while many negative emotions are related to withdrawal (e.g., fear and disgust), others, such as anger, are related to approach mechanisms. Even the emotion of fear, which is often considered to be a prototypical aversive or withdrawal-based emotion, can also be associated with the tendency to approach a place of safety. Thus, it is overly simplistic to equate positive emotions with approach and negative emotions with withdrawal. Davidson (1998a) has suggested that it is therefore useful to emphasize the action tendencies related with different emotions. It is difficult to determine how much this differential activation of the two cerebral hemispheres is due to individual differences in response to affective stimuli (affective style) rather than to a momentary response to particular situations or objects. Nevertheless, a good deal of evidence from EEG research in both animals and humans has shown that approach-related and withdrawal-related emotions do seem to be related to different patterns of cerebral asymmetry (Davidson, 1992b, 1998a).

### *The functional neuroanatomy of valence*

Two meta-analyses have specifically examined the neural correlates of (a) emotional valence (positive versus negative emotions) and (b) action tendency (approach versus withdrawal emotions) coming from studies using PET and fMRI (Murphy et al., 2003; Wager et al., 2003). Unfortunately, neither of these meta-analyses assessed the neural correlates of arousal. The majority of work at that time had concentrated on investigating valence with relatively little research being conducted on the correlates of arousal. Moreover, many of the studies investigating valence have actually confounded valence and arousal. Thus, we will begin by reviewing studies assessing the neural correlates of emotional valence and then we will consider some more recent studies specifically examining both valence and arousal.

Murphy et al. (2003) assessed 81 studies that examined negative emotions and 30 studies that examined positive emotions. They hypothesized, on the basis of the valence asymmetry model, that greater left-sided activation of the prefrontal cortex should occur for positive emotions, whereas greater right-sided activation should occur for negative emotions. Against expectation, no statistically significant differences were found in the degree of lateralization observed between positive and negative emotions. However, some support was found for the hypothesis that different neural systems are involved in approach and withdrawal action tendencies. Approach-related emotions were associated with greater activation within the left PFC. However, no laterality differences were reported for withdrawal-related emotions. Thus, this meta-analysis provides only partial support for the valence asymmetry model.

The meta-analysis conducted by Wager et al. (2003) included a larger range of studies and did find differences in neural activation for valence. Positive emotions were associated with greater activation of the left lateral PFC as well as the basal ganglia, whereas negative emotions were associated with increased activation of the insula. In agreement with Murphy et al.'s analysis, greater activation of the left lateral PFC was related to approach emotions, as was activation of the medial PFC. A range of brain areas was correlated with withdrawal-related emotions: amygdala, left medial PFC as well as the anterior cingulate, in addition to the basal ganglia, left insula and left fusiform and superior occipital cortices.

Thus, we can see that these two meta-analyses give a rather inconsistent picture. This is perhaps not too surprising as studies included in the analyses differed widely in terms of the type of tasks that people were undertaking when their brain was being scanned (e.g., rating IAPS pictures, passively viewing emotional facial expressions, recalling positive and negative situations and so on). In addition, given that prefrontal cortical areas are also involved in a range of cognitive processes it is often very difficult to separate out the effects of cognitive and emotional processes in these types of studies.

A number of studies conducted since these meta-analyses have shown that valence does appear to be associated with increased activation of the vmPFC as well as the dlPFC and vlPFC (Anders et al., 2004; Anderson et al., 2003; Dolcos et al., 2004a; Small et al., 2003). A potential confounding factor, however, is that these same regions are also involved in cognitive processes such as attention and evaluative judgement. In other words, if the simple act of judging a photograph can activate the vmPFC, then it is very difficult to isolate any additional activation that might be due specifically to the valence of the photograph. This problem was tackled directly in an fMRI study that explicitly controlled for preceding attention as well as cognitive processes like judgment (Grimm et al., 2006). The researchers compared the pattern of brain activity when people were simply passively viewing emotional pictures with when they were judging emotional pictures. The pattern of brain activity due to the process of judgment could then be distinguished from the brain activity associated with the valence of the pictures. A large number of IAPS pictures were used and participants either had to judge whether each picture was positive or negative during a 4-second presentation or to passively view each picture for 4 seconds. Following scanning, each participant rated all of the images for both arousal and valence on a 1 to 9 scale. These ratings revealed that the positive and negative pictures did not differ in terms of arousal. The fMRI analysis demonstrated that activation within the vmPFC did indeed correlate positively with valence. More positive ratings were associated with a greater degree of activation in the vmPFC for both positive and negative pictures. In other words regardless of whether a picture was negative (e.g., a growling dog) or positive (e.g., a smiling baby) increasing ratings of positivity were associated with increased activation of the vmPFC. This neural activity seemed to be specifically related to emotional valence since vmPFC activity and valence did not correlate when people were judging the photographs.

This study is important because it shows that emotional pictures can activate the vmPFC in the absence of any cognitive task. In addition, this relation is independent of valence. Grimm et al. (2006) conclude that activity in the vmPFC may reflect affective value or significance in a general sense regardless of whether it is positive or negative. This study also found that valence was correlated with activity in both left and right dlPFC, but only during an unexpected judgment condition. This is consistent with another report that activity in the dlPFC seems to be involved in emotional judgment (Dolcos et al., 2004b). These results are important and suggest that a number of distinct prefrontal cortical regions might contribute to different aspects of emotional stimulus processing. In particular, the vmPFC may relate to the affective significance of an emotional stimulus whereas the dlPFC may relate to the evaluative aspect of valence.

### *The functional neuroanatomy of arousal and valence*

The previous section discussed the regions within the prefrontal cortex that are associated with the valence of a stimulus. However, so far we have not looked at studies examining both valence and arousal. As we have seen, EEG studies have shown that increased cortical activity is associated with increasing arousal (Lang et al., 1997). In addition, the fact that the startle response is enhanced as arousal increases provides indirect evidence that the amygdala might be involved in arousal, because the amygdala has been shown to control startle in animal work (Lang, 1995; LeDoux, 1996). More recent studies using fMRI have provided direct evidence that the activation of the amygdala is correlated specifically with emotional arousal (Anders et al., 2004; Anderson et al., 2003; Dolcos et al., 2004a; Williams et al., 2001). Anderson et al. (2003) presented people with a number of odours that were rated for both valence and intensity. A clear double dissociation was found. The activity of the amygdala varied with the intensity of the odour, but it did not react to its valence. In contrast, valence was associated with increased activity in the orbitofrontal cortex (OFC) but this region did not react to differences in intensity. A very similar dissociation has been reported for different tastes, with the amygdala responding to increases in intensity and the OFC responding to variations in valence (Small et al., 2003).

Another study reported a double dissociation between the neural mechanisms underlying intensity and those underlying valence using word stimuli (Lewis et al., 2007). A variety of words were selected from the ANEW set (Affective Norms for English Words), which are rated on a 1–9 scale for both valence (1 = very unpleasant, 9 = very pleasant) and arousal (1 = not arousing, 9 = very arousing) (Bradley and Lang, 1999a). Each word was presented for 1 second and people had to decide (by pressing a button) whether the word could be used to describe themselves (yes/no). The results supported previous work by showing that parts of the OFC responded strongly to the valence of the word whereas responses in insula, basal ganglia and amygdala varied in line with the arousal ratings of the words (Lewis et al., 2007). This functional dissociation between brain regions that are modulated by valence (orbitofrontal cortex) and brain regions that are modulated by arousal (amygdala and associated area) suggests that these two dimensions may well be processed in a distinct manner, supporting some dimensional models of emotion (e.g., Russell, 1980).

Lewis et al. (2007) found a more complex relationship, however, in that different sub-regions of the OFC responded to negative and positive valence. Increasing positive valence was related to enhanced activity in the right lateral OFC as well as in the anterior insula. In contrast, increasing negative valence was related primarily to increased activity in the posterior insula and the ACC, as well as the right OFC and right medial OFC. This pattern of brain activity is more supportive of the dimensional models proposing separate coding of PA and NA (Watson and Tellegen, 1985).

However, Lewis et al. also found that large areas of the brain were activated by the conjunction of valence and arousal, which suggests that valence and arousal may be integrated into a single representation (Watson and Tellegen, 1985; Winston et al., 2003). For example, a number of areas within the left medial OFC and striatum were activated in response to the interaction between valence and arousal, although this occurred only for negative words (Lewis et al., 2007). This valence-specific brain response to arousal supports the idea that emotional content influences the way in which we respond to arousal.

*The neuroscience of reward and punishment*

Edmund Rolls (1999, 2005) has developed a valence-based model of emotions from research examining responses to *reinforcement* and *punishment*. Following on from the behavioural tradition in psychology (Watson, 1919), the model proposes that emotions are essentially coordinated responses to *reinforcing* stimuli. In behavioural terminology, *instrumental reinforcers* are stimuli that can alter the probability that an action will be produced. For example, if positive reinforcement is delivered (e.g., food) then an animal or human will work to achieve that reward. However, if the reward is not delivered then there is less probability of action. Rolls' scheme classifies emotions in terms of reinforcing effects as shown in Figure 5.14. In Figure 5.14, the vertical axis describes emotions associated with the delivery of a reward (up) or punisher (down). The horizontal axis describes emotions associated with the non-delivery of an expected reward (left) or the non-delivery of an expected punisher (right).

It should be made clear that Rolls explicitly states that his classification system is not intended to represent a dimensional scheme, since the parameters plotted on the vertical and horizontal axes do not represent *independent* dimensions. This means that the four directions shown in Figure 5.14 can be at least partly independent of each other. In other words, an individual's sensitivity to a reward (S+) might be completely separate from his or her sensitivity to punishment (S–). With this caveat, Rolls' model

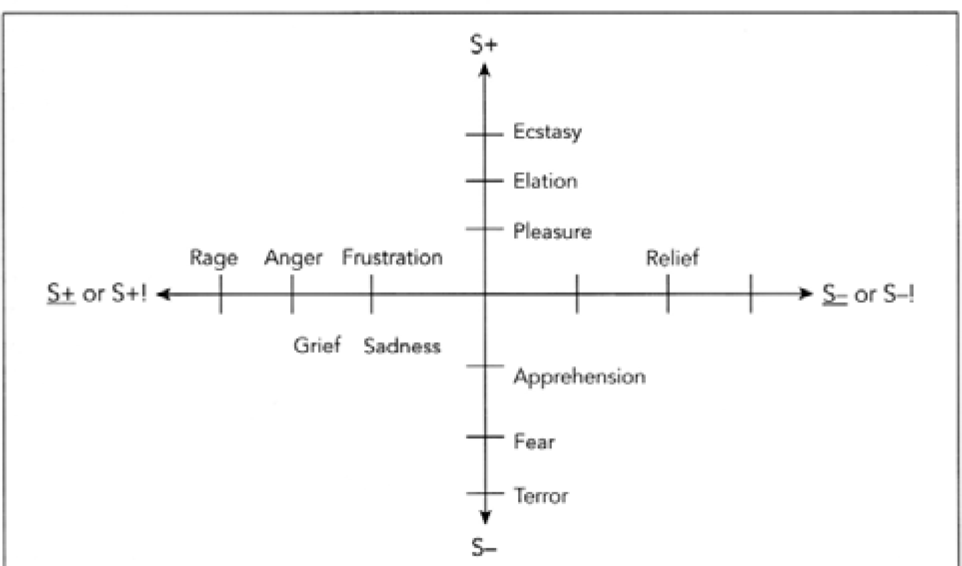


**FIGURE 5.14** Rolls' classification of emotions according to different reinforcement contingencies
S+ = delivery of a reward
S– = delivery of a punisher
S+ = omission of a reward (extinction)
S+! = termination of a reward (timeout)
S– = omission of a punisher (avoidance)
S–! = termination of a punisher (escape).

*Source:* Rolls (2005).

can be considered a dimensional approach in so far as emotions are explained in terms of responses to valence (pleasure and displeasure) as well as arousal or intensity.

Much research suggests that the OFC plays a crucial role in coding stimuli that relate to reward and punishment (Rolls, 2005). For example, in studies of monkeys with electrodes implanted deep within the OFC, it has been found that neurons in this region fire vigorously when a monkey tastes a favourite food or even if the monkey sees an item that is related to the food (see Rolls, 2005 for review). There is evidence that these neurons do indeed code what might be called the 'hedonic value' (i.e., pleasantness) of the food. If the monkey is allowed to eat the food until it is satiated, the firing of the OFC neurons declines in line with the decrease in the food's pleasantness. Functional imaging studies with humans have shown that the OFC becomes similarly activated in response to pleasant foods. In one study, for example, people were asked to rate the pleasantness of the taste of chocolate milk and of tomato juice. They were allowed to drink these drinks until they were satiated and, not surprisingly, the ratings of how pleasant the drinks were declined significantly when the items had been consumed. The interesting finding was that the activation of the OFC decreased as the pleasantness rating decreased (Kringelbach et al., 2003). Importantly, however, the OFC still remained activated to the flavour of food that had not been consumed because the person was satiated, showing that the OFC does indeed seem to code the valence or the pleasantness of the food, rather than other sensory aspects of it.

Rolls and his colleagues have also found that different regions within the OFC respond to pleasant and unpleasant flavours, providing further support for the notion that positive and negative stimuli are coded separately in the brain. For example, activation of the medial OFC correlated with an individual's rating of the pleasantness of a flavour, whereas the unpleasantness of a flavour was correlated with activation in the lateral OFC. A meta-analysis of the literature has confirmed that rewarding (pleasant) stimuli modulate medial parts of the OFC whereas stimuli associated with non-reward (unpleasant stimuli) activate more lateral parts of the OFC in humans (Kringelbach and Rolls, 2004). One study showed a double dissociation between these regions using fMRI in which activation of the medial OFC was associated with a monetary reward, whereas a monetary loss resulted in activation of the lateral OFC (O'Doherty et al., 2001). This pattern of results is consistent with the notion that the medial OFC plays a role in decoding the reward value of a stimulus and that the lateral OFC is involved in evaluating punishers (Rolls, 2005).

The OFC is also anatomically connected to the nucleus accumbens (NAcc), which is situated at the front of the subcortical part of the forebrain. This area has been implicated in the neural representation of both reward and punishment. The NAcc is heavily innervated by both dopamine (DA) and opioid neurotransmitter systems and is often considered to be the 'pleasure' centre of the brain, or the site of positive affect. In many studies with rats, the release of DA in the NAcc region has been shown to be associated with the sight and taste of pleasant food, anticipation of intrinsically rewarding drugs such as heroin or amphetamines, and with the chance of engaging in sexual activities (for review see Berridge, 2003). DA release also appears to be related to reward in humans. One study using PET showed that DA systems in the NAcc were activated when people won money during a computer game (Koepp et al., 1998). To summarize, research using surgical techniques with animals (rats and monkeys) as well as neuroimaging techniques with humans demonstrates that the OFC and the NAcc are important regions for coding aspects of reward and punishment.

As we have seen, the reward system seems to be controlled by the action of DA in the brain. However, it turns out that 'reward' or 'pleasure' is actually much more complex than we might have thought. The psychological models of valence we have discussed generally talk of pleasant versus unpleasant stimuli, and the assumption is that pleasant stimuli are rewarding, while unpleasant stimuli are related to non-reward or to punishment. However, it seems that reward is not, in fact, a unitary concept, but consists of many different psychological components (Berridge and Robinson, 1998). Berridge and Robinson (2003) argue that three processes are necessary for a stimulus to acquire rewarding properties. First, the individual has to be *motivated* to act and learn. Second, he or she must *learn* about the relationships among stimuli and the consequences of actions relating to these stimuli. Finally, the consumption of a reward can produce hedonic *consequences* in terms of pleasantness. Figure 5.15 shows these different components of reward (Berridge, 2003; Berridge and Robinson, 1998). The categories of motivation, learning and emotion or affect each consist of different psychological components, as shown in Figure 5.15. It is important to note that there are both explicit and implicit components in each category. Thus, explicit processes (e.g., explicit desire, expectation, or pleasure) are consciously experienced, whereas implicit processes (incentive salience, habits, and liking responses) may not be accessible to conscious awareness.

Berridge and Robinson (2003) review evidence indicating that different brain systems can influence the components independently of each other. Thus, some brain manipulations can alter the motivational process without influencing how well an

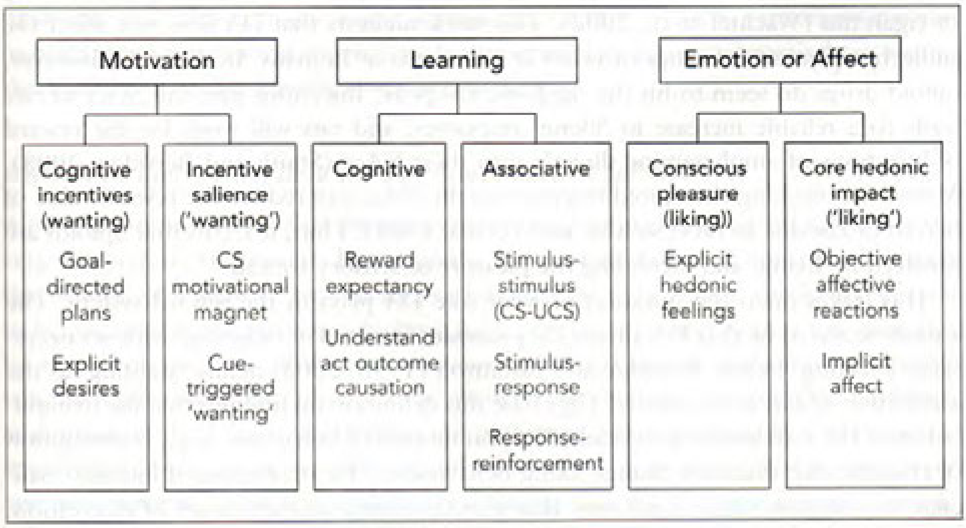


**FIGURE 5.15** Berridge and Robinson's components of reward

Source: Based on Berridge and Robinson (2003).

organism can learn the associations between stimuli and actions. An important point made by Berridge and Robinson is that both motivational and emotional components can occur without any conscious awareness of them. Imagine a situation in which you may react to a rewarding stimulus (e.g., a cigarette or a chocolate) without necessarily being aware of your hedonic reaction. This is common in smokers, who often smoke out of habit and may not be aware that they are smoking. Experimental evidence for such implicit emotion comes from a study in which happy facial expressions were presented subliminally so that people were not aware of them. Subjective ratings of mood and feelings did not change when happy expressions were presented, confirming that the stimuli were indeed outside awareness. However, the subliminal presentation caused thirsty people to drink a greater quantity of a fruit drink a few moments later and also led to them rating the drink higher in terms of 'pleasantness' (Berridge and Winkielman, 2003).

An abundance of evidence indicates that DA systems, especially in the NAcc, are important in controlling the brain's reaction to rewarding stimuli. However, several studies have found that administering drugs that lead to a reduction in brain DA does not necessarily impair a rat's hedonic reaction to a sweet taste. Many species, including rats, produce a distinctive 'liking' facial response (e.g., tongue protrusions) in response to sweet drinks, whereas bitter tastes elicit gaping 'disliking' facial responses (Berridge, 2000). When brain dopamine was reduced the rats' facial responses did not indicate that their enjoyment of the drink was affected. Indeed, even massive lesions that eliminated almost all of the DA in the NAcc and striatum failed to disrupt taste 'liking' (Berridge and Robinson, 1998). Conversely, injections of amphetamine into the shell of the NAcc, which leads to an increase in DA, failed to lead to an increase in 'liking' responses to a sweet taste.

Research with humans has also shown that drugs that block the action of DA do not seem to affect the subjective pleasure of either amphetamines (Brauer et al., 2001) or cigarettes (Wachtel et al., 2002). This work suggests that DA does not affect the subjective pleasure of drugs or tastes in either rats or humans. In contrast, however, opioid drugs do seem to hit the 'hedonic hotspots'. Injections into the NAcc of rats leads to a reliable increase in 'liking' responses, and rats will work for the reward of injections of amphetamine directly into their NAcc (Smith and Berridge, 2005). Moreover, blocking the opioid receptors in the NAcc can reduce the reward value of heroin or cocaine to rats (Stewart and Vezina, 1988). Thus, it seems that opioids are involved in 'liking' and increasing the pleasure of sensory stimuli.

This leaves open the question of what role DA plays in the reward system. The answer seems to be that DA affects the processes involved in 'wanting' without necessarily affecting 'liking'. Berridge and Robinson (1998, 2003) define 'wanting' as the attribution of *incentive salience*. They base this definition on findings that the manipulation of DA systems has powerful effects on motivated behaviour (e.g., consumption of rewards) but does not change liking behaviours. The attribution of incentive salience to a sensory input transforms that stimulus into a wanted target of motivation. Incentive salience or 'wanting' is strongly influenced by DA, but also depends on other brain structures such as connections between the NAcc and the amygdala and

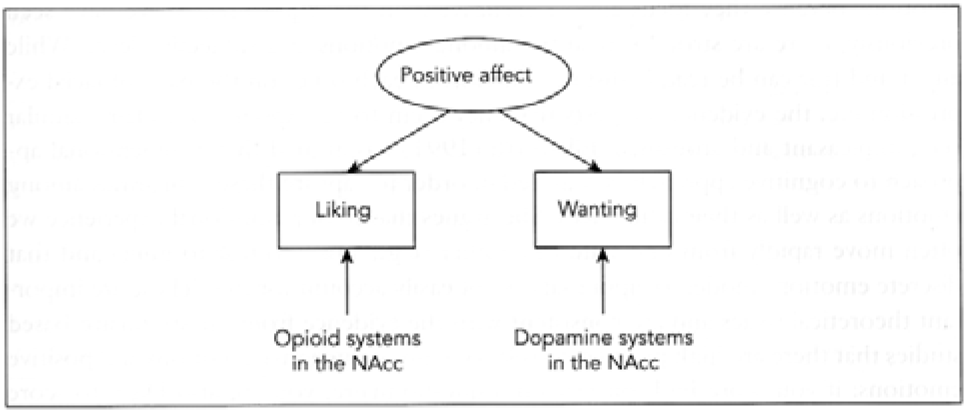


**FIGURE 5.16** Berridge et al.'s components of positive affect

parts of the cortex. Stimuli that have been attributed with incentive salience become what Berridge calls '***motivational magnets***' because they elicit appetitive approach and even consumatory behaviour. The relations between wanting and liking and neurotransmitter systems in the brain are clearly complex. However, the important point for our current purposes is the demonstration that even something as apparently straightforward as positive affect can be broken down into different component parts and that these components are modulated by different neurochemical systems. This structure is shown in Figure 5.16.

## Cognitive appraisals

If emotions are structured primarily in terms of valence and arousal as dimensional models suggest, then cognitive appraisals should occur *primarily* for the dimensions of arousal and valence. Since people do report a number of distinct emotions it is also important for dimensional theories to demonstrate that cognitive appraisal can lead to the impression of discrete emotions (see Table 5.1).

### *Are valence and arousal the dominant dimensions of appraisal?*

Almost all forms of appraisal theory assume that a simple appraisal of valence is the very first step in the process. For example, the work of Robert Zajonc demonstrates that stimuli of which we are not aware (but have been presented subliminally) tend to be ***preferred*** over stimuli to which we have not been exposed. Somewhat ironically, he argued on the basis of this ***mere exposure effect*** that emotions do not require any cognitive processes, but rather, can be elicited directly from the stimulus. However, as pointed out by Ellsworth (1994b), the preferences demonstrated by Zajonc correspond very closely to the simple appraisal of valence: is something ***good*** or ***bad***. As we saw in Chapter 4, many appraisal theories assume that specific appraisals lead to specific discrete emotions (Lazarus, 1991; Stein and Trabasso, 1992). Phoebe Ellsworth has argued, however, that these approaches fail to capture the ***similarities*** among emotions because they focus almost exclusively on the *differences.* As we have seen previously, there are strong similarities among emotions at a subjective level. While anger and fear can be readily distinguished from each other on the basis of facial expression etc, the evidence suggests that they seem to be *experienced* as fairly similar (i.e., unpleasant and arousing). Ellsworth (1991) has argued that a dimensional approach to cognitive appraisals is required in order to capture these similarities among emotions as well as their differences. She argues that in our emotional experience we often move rapidly from one state to another (e.g., anger to fear to guilt) and that discrete emotions models of appraisal cannot easily account for this. These are important theoretical issues and are consistent with the evidence from questionnaire-based studies that there are high positive correlations among negative emotions and positive emotions: if you score high on fear on a questionnaire, you are also likely to score highly on sadness.

Craig Smith and Phoebe Ellsworth have developed a theory of cognitive appraisal that attempts to provide a better account of the similarities among emotions, as well as the differences (Smith and Ellsworth, 1985, 1987). In an extensive analysis of the semantic content of a wide range of emotions, they derived eight different dimensions of meaning that are important appraisal processes in producing a range of emotions. People were asked to recall past experiences that were associated with each of 15 emotions. Once people had recalled key episodes they were asked to describe these episodes in as much detail as possible. They were then asked about their experiences using questions that were designed to tap into the eight different appraisal dimensions listed in Table 5.3. These dimensions had been derived from previous theories and studies. Analysis of the ratings showed that people reliably used six broad dimensions to differentiate among the 15 different emotions. These six dimensions were pleasantness, human agency, certainty, attention, effort and situational control. Importantly, for most of the 15 emotions a *unique* pattern of cognitive appraisals could be identified.

As shown in Table 5.3, appraisals of valence (pleasantness) and arousal (anticipated effort) were included in the list. However, a number of other appraisals were also identified. The important finding from this study is a strong relation between the cognitive interpretation of an event and the emotional reaction to it. However, it is important to note that we cannot draw any *causal* conclusions from this study. People were asked to recall an emotional experience from the past and then report the appraisals that were involved in that situation, so the results rely on a retrospective report. This leaves open the question of whether appraisals like these remembered ones actually occur in an ongoing situation. Parkinson et al. (2005) have criticized these studies on the basis that they examine people's theories about what causes their emotions rather than the actual causes of the emotions themselves. Nevertheless, the appraisal dimensions uncovered by Smith and Ellsworth do illuminate the ways in which people construct their own emotional experience and it seems that arousal and valence are just two of the dimensions used.

Theories of cognitive appraisal differ in terms of which appraisals are considered to be most important. However, appraisals such as novelty, intrinsic pleasantness,

TABLE 5.3 The eight dimensions of appraisal identified by Smith and Ellsworth

| *Dimension* | *Description* |
|---|---|
| Attention | Degree to which you focus on and think about the situation |
| Certainty | Degree to which you are certain about what is going to happen |
| Control–coping | Extent to which you have control over the situation |
| Pleasantness | The degree to which the event is positive or negative |
| Perceived obstacle | Extent to which the pursuit of your goals is prevented |
| Responsibility | Extent to which you are responsible for events |
| Legitimacy | Extent to which the event is perceived as fair or unfair |
| Anticipated effort | Extent to which you must expend energy to respond to the event |

certainty or predictability, goal significance, agency, coping potential, and compatibility with social or personal standards are common across a range of theories (see Ellsworth and Scherer, 2003, for review). This body of work therefore does not generally support two-dimensional models since people seem to consider many dimensions in the construction of their emotional experience. Thus, in terms of the criteria outlined in Table 5.1, it would seem that research on cognitive appraisals does not support the notion that valence and arousal are the primary ways in which people construe their emotional experience.

### *Does cognitive interpretation of affective states result in the impression of distinct emotions?*

From a cognitive appraisal viewpoint, the second criterion outlined in Table 5.1 is the notion that people's reports of discrete emotion categories must come from a particular cognitive conceptualization of affective experiences. As we have seen, there is evidence that we are able to subjectively experience variations in our physiological state. Indeed, this notion was the basis of one of the earliest theories of emotional experience (James, 1884). William James proposed that the conscious experience of emotion results from one's perception of autonomic arousal. This theory placed an emphasis on the *physiological* determinants of emotional experience and proposed that people can distinguish among different emotions on the basis of the physical reactions they experience. Thus, when we perceive an object of fear (a bear in the woods for example), our body responds to this and the *feeling* of these bodily changes is the emotion. However, this theory has some difficulty with the fact that physiological arousal can occur without the experience of emotion (Cannon, 1927). For example, when we engage in vigorous exercise we might become very aroused in a physiological sense but will probably not experience any particular emotion. Cannon also argued that physiological changes are simply too slow to precede the conscious experience of emotion. A further problem is that people experiencing very different emotions, such as fear and anger, often show almost identical patterns of autonomic arousal. Finally, Cannon reported several experiments in which the spinal cord of animals was surgically cut so that no physiological sensations could be experienced below the

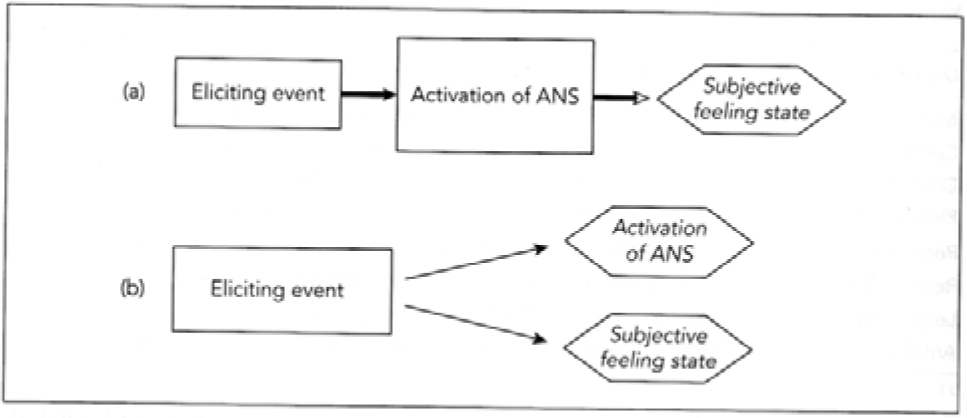


FIGURE 5.17 Theories of emotional experience
(a) James–Lange
(b) Cannon–Bard

level of the cut. In spite of this absence of bodily sensations, however, it seemed that these animals still expressed emotions. On the basis of this evidence, Cannon (1927) argued that *emotion occurs when the thalamus sends signals simultaneously to the cortex (creating the conscious experience of emotion) and to the autonomic system*. His main argument was that physiological changes were very similar across different emotions and therefore could not be used to distinguish among different feeling states as suggested by James. Figure 5.17 illustrates the key differences between the James–Lange and the Cannon–Bard theories.

Subsequent evidence has suggested that there may be some differences in ANS activity between different emotions, and some of the critiques raised by Cannon have been overturned by subsequent evidence (Damasio, 1999). Nevertheless, the fact that many emotions seemed to have relatively similar patterns of physiological arousal presented a problem for the James–Lange hypothesis and formed part of the inspiration for a now-classic experiment conducted by Stanley Schachter and Jerome Singer in 1962.

### *Schachter and Singer – two factor model*

Schachter and Singer (1962) proposed that the experience of emotion depends on two factors: autonomic arousal and cognitive interpretation of that arousal. They hypothesized that when you experience physiological arousal you search your environment for an explanation. Thus, there is some agreement with James' theory in accepting that emotion is inferred from arousal. However, there is also agreement with Cannon's position that different emotions were thought to yield indistinguishable patterns of arousal. These views were reconciled by the suggestion that people look to *external* rather than to *internal* cues to differentiate and label their specific emotions. Thus, an emotional experience is considered to have two parts: a physiological element, much as described by William James, and a cognitive appraisal element, much as described by Magda Arnold (1960). This is illustrated in Figure 5.18.

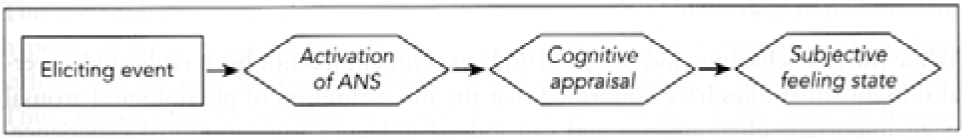


**FIGURE 5.18** Schachter and Singer's two-factor model

This hypothesis was tested in an intriguing experiment (Schachter and Singer, 1962). Male college students were led to believe that they were participating in an experiment about the effects of a vitamin injection on vision. Some participants were then injected with adrenaline, which is known to produce autonomic arousal, while others received a saline injection, which has no effect on arousal. Some of the participants in the group receiving adrenaline (*informed* group) were told that the 'vitamin' produced certain side-effects such as a pounding heart, tremors, and a flushed feeling – the typical effects of an injection of adrenaline. However, other participants were told that the drug would have no side effects (misinformed). Individuals who had received the placebo were also told accurately not to expect any side effects (informed) or to expect arousal effects (misinformed). After receiving the injection, the participants were asked to wait in a room with one other participant, who was actually a confederate of the experimenter. The confederate behaved in one of two ways: in the *euphoric condition* he was very active and playful, running around the room and making paper aeroplanes and so on; in the *angry condition*, however, he was disagreeable and constantly complained about having to fill out questionnaires.

The affective responses of the participants were assessed by the experimenters through a one-way mirror as well as by subjective questionnaire. The first finding was that the informed subjects showed very few signs of experiencing emotion. Of more interest, however, was the finding that the misinformed individuals generally described and labelled their mood in accordance with the situational manipulations. In other words, those who had received adrenaline and experienced physiological arousal without any adequate explanation tended to feel either euphoric or angry depending on the confederate's behaviour. However, those who had received adrenaline and experienced physiological arousal but had an adequate explanation for their symptoms did not experience any emotion. Thus, the emotional experience was not determined by physiological arousal alone, but rather by physiological arousal in combination with an appraisal of the situation. If I feel aroused and my companion is very angry then I will tend to interpret my own arousal as anger. However, if I feel aroused but know that this is because I have taken adrenaline then I will be less likely to be influenced by another's emotional behaviour.

This experiment has been highly influential in psychology, even though a number of problems have been noted. For example, in spite of several attempts, no study has been able to fully replicate the effects (Marshall and Zimbardo, 1979; Reisenzein, 1983). Thus, although this theory has had a very strong influence on subsequent research, it does not appear to be valid. Nevertheless, it was important in focusing the attention of researchers on the role of *cognitive factors* (i.e., a person's interpretations) in determining emotional states.

*Misattribution of arousal*

While the full Schachter and Singer (1962) experiment has not been replicated, several subsequent studies have confirmed that the misattribution of physiological arousal is an important phenomenon and can indeed influence our emotional experience. In one experiment participants engaged in intense physical activity, which resulted in physiological arousal, and then rested until they thought that their arousal had subsided. It was found that participants rated erotic images as more arousing and cartoons as being much funnier than people who had not recently engaged in physical activity (Zillmann, 1979).

A similar misattribution of arousal has been reported in an imaginative real-life experiment. Dutton and Aron (1974) interviewed men who had crossed over the Capilano River in Vancouver, Canada by one of two bridges. One bridge was a wide sturdy wooden bridge, which was about 10 feet above the water. However, the other was a suspension bridge, which was almost 200 feet above the water and consisted of boards and steel cables with very low hand-rails. The entire bridge swayed alarmingly and people generally felt fairly nervous when crossing. In the experiment, men who had just crossed the river were approached by a female researcher who asked them to fill out a survey on local scenic attractions. A key part of the experiment, however, was that the interviewer gave each participant her telephone number and suggested that he get in touch if he would like to talk further. More phone calls were made by men who had crossed over the suspension bridge than by men who had crossed over the low bridge. Dutton and Aron (1974) concluded that the arousal produced by the bridge was misattributed to attraction to the woman interviewer. This line of research demonstrates that bodily arousal is indeed used to colour our subjective experience of the world. However, this arousal is interpreted in terms of current context and may not necessarily provide an accurate reflection of what caused the arousal in the first place.

Recent neuroscience studies have provided potentially relevant data showing that the amygdala only seems to respond to arousing stimuli in a particular emotional context. This suggests that the amygdala and nearby structures, such as the ventral striatum which includes the NAcc, may respond to the general affective significance of a stimulus rather than to arousal or valence specifically. For example, some studies have shown that activity within the NAcc increases in response to generally salient stimuli regardless of whether they are positively or negatively valenced (Breiter et al., 1996; Liberzon et al., 2003; Phan et al., 2004). The NAcc is anatomically connected to a number of regions within the PFC as well as to a range of subcortical regions such as the amygdala. Therefore, it is possible that the NAcc may play an important role in determining the *affective significance* or *salience* of a stimulus (Berridge and Robinson, 1998).

*The conceptual act model*

Lisa Feldman Barrett has developed the *conceptual act model*, which proposes that discrete emotions are an illusion created by a cognitive process of categorizing what she calls *core affect* (Feldman Barrett, 2006b; Russell and Feldman Barrett, 1999).

This is essentially an updated version of the Schachter and Singer (1962) model. The hypothesis is that what we *perceive* and *experience* as individual emotions (anger, fear, sadness etc) actually emerge from more basic or fundamental psychological processes. Thus, rather than an emotion like anger being truly discrete in the sense of having a distinct neural circuitry etc which can be contrasted with sadness, which will have another distinct neural circuitry, the emotion we term anger is actually constructed by how we perceive and categorize changes in a more fundamental and general *core affective system*. It is this general affective system that is hypothesized to be the fundamental or basic building block of emotional life (e.g., Feldman Barrett, 2006a and b; Russell, 1980, 1991; Russell and Feldman Barrett, 1999).

Russell and Feldman Barrett (1999) do, however, distinguish what they call *prototypical emotional episodes*, which correspond to *emotions* (i.e., a synchronized set of events concerned with a specific object) as defined in this book. They point out that these *prototypical emotional episodes* are very rare, and contrast them with *core affect*:

> We use the term core affect to refer to the most elementary consciously accessible affective feelings (and their neurophysiological counterparts) that need not be directed at anything. Examples include a sense of pleasure or displeasure, tension or relaxation, and depression or elation. Core affect ebbs and flows over the course of time. (Russell and Feldman Barrett, 1999, p. 806)

The notion of core affect is the same as the concept of mood as defined in this book. Therefore, the hypothesis is that our background mood states are experienced along the general dimensions of valence and arousal, and that these states are categorized into discrete emotion categories based on a cognitive appraisal of the current context. Feldman Barrett (2006b) reviews extensive evidence that conceptual knowledge can and does influence the subjective experience of emotions and moods (see also Dutton and Aron, 1974; Schachter and Singer, 1962). Thus, the second criterion for dimension models as outlined in Table 5.1 does appear to have been fulfilled.

## COMPARING DISCRETE AND DIMENSIONAL APPROACHES

Lisa Feldman Barrett (2006a, 2006b; Feldman Barrett, Mesquita et al., 2007) has recently argued that progress in emotion science has been limited by the assumption that a core set of basic emotions is given to us by nature. She suggests that the hypothesis of discrete emotions is not supported by the evidence and a dimensional perspective, in combination with the notion of conceptual categorization of core affect, provides a better explanation of the data. However, as illustrated in Table 5.4, emotion scientists taking discrete emotions or broad dimensions as the fundamental building blocks of affect frequently are studying quite different aspects of affect. Discrete emotions theorists often focus on the neural or physiological underpinnings of *emotions* or *moods* (often in rodents). Some even argue that the subjective experience of the emotion is irrelevant to the understanding of the emotion itself. In contrast,

TABLE 5.4 The contrast in emphasis between discrete emotions approaches and dimensional approaches in investigating the fundamental nature of emotion.

| *Type of approach* | *Typical core data* | *Assumed underlying mechanisms* |
|---|---|---|
| Discrete emotions | RTs to prototypical stimuli (e.g., angry, happy, fearful expressions etc) | Cortical-subcortical neural circuits with the emphasis on the subcortical structures |
| | Recognition of prototypical facial expressions | |
| | ANS specificity to particular emotions | Cognitive appraisal |
| | Activation of specific neural circuits | |
| Dimensions | Subjective report of feelings | Cortical-subcortical neural circuits with the emphasis on the cortical structures |
| | ANS response to general dimensions (e.g., positive versus negative affect) | |
| | Neural activation to general dimensions | Cognitive appraisal |

those adopting a dimensional approach are more likely to focus on subjective report of feelings as the main dependent variables. While there are exceptions, researchers in the two traditions tend to:

(a) focus on different aspects of affect (e.g., feelings versus neural or cognitive structures);
(b) use different paradigms to study what they consider to be emotion (e.g., questionnaires versus fMRI); and
(c) study different species to address these (different) questions (e.g., rodents versus humans).

The problem arises when a theory developed from one of these traditions is then generalized in an attempt to explain 'emotion' as a whole.

It is difficult at this point to determine whether discrete emotions perspectives or dimensional perspectives provide a more accurate view of emotions and moods and how they are structured. A key challenge is to examine these different research traditions and determine whether the empirical evidence from both approaches can be integrated in a sensible way to provide a comprehensive understanding of affect. In Chapter 11, the conclusion is drawn that research from both traditions is important and essentially provides information from different *levels of analysis* (e.g., subjective report versus neural activation). If emotion scientists are careful to define the different elements of affect (emotions, moods, feelings, emotion schemas) then data from both of these approaches can be integrated to provide a more comprehensive overview of affect.

A further complication is that individual differences in how people respond to different situations are usually not considered in research on the structure of affect. These consistent differences in people's *responses* to emotional situations, as well as differences in how they *perceive* and *interpret* emotional situations, however, are likely to be influential in terms of how affective life is structured.

## CHAPTER SUMMARY

Chapter 5 discussed evidence that our affective experience is structured around a small number of underlying dimensions. Evidence from self-report data suggests that valence and arousal emerge as important elements of our subjective experience. However, on examination of the pattern of cognitive appraisals that people make, it seems that a wide range of dimensions are used. This does not support the view that a small number of dimensions are primary. Nevertheless, physiological responses do seem to be related to the broad dimensions of valence and arousal, and brain-imaging studies have also found that valence and arousal are coded within the brain. Importantly, however, neurobiological research has found that valence may not be as fundamental as some researchers have assumed. In particular, *positive affect* can be broken down further into sub-components such as 'wanting' and 'liking'. There is some evidence for both the discrete emotions view and the dimensional view, although it must be remembered that these theories and the experiments designed to test them are often aimed at different levels of analysis (e.g., subjective experience or feelings versus coordinated physiological responses).

## RECOMMENDED READING

An excellent overview of the structure of emotion in terms of self-report data is provided in:

James A. Russell and Lisa Feldman Barrett (1999) 'Core affect, prototypical emotional episodes, and other things called emotion: Dissecting the elephant', *Journal of Personality and Social Psychology*, 76, 805–19.

A recent series of excellent articles by Lisa Feldman Barrett also provides a detailed discussion of dimensional approaches to emotion and questions whether discrete emotion categories can be considered as 'natural kinds'.

Lisa Feldman Barrett (2006) 'Are emotions natural kinds?', *Perspectives on Psychological Science*, 1, 28–58.

Lisa Feldman Barrett (2006) 'Solving the emotion paradox: Categorization and the experience of emotion', *Personality and Social Psychology Review*, 10, 20–46.

Lisa Feldman Barrett and Tor D. Wager (2006) 'The structure of emotion: Evidence from neuroimaging studies', *Current Directions in Psychological Science*, 15, 79–83.

Critiques of this approach are provided by:

Carol E. Izard (2007) 'Basic emotions, natural kinds, emotion schemas, and a new paradigm', *Perspectives on Psychological Science*, 2, 260–80.

Jaak Panksepp (2007) 'Neurologizing the psychology of affects', *Perspectives on Psychological Science*, 2, 281–96.

Excellent discussions of the brain mechanisms involved in the reward system is provided in the following sources:

Kent Berridge and Terry Robinson (2003) 'Parsing reward', *Trends in Neurosciences*, 26, 507–13.

Edmund T. Rolls (2005) *Emotions Explained*. Oxford: Oxford University Press.