2 THE NATURE AND MEASUREMENT OF EMOTIONS, MOODS AND FEELINGS

There is little doubt that emotions, moods and feelings play a central role in our lives. Consider the overwhelming joy of a parent upon seeing his infant take her first step; the ongoing sadness we feel when one of our parents dies; the intense fear we might feel when approached by a large growling dog. Emotions, moods and their associated feelings are constant companions to our everyday life. This chapter presents a brief history of scientific research on *affect* in order to determine what is generally meant by the terms *emotions, feelings* and *moods*. A particular aim is to describe the various methods that have been used to measure the different aspects of affect. Since the success of any scientific endeavour can stand or fall on the quality of the measurement techniques available it is important to evaluate those that emotion scientists commonly use.

DEFINING EMOTIONS AND MOODS

Emotion

There is no general agreement in emotion science on how emotion should be defined. However, many theorists agree that each emotion consists of a number of different components – subjective report, physiological response, cognitive appraisal and so on. It is generally assumed that each component fulfils a specific *function* in coping with the situation that has triggered the emotion. An important question concerns whether *cognitive appraisals* should be considered as *causes* of emotions (which is implied by most appraisal-based models – Arnold, 1960; Lazarus, 1966), or whether they should be thought of as *components* of emotion. The *component process model* (Scherer, 1979, 1984, 2001) proposes that appraisals are important components of emotion and that emotions are only experienced when several different subsystems are coordinated in order to produce *an adaptive reaction to an event that is appraised as significant for the person's well-being*. The component process model breaks down emotions in terms of their *functions* and identifies the main 'organismic subsystems' that have evolved to achieve these functions. The key point is that the *components* of an emotion episode are the particular states of the five subsystems at any given point in time. The *process* refers to the coordinated changes that take place over time, hence the name *component process* model. From this perspective, an emotion is considered to be an 'episode of interrelated, synchronized changes in the states of all or most of the five organismic subsystems in response to the evaluation of an external or internal stimulus event as relevant to major concerns of the organism' (Scherer, 2005, p. 697). In other words, all components including the appraisal of the situation are considered

TABLE 2.1 The relationship between the components of emotion and the organismic subsystems and functions of emotion

Emotion component	*Organismic subsystem*	*Emotion function*
Cognitive component (appraisal)	Information processing	Evaluation of events and objects
Neurophysiological component (bodily symptoms)	Support	System regulation
Motivational component (action tendencies)	Executive	Preparation and direction of action
Motor expression component (facial and vocal expression)	Action	Communication of reaction and behavioural intention
Subjective feeling component (emotional experience)	Monitor	Monitoring of internal state and organism–environment interaction

Source: Adapted from Scherer (2001).

to be an integral part of the emotion episode. The five components and their respective subsystems are outlined in Table 2.1.

Three of the components of emotion outlined in Table 2.1 – bodily symptoms, behavioural expression and subjective experience – have long been considered to be crucial elements of emotion. The induction of ***action-tendencies*** has also been widely assumed to be related to emotional arousal (e.g., flight–fight tendencies) as well as being important in differentiating among different emotions (e.g., Frijda, 1986). Scherer (2005) acknowledges that the inclusion of the cognitive component is controversial, since some theorists make the assumption that emotion and cognition are separate but interacting systems. For example, Izard (1977) has argued that a distinction should be made between an ***emotion*** and an ***emotion schema***. On this view, 'emotion' refers to a coordinated response to an environmental event and does not require any prior appraisal. In contrast, 'emotion schema' refers to a mental representation that integrates these emotional responses with complex cognitive appraisals. Izard suggests that researchers' tendency not to distinguish between emotions and emotion schemas has resulted in much confusion in emotion science (Izard, 1977; 2007).

The component process view argues that all five components – cognitive, bodily symptoms, action tendencies, expression and feelings – probably operate independently of each other most of the time. The special nature of emotion, from this perspective, requires that all of these systems become coordinated and synchronized for a short period of time, and that this synchronization is driven by appraisal processes (Scherer, 2005). For example, someone might wonder whether the new person he has just met might be a potential romantic partner. Is the cab driver's speeding putting my life in danger? Is it safe to take an ecstasy pill offered at a party? Emotions can therefore be seen as reactions to events and situations that seem to be important to our welfare (Ekman, 2004). It is commonly assumed that emotions begin very quickly and that we are usually not aware of the processes in our mind that trigger them. While there is still some controversy regarding the extent of cognitive appraisal required to elicit an emotion there is fairly general agreement that emotions prepare us to deal with significant events (either good or bad) without having to think too much about them (e.g., LeDoux, 1996; Öhman, 2000).

Emotions can be understood then as coordinated reactions to a number of different objects and situations which are often called *emotionally competent stimuli*. An important question, of course, concerns what constitutes an 'emotionally competent stimulus'? Is any stimulus that is appraised as significant in some way emotionally competent? Or are some stimuli more likely to be always appraised as significant because of their biological or social significance? One possibility is that the stimuli that elicit emotions can be broken down into the broad categories of *rewards* and *punishers* (e.g., Rolls, 1999, 2005). A *reward* is anything for which an animal (or human) will work, while a *punisher* is anything that an animal or human will work to escape or avoid. Thus, emotions can be defined as 'states elicited by rewards and punishers, that is, by instrumental reinforcers' (Rolls, 2005, p. 11). Take happiness as an example. Imagine that you receive a prize for writing the best essay in your class. This reward produces a state of pleasure or happiness. In contrast, a punisher such as failing an examination might produce a state of fear and apprehension. The reduction of emotionally competent stimuli to rewards and punishments is an elegant way of describing the induction of emotions. However, this reduction does seem to lose something of the complexity of the stimuli and the appraisals that can elicit specific emotions.

Some investigators have suggested that emotions are best understood as *action tendencies* which prepare the organism to *act* in some ways rather than others (e.g., Frijda, 1986). From an evolutionary perspective, emotions are the means by which nature regulates behaviour in relation to the agendas set by the demands of biological evolution (Tooby and Cosmides, 1990). From a cultural or social constructionist perspective emotions are the means by which our relationships with others in a group or society are regulated (Mesquita, 2003). Whatever perspective one takes, it is clear that emotions have important biological, psychological and social functions. Ray Dolan (2002) has suggested that, as psychological experiences, emotions have three unique qualities:

1. Unlike most psychological states, emotions are *embodied* and manifest in clearly recognizable and stereotyped, behavioural patterns of facial expression, comportment and autonomic arousal.
2. They are less susceptible to our *intentions* than other psychological states.
3. They are less *encapsulated* than other psychological states, as evident in their global effects. When we are sad, the whole world looks grey, we find it difficult to concentrate and we become highly selective in what we can remember.

MOOD

In psychiatry, the word 'mood' is used to denote states of happiness and sadness and their extremes (mania and depression). In everyday usage, however, the term 'mood' is often used to cover a much wider range of feelings. For example, we might describe a 'moody' person as one who experiences a range of emotions in fairly unpredictable ways. Morris defines mood in a broad way as being a cue to the person about the resources available to meet environmental demands (Morris, 1989, 1992). Lazarus (1991) presents a similar notion in suggesting that 'moods are concerned with larger, longer lasting, existential issues about the person's life and how it is going ... moods are transcendentally important ... in how we judge our adaptational status' (p. 49). Thus, in a general sense moods are seen as appraisals of our general well-being.

Prinz (2004) has also argued that mood reflects one's general position in life, which can explain why some situations can elicit very strong emotions without necessarily inducing moods. Take road rage as an example. Being cut up on the highway can produce intense anger and aggression but does not tend to lead to ongoing mood changes since being cut up on a motorway is not typically construed as evidence that one is not faring well in life (Prinz, 2004). In contrast, losing one's job marks a potential reduction in financial security and therefore is likely to induce an intense emotion as well as an enduring mood state. Prinz concludes that the functions of moods and emotions are different: moods are set up to detect global changes in organism–environment relations, while emotions are set up to detect more localized changes.

Damasio (1999) defines moods as 'states of emotion' that tend to become frequent or even continuous over long periods of time. Since moods are essentially emotions that are dragged out over time, according to this view, the collections of responses that characterize emotions (bodily changes, feelings etc) are also experienced over longer durations. The assumption that moods are a subset of emotions is also reflected by Prinz (2004) who argues that moods are a special case of emotion and do not represent an independent category. It is clear that, in order to arrive at a definition of mood, most researchers have contrasted moods with emotions. Therefore, let us have a closer look at the distinctions that have been made between these two terms.

DISTINGUISHING MOODS AND EMOTIONS

As shown in Table 2.2, emotions are considered to be of short duration, to occur in response to sudden specific events, to be relatively intense with accompanying physiological arousal and to tend to bias actions. This fits with the notion that a major function of emotions is to facilitate adaptation to important events. In contrast, moods are seen as more enduring and less intense affective states. They have a more diffuse physiological arousal and tend to bias cognitions rather than actions. Moreover moods may actually be induced by emotions. This pattern fits with the possible function of moods as signals of how we are doing in life in a general way. We should note at this point that there is not universal agreement on these distinctions and good discussions are available in, for example, Ekman and Davidson, 1994, pp. 51–96; Ketter et al., 2003).

Emotions are often elicited by specific events that can occur very suddenly, whereas moods tend to occur in response to events that are more general and develop over time (Davidson, 1994b). Thus, the weather can often induce different mood states

TABLE 2.2 Distinctions between emotions and moods

Distinctions	*Emotions*	*Moods*
Duration	Seconds to minutes	Hours to days
Function	Biasing actions	Biasing cognitions
Nature of antecedent event	Sudden events Specific events Object focused	General non-specific events Emotions Diffuse
Relative intensity	High	Low
Autonomic arousal	Acute Perhaps specific	Variable Diffuse
Neural substrates	Predominance of subcortical activation (?) Rapid neurochemical changes	Predominance of cortical activation (?) Long lasting neurochemical changes

(e.g., Schwarz and Clore, 1983), but is unlikely to induce specific emotions (unless of course there are violent storms or tornados!). In general, it seems that the coordinated reactions we call emotions are related to specific objects, whereas moods lack such an obvious focus (Clore et al., 1994; Frijda, 1994c; Morris, 1989). If one is experiencing the *emotion* of happiness, for example, one is probably happy about a very specific event such as being offered a new job. However, if one is experiencing a happy *mood*, one is not happy about anything in particular, but rather happy in a more general way. In evaluating the literature on the neurobiology of emotion, Edmund Rolls (2005) has come to a very similar conclusion. He distinguishes moods and emotions as follows:

> An emotion consists of cognitive processing that results in a decoded signal that an environmental event (or remembered event) is reinforcing, together with the mood state produced as a result. If the mood state is produced in the absence of the external sensory input and the cognitive decoding … then this is described only as a mood state, and is different from an emotion in that there is no object in the environment towards which the mood state is directed. (Rolls, 2005, p. 13)

On this view, a mood is normally elicited by a reinforcer (just like an emotion) but does not involve the decoding of a stimulus in terms of whether it is a reward or a punisher. Thus, a mood is considered to be an emotion without the cognitive appraisal of the reinforcing properties of a given stimulus. It is therefore easy to see why mood states are not necessarily associated with an object, while emotions are always related to a specific object. In agreement with this, Jerome Kagan has argued that emotions refer to a 'temporary change in psychological and biological processes to particular classes of incentives', while mood refers to 'a salient, enduring emotional quality displayed in a variety of situations' (Kagan, 1994, p. 74). For this reason, emotions tend to be tied to particular situations whereas moods can transcend contexts.

Davidson (1994b) captures a widely accepted view when he suggests that moods are always present in that they provide the emotional colour or background to our everyday life. An interesting implication of this is that, if moods are continually present, then our cognitive processes will always be biased or modulated to some extent. Perhaps moods can be thought of as the *affective background* while emotions can be seen as perturbations or disruptions that are superimposed upon this background (Davidson, 1994b). In general, then, it seems that an *emotion* is best regarded as a reaction to a particular situation or object that can be quite intense, and represents a temporary coordination of various components. In contrast, *mood* can be seen as a generally less intense experience that lasts for a longer time than an emotion, and is often more general or non-specific (e.g., Ekman, 1992a; Ellis and Moore, 1999; Forgas, 1995).

Beedie et al. (2005) have developed the distinction further and pointed out that moods and emotions are likely to differ from each other according to more than one criterion. For example, a difference between moods and emotions at a physiological level will almost certainly result in differences in phenomenal experience, which in turn are likely to lead to differences in the expressions, behaviours and linguistic descriptions linked with the two states. They propose that *folk psychology* (or common sense) theories of mood and emotion might offer the potential for further study of both constructs. Folk theories are based on 'the assumptions, hypotheses and beliefs of ordinary people about behaviour and mental experience' (Colman, 2001, p. 283). Emotion researchers have emphasized the value of folk theories for scientific enquiry (e.g., Lazarus, 1999; Levenson, 1994). For example, Lazarus (1999) argues that, as long as hypotheses are formulated appropriately, folk theories can be evaluated by controlled observation – which is the hallmark of science – as readily as any other theory. Beedie et al. (2005) adopted such an approach by asking 106 people from many different walks of life what they believed to be the difference between an emotion and

TABLE 2.3 A summary of the distinctions between emotions and moods

Criterion	*Emotion*	*Mood*
Anatomy	Related to the heart	Related to the mind
Awareness of cause	Individual is aware	Individual may not be aware
Cause	Specific event	Cause less well defined
Clarity	Clear	Nebulous
Consequences	Behavioural and expressive	Cognitive
Control	Uncontrollable	Controllable
Display	Displayed	Not displayed
Duration	Brief	Enduring
Experience	Felt	Thought
Intensity	High	Low
Intentionality	Related to specific object	Objectless
Physiology	Distinct responses	No distinct responses
Stability	Fleeting and volatile	Stable
Timing	Rises and dissipates rapidly	Rises and dissipates slowly

Source: Adapted from Beedie et al. (2005).

a mood. The resulting responses were analyzed by means of standardized qualitative procedures. In addition, they conducted a content analysis of 65 articles published in the scientific literature, all of which included criteria to distinguish moods and emotions. The eight key themes that emerged were: intensity, duration, physiology, cause, awareness of cause, consequences, function and intentionality. Interestingly, all of these criteria also emerged in the answers given by the respondents in the study. A summary of these results is presented in Table 2.3.

Beedie et al.'s study has provided a fascinating insight into the distinctions people make in everyday life between moods and emotions. The authors are careful, however, to point out the potential limitations of this kind of qualitative analysis. For example, if people represent emotional reality accurately then it makes sense to use these representations when trying to understand the underlying phenomena. However, if it turns out that people's representations are distorted in some way then a reliance on self-report measures means that we are 'in danger of developing theories based on emotional ideology instead of emotional reality' (Parkinson, 1995, p. 347). This brings us to the important question of how we can adequately *measure* the various components of emotions and moods.

THE MEASUREMENT OF AFFECT

There are clearly a number of components involved in both emotions and mood states. It comes as no surprise, then, that a wide range of measurement instruments is available. Some of these focus on subjective self-report (how someone feels), others focus on physiological and behavioural indicators, while others provide direct measures of brain activity. Another issue concerns how emotions and moods can be elicited under laboratory conditions. If we look carefully at specific studies, we will see that it is sometimes unclear whether a mood state or an emotion is being investigated, and it is likely that a mixture of moods and emotions might be activated in many of these studies. To illustrate, moods are often induced by asking people to recall a traumatic (or exciting) event that happened to them. In other studies, they are given lists of negative or positive statements to read. For example, a common method used is a *mood induction procedure* developed by Velten (1968). This technique requires a person to read a list of either sad (e.g., 'I am less successful than other people') or happy (e.g., 'I can feel a smile on my face') self-statements. Subjective report generally indicates that positive and negative moods can be reliably induced by these methods. However, it is not always clear whether it is a mood or an emotion that is being induced. If we give someone a long list of negative statements (e.g., I am a failure; the world is a bad place etc), for example, we might just as easily induce the emotion of sadness as the mood of sadness.

Inducing emotions might be somewhat easier in animals. For example, the smell of a cat seems to induce an instant fear response in rats (Panksepp, 1998). Thus, cat odour is presumably a strong emotionally competent stimulus for rats. Emotionally competent stimuli, such as angry facial expressions, are often used to induce emotions in humans. More cognitive tasks (e.g., remember a traumatic event) are also widely used, but these may be less effective in eliciting genuine emotions over and above changes in mood state. A further complication relates to the fact that the neurophysiological bases of moods and emotions are likely to be shared. This is particularly the case if moods are a subset of emotions as many investigators have argued (e.g., Damasio, 1999; Izard, 1977; Prinz, 2004; Rolls, 2005). Coan and Allen (2007) provide an excellent overview of how affective responses can be elicited and measured under laboratory conditions. The following sections provide a brief overview of the more common techniques used to measure emotions, moods and feelings.

MEASURING EMOTIONS

An obvious feature of an emotion is that it is accompanied by a *subjective experience*, or what we would normally call a *feeling*. We can generally tell somebody else how it *feels* to be angry, sad, in love and so on. Many theorists argue that such conscious states can only be reported from a first-person point of view. In other words, no matter how many other components or correlates of emotion we measure, we cannot replace the direct report of the person experiencing the feeling (e.g., Feldman Barrett, Mesquita et al., 2007). Nevertheless, many emotion scientists argue that emotions cannot be described completely by relying solely on subjective report. While it is important to know how somebody feels and the range of emotions they experience, the problem is that emotions also involve a host of physiological changes (e.g., your heart might beat faster if you are feeling afraid etc) as well as behavioural changes (e.g., a smoker might smoke more when feeling anxious), and we may not always be aware of these changes. Thus, relying on a purely subjective account of what it feels like to be fearful, or angry, or happy can be highly informative but is likely to fall short of giving us an understanding of the complexity of emotions.

Many investigators assume that emotions evolved from rather simple reflexive actions, and that many of these action tendencies and their physiological correlates are still part of the human response repertoire (e.g., Frijda, 1986). Obtaining a measure of these behavioural and physiological outputs can therefore provide an alternative window into the processes and mechanisms involved in emotions. To illustrate, the primitive response of moving towards positive things and moving away from negative things is the basis for all behaviour (Schneirla, 1959). When confronted by the species appropriate stimuli of *appetite* or *aversion*, insects, birds, fishes, reptiles, and mammals all show similar stimulus-driven *approach* and *avoidance* behaviour. Thus, measures of simple approach and avoidance behaviour can be easily designed and are likely to be informative in terms of investigating emotions. In complex organisms, including humans, however, the development of extensive neural mechanisms allows for a greater variety and complexity of responses. It is clear that humans can do more than approach or avoid and this greater flexibility facilitates adaptation to a range of different environments. Many behavioural, physiological, neural and subjective responses have been utilized to measure these more complex aspects of the different components of emotion.

Measurement of the behavioural correlates of emotion

A range of useful behavioural responses are shared by most living organisms. For example, the behaviours associated with aggressive attack and defence (e.g., increasing apparent size, biting, kicking etc) are highly developed survival tools that vary only in detail across a range of species. For humans, some of the more obvious behaviours associated with emotions are facial expressions. Think of the wide grin a person might have when finding out that he has passed an important exam, or the drooping lips and downcast aspect of a sad face when someone finds out that she has not got the job she really wanted. Other behaviours include screaming when afraid, or shouting loudly when angry. A problem for researchers is that people are, of course, able to suppress many of these behavioural indicators of emotion. Someone may feel very sad and depressed, but nevertheless may make a big effort to appear happy to others by smiling and joking. Thus, relying only on the observation of behaviours as indicators of emotion can be problematic. In addition, there are varying cultural rules about which emotions it is acceptable to express. For example, in Japan it is not socially acceptable to display anger or aggression. Thus, when studying emotion on the basis of behavioural responses we need to be careful that we are aware of possible cultural differences in expression. What we observe on the outside may not always accurately reflect the emotion being experienced on the inside.

Observational techniques are also used in both animal and human research. By observing children or animals in naturalistic environments, for example, a number of different behavioural responses (e.g., fear displays) can be examined in relation to the presence of particular stimuli. Many animal species exhibit a range of behaviours that indicate emotional states, especially distress. For instance, newborn rats emit ultrasonic vocalizations if they fall out of their nest, and these calls lead the mother to retrieve the infant instantly. Rodents are also highly sensitive to odours, which can often act as strong signals of danger eliciting specific behaviours which might be interpreted as *fear* responses. A common behavioural measure in animal studies is the amount of locomotion engaged in. For example, introducing cat fur into a rat's cage can have a dramatic effect on the rats' behaviour. Even when rats have had no experience with cats, the percentage of time spent in exploring their environment decreases by almost 100% when a cat smell is introduced (Panksepp, 1998).

Mice have also been shown to avoid mice who have received strong electric shocks more than non-stressed mice by smell alone, indicating that there is likely to be a chemical alarm signal to which the mice are reacting (Carr et al., 1970). Field work has also found that one species of small African monkeys, called vervets, has developed an extensive range of alarm calls, each of which seems to indicate a different type of predator. For example, one alarm call relates to aerial predators such as eagles, another to ground predators such as snakes, and one relates specifically to leopards. When these calls are taped and played back to the monkeys in the wild they react to the different vocal signals as if the appropriate predator was actually present. In response to the call indicating the presence of eagles they might look up into the sky and attempt to take cover, whereas in response to the 'snake' alarm call they might look frantically around the grass and perhaps run up a tree (Seyfarth et al., 1980a).

Charles Darwin was one of the first scientists to explicitly link behavioural expressions of emotions between humans and other animals in his classic book *The Expression of Emotions in Man and Animals.* Among the most common behaviours associated with human emotions are, of course, facial expressions. Darwin (1872/1998) conducted one of the first studies of facial expression and concluded that similar facial expressions indicated similar emotions throughout the world. Paul Ekman has been one of the most prolific contemporary researchers on the nature of facial expressions, and has been a strong advocate of the idea that facial expressions of emotion are universal rather than culture-specific (Ekman, 1992a, 1999). Ekman noted that wherever he travelled in the world he had little difficulty in recognizing people's emotional expressions in spite of language barriers. To study this more systematically, he investigated an isolated non-literate group of people in Papua New Guinea (Ekman et al., 1969). He showed them photographs of common emotional expressions, which had been posed by Caucasian (American) actors and asked them to indicate what emotion the faces expressed. The success rate for these people, who had little experience with Caucasian faces, was well above chance. For the emotions of happiness, surprise, anger, fear, sadness and disgust there was very high agreement. He then asked the New Guineans to show him what their face would look like if they were happy, sad, fearful and so on. The videotapes of these posed expressions were then presented to American students, along with the (translated) labels to which the New Guineans had been responding, and it was found that there was very high agreement in associating particular emotions with particular facial expressions. These results strongly suggest that facial expressions of emotion might occur cross-culturally, and this work will be discussed in more detail in Chapter 4.

This brief overview indicates that there are clear behavioural indicators of what emotion an animal or a person is experiencing. This should not surprise us, of course, given the important role that emotions are likely to play in social communication. The fact that there are clear behavioural indicators of emotion is consistent with both biological and cultural accounts of emotion. Investigating the behavioural correlates of emotion can be highly informative in helping us to understand the role of emotions in everyday life.

Measurement of the physiological correlates of emotion

In addition to behavioural responses, emotions are also associated with a range of physiological reactions such as your heart racing when you feel very excited or very frightened. Likewise, when you are anxious or nervous you may notice the palm of your hand sweating. Less obvious are a range of internal changes, such as various hormones that may be released into the bloodstream during emotional episodes. To illustrate, under conditions of extreme danger (e.g., being attacked by a predator), blood will be diverted towards the muscles and the brain to allow for fast reactions, and away from less vital functions such as digestion. Meanwhile, extra adrenaline is produced

TABLE 2.4 The sympathetic and parasympathetic sections of the ANS and physiological responses associated with emotions

Sympathetic ANS (dominant during arousal)	*Parasympathetic ANS (dominant during rest)*
Pupil dilation	Pupil constriction
Inhibition of saliva production	Flow of saliva stimulated
Acceleration of heart rate	Heart rate slowed
Bronchi dilated	Bronchi constricted
Digestion inhibited	Digestion stimulated
Adrenaline and noradrenaline released	–
Conversion of glycogen to bile increased	Release of bile stimulated
Bladder contraction inhibited	Bladder contracted

by the adrenal gland causing accelerated heart rate, constriction of the blood vessels (vasoconstriction), increased breathing rate and reduced activity in the gut. Many scientists assume that these responses are selected by evolution to prepare the body for 'flight' or 'fight'. These physiological changes are controlled by the *autonomic nervous system* (ANS), which is a complex network of fibres that extends throughout the body and sends signals to the various body organs, muscles and glands. The ANS is concerned with regulating the functioning of the body's internal environment, and, as we shall see, this is very important for emotion. There are two main sections of the ANS (see Table 2.4): the *sympathetic ANS* controls the effects associated with arousal, while the *parasympathetic ANS* controls the effects that occur when we are resting.

A number of techniques have been developed to measure the physiological correlates of emotion, and these methods usually measure arousal in one way or the other (see Coan and Allen, 2007, for further details). A brief description of some typical techniques is outlined in Table 2.5.

Measurement of the neural correlates of emotion

In recent years, there have been significant advances in uncovering how emotions are represented within the brain. Historically, a group of brain areas known as the *limbic system* was hypothesized to be associated with the experience and expression of emotions (see Box 1.1). While some of the structures that make up the *limbic system* (e.g., cingulate cortex, hippocampus, thalamus, hypothalamus, amygdala) are important for emotions, recent research indicates that different brain circuits control different aspects of emotion and many brain areas involved in emotion are also involved in a range of other functions (e.g., Lane and Nadel, 2000; LeDoux, 1987).

Much of what we know about the brain and emotion comes from research with animals (see LeDoux, 1996; Panksepp, 1998; Rolls, 1999). For example, the surgical removal of specific brain structures has led to success in increasing the understanding of the functions of particular brain regions in relation to certain tasks. Another common technique used in animal research is *single cell recording*. This involves the surgical implantation of an electrode deep within the brain which can directly measure

TABLE 2.5 Common techniques for measuring physiological responses in emotion science

Technique	*Description*
Skin conductance response (SCR)	By applying a small electric current across the fingers the electrical resistance of the skin can be measured. Even very small differences in the amount of sweat can be detected. These changes are usually measured in units called micro siemens (µS). The SCR is sometimes called the *galvanic skin response* (GSR) and is a very sensitive measure of physiological arousal.
Heart rate (HR)	The number of heart beats that occur per minute (bpm) can be measured by a simple transducer which converts the movement produced by the pulse into electrical energy. Changes in HR provide a good index of changes in arousal.
Blood pressure (BP)	Systolic blood pressure (SBP) is the pressure in the arteries when blood has been pumped out of the heart, whereas diastolic blood pressure (DBP) is the lower pressure when blood is being drawn back into the heart. BP is measured in millimetres of mercury (mmHg) and normal BP is expressed as SBP over DBP.
Cortisol level	The steroid hormone cortisol can be measured in the blood, urine or saliva and is a good indicator of ANS arousal.
Electromyography (EMG)	Small electrodes can be placed on the skin (usually over the muscles beneath the eyes) and the level of muscle tension and activity can be measured. The *startle reflex* is measured by EMG and is the sudden muscle contraction that occurs when you blink or are surprised. This is another a good measure of arousal.
Respiration rate	Changes in respiration rate can be measured in terms of breaths per minute and also provides a good measure of physiological arousal.

the activity of a single neuron or a small group of neurons. Electrodes are sometimes implanted within the brain of a person in order to control epileptic seizures and this provides an opportunity to measure the response of small groups of neurons while that person is engaging in some emotion-related task (e.g., looking at emotional pictures).

The major advance in uncovering the neural basis of human emotions has come about by the dramatic technological developments in the ***functional*** imaging of the brain. The techniques in widespread use are ***positron emission tomography (PET)***, ***functional magnetic resonance imaging (fMRI)***, ***electroencephalography (EEG)***, and ***magnetoencephalography (MEG)***. Both PET and fMRI work by detecting changes in regional blood flow and metabolism within the brain. For example, neurons in the brain that are more active use more glucose and oxygen. When this happens, more blood is sent to the active areas. PET involves a person being injected with a mildly radioactive substance that emits positrons (positively charged electrons), and these can then be detected by the PET scanner, thus revealing those areas within the brain where most metabolic activity is taking place. fMRI works by taking advantage of the fact that blood containing a lot of oxygen has a different magnetic resonance from blood with less oxygen. More active regions of the brain use more oxygen, and this activity can be detected by using an 11-ton magnet which surrounds the person's head. fMRI is now the method of choice since it is completely non-invasive (e.g., it

TABLE 2.6 Techniques used to measure brain activity

Technique	*Advantages*	*Disadvantages*
Single cell recording	Can measure single neurons Excellent temporal resolution Excellent spatial resolution Direct measure of activity	Invasive
PET	Good spatial resolution	Poor temporal resolution Invasive Indirect measure of activity
fMRI	Excellent spatial resolution Non-invasive	Poor temporal resolution Indirect measure of activity
EEG and ERPs	Excellent temporal resolution Non-invasive	Poor spatial resolution
MEG	Excellent temporal resolution Fairly direct measure of neural activity	Poor spatial resolution Other sources of magnetism may interfere with measurement

does not require any injections of radioactive substances) and also the scans can be made much more rapidly (around 50 msec) than PET (around 1000 msec). Thus, by detecting changes in blood flow, both PET and fMRI can reveal the areas of the brain that are most active during a given task.

EEG works by measuring the electrical activity of the brain. This is also a non-invasive technique involving the placement of several small electrodes around the person's head. These electrodes are taped to the head, along with conductive paste to allow for a low-resistance connection. They are then connected to a series of amplifiers and recording devices which give a continuous read-out of the electrical activity occurring in the cortex. From this EEG reading, we can obtain a measure called an *event-related potential*, or ERP, which is a specific electrical signal occurring in response to a specific stimulus. The ERP has proved very useful in emotion research.

Finally, the newer MEG technique involves the use of a super-conducting quantum interference device (SQUID), which can measure the magnetic fields produced by the brain's electrical activity. All of these methods have been used in emotion research and each has its own advantages and disadvantages as shown in Table 2.6.

Measurement of the subjective correlates of emotion

Many people consider that the subjective component of emotion is the most important because what an emotion feels like is often what is most salient to us. However, whether it is possible to obtain an accurate account of our own inner experience is a question that has had a chequered history in psychology. The founding fathers of experimental psychology in both Europe (Wilhelm Wundt) and the USA (William James) were both strong advocates of *introspection* as an important method for the fledgling science. As argued by William James, 'Introspective observation is what we have to rely on first and foremost and always. The word introspection need hardly be defined – it means, of course, looking into our own minds' (James, 1890/1950).

For a variety of historical and methodological reasons introspection is now rarely used in cognitive psychology or cognitive neuroscience. Nevertheless, there have been recent calls to reconsider the potential of introspective report in contemporary cognitive research (Hurlburt and Heavey, 2001; Jack and Roepstorff, 2002). One reason why introspection is often not trusted by cognitive psychologists or neuroscientists arises from evidence that we are not particularly good at looking into our own minds. For example, people generally have a very poor understanding of the causes of their own behaviour. Nisbett and Wilson (1977) reviewed situations in which it had been shown that external factors could predict which objects people would choose (e.g., they might always choose the object in a particular location on a display). However, when asked *why* they chose a particular item people usually provided very elaborate reasons (e.g., it looked nicer, it seemed to be a better quality etc) rather than the real reason which was manipulated by the experimenter. We all have a natural tendency to provide a reasonable explanation for our behaviour but this is often wrong. This has led some to conclude:

> the accuracy of subjective reports is so poor as to suggest that any introspective access that may exist is not sufficient to produce generally correct or reliable reports. (Nisbett and Wilson, 1977, p. 233)

Related to this, there is also a deeper problem in relying solely on a subjective account of emotions because we are often unaware of the triggers that elicit our emotions in the first place. Thus, in addition to being poor at knowing *why* we do certain things (Nisbett and Wilson, 1977), we may also not have much knowledge of what triggers our emotions. There is substantial evidence from cognitive psychology that stimuli which are presented outside our conscious awareness can still affect our behaviour. A good example is the *mere exposure effect*, which is the finding that we tend to like stimuli that have been repeatedly presented even though we may not be aware of the repeated presentation (Zajonc, 1968). This preference for familiar items is the basis for successful advertising. In a classic demonstration of a subliminal mere exposure effect, a number of Chinese ideographs were presented to people who could not speak Chinese for just 1 ms at a time. Not surprisingly, people were unable to select which particular ideographs had been presented from among similar shapes. Thus, when asked to recognize which items had been presented and which had not, people responded at a chance level (i.e., 50% correct). However, when the question was changed and people were asked to say which shapes they *preferred*, stimuli that had previously been presented were selected well above the level that would be expected by chance (around 65%). Thus, even though there was no explicit recognition of the items, those items that had been presented subliminally were preferred over those that had not been presented. People preferred stimuli that they were not aware they had seen. Subjective report would clearly be useless in a situation like this, as we cannot report what we are not aware of! Box 2.1 presents further evidence that emotions can be activated by stimuli that are presented outside conscious awareness (LeDoux, 1996; Morris et al., 1999, 2001; Öhman and Mineka, 2001).

BOX 2.1

Can an emotional response be elicited without conscious recognition of the eliciting stimulus?

This fundamental question concerns whether we need to consciously perceive a stimulus in order for an emotion to occur, or whether an emotion can be elicited by the presence of 'hidden' stimuli of which we are not consciously aware. This question has been addressed experimentally by the use of the '*visual backward masking*' paradigm which can render a briefly presented stimulus invisible. The extent to which a target stimulus is perceived is dependent on the time interval between the onset of the target (let's say a photograph of a face) and the onset of the masking stimulus (which might be a photograph composed of face parts). This interval is usually called the *stimulus onset asynchrony* (SOA). When the SOA is short (less than 30 ms), the masking stimulus tends to completely block any recognition of the target stimulus. When asked to say what they saw, people generally report seeing the second stimulus (the mask) but not the first. Nevertheless, even though the target stimulus is blocked from awareness several experiments show that masked stimuli can influence a person's behaviour and judgment (see Bornstein and Pittman, 1992).

Öhman and Soares (1994) used the backward masking paradigm to investigate the automatic activation of a fear response. They selected two groups of highly fearful people, one group were afraid of snakes but not spiders, while the other group were afraid of spiders but not snakes. A (non-fearful) control group was also tested. Pictures of snakes, spiders, flowers and mushrooms were presented on a screen for 30 ms and then followed by a masking stimulus (pictures of similar objects cut into pieces and randomly re-assembled) for 100 ms. When the feared objects were viewed under conditions of full awareness there was a distinct psychophysiological response consisting of a large skin conductance response (SCR – sweaty palms), heart-rate acceleration, blood pressure increases, and an enhanced startle reflex. Snake-fearful participants showed enhanced SCRs to pictures of masked snakes, while spider-fearful participants showed enhanced SCRs to spiders, even though they were not aware of what was being presented. The non-fearful control participants showed no difference in SCRs to the fear-related or control stimuli.

Morris et al. (1998) also used backward masking in an experiment measuring brain activity by means of fMRI. They found that the presentation of fearful facial expressions led to an activation of the amygdala, even though participants were not aware of what was being presented. Thus, both functional neuroimaging and psychophysiological research demonstrate that the physiological and neural components of emotion can be activated without any conscious recognition of the eliciting stimulus. Unfortunately, people were not asked if they experienced any emotion in these experiments and so we have no index of the subjective component of emotion.

The evidence that emotional responses can be activated by stimuli of which we are not aware has led many researchers to suggest that we need indices of emotion other than self-report. However, cognitive scientists have probably gone too far and have tended to abandon the attempt to measure subjective report altogether (Jack and Roepstorff, 2002).

While traditional introspective measures of subjective experience have been problematic, better methods of investigating people's subjective experience are being developed. One such method, for example, involves interrupting the flow of consciousness by means of a bleeper (Hurlburt and Heavey, 2002; Hurlburt, 1997). This method is called *descriptive experience sampling* (DES), and uses a beeper that goes off at random times to cue people to report their ongoing inner experience at that moment. They are asked immediately, 'What was occurring in your inner experience at the moment of the beep?' With practice, people can get quite good at this technique and can answer the question with ease. Given that introspective report is the only type of evidence that can bear directly on our consciousness and subjective states (Feldman Barrett, Mesquita et al., 2007; Jack and Roepstorff, 2002), it is clearly important to develop more accurate methods of accessing subjective experience. Methods such as DES or simply keeping a diary record (Bolger et al., 2003) have tremendous potential in emotion science, although they have not yet been used very extensively. Far more common is the use of questionnaire measures, which are designed to enable people to report subjective feeling states.

Questionnaire-based measures of emotion

When assessing the subjective experience of emotion it is important to ask whether we are interested in fairly transient states or whether we want to index more stable feelings of emotion. For example, on a particular day I might feel very irritable and angry, whereas on most days I might feel very calm and happy. When filling out a questionnaire we need to be sure that we are assessing how people feel at the particular time they are been assessed and not reporting their more general feelings. This distinction between *state* and *trait* aspects of emotion is important for all emotion components, of course, but has been addressed primarily in relation to the subjective assessment of emotions and moods. Charles Spielberger (1966) was one of the first to argue that emotional phenomena can be described as having two forms: *state* and *trait*. This distinction is often made in terms of the *duration* of an emotional experience. To say that somebody is high in self-reported trait-anxiety or depression, for example, means that this is a relatively enduring ongoing state of affairs. As described by Lazarus (1994), an emotion *trait* refers to a tendency to react in a particular way to what he calls an 'adaptational encounter'. In contrast, an emotion *state* refers to a transient reaction to specific situations. Thus, the level of state emotion reported provides an index of how someone feels at a particular moment. It is no surprise then that state emotion often has a greater range of intensity than trait emotion. It should be noted, however, that state and trait aspects of emotion do not imply that there are necessarily differences in the quality of the experience. The idea is that the emotional state (e.g., anger) often

TABLE 2.7 Some common questionnaire-based measures of felt emotion and the feeling states that they are designed to measure

Instrument	*Description*
Beck Depression Inventory (BDI)	A 21-item questionnaire designed to measure *depression*. Each item (e.g., 'I am useless') is rated on a 0–3 scale (completely disagree to completely agree). Thus the range of possible scores is 0–63.
Beck Anxiety Inventory (BAI)	Similar to the BDI except that items relate to *anxiety* rather than depression.
Spielberger Trait-State Anxiety Inventory (STAI)	This consists of two 20-item sections. One asks people to report how they 'generally feel' and this indicates *trait anxiety*, while the other asks people to report how they feel 'right now' and this indicates *state anxiety*. The range for both measures is 20–80.
Profile of Mood States (POMS)	This consists of 65 scales that provide a measure of six different mood states. These are: Tension–Anxiety; Depression–Dejection; Anger–Hostility; Fatigue; Vigour; Confusion–Bewilderment; and Total Mood Disturbance.
Positive and Negative Affect Scales (PANAS)	Consists of 20 adjectives (e.g., determined, upset) which people rate on a scale of 1 (very slightly or not at all) to 5 (extremely) according to how they feel 'right now'. Two separate indices are provided for *positive affect* (PA: range = 5–50) and *negative affect* (NA: range = 5–50).
Multiple Affect Adjective Checklist (MAACL)	Consists of a number of adjectives, which people can select according to how they feel at a given moment.

refers to a particular episode of limited duration, while an emotional trait refers to the tendency of the individual to experience a particular emotion with increased frequency. Therefore, if we talk of someone as being an angry person, we do not mean that that person is angry all of the time, rather, we mean that he becomes angry more easily and more frequently than most people. Likewise, people who differ on trait-anxiety, for example, differ in the number of times that they experience elevations in state-anxiety, and do not necessarily differ permanently in the level of felt anxiety. Some of the more common questionnaire measures of felt emotion (or mood) are presented in Table 2.7. These questionnaires are widely used in emotion science and we will come across many of these in future chapters.

Measurement of the cognitive correlates of emotion

In emotion science (and indeed psychology generally) the term *cognition* is used in a number of different ways. When we talk about the cognitive correlates of emotion, many scientists assume that we are talking about the fundamental biases in perception, attention and memory that seem to be a feature of different emotional states. Many of these biases have been uncovered by means of behavioural techniques for deriving objective measures of internal processes. These techniques originating in cognitive psychology have proved to be very useful in emotion research.

Probably the most widely used behavioural measure is the simple *reaction time*, or RT. This is a precise measure (usually in milliseconds, ms) of how quickly people can make a motor or verbal response to a particular stimulus. For instance, we might ask someone to press one button (A) when a noun with a positive valence (e.g., holiday, prize) is presented on a computer screen but to press another button (B) when a noun with a negative valence (e.g., cancer, failure) is presented. The computer measures the time that elapsed from the onset of the word on the screen to the time that the person pressed the correct button (e.g., 520 ms). We can also get a measure of errors in this type of task by calculating how many times across a large number of trials the person made the correct and incorrect responses. In a typical experiment, several hundred individual trials may be presented in a random order (e.g., 100 positively valenced word trials and 100 negatively valenced word trials) and the average RT can then be calculated for each condition in the experiment. Researchers are usually careful to ensure that only RTs for the correct trials (i.e., those trials in which the participant made the right response) are included in the average, and then the mean error-rate can also be calculated and compared for each condition. In the above example, we might find that the RT to positive words was 785 ms on average, while the mean RT for negative words was 620 ms. Likewise, we might find that the mean error-rate for positive and negative words was 7% and 5%, respectively. This pattern of results would suggest to us that negative words are processed more quickly and more accurately than positive words. Thus, RT can provide us with an indirect measure of mental activity and has been used in a wide variety of behavioural tasks in emotion research (as well as in other areas of psychology).

In addition to investigating how quickly people can respond to emotionally valenced information, we can also ask whether our memory is better or worse for information that differs in valence. Are we more likely to remember an exciting or frightening event than an event that is fairly neutral? There are different ways in which we can assess memory and a number of different tasks have been used in emotion science. For example, one technique would be to show people lists of 20 positive and 20 negative words and ask them to simply look at each word for 1 second. Then half an hour later, after doing a variety of other tasks, we could unexpectedly ask people to recall as many of the words as they can. The key comparison would be to see whether people are more likely to recall the negative or the positive words. We might find, for instance, that people recalled an average of 8 of the negative words (40%), but only 5 of the positive words (25%) and this 15% difference might suggest to us that negative information is more likely to be remembered. There are many variations of this type of simple *recall* task, and there are also a number of different tasks which use RT as the main dependent (or outcome) variable. The more common behavioural tasks used in emotion research are briefly described in Table 2.8.

Summary

It seems that a complete account of emotion must take into account many different aspects or components of emotion. The components that are agreed upon by most emotion researchers are *behavioural, physiological and neural*, while there is more controversy about whether *cognitive factors* (e.g., appraisals and biases) are components of emotion, or, rather, are causes of emotion. Finally, most agree that the *subjective*

TABLE 2.8 Some common behavioural tasks used to index internal cognitive processes in emotion research

Type of task	*Description*
Emotional Stroop	Emotional (e.g., hate) and neutral (e.g., hand) words are presented in different colours and the RT to indicate the ink colour is measured.
Visual search	An array of negative (e.g., pictures of snakes) and neutral or positive (e.g., pictures of flowers) stimuli is rapidly presented (every 300 ms) on a computer screen, and the RT to determine whether a particular target is presented in the display is measured.
Dot-probe	Pairs of pictures (e.g., a happy and an angry facial expression) are displayed side by side for about 500 ms. When the pictures disappear a probe appears in one of the two locations. Faster RTs are often observed when the probe replaces the negative picture.
Attentional cueing	A cue (flash of light, or object which can be negative or positive) is briefly presented (usually around 50 ms) in a particular location on a computer screen. RTs to detect a neutral target such as the letter X are usually faster when the image appears in the cued location.
Simple recall	Lists of words or pictures are presented for about 5 seconds each during an *encoding phase*. Some time later people are asked to recall as many items as they can. This is often called a *retrieval phase*. The valence of the stimuli can be varied.
Recognition memory	List of words or pictures are presented during an *encoding* phase just as with simple recall. However, during retrieval people are given cues (e.g., lists of words that have been presented as well as similar words that have not been presented). The task is to identify or *recognize* the items that were previously presented. Performance on recognition tasks is usually much better than with simple recall (e.g., remembering someone's name is much easier if you are given a choice of four names to choose from).
Implicit memory	Several tasks measure memory at an implicit level (i.e., indirectly). For example, during the encoding phase a list of words may be presented for about 5 seconds each. Then, after several other unrelated tasks, a person might be asked to complete word fragments for which there are a number of different solutions (e.g., D_E, could be DIE or DYE). People tend to complete word fragments by using words that were presented in the original list. This is evidence of *implicit* memory, the important point being that people have no explicit knowledge of the fact that the item was presented previously.

component is important, although some scientists are sceptical that feelings can be accurately measured. There is a general sense that feelings are different in some way from the other components of emotion. For this reason, we will devote an entire section of this chapter to *feelings* because they are effectively the mental representations of both emotions and moods.

MEASURING MOODS

The terms 'emotions' and 'moods' have often been used interchangeably and a failure to keep a clear separation between the two concepts may have hampered the development of research in emotion science. Indeed, most of the measures discussed in the previous section can also be used to measure mood states and it is not always clear whether moods or emotions are being measured.

Measurement of the physiological and neural correlates of mood

As we saw when discussing the different components of emotions, a variety of physiological (e.g., HR, SCR, cortisol) and brain imaging (e.g., EEG, PET, fMRI) measures are available to emotion scientists. All of these techniques are equally applicable to the study of mood states. Indeed, investigating the psychophysiological correlates of mood has less practical problems given the different time frames involved. For example, if emotions only last a couple of seconds this does not give much time to assess the changes in regional blood flow when emotions are elicited. However, since moods are thought to last for longer periods the investigation of mood states should be easier than investigating emotions. These practical issues raise the important question of just what is being measured in brain imaging studies of emotions. A further complication is that most of what we know about the neurophysiology of mood states comes from the investigation of abnormal mood states. Mood disorders (depression and mania) are common and are thought to reflect the altered functioning of many parts of the brain at the same time. This is not surprising when one considers the range of symptoms that are typical of major depression, as shown in Table 2.9. Major depression is diagnosed when these behavioural and subjective symptoms occur every day for at least two weeks and are not related to any obvious reason (e.g., death of a loved one). Clinical or major depression affects about 5% of the population in developed countries.

Given the range of symptoms associated with depressed mood, brain measures have tended to focus on variations in the level of diffuse neuromodulatory systems in regulating mood. The first indication that problems with modulatory systems might be involved in depression came with the discovery of the drug *reserpine* in the 1960s. This drug was designed to reduce high blood pressure, but it was discovered by accident that the drug produced psychotic depression in about 20% of patients. It is now known that reserpine lowers the levels of some neurotransmitters such as *dopamine (DA)* and *serotonin (5-HT)*. It has therefore been hypothesized that a reduction of these neurotransmitters in the brain might be important in inducing depression. This idea was supported by another accidental discovery. A group of drugs designed to treat tuberculosis were found to lead to a marked elevation in mood. These drugs inhibit *monoamine oxidase (MAO)*, the enzyme that destroys the monoamine neurotransmitters, and therefore produce increased levels of these neurotransmitters in the brain. There are four monoamine neurotransmitters: dopamine, serotonin, adrenaline

TABLE 2.9 Symptoms associated with major depression

Lowered mood
Decreased interest or pleasure in all activities
Loss of appetite or increased appetite
Insomnia or hypersomnia
Fatigue
Feelings of worthlessness and guilt
Diminished ability to concentrate
Recurrent thoughts of death

(also known as epinephrine), and noradrenaline (also known as norepinephrine). These observations led to the *monoamine hypothesis of mood disorders*, which proposes that depressed mood (as measured by subjective report or behavioural observations) is related to a depletion of monoamine neurotransmitters (particularly serotonin and noradrenaline) in the brain, whereas elevated mood is related to an increase in the amount of monoamine activity.

There is support for this hypothesis in that most of the drugs that are effective in treating depression lead to an increase in neurotransmission at what are called *serotonergic* and/or *noradrenergic* synapses. However, things are not so straightforward because some drugs that increase activity in the same neurotransmitter systems do not have the effect of raising depressed mood. For example, cocaine increases the levels of these neurotransmitters in the brain but it does not have an anti-depressant effect in depressed patients. In addition, while anti-depressant drugs increase neurotransmission almost immediately, it usually takes several weeks for their anti-depressant effects to emerge clinically. This implies that some other action of these drugs is important in changing mood. One possibility is that anti-depressant drugs might promote long-term adaptive changes in the brain (e.g., modification of receptor systems) and it is these changes that alleviate the depressed mood. One such adaptation occurs in what is known as the *hypothalamic–pituitary–adrenal (HPA) axis*. The activity of the HPA is critical in helping an individual respond to stress and is closely involved with anxiety disorders. However, this system is now thought to be intimately involved in mood disorders as well (Nemeroff, 1998).

The HPA system regulates the secretion of cortisol from the adrenal gland in response to stress. The hypothalamus releases a chemical called *corticotropin-releasing hormone (CRH)*, which is a chemical messenger that travels to the pituitary gland positioned just below the hypothalamus. The pituitary gland then releases a hormone called *adrenocorticotropic hormone (ACTH)*, which travels in the blood stream to the adrenal glands situated on top of the kidneys. The presence of ACTH at the adrenal gland stimulates the release of *cortisol*, which is important in coordinating the body's physiological response to stress.

According to Charles Nemeroff (1998), the HPA axis is the main site where genetic and environmental influences converge to cause mood disorders. It is known that increased activity of the HPA axis is associated with anxiety disorders and it is also known that there is a high degree of co-morbidity between anxiety and depression. In other words, people with clinical depression are also highly anxious, while people with anxiety disorders are often also depressed. As with anxiety, research has shown that overactivity of the HPA axis is also common in major depression (Heuser, 1998). It is of interest to note that the HPA system is itself regulated by the amygdala and the hippocampus, two brain areas that are known to be critical to affect. Activation of the amygdala *stimulates* the HPA system while the hippocampus *suppresses* the HPA system. The hippocampus contains receptors that are sensitive to circulating cortisol and this sensitivity is critical in the feedback regulation of the HPA axis in order to prevent excessive cortisol release. A graphic representation of this system is shown in Figure 2.1.

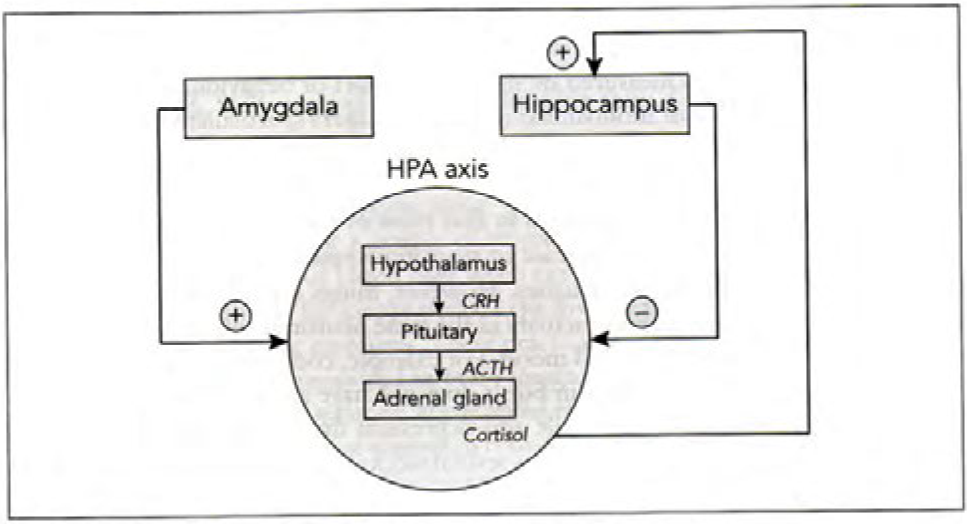

FIGURE 2.1 Regulation of the hypothalamic–pituitary–adrenal (HPA) axis

The receptors in the hippocampus that are sensitive to circulating cortisol are called *glucocorticoid receptors*, and the number of these receptors has been found to be reduced in depression (Plotsky et al., 1995). A reduction of glucocorticoid receptors would disrupt the feedback mechanism of the HPA, which would explain why the HPA is overactive in depression and anxiety. Evidence for this overactivity comes from the finding that the concentration of CRH in the cerebrospinal fluid is increased in untreated depressed patients relative to healthy controls (Catalan et al., 1998; Nemeroff et al., 1984). In the Catalan et al. study, for example, a strong correlation was found between concentration of CRH and depressive mood, with the highest levels occurring in the most severely depressed patients.

In a fascinating series of studies, it has been found that the number of glucocorticoid receptors present in the brain is regulated to a large extent by the nature of life experience. For example, rats receiving abundant maternal care when they are pups have a greater number of glucocorticoid receptors in their hippocampus, have less CRH in their hypothalamus, and show less anxiety when they are adults compared to rats receiving inadequate care as pups (Liu et al., 1997). An interesting finding, however, is that an increase in tactile stimulation seems to make up for a lack of maternal care. For example, young rats who were patted and stroked very frequently had an increased number of glucocorticoid receptors compared to those who received minimal tactile stimulation. Unfortunately, however, the beneficial effects of experience, which allow the animal to handle stress better in later life seem to be restricted to a critical period of early postnatal life (Liu et al., 1997). Similar findings have been reported in human research, and it is known that childhood neglect and abuse can significantly increase the risk of the development of mood and anxiety disorders in later life (see Chapter 9). The animal experiments showing reduced glucocorticoid receptors, elevations in CRH and decreased feedback inhibition of the HPA axis suggest that the brain might be particularly vulnerable to mood disorders in these individuals. Ryff and Singer (2003) support this notion by pointing out that the linkage of affective experience to health outcomes seems to be more closely related to mood states than to emotions. The factors that have most consequences for health are 'those features of the affective experience of long duration: prolonged mood states and emotional dispositions, and more important, chronic recurrent emotions and their cumulation over time' (p. 1093). Chronic overactivity of systems such as the HPA axis is strongly associated with the development of cardiac disease and general physical decline, but the good news is that these effects can be offset to some extent by positive mood states, such as optimism and hope (see Ryff and Singer, 2003, for review).

In addition to research examining the role of neuromodulatory systems in mood states, research has also been conducted on the neural structures and mechanisms underlying mood (see Ketter et al., 2003, for review). Studies using fMRI have shown that emotions may be mediated primarily by phylogenetically old anatomical structures including the amygdala, and the anterior cingulate cortex (ACC). These structures are closely linked to motor circuits and could therefore provide action-oriented responses which are triggered by perceptual inputs. In contrast, moods may be related to a more refined cognitively-oriented response which is triggered by more complex cognitive processing. This cognitive response is likely to be mediated by more recent (in evolutionary terms) regions within the prefrontal cortex (PFC) areas (Ketter et al., 2003).

Measurement of the cognitive correlates of mood

The most common research strategy in this field is to investigate the effects of mood on memory or social judgment. In a typical experiment, a particular mood state is induced (usually happy or sad) by means of reading valenced sentences, hypnosis, or the recall of autobiographical events relating to the relevant mood. The induction of the appropriate mood state is usually confirmed by means of a self-report measure such as the POMS or the MAACL (see Table 2.7). Participants are then asked to perform some task such as learning a list of words, which generally relate to both positive (e.g., joy, holiday) and negative (e.g., death, cancer) valence. Later, when people are once again in a neutral mood, they are asked to recall as many of the words as they can. A typical finding is that people who were in a happy mood when they learned the material are more likely to recall positive words, whereas people who were in a sad mood when learning the material are more likely to recall the negative words (Bower et al., 1981). This is an example of ***mood congruent encoding***, which is discussed in Chapter 7, and demonstrates that people who are in a particular mood state are more likely to encode and remember information that is consistent with that mood state.

In addition to memory, studies have also found that current mood state can be an important determinant of the type of judgments people make about their future. For instance, when people were asked general questions about how healthy and happy they are likely to be in the future, it was found that their current mood state predicted whether they were likely to make positive or negative judgments (Schwarz and Clore, 1983). Current mood as determined by the weather also influences how we judge our current well-being and satisfaction with life. In an interesting study, Schwarz and Clore (1983) telephoned people in Illinois on either a cloudy overcast day or on a bright sunny day. One group of people were asked 'How's the weather down there today?' and then were asked to rate their general life satisfaction on a scale of 0 to 8. Another group were simply asked to rate their satisfaction with life and no mention was made of the weather. The interesting finding was that people were much less satisfied with their life on a cloudy day compared to a sunny day, but *only* if they had not been asked about the weather. In other words, when people could attribute their current mood state to the weather this did not seem to influence their general sense of well-being. However, when they did not attribute their current mood to the weather then this mood state seemed to have an important influence on their judgment of general satisfaction with life.

It also seems to be the case that different mood states can bias our perceptions so that we tend to notice information which is consistent with our current mood state. An experiment reported by Niedenthal and Setterlund (1994) demonstrates this nicely. They induced either a sad or a happy mood in people by playing them different types of music. Music is known to be a powerful modulator of mood state and has been widely used in mood induction research. Once the different mood states were induced, people were asked to make ***lexical decisions*** to words presented on a computer screen as quickly as they could. Thus, if a real word in English was presented they had to press one button, whereas if a non-word (e.g., Chaer) was presented they had to press the other button. Reaction time (RT) was the main dependent measure used. The results clearly showed that when people were in a happy mood they were quicker to identify happy words than sad ones. However, when they were in a sad mood their RTs for sad words were faster than their RTs for happy words.

Summary

It is clear that mood states, just like emotions, have a range of behavioural, neural, physiological and cognitive components. Much of the focus in measuring the neural components of mood has been on assessing levels of different neurotransmitters in the brain. Mood states also have clear subjective components in that we 'know' what it feels like to be sad as opposed to happy, or irritable, or apprehensive. An interesting question concerns whether feelings are related to emotions or moods, or both. Feelings may not differ between emotions and moods. For example, the emotion of sadness may feel very similar to a sad mood. Alternatively, an emotion may feel different from a mood.

THE EXPERIENCE OF EMOTIONS AND MOODS

As discussed in previous sections, emotion scientists have identified a number of different components of emotions and mood states, and developed a variety of methods to measure these states. One component is the conscious experience of affect – the feeling states that many would argue are the essential ingredients of human emotion and represent what we most notice and remember about our emotional lives. When we talk about emotions and moods in everyday life, we almost invariably talk about how we *felt* in various situations (sad, angry, happy etc). As Ray Dolan (2002) rather nicely put it 'what we notice and remember is not the mundane but events that evoke feelings of joy, sorrow, pleasure, and pain' (p. 1191). Indeed many of the important events in our lives are probably characterized mainly on the basis of the intensity of our feelings in the situation at the time. This idea has been supported by a study in which Jaak Panksepp (2000) asked people from different walks of life to rank various components of emotion (e.g., feelings, physiological changes, thoughts etc) in order of importance. Almost all of the groups he tested rated feelings as being the most important. The only group who did not concur was a group of philosophy majors, who claimed that thoughts were more important than feelings!

Some emotion theorists have even argued that affective responses (emotions and moods) and feelings are so closely related in everyday life that it makes little sense to distinguish them. It is not difficult, however, to see that feelings can be quite separate from the other components. Imagine the following scenario: you are deep in thought about an essay you have to write by the end of the week and step out onto the road without seeing an oncoming car. Your heart races and you leap out of the way just in time to avoid a collision. When the danger has passed, you are overwhelmed by a feeling of fear and the realization that you could have been killed. The pattern of physiological reactions that took place in order to get you out of harm's way is clearly separate from the feeling of fear that you later experience. Thus, in a general way a feeling is a perception of an internal emotional state. Damasio (1999) suggests that: 'Feelings are the mental representation of the physiological changes that occur during an emotion'. It can also be argued that feelings are the mental representation of the physiological changes that occur during a mood state.

WHAT AND HOW DO WE FEEL?

It is somewhat surprising that the amount of research conducted on feelings lags way behind research on other aspects of emotion (Scherer, 2004). This is partly to do with the historical tendency to use the terms 'emotion' and 'feeling' as synonymous. However, many researchers (e.g., LeDoux, 1996, 2000) now emphasize the importance of distinguishing between emotions and feelings and this distinction may be one of the primary reasons that emotion has now assumed 'center stage in neuroscience' (Winston and Dolan, 2004, p. 204). Another reason why the study of feelings has lagged behind is that the necessity of relying on the use of verbal self-report has led cognitive psychologists and neuroscientists to avoid the topic. However, there seems little doubt that the only way to directly measure the contents of a subjective representation of an emotion or mood is to ask people to report on their own mental state (Feldman Barrett, Mesquita et al., 2007). There is growing evidence that emotions and moods are represented in consciousness primarily as states of pleasure or displeasure (Feldman Barrett, Mesquita et al., 2007; Edelman and Tononi, 2000).

It is important to point out that the subjective perception of emotion depends not just on a perception of how we feel at a subjective level, but also on a self-perception of other components of emotion such as physiological changes. In agreement with this, studies using self-report measures indicate that, in addition to pleasure/displeasure, many mental representations of emotions and moods also include some arousal-based content. Thus, the mental representation of an emotion often indicates whether the degree of pleasantness (or unpleasantness) was weak or strong. Klaus Scherer, in particular, has argued that feeling has a special status as a component of emotion because it plays an important role in integrating and regulating the component process itself (Scherer, 2000b, 2003, 2004). Thus, feeling is a complex combination of information coming from a variety of different systems and seems to represent valence and arousal in consciousness awareness. It is of interest to note that we do not seem to report different emotions when asked to report on our affective feelings, instead we seem to report broad dimensions of pleasure/displeasure and arousal.

Antonio Damasio (1999) has attempted to provide a conceptual analysis of feelings by considering the neural mechanisms necessary to allow for the conscious mental representation of emotions. He agrees with William James in assuming that feelings are essentially an awareness or consciousness of bodily states. He postulates two levels of bodily representation that are arranged in a hierarchical manner.

First-order bodily representations: In order to experience feelings our brain must first have a way in which to represent our body as a distinct unit. Our body, as a unit, is mapped in our brain, in structures that regulate life and signal the status of our internal states continuously. Likewise, the characteristics of an external object that might elicit an emotion (i.e., an emotionally competent stimulus) are also mapped within our brain in the sensory and motor structures that are activated by the interaction of the organism (our body) with the external object (e.g., a snake or someone we love). Both the body and the external object are mapped as neural patterns, and it is these patterns that Damasio considers to be first-order maps. The key is that the changes in these sensory-motor maps which relate to the external object can cause changes in the maps pertaining to the body (organism). These changes can then be re-represented in other maps which represent the relationship of the external object and the organism. These are what Damasio calls 'second-order maps'.

Second-order bodily representations: The neural patterns formed in second-order maps can become mental images in the same way as the neural patterns in first-order maps. Damasio argues that because of the body-related nature of both first- and second-order maps, the mental images that describe the relationship are feelings. This second-order re-representation of the first-order representations (of the body and of the external object) help to provide integrated feedback which in turn can be modified through our ongoing experience, and therefore can be exploited in terms of guiding behaviour.

Damasio (1999) argues that 'consciousness is the critical biological function that allows us to know sorrow or know joy, to know suffering or know pleasure, to sense embarrassment or pride, to grieve for lost love or lost life' (p. 4). In other words, he makes the case that one cannot actually experience (feel) an emotion unless there is consciousness. Thus, while there are coordinated responses that constitute an emotion and subsequent brain representations that constitute a feeling, we can only really know that we feel an emotion when we sense that emotion as occurring within our own bodies. Knowing that we have a feeling can only occur, according to Damasio, *after* we have built the second-order representations necessary for core consciousness. While Damasio's theory of consciousness is outside the scope of this chapter the argument that feelings are dependent on consciousness (which is one of the most difficult and elusive topics within science) goes some way towards explaining the difficulties inherent in investigating the nature of feelings, or how we come to know our emotions.

Measurement of the neural and physiological correlates of feelings

There have been some attempts to uncover the neuronal basis of feeling states (see Winston and Dolan, 2004, for review). A real difficulty in this endeavour relates to the fact that feelings are, by definition, private mental states, although no more so than any other mental state. Another difficult problem is that feelings occur *after* emotions in most models of feelings and emotions, making it very difficult to separate out the functional neuroanatomy of the feeling from that of the emotion (Winston and Dolan, 2004). This means that many experiments tend to confound emotions and feelings.

The most common method to investigate the neural correlates of feeling states is to induce one mood or the other in people by presenting them with stimuli known to produce particular mood states. Note that a further confusion here is the induction of mood states, rather than emotions, in these studies. While there may be much overlap between emotions and moods, as discussed in the previous section, they are almost certainly not identical states. In one of the first studies of this kind, George et al. (1995) presented happy, sad and neutral faces as well as asking people to recall personal real-life events in order to induce feelings of sadness and happiness. While people were experiencing these mood states, the regional blood flow within the brain was measured by means of fMRI. Widespread increases and decreases in *regional cerebral blood flow* (rCBF) were found in frontal, temporal and cingulate regions depending upon the mood elicited. In a similar study, participants were asked to recall happy, sad or disgusting events or to watch films designed to elicit happy, sad or disgusted feelings while PET scans were being taken (Lane et al., 1997). Brain activity during these conditions was compared to activity during neutral conditions and a variety of common and distinct patterns of activity were observed. However, as pointed out by Winston and Dolan (2004), no direct comparisons were made between the happy, sad and disgusted conditions so the authors could not draw any strong conclusions regarding differences between the different feeling states.

Damasio et al. (2000) used PET scanning and also asked people to generate the feelings of fear, happiness, sadness, and anger. Unfortunately, like the study reported by Lane et al. (1997), no direct comparisons of the different feeling states were made, rather each feeling state was compared with a neutral baseline. It is of interest that rCBF increased in brain-stem (pons) and hypothalamic areas *regardless* of which mood was being experienced. This, of course, supports the view that feelings are associated with changes in ANS functions, which are controlled by these brain areas (Damasio, 1999). A number of cortical areas (orbitofrontal, anterior and posterior cingulate, and secondary somatosensory cortices) were also activated in response to feeling states (Damasio et al., 2000). There are two problems with this study. First, the temporal resolution of PET is quite poor, making it difficult to know whether the activity in the various brain areas occurred before or after the conscious experience of the feelings. Second, because the feelings were self-generated it is possible that people deliberately attempted to modulate their own bodily states in order to produce the required mood state. If this happened, the rCBF in the various brain areas would be due to the physiological activation and not to the feeling state *per se*. A number of recent papers by Hugo Critchley and his colleagues have provided more direct support for the notion that changes in bodily states are critical to the generation of feelings and that the insula may play a crucial role in the elaboration of affective feelings. Some key studies from this group are presented in Box 2.2.

BOX 2.2

Neural basis of feeling states

Damasio has hypothesized that the cerebral representation of bodily states is the substrate for emotional feelings. This model proposes a first-order autoregulatory representation of bodily state at the level of the pons, and a second-order experience-dependent re-mapping of changes in bodily state within structures such as the cingulate cortex.

This model was directly tested in a study reported by Critchley et al. (2001a). They used PET scanning and tested people with a rare neurological disorder called *pure autonomic failure (PAF)* as well as control participants. PAF is usually acquired in middle age and only affects the ANS. People with PAF cannot modulate their bodily state via the ANS but they have no other neurological deficits. Because of this, the role of peripheral autonomic feedback in emotional processing can be selectively studied in these patients. Critchley et al. (2001a) presented participants with a variety of mental and physical stress tasks and found that increases in both blood pressure and heart rate occurred for the control participants but not for the PAF participants as expected. The PET scanning demonstrated significantly increased activity in dorsal pons for the PAF participants compared to controls. Moreover, PAF patients also showed increased anterior cingulate activity associated with increased exertion. This suggests that the anterior cingulate modulates ANS function and integrates it with feedback about ongoing autonomic changes. In PAF patients cingulate activity is increased in the absence of ANS changes in an attempt to generate a task-appropriate autonomic tone (Winston and Dolan, 2004). Most crucially, the authors also found subtle deficits in emotional experience when they compared PAF patients with those with Parkinson's disease who were similarly disabled. Patients with PAF reported fewer emotional experiences in general. This study provides empirical support for the notion that there is a hierarchical representation of bodily states.

BOX 2.2 continued

In a subsequent study, a backward masking paradigm was used in which angry faces were presented to PAF and control patients while undergoing fMRI scanning. One of the angry faces was accompanied by a short burst of white noise (CS+) on 30% of the trials, while the other face was never accompanied by the aversive stimulus (CS–). Critchley et al. (2002) found that both the right and left amygdalae responded to masked CS+ faces, whereas only the right amygdala responded to unmasked CS+ faces. Importantly, the right amygdala response to unmasked faces was modulated by ANS arousal, whereas the amygdala response to the masked faces was not modulated by ANS arousal. The most interesting result, however, was that increased activity in the insula in response to CS+ faces statistically interacted with both masking and ANS arousal. These results suggest that the insula plays a crucial role in integrating affective processing with representations of bodily states, which ultimately results in feelings (see Morris, 2002, for discussion). The suggestion is that the amygdala may be involved in the early translation of sensory processing into automatic affective responses, whereas the insula is involved with the transfer of these automatic affective responses into subjective feelings (Critchley et al., 2002; Morris, 2002).

Summary

Research on the neural and physiological correlates of feelings has lagged behind research on emotions and moods. One difficulty is that emotions and moods have not been distinguished in many studies. Subjective measures using verbal report are the only way to directly ascertain how someone is feeling at a given moment. An important theoretical question concerns whether each distinct emotion or mood state has a distinctive feeling, or whether we have broad good and bad feelings, which might also vary in terms of intensity. The evidence from studies using self-report measures suggests that the latter is the case.

CHAPTER SUMMARY

This chapter outlines the distinction between *emotions*, *moods* and *feelings*. Emotions and moods are primarily dissociated on the basis of duration and intensity as well as being focused on a specific event (emotions) rather than being more diffuse and 'objectless' (moods). Feelings refer to the subjective mental representation of both emotions and moods. The content of these mental representations tends to involve elements of *valence* (pleasure versus displeasure) and *arousal* (strong versus weak). A key feature of emotions is that they are coordinated sets of responses (behavioural, autonomic, neural) to a specific set of circumstances. Hence, they tend to have a rapid onset and only last for a brief time. In contrast, moods are less intense and may last for a very long time. Indeed if mood states endure for more than a couple of weeks they are usually considered to have become *mood disorders*. Much of what we know about the neurochemistry of mood comes from the investigation of abnormal mood states such as clinical depression and mania. In general, emotions may have more to do with behavioural and expressive responses, while moods may have more to do with ongoing cognitive evaluations of one's situation in life. Interestingly, frequent negative mood states appear to be more related to negative health outcomes than frequent emotion episodes. A large number of measurement techniques have been developed to assess the different components of emotions and moods and these were also briefly discussed.

RECOMMENDED READING

An excellent discussion and commentaries on the distinctions between emotions and moods is provided in:

Paul Ekman and Richard J. Davidson (1994) *The Nature of Emotion*. New York: Oxford University Press. (Question 2: pp. 49–96).

A number of edited books are available containing relevant chapters by different authors. These are:

Tim Dalgleish and Mick Power (1999) *Handbook of Cognition and Emotion*. Chichester: Wiley.

Richard J. Davidson, Klaus R. Scherer and H. Hill Goldsmith (2003) *Handbook of Affective Sciences*. New York: Oxford University Press.

Michael Lewis and Jeannette M. Haviland-Jones (2000) *Handbook of Emotions*, 2nd edn. New York: Guilford Press.

J.A. Coan and John J.B. Allen (2007) *The Handbook of Emotion Elicitation and Assessment*. New York: Oxford University Press.

The following article provides an excellent overview of the conscious experience of emotion:

Lisa Feldman Barrett, Batja Mesquita, Kevin Ochsner and James Gross (2007) 'The experience of emotion', *Annual Review of Psychology*, 58, 373–403.