

EMOTIONS AS DISCRETE CATEGORIES

Many emotion scientists view emotions as instances of discrete categories such as anger, fear, sadness, happiness and so on. Frequently associated with such a view is the additional assumption that a small number of emotions might be *basic* or *primary* in some way. These conclusions are drawn from empirical evidence from a variety of research traditions. Their assumption is that different emotions have different neurological structures, and that these are activated fairly directly and automatically by the appropriate stimuli and/or appraisals (Dolan, 2002; LeDoux, 1996; Panksepp, 1998). As would be expected from this perspective, some emotions seem to appear in all cultures, as well as across many animal species. This suggests that at least some emotions may be *primary* or *basic* in that they are given to us by nature and represent biological phenomena that exist independently of our perception of them. As argued by Panksepp 'these systems constitute the core processes for the "natural kind" of emotion' (2000, p. 143).

We should be careful, however, not to take the term *basic emotion* too literally. While theorists often talk of a set of biologically basic emotions such as anger, fear, happiness, sadness, and disgust, they are usually referring to a group of related affective states (e.g., emotion families) rather than to specific emotions (Ekman and Davidson, 1994). The term '*emotion family*' refers to a set of phenomena which are related to each other by a number of common characteristics (Ekman, 1992a). Each emotion family is assumed to consist of a primary *theme* as well as a number of *variations* (Ekman, 1992a; Ekman and Friesen, 1975). The *theme* comprises the characteristics that are unique to that emotion family: commonalities in physiological activity, in expression and action patterns; in the nature of the antecedent events that elicit the emotions; and the appraisal processes. In contrast, *variations* on a central theme can be produced by a range of factors: individual differences in biology and genetic inheritance; different learning experiences; differences in the contexts in which an emotion might occur and so on.

What do we mean by basic emotions?

The term 'basic' has many different meanings in the context of emotions (e.g., Averill, 1994; Ortony and Turner, 1990). In everyday language, the term 'basic' usually

implies that an object is considered fundamental if it fulfils an important function. With regard to emotions, the 'basic' emotions might be those that are critical for the survival of:

- (a) the species – *biological criterion*,
- (b) the society – *social criterion*, or
- (c) the self – *psychological criterion*.

As pointed out by Averill (1994), the biological criterion is the most common interpretation within emotion science (Darwin, 1872/1998; Ekman and Friesen, 1971; Izard, 1977; Tomkins, 1962, 1963). Since human beings, along with other species, are the product of millions of years of evolution many assume that biological mechanisms are more fundamental in some way than social, cultural or psychological mechanisms.

This notion has been challenged, however, on the basis that biological mechanisms only set loose constraints on behaviour. A culturally-based concept assumes that the particular form of emotions is constructed to a large extent by social factors (Averill, 1980; Mesquita, 2003). Thus, some emotions are specific to particular cultures and may even be defining features of that culture. Examples are the emotion of *amae* – contentment arising from complete acceptance by another person – in Japan and the emotion of *liget* – the feeling of exhilaration when taking a head – among the head-hunting Illongot people of the Philippines. *Liget* is considered to be a basic emotion in this society, but does not exist in any other cultures. Thus, there are many emotions that may be basic in a social sense that may not be basic in a biological sense.

The notion that different emotions represent different *categories*, some of which may be more basic than others, remains the dominant approach within emotion science (Ekman, 1973, 1992a; Izard, 1977, 1993, 2007; LeDoux, 1996; Panksepp, 1998; Plutchik, 1980; Tomkins, 1962, 1963). Izard (2007) has recently argued that basic emotions involve internal bodily activities and expressive capacities that derive from evolved neural structures. They are elicited by emotionally competent stimuli, and have unique regulatory properties that can modulate both cognitive processes and action tendencies. Izard also assumes that each basic emotion has a unique *feeling*. A central assumption behind discrete emotions approaches is that (at least some) emotions are products of our evolution and therefore have a strong biological basis. The crucial element that distinguishes one emotion from another is the fact that 'our appraisal of a current event is influenced by our ancestral past' (Ekman, 1999, p. 46). Many discrete emotions theorists rely primarily on animal data (LeDoux, 1996; Panksepp, 1998). Others focus on research with humans, often emphasizing the *universality* of the physiological and expressive correlates of emotion (Ekman and Friesen, 1975). Many cognitive appraisal models of emotion also suggest that emotions are organized into discrete categories, even though they do not necessarily assume that these emotions are primitive in a biological sense (Frijda, 1986; Lazarus, 1991; Scherer, 1984). A brief historical overview of discrete emotions approaches is presented in Box 4.1.

BOX 4.1

A brief overview of some influential approaches assuming the existence of a set of discrete emotions

The discrete emotions approach is a very old method of trying to understand emotions. Descartes, for example, assumed that there were only 6 primary emotions, or passions, and that all others were composed of mixtures of these six. He suggested that *love, hatred, desire, joy, sadness and admiration* were primary emotions, but gave no rationale for his choice.

It was Charles Darwin who set the stage for scientific theories of discrete emotions in his now classic book *The Expression of Emotions in Man and Animals* (Darwin, 1872/1998). Darwin was fascinated with the fact that the same facial expressions seemed to occur in a wide variety of cultures, and even across different species, and he interpreted this as indicating that some emotions must indeed be universal or basic (see Figure 4.1). Darwin was one of the first scientists to propose that there are a small number of innate emotional states which can be communicated to others by means of expressive behaviours (facial, vocal, and so on). The evidence he presented for this view was that:

- 1 some facial expressions appear in similar form in lower animals, especially primates;
- 2 some facial expressions are seen in infants and young children in the same form as in adults;
- 3 some facial expressions are shown in identical ways by people who are born blind and those with normal vision; and
- 4 some facial expressions appear in similar form in widely distinct races and groups of humans.

These arguments inspired a still vibrant research tradition and lively debate on the relationships between emotions and facial expressions (Ekman, 1992b, 1994d; Russell, 1994, 1995).

Categorical emotions approaches are usually infused with the notion that emotions evolved because they were adaptive in dealing with a number of fundamental life tasks that are common to all members of a species (and are often common across species as well). One influential cognitive theory, for example, proposed that each emotion is associated with a specific predicament or what can be termed a 'core relational theme' (Lazarus, 1991). The experience of loss, for example, is the core relational theme relevant to sadness, whereas facing uncertainty and threat is the core relational theme underlying fear. Johnson-Laird and Oatley (1992) have also argued that universal human experiences such as losses, achievements, frustrations have led to the evolution of specific emotions. These specific emotions have been adapted over the life of a species to help deal with a number of common predicaments. From this perspective, basic emotions are considered to be biologically primitive in the sense that they relate to needs that must be met if an individual or a species is to survive. Happiness, for example, might be related to the need to reproduce, fear to the need for protection, sadness to the need to maintain possession of a pleasurable object (Plutchik, 1962).

BOX 4.1 continued

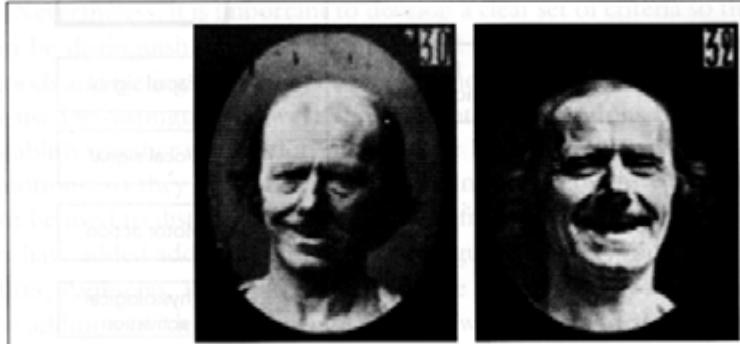


FIGURE 4.1 Some common facial expressions noted by Charles Darwin. *S. & G. RUDOLPH*
These images were initially published by Guillaume Duchenne in his 1862 book *Mécanisme de la Physionomie Humaine* and later republished by Charles Darwin in *Expressions of Emotions in Man and Animals* (1872/1998).

Other discrete emotions theorists have concentrated on trying to uncover the neural circuits underlying emotions, and have primarily conducted experiments with rats (Gray, 1990; LeDoux, 1996; Panksepp, 1998). This neurobiological research suggests that a number of separate emotions have been constructed by natural selection rather than by the experiences gained during the lifespan of the individual. Thus, researchers with a neurobiological background who primarily study rodents (Gray, 1990; Panksepp, 1998) and those with a cognitive background who primarily study humans (Izard, 1977; Johnson-Laird and Oatley, 1992; Lazarus, 1991) converge on the same conclusion: the primary function of basic emotions is to mobilize the individual to respond to fundamental and universal life tasks. The key point here is that the individual is prepared to respond to these life events in ways that have been adaptive in the past history of both the species and the individual's own life.

CRITERIA FOR BASIC EMOTIONS

The central idea underlying a discrete emotions approach is that once an emotion is triggered a set of easily recognizable behavioural and physiological responses is produced. These responses are coordinated in time and correlated in intensity. A schematic model of emotion is shown in Figure 4.2. The model follows Levenson (1994) and assumes that once an emotion has been activated a set of subroutines for the various response systems is then activated, much as we might find in a computer program (Tomkins, 1962, 1963). As shown in Figure 4.2, an emotion can be activated directly from an environmental event or by means of an appraisal of this event. The resulting activation of a specific neural circuit, in turn, activates a set of behavioural and physiological responses to the emotion. The subroutine for 'feeling' has been separated out

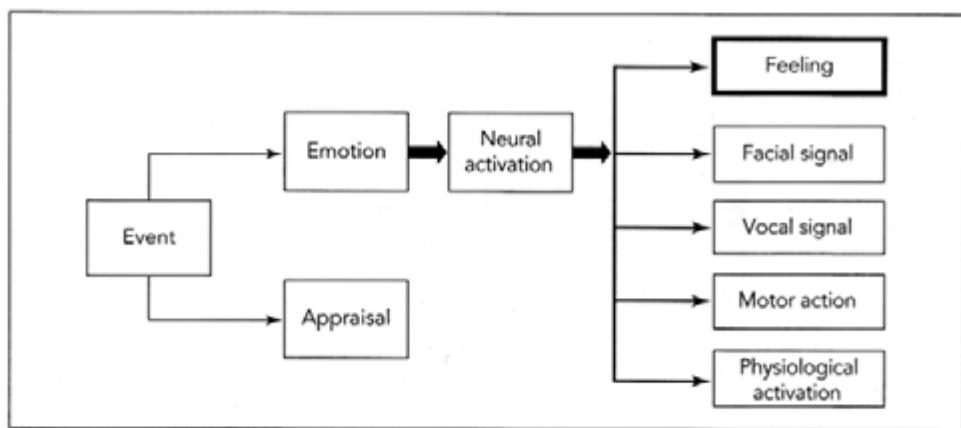


FIGURE 4.2 A schematic model of emotion from a discrete emotions perspective

Source: Adapted from Levenson (1994).

in Figure 4.2 because it is not clear how direct is the association between the activation of emotion neural circuits and the resulting feeling state.

Different emotions such as anger, sadness and happiness are assumed to be associated with different coordinated response patterns. However, no clear set of criteria has been used consistently to identify the basic emotions. Different theorists often use different criteria and therefore include different emotions in their lists of 'basic' emotions. Ortony and Turner (1990) have claimed that this lack of agreement calls into question the entire notion of 'basic emotions'. This seems to be an exaggerated response. While the lack of consensus cannot be denied, there is actually much more agreement than Ortony and Turner acknowledge. For example, in spite of wide differences in the criteria used – distinctive universal signals, distinctive physiology, and

TABLE 4.1 Criteria for distinguishing basic emotions from each other and from other affective phenomena

Criteria	Distinguish between discrete emotions	Distinguish emotions from other affective phenomena
Distinctive universal signals	✓	
Distinctive physiology	✓	
Universal antecedent events	✓	
Dedicated neural circuits	✓	
Presence in other primates		✓
Coherence among response systems		✓
Quick onset		✓
Brief duration		✓
Automatic appraisal		✓
Unbidden occurrence		✓

Source: Based on Ekman (1992a, 1999).

distinctive appraisal scenarios – many theorists have converged on happiness, fear, anger, disgust and sadness as prototypical examples of basic and discrete emotions.

Nevertheless, it is important to develop a clear set of criteria so that basic emotions can be distinguished from each other and from other affective phenomena, such as moods and feelings. Paul Ekman (1992a and b) outlined nine criteria: three which can be used to distinguish between the different basic emotions, and six which are used to establish whether an emotion is basic. The latter criteria may occur in all of the basic emotions, so they cannot be used to distinguish between emotions. However, they can be used to distinguish basic emotions from moods and feelings. Ekman and others have added additional criteria to distinguish basic emotions (Ellis and Toronchuk, 2005; Panksepp, 1998). Table 4.1 lists the criteria outlined by Ekman in 1992, with the addition of 'dedicated neural circuits', which was added in 1999.

OVERVIEW OF EMPIRICAL EVIDENCE FOR DISCRETE EMOTIONS

Distinctive signals

Expressing emotions by means of various signals is widespread in nature. Animals use loud noises, flapping of wings, the laying down of scent and so on as a way of indicating their affective state to other animals. Many emotions that are opposites are expressed by means of opposing actions or postures (Darwin, 1872/1998). Comprehensive reviews and discussions of how emotions are expressed across species are available (Darwin, 1872/1998; Snowdon, 2003).

Tomkins (1962, 1963) was one of the first to suggest that each discrete emotion in humans was characterized by a very specific response pattern which was produced by an innate neuromotor programme. This hypothesis was subsequently translated into the idea that one of the outcomes of these neuromotor programmes is to elicit discrete and distinctive facial and vocal signals for each of the different emotions (Ekman, 1972; Izard, 1971, 1977). There is a large body of research designed to investigate whether universal signals of emotions do, in fact, occur. Most of this research has been concerned with *facial expressions of emotions* (Ekman, 1992c), while some work has also been conducted on *vocal expressions of emotion* (Scherer et al., 2003).

Recognizing different facial expressions

From the earliest research, an important question has been the possibility that some emotions might have similar facial expressions across cultures, and even across species. Early studies investigated how accurate people were in labelling the emotions expressed in photographs of faces. The typical technique was to photograph an actor expressing a range of different emotions and then to ask people from different cultures to say what emotion was being expressed. The results were not satisfactory. The main problem was that people used a large number of words to describe the different expressions. For example, in one study the posed picture for 'hate' was variously identified as mental pain, disgust, dread and so on. This led researchers to present people

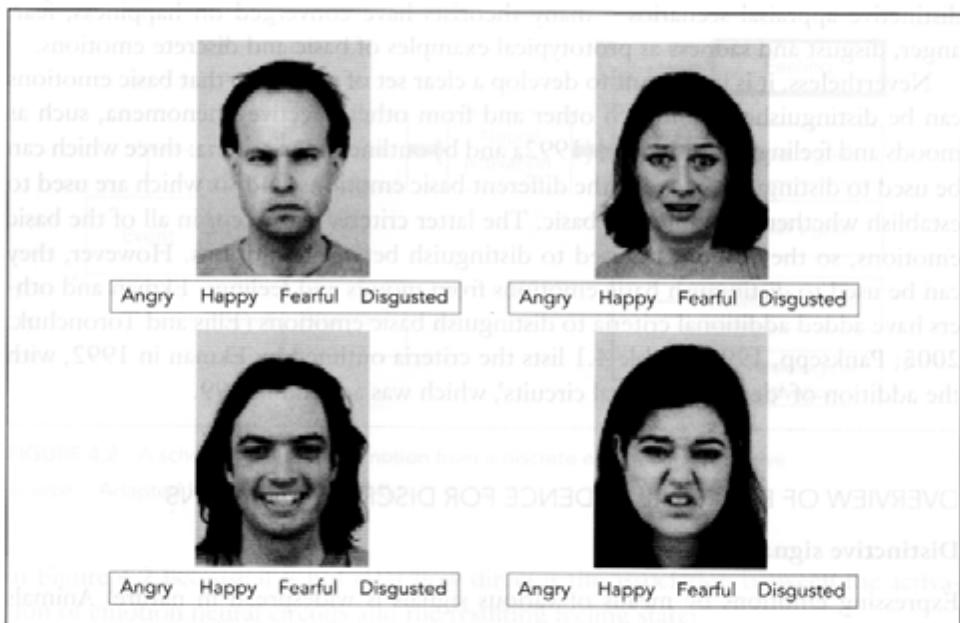


FIGURE 4.3 An example of a typical method used to assess the universality of emotion recognition. Images taken from Karolinska Directed Emotional Faces (KDEF) developed by Lundqvist et al. (1998).

with a limited number of words from which to select the most appropriate label for the posed expression. As shown in Figure 4.3, usually up to six words are given (e.g., disgusted, angry, happy, fearful, neutral, surprised).

The accuracy and reliability of people's recognition of different emotional expressions improves considerably when a limited number of labels is available. In one study, 69 photographs of facial expressions were prepared, showing typical examples of either a neutral expression or interest, joy, surprise, distress, fear, shame, disgust, and rage (Tomkins and McCarter, 1964). Participants were given the photographs in a random order and were asked to match each image with the appropriate label. A high degree of agreement was found among participants.

Given that people can identify emotions fairly well from photographs within their own culture, the next question was whether the same result would be found in cross-cultural studies. Ekman and his colleagues showed a large number of photographs of Caucasians to people from different countries (USA, Brazil, Japan, New Guinea and Borneo) and found that the majority of people in each culture agreed on the emotion being expressed by each face (Ekman et al., 1969). This study did not provide conclusive support for the idea that emotional expressions are universal, however, because people in the preliterate societies had lower levels of agreement than those from the Western countries. They may also have been influenced by Western-made movies.

To get around this problem, Ekman and Freisen (1971) conducted a now classic study with members of the Fore linguistic cultural group of New Guinea. Until 1960

these people were an isolated 'stone age' culture who had had little or no contact with Westerners. The people taking part in the study were selected precisely because they had seen no movies, did not understand English or pidgin, had not lived in any government towns, and had never worked for a Caucasian. On the basis of these criteria, 180 adults and 130 children were tested, which is a relatively large sample. Each person was read a simple story and then shown 3 different photographs. He or she was then asked to select the photograph in which the person's face best described the emotion described in the story. All of the stories were straightforward and short such as 'his/her child has died and she is feeling very sad' or 'she/he is looking at something that smells very bad'. Using this technique, high agreement was found for both adults and children for almost all of the emotion expressions. For adults, the median agreements were:

happiness	92%
anger	87%
sadness	81%
disgust	83%
surprise	68%
fear	64%

In a follow-up study, the authors obtained pictures of posed emotional expressions in these same New Guineans and showed them to US college students. The US students also judged the correct emotion in almost all cases. These results are powerful and led Ekman and Freisen (1971) to draw the conclusion that 'particular facial expressions are universally associated with particular emotions.' In a summary of much of this cross-cultural work, Ekman (1992a and b) has argued that there is now substantial evidence that six basic emotions can be identified on the basis of universally recognized facial expressions: happiness, surprise, fear, sadness, anger, and disgust combined with contempt.

While research on facial expressions provides strong evidence for the universality hypothesis, there have been a number of critiques of this body of research. For example, presenting people with a small number of emotion labels and asking them to make a forced choice may lead to an inflated estimate of the level of agreement in the choice of emotion terms (Russell, 1994). Indeed, as we have seen, agreement is not as good when people are asked to use their own terms to describe the emotions being expressed. Ortony and Turner (1990) have also questioned the validity of research on the universality of facial expressions on slightly different grounds. They raise the possibility that it may not be the facial expressions themselves that are universal signals, but rather that some *components* of facial expressions (e.g., furrowed brows) may be the universal signals. As yet there has not been an extensive study to investigate whether particular components of expressions are universally recognized. Until further evidence is available, we must accept that, at least some, facial expressions may be universal and are readily recognized across different cultures.

Recognizing emotional prosody and vocalizations

Another way of signalling emotions is, of course, by means of vocalizations. Some of these also may be universal; for example, the 'yuck' sound we make when we taste something unpleasant (indicating disgust), or the scream which conveys fear or terror. The typical methodology used to determine the recognition of emotional vocalizations is similar to that used in the research on facial expressions. A professional actor is usually asked to read out standard phrases or nonsense syllables in a particular emotional tone – depressed, happy, angry and so on. These recordings are then played in a random order to participants who are asked to indicate the emotions being expressed. As in the facial expression literature, people are usually provided with a set of standard labels for each of the segments. Klaus Scherer (1989) reviewed this literature and concluded that the agreement between observers was around 60%, which is about five times higher than would be expected by chance. Of course, many of the same criticisms that were made of the facial expression recognition literature also apply here. Several studies, for example, used a small number of emotions and provided people with a set of labels, so that agreement may have been somewhat overestimated. Moreover, early studies did not take into account differences in intonation between variants of the same specific emotion. For example, 'hot' anger and 'cold' anger may have quite different vocal characteristics but nevertheless refer to the same specific emotion of anger (Scherer, 1986).

Banse and Scherer (1996) attempted to deal with this problem by asking professional actors to portray a number of specific emotions in which at least two variants of the emotion families were expressed. They found that the accuracy of emotion recognition between emotion families was 55%, whereas chance accuracy would have been 10%. This demonstrates that the recognition of emotion from standardized vocal portrayals is well above what would be expected by chance. Unfortunately, there are very few cross-cultural studies of vocal recognition, but those that do exist indicate that recognition of some emotions by means of vocal portrayals may be universal (Frick, 1985). It should be noted, however, that in a recent study the accurate identification of emotions, while high, did decrease as the similarity in language from the actors' native language (German) got more distant (Scherer et al., 2001). This was the case even though language-free speech samples were used. These results suggest that the portrayal of emotion by the voice is probably influenced by culture. While there is some evidence for cultural specificity in these data, a review has pointed out that there is still a striking similarity in the patterns of errors that occur across the different languages. Thus, there is some evidence that the recognition of discrete emotions by vocalizations may be universal (see Scherer et al., 2003, for review).

Emotional prosody also enhances neural activity in the auditory cortex (Grandjean et al., 2005). Participants in an fMRI study wore headphones and had to selectively attend to either the right or the left ear on different trials and make a gender decision on the voice that they heard. The voices produced word-like but meaningless utterances that were delivered in either an *angry* or a *neutral* prosody. As shown in Figure 4.4, the *angry* speech prosody increased neural activity in the superior temporal sulcus

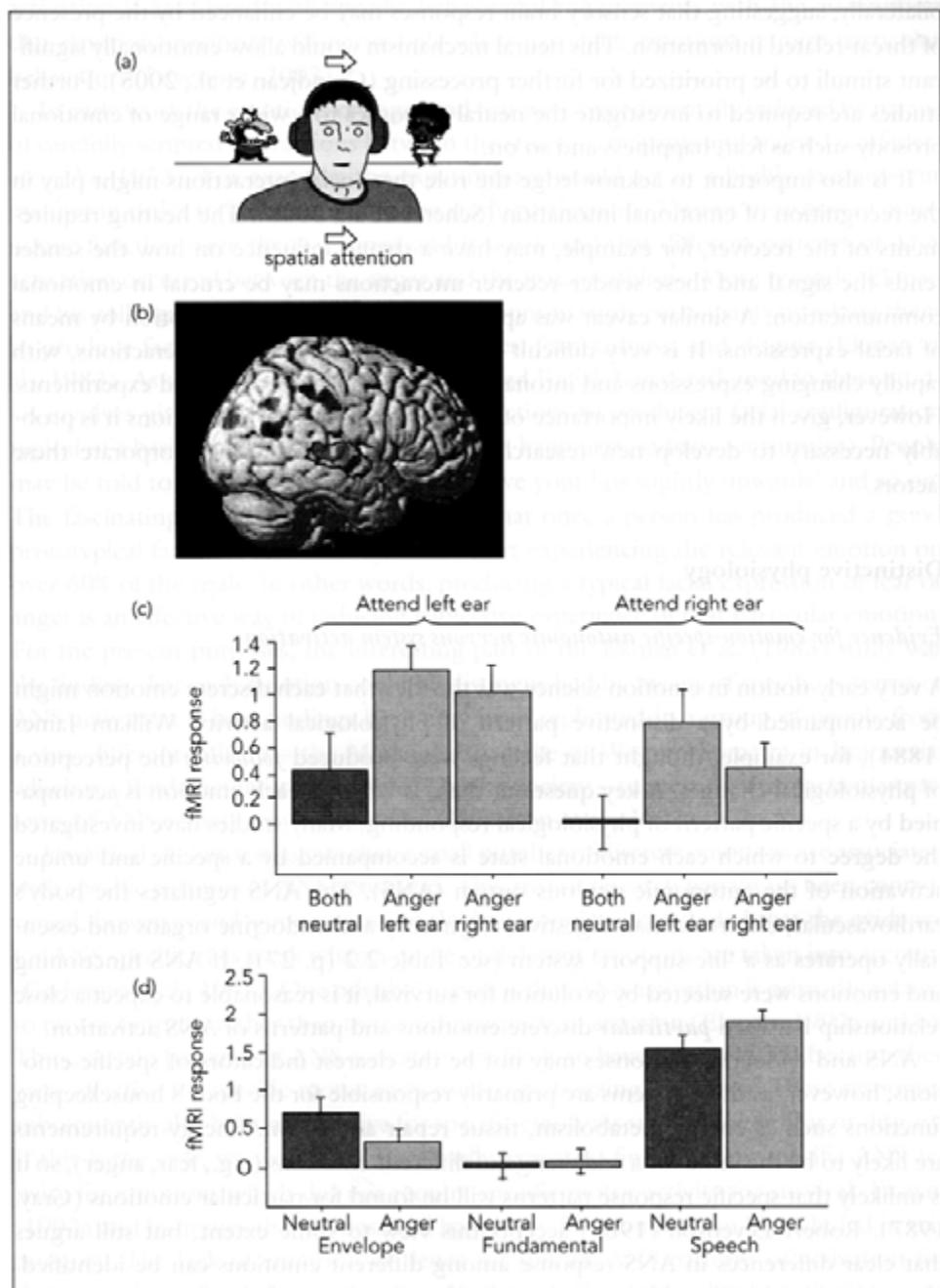


FIGURE 4.4 Cortical activations elicited by spatial attention and emotional prosody

Source: Grandjean et al. (2005).

bilaterally, suggesting that sensory brain responses may be enhanced by the presence of threat-related information. This neural mechanism would allow emotionally significant stimuli to be prioritized for further processing (Grandjean et al., 2005). Further studies are required to investigate the neural responses to a wider range of emotional prosody such as fear, happiness and so on.

It is also important to acknowledge the role that social interactions might play in the recognition of emotional intonation (Scherer et al., 2003). The hearing requirements of the receiver, for example, may have a strong influence on how the sender sends the signal and these sender-receiver interactions may be crucial in emotional communication. A similar caveat was applied to the signalling of emotion by means of facial expressions. It is very difficult to include dynamic social interactions, with rapidly changing expressions and intonations etc, into laboratory-based experiments. However, given the likely importance of these sender-receiver interactions it is probably necessary to develop new research methodologies that can incorporate these factors.

Distinctive physiology

Evidence for emotion-specific autonomic nervous system activation

A very early notion in emotion science was the idea that each discrete emotion might be accompanied by a distinctive pattern of physiological activity. William James (1884), for example, thought that feelings were produced *following* the perception of physiological changes. A key question, then, is whether each emotion is accompanied by a specific pattern of physiological responding. Many studies have investigated the degree to which each emotional state is accompanied by a specific and unique activation of the autonomic nervous system (ANS). The ANS regulates the body's cardiovascular, electrodermal, digestive, respiratory and endocrine organs and essentially operates as a 'life-support' system (see Table 2.2 (p. 27)). If ANS functioning and emotions were selected by evolution for survival, it is reasonable to expect a close relationship between *particular* discrete emotions and patterns of ANS activation.

ANS and endocrine responses may not be the clearest indicators of specific emotions, however, as these systems are primarily responsible for the body's housekeeping functions such as energy metabolism, tissue repair and so on. Energy requirements are likely to be the same for a wide range of different emotions (e.g., fear, anger), so it is unlikely that specific response patterns will be found for particular emotions (Gray, 1987). Robert Levenson (1988) accepts this view to some extent, but still argues that clear differences in ANS response among different emotions can be identified. He points out that, in addition to its main function in regulating homeostasis (i.e., to maintain a consistent and stable internal bodily state), the ANS provides support for behavioural demands. If the *function* of emotions is to organize and coordinate the response to some environmental demand, and if this synchronization requires the mobilization of particular adaptive behaviours, then specific patterns of activation would be necessary to support that behaviour. Levenson has demonstrated that ANS

activation is associated with specific behavioural requirements with the assumption that emotion specificity will occur only when particular emotions require particular behaviours (Levenson, 2003).

In early work the emotions of anger and fear were experimentally induced by means of carefully scripted interactions between the study participants and trained confederates (Ax, 1953). For example, the experimenter would act in a highly incompetent manner in order to induce anger in the study participants. Various measures of autonomic function were then obtained and it was found that different patterns of ANS activation occurred between the anger and the fear conditions. More recently, Ekman and his colleagues induced a number of emotions in study participants by asking them to produce facial expressions related to anger, fear, sadness, and disgust (Ekman et al., 1983). As an interesting aside, the Directed Facial Action task used in these studies involves giving participants precise instructions to produce a facial configuration typical of a basic emotion (anger, disgust, fear, happiness, sadness, or surprise). People may be told to 'raise your eye-brows' or 'move your lips slightly upwards' and so on. The fascinating aspect of this technique is that once a person has produced a good prototypical facial expression they then report experiencing the relevant emotion on over 60% of the trials. In other words, producing a typical facial expression of fear or anger is an effective way of inducing subjective experience of that particular emotion. For the present purposes, the interesting part of the Ekman et al. (1983) study was the finding that each emotion could be distinguished by means of specific patterns of ANS activation. These findings have now been replicated in a group of people from a very different culture – the Minangkabau tribe of Western Sumatra in Indonesia, which is a fundamentalist matriarchal Muslim society – suggesting that particular patterns of ANS activity may be universal (Levenson et al., 1992).

Empirical evidence suggests that a small number of discrete emotions are associated with specific patterns of ANS activation. This area of research has always been controversial, however, and some reviews of the literature have concluded that the evidence for ANS specificity is weak when a range of different emotions are taken into account (Cacioppo et al., 1997). One possible reason is that ANS activation is primarily related to motor outputs, rather than to the other aspects of emotion (Ekman, 1992a and b). Thus, certain patterns of ANS activation are likely to have been selected because they were effective for specific motor responses (e.g., freezing, fighting). These responses subsequently also became adaptive for specific emotions such as anger, fear or disgust. If this is the case, we would not necessarily expect to find emotion-specific ANS activity for emotions which did not require specific motor activity for survival. Ekman (1992a and b) argues that sadness and happiness, for example, can be included in this category. The lack of empirical evidence for specific ANS patterns of activation for these emotions, then, does not necessarily damage the universality hypothesis.

Distinctive neural circuits

If a small set of *basic* and *discrete* emotions exist, then we would expect to find patterns of neural activation that are relatively specific to each of these emotions. It has

been suggested, for example, that the best criterion to identify basic emotions is the 'specification of brain circuits that generate coherent emotional behaviours along with valenced states in animal models that have homologous counterparts in human brains' (Panksepp, 2004, p. 138). Research on animal models of emotions takes this approach. More recently, there has also been an explosion of research using brain-imaging methodologies to investigate the neural correlates of specific emotions in humans.

Animal research

Some research has focused on identifying neurochemical systems that influence emotional responses (e.g., Panksepp, 1998). Others have concentrated on the role of specific anatomical structures in influencing the learning and expression of specific emotions, especially fear (e.g., LeDoux, 1996).

Panksepp (1998) hypothesizes that affective processes arise from *subcortical* emotional action systems. The assumption is that these subcortical circuits are shared by all mammals, have been shaped during evolution, and lead to unique affective *experiences or feeling*. If human feelings arise from the same subcortical structures as all other mammals (and many other species as well), the clearest understanding of feelings is likely to come from detailed neurobiological studies with animals such as rats. This is a controversial position on a number of grounds. First, many investigators doubt whether many species have feelings at all (as opposed to emotions) (Rolls, 2005). Second, many neuroscientists argue that feelings are 'red herrings' in terms of the scientific understanding of emotions (LeDoux, 1996). In their view, feelings are responses produced by the activation of an emotion circuit and are of no more importance to the overall emotion than other components, which might be behavioural or physiological. Other neuroscientists argue that feelings are likely to be implemented by cortical brain areas and are unlikely to arise directly from subcortical structures (Berridge, 2003; Rolls, 2005). Finally, many emotion scientists would argue that it is easier to study feelings in humans where they can be measured more directly.

Panksepp's approach: emotional action systems

Panksepp (1998) argues that the functioning of neurotransmitter systems lies at the heart of emotional action systems which have evolved over many millennia. Since the original discovery of chemical synaptic transmission more than 50 neurotransmitters and neuromodulators have now been identified in the brain. Most of these substances fall into one of three broad chemical categories: amino acids, amines, and peptides. Table 4.2 shows some of the major neurotransmitters, most of which are involved in emotions. A brief overview of the principles of neurotransmission is presented in Box 4.2.

The logic of Panksepp's approach is that we should study animals under fairly naturalistic conditions (playing, fighting etc) so that those neurotransmitters that are important for particular affective systems can be identified. These neurotransmitters can then be manipulated in humans by means of psychoactive drugs to investigate how variations in levels of different neurotransmitters can affect subjective feelings.

TABLE 4.2 Major neurotransmitters

Amino acids	Amines	Peptides
Gamma-amino butyric acid (GABA)	Acetylcholine (ACh)	Cholecystokinin (CCK)
Glutamate (Glu)	Dopamine (DA)	Dynorphin
Glycine (Gly)	Epinephrine	Enkephalins (Enk)
	Histamine	Neuropeptide Y (NPY)
	Norepinephrine (NE)	Somatostatin
	Serotonin (5-HT)	Substance P
		Thyrotrophin-releasing hormone
		Vasoactive intestinal polypeptide (VIP)

BOX 4.2

The principles of neurotransmission

It is important to understand how information is transferred around the brain. There are many different anatomical parts of the brain, as we have already seen, and many of these regions are connected to each other by means of nerve fibres and groups of brain cells (*neurons*). It was once thought that neurons communicated with each other only by means of electrical impulses. Waves of electrical activity moving from neuron to neuron can be observed in the brain, and are measured by EEG. However, it is now known that these electrical impulses can be produced by the action of chemicals, often called *neurotransmitters*. When one of these chemicals interacts with receptor cells on a neuron this can result in the firing of that neuron.

In the 1920s, Otto Loewi provided definitive evidence that information is transmitted around the nervous system primarily by means of chemicals rather than electrically. He made this discovery by means of an ingenious experiment. It was known at the time that activating the vagus nerve led to a slowing of the heart. The question was whether this happened because of an electrical signal from the nerve to the heart, or by means of a chemical signal from the nerve to the heart. Loewi isolated a frog's heart with the vagal nerve left intact. He stimulated the vagal nerve and found that, as expected, the heart rate slowed down. He then took the solution that had bathed this heart and applied it to a second isolated frog's heart. This heart also slowed down, providing definitive evidence that the solution contained a chemical which affected the functioning of the second heart. The chemical that Loewi had isolated was acetylcholine (ACh), and it is now well-established that information is almost always passed around the nervous system by means of chemical transmission.

Many different neurotransmitters have been discovered. They are generally held in synaptic vesicles within neurons, and are released into a small gap between neurons when a particular neuron is stimulated. These neurotransmitters then drift across the small gap between the pre-synaptic and the post-synaptic neurons

continued overleaf

BOX 4.2 continued

where they react with receptors on the neighbouring neuron. If the chemical structure of the neurotransmitter provides a good fit with the receptor – a bit like a lock and key mechanism – this neuron then fires. It releases its own neurotransmitters and so the message moves onwards. A diagrammatic representation of this process is shown in Figure 4.5.

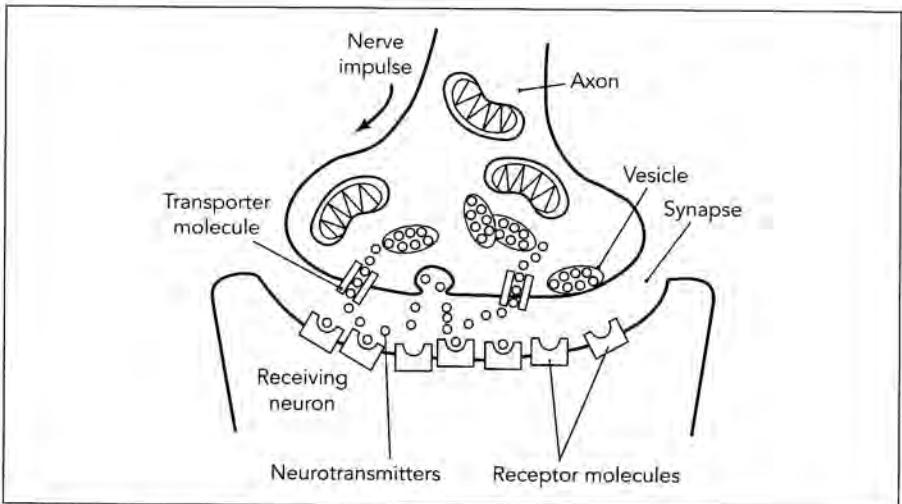


FIGURE 4.5 Neurotransmission

Source: Levitan and Kaczmarek (1997).

Panksepp (1998) proposes that affective processes in the brain can be divided into three general categories, which differ in level of complexity. As shown in Table 4.3, the proposed outline is very similar to Paul MacLean's (1990) notion of a triune brain going from the brain stem (lower functions) to mid-brain limbic systems (emotions) to cortical areas (higher cognitive functions). The 'Blue-ribbon, grade A emotions' are called 'basic emotions' in other taxonomies.

On the basis of many years of animal research, Panksepp (1998) has concluded that there are seven primary 'affective systems' which can be considered 'basic' and are gifted to us by evolution. All of these affective systems seem to be influenced by serotonin (5-HT) and norepinephrine (NE), which have fairly general effects. However, some systems are also affected by specific neurotransmitters depending on where they are within the brain. These seven systems and key neurochemicals are outlined in Table 4.4.

Oxytocin, maternal care and romantic love

To illustrate how emotional systems might be identified on the basis of the underlying neurochemistry we will focus on the care system. The peptide, *oxytocin*, appears to be crucial for the development of maternal behaviour, pair-bonding and perhaps even

TABLE 4.3 Three levels of complexity in affective systems

	Reflexive affects	Blue-ribbon, grade A emotions	Higher sentiments
Examples	Startle reflex Gustatory disgust Pain Homeostatic distresses (e.g., hunger) Pleasures (good tastes)	Fear Anger, Sadness Joy Affection Interest	Shame Guilt Contempt Envy Humour Empathy Sympathy
Brain structures	Brain stem regions	Mid-brain regions (e.g., periaqueductal grey PAG)	Frontal cortex

Source: Based on Panksepp (1994).

TABLE 4.4 Basic emotional systems of the mammalian brain with some key neuroanatomical and neurochemical components

Basic emotional systems	Key brain areas	Key neurochemicals
Seeking	Nucleus accumbens-VTA Mesolimbic mesocortical outputs Lateral hypothalamus-PAG	(DA)+, glutamate (+), many neuropeptides, opiates (+), neurotensin (+)
Rage	Medial amygdala to BNST Medial and perifornical hypothalamus and dorsal to PAG	Substance P (+), ACh (+), glutamate (+)
Fear	Central and lateral amygdala to medial hypothalamus and dorsal PAG	Glutamate (+), many neuropeptides, CCK, NPY
Lust	Corticomedial amygdala BNST Preoptic and ventromedial hypothalamus Lateral and ventral PAG	Steroids (+), vasopressin and oxytocin, CCK
Care	Anterior cingulate, BNST, Preoptic area, VTA, PAG	Oxytocin (+), prolactin (+), DA (+), opioids (+/-)
Panic	Anterior cingulate BNST and preoptic area Dorsomedial thalamus Dorsal PAG	Opioids(-), oxytocin(-), prolactin (-), CRF (+), glutamate (+)
Play	Dorsomedial diencephalon Parafascicular area Ventral PAG	Opioids (+/-), glutamate (+), ACh (+)

Notes:

The monoamines 5-HT and NE are not listed because they influence all emotions in non-specific ways. For the same reason, the higher cortical regions of the brain, which are also involved in emotionality (mostly frontal and temporal areas) have also been omitted.

ACh, Acetylcholine; BNST, bed nucleus of stria terminalis; CCK, Cholecystokinin; CRF, Corticotrophin-releasing factor; DA, Dopamine; NPY, Neuropeptide Y; PAG, Periaqueductal grey; VTA, Ventral tegmental area; -, inhibits prototype; +, activates prototype.

Source: Adapted from Panksepp (2006), using data from Panksepp (1998).

romantic love. Oxytocin is important for female sexuality, and also plays an important role in childbirth and breastfeeding. However, it also has a wider role in the development of nurturance and maternal behaviour. For example, most rat species show wide individual differences in maternal behaviour, such as licking and grooming of pups. These differences seem to be directly related to variations in oxytocin receptor expression. It has been found that oxytocin receptor levels were much higher in the bed nucleus of the stria terminalis (BNST) and medial preoptic areas of rats who engaged in more licking/grooming behaviour compared with those mothers who engaged in low levels of licking and grooming (Francis et al., 2000). A follow-up study found that female rats who received higher levels of licking and grooming as pups had a higher number of oxytocin receptors in the BNST and the central nucleus of the amygdala. These females went on to become far less fearful and more maternal than rats with lower levels of oxytocin receptor binding (Francis et al., 2002). Moreover, when the action of oxytocin was blocked by injecting a receptor antagonist into the VTA region of the rat brain, the onset of maternal behaviours was also blocked (Pedersen et al., 1994). This provides a very strong indication that the release of oxytocin is crucial for the development of normal maternal behaviours. It is interesting to note that oxytocin is also involved in the panic system, which is closely related to separation distress. If a young animal gets separated from its mother or from the group he or she will send out distress signals. The injection of oxytocin into the brain leads to a dramatic reduction in the number of such distress calls (see Panksepp, 1998, for discussion). Thus, an increase in the level of oxytocin results in increases in maternal behaviour and decreases in separation distress calls. Conversely, reductions in oxytocin lead to a reduction in caring and nurturance and to an increase in separation distress.

This is a good demonstration of a *double dissociation* between two systems and the underlying chemistry. It makes absolute sense, of course, that the panic system and the care system should be linked in this way, but it is also an important illustration of how difficult it can be to identify *separate* neural circuits for different emotions. It is almost certain, for example, that each neurochemical is involved in a number of different emotions. We already know that 5-HT and NE seem to be involved in all emotions. As shown in Table 4.4, glutamate also seems to be involved in most of the primary emotional systems. This is not surprising when we consider how evolution works. Natural selection operates on the basis of small and gradual changes in biological systems or processes, so a particular neurochemical is likely to become involved in a range of different behaviours. Oxytocin is an excellent example of this. Its original role was almost certainly to maintain female sexuality and to induce milk production in the breast. However, as we now know, oxytocin seems to play a role in mediating maternal urges and, perhaps also, feelings of romantic love as well as maternal love.

It is, of course, extremely difficult to know whether oxytocin is really affecting maternal *feelings* of love, rather than acting directly on specific maternal behaviours (e.g., grooming). Many of these behaviours can, of course, occur in the absence of feelings. For example, licking and grooming and retrieving young if they fall out of the nest are fairly stereotypical responses that may or may not be associated with specific feelings. Studies with prairie voles, however, have provided an intriguing indication

that oxytocin may play an important role in the development of pair-bonding. Prairie voles are of particular interest because they tend to pair for life and are strictly monogamous. In one experiment, oxytocin was injected directly into the brains of these voles. They went on to establish social bonds far more quickly than usual. However, when a receptor antagonist was injected into the voles' brains so that oxytocin could not act in the normal way, they became highly promiscuous (Cho et al., 1999). These findings show that oxytocin is critical for the development of pair-bonding. These experiments can still not tell us, however, whether this pair-bonding is really mediated by feelings.

In human studies using fMRI, groups of mothers were asked to look at pictures of their own baby and photographs of other babies that they had known for a similar amount of time. In addition, people who reported that they were 'deeply in love' observed photographs of their boyfriend/girlfriend and photographs of other friends while the fMRI machine was scanning their brain. It was found that a wide range of subcortical areas rich in oxytocin receptors (e.g., PAG, VTA), as well as areas of the insula and cortex, were activated to a greater extent when photographs of the loved ones were being observed (Bartels and Zeki, 2004). Unfortunately, there was no measure of subjective feelings in this study and no direct measure of oxytocin levels. It is therefore difficult to draw conclusions about the role of oxytocin in generating feeling states. Nevertheless, research with rats, prairie voles, and humans all indicate that oxytocin is clearly important for the development of social attachments and pair-bonding, sexual behaviour, as well as the development of maternal care.

It would be interesting to conduct studies that deliberately increase or decrease oxytocin production in humans and then examine the resulting changes in people's reports of how their feelings change. No such study has yet been conducted. However, a relevant study has reported that oxytocin reactivity is correlated with the behavioural displays of romantic love (Gonzaga et al., 2006). A group of women were asked to recall a vivid love-related experience and a number of behavioural markers and subjective reports were taken. During these recall periods a series of blood samples were also obtained so that the degree of oxytocin reactivity could be measured. Interestingly, oxytocin reactivity did not correlate with subjective feelings, even though it did correlate with behavioural indicators of love. This evidence is preliminary but it does suggest that oxytocin is not directly related to feelings.

LeDoux's approach: fear conditioning

Much of what we know about the neural pathways involved in the fear system has come from studies of *fear conditioning*, and Joseph LeDoux has been a leading exponent of this approach. Fear conditioning is a simple procedure in which an external stimulus (usually an auditory tone) is used as the *conditioned stimulus* (CS), and this is paired with an *unconditioned stimulus* (US) such as a mild electric shock to the foot. This is a very useful and elegant procedure because the US is associated with a clear unconditioned response (UR) such as freezing in rats. Once a tone has been presented with a foot-shock on a couple of occasions, the rat will begin to exhibit a *conditioned response* (CR) to the presentation of the tone alone. The use of this simple procedure with rats has demonstrated that the amygdala is a crucial neural structure in

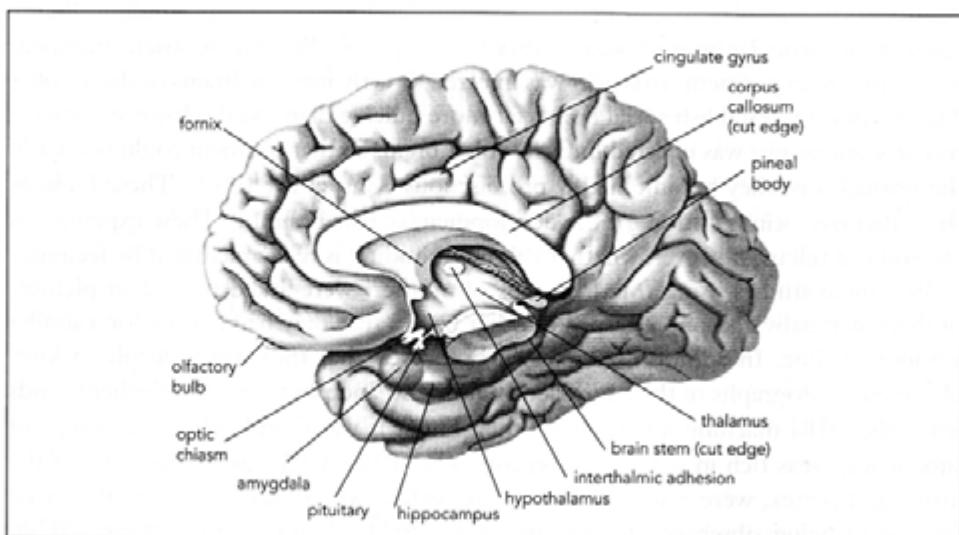


FIGURE 4.6 The position of the amygdala and hippocampus within the human brain

Source: Bear et al. (2001).

the processing of fear. Figure 4.6 shows the position of the amygdala within the brain, along with other nearby structures such as the hippocampus.

Anatomical studies have shown that there are up to 13 different sections of the amygdala, all of which may serve different functions. However, it is common to group these sections into three major parts (see Figure 4.7): the corticomedial nuclei, the basolateral nuclei and the central nucleus. LeDoux has conducted numerous experiments with rats, and has proposed that there are two different routes from an initial (auditory) fear stimulus to the amygdala. When a sound is detected by specialized cells in the ear, a signal is sent to the thalamus, which is the part of the brain that integrates sensory signals. Once in the thalamus, this signal can be sent *directly* to the amygdala, which is a very fast route or the so-called 'quick and dirty route' (LeDoux, 1996). Alternatively, the signal can go from the thalamus to the auditory cortex and from there to the amygdala by bundles of nerve fibres. This route is slower (although still fast) and has sometimes been called the 'high road', in contrast to the faster 'low road', to a fear response (LeDoux, 1996). A schematic diagram of the anatomical connections between the auditory system and the amygdala is shown in Figure 4.7.

Research with rats confirms that the amygdala is critical to the learning of danger signals, which is a crucial survival mechanism. If the basolateral nuclei of the amygdala are surgically removed, or if amino acid receptors in this region are inactivated, then rats do not acquire a conditioned fear response (LeDoux and Phelps, 2004). In other words, while they react normally to the US (electric shock) they do not develop a fear response to the CS (tone). Thus, the basolateral nuclei appear to be crucial for fear learning.

Research has also shown that the *context* in which particular associations are learnt is important for the overall process of learned associations. For instance, in fear

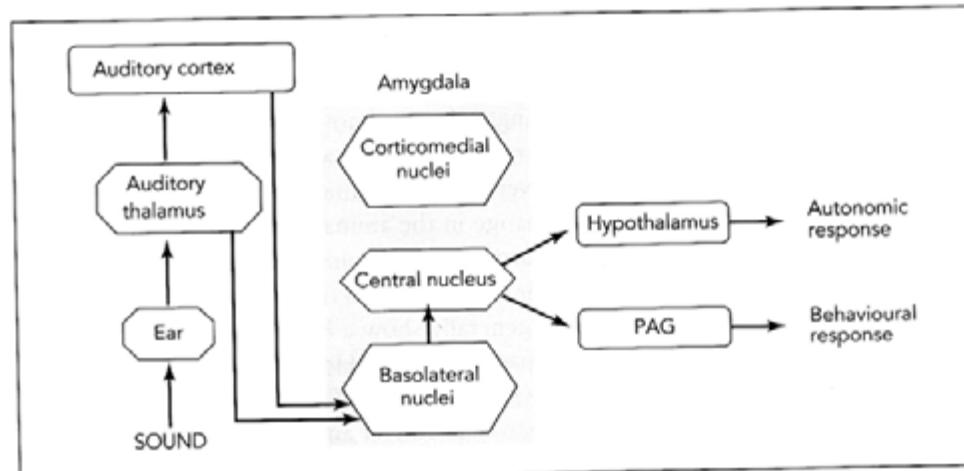


FIGURE 4.7 A neural circuit for learned fear

Sound waves enter the ear where they pass through the auditory system to the thalamus. The signal is then transmitted from all regions of the auditory thalamus to the auditory cortex. The signal can go directly from the thalamus to the amygdala, or it can go via the cortex. In both cases, the signal enters the sensory input region of the amygdala, the basolateral nuclei. Information within the amygdala is constantly integrated and updated with information coming from other areas of the brain (not shown in diagram) and then transmitted to the central nucleus of the amygdala. The central nucleus is the main output region of the amygdala and from here signals can be sent to numerous brain areas including the hypothalamus and the periaqueductal grey (PAG), which control a range of individual responses such as hormone release, changes in blood pressure, and freezing behaviour.

conditioning experiments rats often develop fear reactions to the particular chamber in which the fear conditioning takes place, even in the absence of the CS (Phillips and LeDoux, 1992). It turns out that the development of these *contextual fear associations* depends upon the functioning of the hippocampus, which is also known to be heavily involved in episodic memory. If the hippocampus is damaged prior to conditioning, normal conditioning to the CS can occur, but the rat does not acquire a CR to the *context* (Phillips and LeDoux, 1992).

In addition to the development of specific associations between a fear response and a particular stimulus or context, the *maintenance* of fear is also important. Once a fear response has been learned it tends to be fairly persistent unless the CS is presented many times in the absence of the US. Thus, for example, a rat may have been conditioned to associate foot-shock (US) with a tone (CS), but if that tone is presented many times *without* the accompanying shock to the foot the fear response will gradually diminish and disappear. This is an active process, which is technically called *extinction*. It seems that a number of areas within the PFC are important for this process. If the medial PFC is damaged in rats, the extinction process is impaired and the fear response persists over long periods of time (Morgan and LeDoux, 1995). This suggests that the medial PFC, in conjunction with other cortical areas, is important in terms of regulating how the amygdala and hippocampus respond to situations and stimuli based on their current affective significance (Phelps et al., 2004).

Effects of amygdala damage in non-human primates

As we have seen, surgical removal of the amygdala in rats leads to impairments in fear conditioning. Studies with monkeys have also shown that the amygdala is a key structure for normal emotion processing. What is known as the *Kluver-Bucy syndrome* provided an early clue that this structure is important for emotional behaviour. When the temporal lobes of monkeys were removed, a range of behavioural changes were observed, including a dramatic change in the animals' responses to fearful situations (Kluver and Bucy, 1937). In particular, the animals became very tame and non-aggressive, and seemed to lose their fear for stimuli of which they were normally afraid. These were wild monkeys who generally show a high degree of fear towards humans and would normally not approach a person. However, following the bilateral temporal lobectomy, these monkeys showed little fear of humans and even allowed themselves to be picked up and stroked. Kluver and Bucy also observed other unusual behaviours, such as hypersexuality (increased frequencies of masturbation and homosexual and heterosexual acts) and a tendency to eat a variety of non-food items such as faeces and rocks. In interpreting these results, we need to be aware that the entire temporal lobes were removed and not just the amygdala. Thus, some of the behavioural changes may have been due to the removal of regions other than the amygdala. However, later research has shown that the amygdala does seem to be the key structure for determining the affective significance of particular sensory stimuli (Weiskrantz, 1956). For instance, it has been demonstrated that monkeys show a reduced fear response to snakes following ablation of just the amygdala. This seems to be a genuine reduction in the experience of fear as it is associated with a reduction in the facial expressions and vocalizations that are associated with an acute fear response (Kalin et al., 2001).

Experimental work with monkeys, in which parts of the frontal lobes were damaged, has also shown that this region is important in modulating emotional responses. Bilateral damage to the PFC, for example, results in profound deficits in emotional displays (facial expressions etc) in monkeys, and also leads to severe disruption in a number of social behaviours (Franzen and Myers, 1973). More recently, Raleigh and Brammer (1993) have found very high concentrations of particular types of serotonin (5-HT) receptors in the amygdala and in the vmPFC of monkeys who were very competent in social behaviours (e.g., grooming, cooperation etc). In contrast, the levels of 5-HT receptors in these brain regions were very low in monkeys which did not have good social skills. These findings illustrate the importance of the connection between subcortical and cortical regions (the amygdala and vmPFC) and emotional responses, and emphasize how the adequate functioning of both of these systems is critical to the development of social behaviour.

While the amygdala is an important structure in the development and maintenance of fear responses, other adjacent areas also play important roles in fear. For example, a number of structures extending from the temporal lobe and amygdala, through the anterior and medial hypothalamus, through the periaqueductal grey area (PAG) and then down to the brain stem, and the lower brain stem and spinal cord, control many of the physiological symptoms of fear (e.g., HR and BP response, startle response).

In addition, all of these areas are richly connected to other brain regions, including cortical areas. When these brain systems are stimulated electrically, rats demonstrate a range of fear-like behaviours. At low levels of intensity a freezing response is likely to occur, whereas with higher levels of intensity a flight response is more likely. Panksepp (1998) points out that these are precisely the type of fear behaviours that rats show when a danger such as a predator is either far away (freezing) or close (flight).

Human research

Lesion studies

Much of what we know about how emotions are implemented in the human brain comes from studies of people who have received damage to the brain, often by means of a stroke, a tumour or an accident. One of the most famous case histories in neurology is the story of Phineas Gage. Phineas Gage worked as a foreman on the Vermont railroad and at the age of 25 suffered a bizarre accident, which he was lucky to survive. While tamping gunpowder into a hole to prepare for construction work his tamping iron hit a rock and the powder exploded sending a metre-long rod straight through his head. The tamping iron entered his brain just below the left eye, passed through his left frontal lobe and exited from the top of his head, damaging both frontal cortices. Remarkably, Phineas Gage survived the accident and recovered with language and memory functions intact. However, following the accident it became clear that all was not well. While Gage had made a good physical recovery, his physician, Dr John Harlow, noted that Gage's personality had changed in a profound way. Before his accident he had been a reliable and hard worker and was liked and respected by all who knew him. However, following the accident he became 'fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires' (Harlow, 1868, p. 339). In general, his personality had changed from an organized hard-working man to someone who was frequently socially inappropriate and unreliable. In the words of Harlow, Gage was 'no longer Gage'. In 1994, Hanna Damasio and her colleagues examined Gage's skull which is still preserved in a museum at the Harvard Medical School. By reconstructing the passage of the iron rod through his skull, they were able to determine that the most damaged area of Gage's brain was the vmPFC, especially on the left side (Damasio et al., 1994). The personality changes that Phineas Gage experienced following his injuries suggested that the prefrontal cortex plays an important role in regulating emotions in humans as well as in other primates. Figure 4.8 shows the nature of the damage that Phineas Gage sustained, based on a model developed by Hanna Damasio. Both the model and the actual skull are on display at Harvard University in Boston.

Many studies of people with damage to the prefrontal cortices have shown that these cortical areas are involved in a number of different aspects of emotional functioning. However, on the basis of research with animals, many subcortical structures are also likely to be important for specific discrete emotions (LeDoux, 1996; Panksepp, 1998). A number of studies have examined people with damage to subcortical

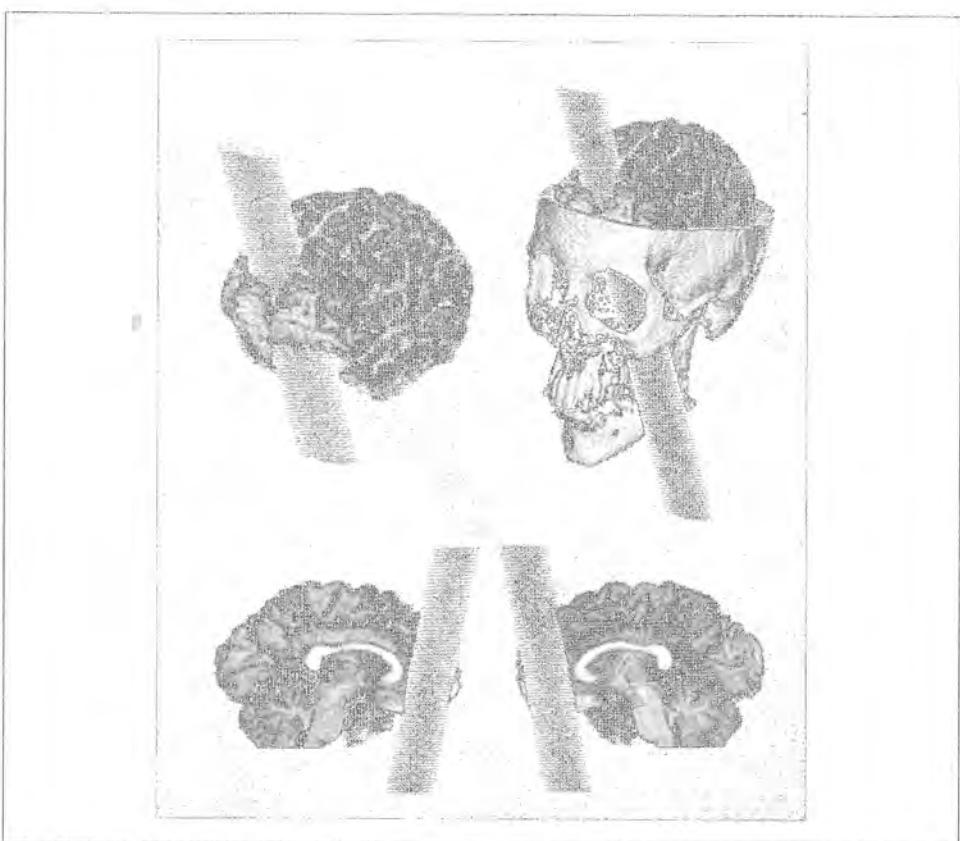


FIGURE 4.8 Model of damage sustained by Phineas Gage

Source: Damasio et al. (1994).

structures, with most research focusing on damage to the human amygdala. The most common consequence of amygdala damage in humans is a change in emotional behaviour, although it is interesting to note that the effects are not as dramatic as those seen in monkeys with lesions to the amygdala (Aggleton, 1992). In terms of evidence for discrete emotions, one of the most interesting consequences of amygdala damage in humans is a very specific deficit in the recognition of fear displays, with recognition of other emotions being left intact. Andy Calder and his colleagues tested two patients with amygdala damage with some standardized facial expression recognition tests. One patient, called DR, had had both the left and right amygdala removed surgically for the treatment of intractable epilepsy. The other patient, SE, had suffered damage to both amygdalae (and some other regions of the right temporal lobe) due to encephalitis. Both patients were shown a series of faces from the Ekman and Freisen (1976b) set and asked to indicate which expression was being presented. Both DR and SE could recognize most emotional expressions easily, but had severe difficulties in recognizing fear expressions, and to a lesser extent anger expressions (Calder et al., 1996). Other studies have confirmed that amygdala damage seems to

be related to very specific deficits in the recognition of fearful expressions (Adolphs et al., 1994). It should be noted, however, that, while a reduced ability to recognize fearful facial expressions and/or vocalizations is a key aspect of amygdala damage in humans, amygdala-damaged patients may have a range of deficits and there are some individuals who do not have any problems at all with recognizing or expressing fear (see Calder et al., 2001). These findings indicate that the role of the amygdala is far more complex than being simply a fear detector. Nevertheless, it is clear that the recognition of fearful facial expressions does seem to be dependent on a functioning amygdala (Adolphs et al., 1995; Calder et al., 1996).

In contrast, damage to the insula and basal ganglia regions of the brain seems to be associated with a particular difficulty in recognizing facial expressions of disgust. In a detailed study of a single patient, known as NK, who had lesions in insula and basal ganglia regions (primarily in the left hemisphere) very specific problems in recognizing facial as well as vocal signals of disgust were found. However, NK's recognition of other emotion categories appeared to be normal (Calder et al., 2000). Moreover, NK filled out a number of questionnaires which showed that his *experience* of both fear and anger was normal, while severe abnormalities were reported in his subjective experience of disgust. This finding indicates that the insula and basal ganglia regions are involved in both the *recognition* and the *experience* of disgust. The association of the insula and feelings of disgust are consistent with a report that electrical stimulation of the insula in conscious patients undergoing surgery for epilepsy resulted in highly unpleasant sensations in the stomach as well as unpleasant tastes and feelings of nausea (Penfield and Faulk, 1955).

Further evidence supporting a distinction between fear and disgust comes from studies of people with Huntington's disease. This is a neurogenetic disorder that, in the early stages of the disease, affects a region of the basal ganglia called the striatum. Sprengelmeyer and colleagues (Sprengelmeyer et al., 1996, 1997) presented the facial expression recognition test to people with Huntington's. The participants had problems with recognizing a number of emotions, but they had particular problems in recognizing the facial signals of disgust. As we saw earlier, evidence on recognition of disgust also comes from a study of a single patient who had focal lesions within the insula and the basal ganglia of the left hemisphere (Calder et al., 2000). These studies, among others, indicate that there may well be different neural circuits underlying fear and disgust, even though there is likely to be some overlap of neural areas. More recently, it has also been reported that lesions to the ventral basal ganglia are associated with selective deficits in the ability to recognize anger (Calder et al., 2004).

While problems in recognizing emotion in others is well established in patients with various types of brain damage, it is important to ask whether the damage to these structures also influences the person's subjective experience of emotion. Can people with this type of damage still *feel* fear or disgust in the appropriate situations? There is not very much evidence available to answer this question, but it has been found that when the amygdala is electrically stimulated during surgery for epilepsy a feeling of fear is often induced (Halgren, 1992). This finding is difficult to assess, however, as many other reactions are also common with this type of stimulation. Nevertheless,

studies of electrical stimulation to the wider fear system – amygdala, PAG, hypothalamus, brain stem – show that people tend to report strong feelings of foreboding when these areas are stimulated. For example, one patient reported that 'Somebody is now chasing me, I am trying to escape from him' (Panksepp, 1985). Anecdotal reports also suggest that the experience of fear is abnormal in people with amygdala damage. For example, the husband of one woman with amygdala damage reported that when they were surrounded by a group of youths who tried to mug him, his wife was relaxed and said that they were just 'larking around'. However, on another occasion she became terrified when two actors in a television programme were mildly aggressive towards each other (see Calder et al., 2001, for review). There is also some evidence from patient NK that damage to the insula and basal ganglia interferes with the subjective experience of disgust (Calder et al., 2000).

To summarize, studies of patients with brain lesions have shown that amygdala damage may lead to specific deficits in the recognition and experience of fear (Calder et al., 1996), damage to the insula and basal ganglia results in deficits in recognizing and experiencing disgust (Calder et al., 2000; Sprengelmeyer et al., 1996, 1997), and damage to the ventral striatum can impair the recognition of anger (Calder et al., 2004). This body of research suggests that discrete emotions are associated with specific brain areas both in terms of recognition of different emotion categories as well as the subjective experience of these emotions.

Fear conditioning with brain injured patients

In addition to tests of emotion recognition, the fear-conditioning paradigm has also been used successfully in human research. Photographs of faces, coloured squares or tones are most commonly used as the CS, while mild electric shock or an aversive burst of noise is the most common US. The typical response measured in human studies is the skin conductance response (SCR), which provides a good index of ANS function. Several studies have shown that the amygdala is indeed crucial for the development of conditioned fear in humans. It has also been found that the hippocampus is essential for the explicit learning of a fear response in humans. A clear dissociation has been reported between patients with amygdala damage and patients with hippocampal damage on a fear-conditioning paradigm (Bechara et al., 1995). In this study, a patient with selective bilateral damage to the amygdala was easily able to learn which visual and auditory stimuli (CS) were linked with the US. However, this individual did not develop a conditioned response to the CS as measured by SCR, which is very unusual. In other words, even though the patient could remember which tone would lead to an electric shock, no anticipatory fear occurred when this tone was presented. In contrast, a patient with selective bilateral damage to the hippocampus was unable to learn the association between the CS and the US, but nevertheless did develop a normal conditioned fear response as measured by SCR. This patient showed anticipatory fear when the crucial tone was presented even though the individual could not remember that this particular tone was associated with the shock. Thus, one patient was able to learn an explicit association between a CS and a US but did not develop a normal fear response to the CS, while another patient could not learn the explicit

association but did develop a normal fear response to the CS. This demonstrates a classic double dissociation, which is an important technique in neuropsychology. Finally, as an important control, Bechara and colleagues found that a patient with bilateral damage to both the amygdala and the hippocampus was not able to learn either the explicit association or the fear response. In an elegant way, this study demonstrates that the amygdala and the hippocampus can operate independently of each other, allowing us to acquire different types of representations of the aversive consequences of particular events. These different kinds of representations, explicit/hippocampal and implicit/amygdala are likely to be useful in a range of different situations. For example, it is sometimes important to respond to threat instantly even if we do not explicitly *know* what the threat is (e.g., a snake hidden in the grass). At other times, it is important to know that danger may occur in a particular situation even if we have never experienced that situation directly. Thus, if I tell you that there is an aggressive dog living beside a path in your local park you will probably experience a fear reaction if you happen to walk down that path, even though you have never experienced any threatening event in that location. Research indicates that the amygdala and the hippocampus may play different roles in modulating these different aspects of fear (Phelps, 2004).

Evidence of how important explicit knowledge can be in the development of a fear response was reported by Elizabeth Phelps and her colleagues in another elegant study (Funayama et al., 2001). Participants were told that there was a possibility that they would receive an electric shock when they saw a particular coloured square (e.g., a blue square) but that no shock would occur when other coloured squares were presented. Even though no shock was ever administered throughout the experiment, normal participants (i.e., non-brain-damaged) understood that a blue square might indicate a forthcoming shock and, as we would expect, they developed a normal fear response (as measured by SCR) any time the blue square was presented. In marked contrast, patients with amygdala damage did not develop this SCR to the blue square even though they could easily report the explicit link between the blue square and the possibility of getting a shock. This study is important in demonstrating two things. First, the study shows that the amygdala modulates the fear response but that it, in turn, is modulated by the hippocampus. Because no shock was ever administered, the fear response can only have developed in response to the *explicit knowledge* of the CS-US (blue square-electric shock) link. This explicit memory is, of course, controlled by the hippocampus, which must have sent a signal to the amygdala so that the amygdala itself responded as soon as the blue square was presented. Second, for the people with amygdala damage, the amygdala could not respond and therefore a fear response did not develop. This demonstrates the crucial role that the amygdala plays in the development of a normal fear reaction.

Is the amygdala specific to fear?

While the amygdala has been implicated in both the recognition and the experience of fear, it is also clear that this structure is involved in a number of other emotions. For example, when electrodes were implanted into the dorsolateral amygdala of monkeys,

it was found that specific neurons within this region were activated by stimuli that indicated reward to the same extent as stimuli that indicated punishment (Sanghera et al., 1979). It has also been found that the amygdala responds to a range of positive stimuli (e.g., happy faces) but that this response is strongly modulated by a person's personality traits (Canli et al., 2002). Thus, it is clearly not the case that the amygdala is involved only in fear. Instead, this neural structure may play a wider role in a range of different emotions. This makes it difficult to establish whether the amygdala is part of a neural circuit that is specific to fear, or whether it may be part of a neural circuit underlying any significant affective stimuli.

Brain imaging of emotions

Lesion studies can be problematic to interpret since damage frequently affects a number of different brain areas. This makes it difficult to attribute particular functions to specific brain regions. However, advances in brain imaging technology have opened up new ways of investigating the hypothesis that individual emotions such as fear, anger, sadness, disgust, happiness are associated with specific neural circuits. In particular, PET and fMRI allow us to observe which brain areas are involved in emotion in conscious healthy individuals. A problem with many brain imaging studies of emotion, however, is that the researchers do not make a clear distinction between emotions, moods and feelings (the subjective experience of emotions). In addition, they often do not make a distinction between the *perception* of emotion and the *expression* of emotion in either behavioural outputs or feelings. These different aspects of emotions (or moods) may have different neural substrates and this is important to bear in mind when evaluating neuroimaging studies of emotion (Murphy et al., 2003).

Many neuroimaging studies have examined emotion perception by presenting people with emotional stimuli (usually visually) and then examining which brain areas are differentially activated to different emotions. While a wide range of stimuli can be used (e.g., positive and negative pictures; positive and negative words; aggressive and calm prosody etc), most studies have used photographs of different facial expressions. These are useful stimuli because:

- they are highly significant social stimuli that are familiar to everyone,
- the same individual's face can be used so that there is a good control between different emotional expressions. In other words, the same person can be presented expressing anger, happiness, fear, disgust and so on. This degree of matching would be much more difficult to achieve using pictures of different scenes, and
- different facial expressions may relate to different basic emotions, as suggested by the work of Paul Ekman. Thus, examining the neural correlates of processing different facial expressions might tell us something about the neural circuits underlying different basic, or discrete, emotions.

In an early study, photographs of faces with fearful and happy expressions were presented one by one to participants while their brain activity was monitored by means of PET (Morris et al., 1996). There was a clear differential activation of the left amygdala

to fearful relative to happy faces. Two recent studies, have examined a wider range of emotional expressions (fear, disgust, happiness and sadness) but these studies report a conflicting pattern of results. Surguladze, Russell et al. (2003) found that the amygdala was activated by high intensity fearful expressions, while the hippocampus, anterior insula, and putamen were activated to increasing intensities by fearful, disgusted and happy expressions, respectively. Moreover, linear decreases in hippocampus and putamen responses occurred to increasing intensities of sadness. In contrast, a similar study, also using fMRI, did not find any differential activation among these different emotions. Instead, it found that a number of brain regions tended to respond to increasing intensities of emotion, rather than individual emotions (Winston et al., 2003).

Given the relative newness of neuroimaging studies of emotion and the low participant numbers in each study (usually around 12 participants), it is difficult to draw conclusions from any single study. For this reason, the use of meta-analysis is a useful technique. Meta-analysis is a statistical technique that reviews a large number of studies using similar methodologies so that a greater degree of statistical power can be used to draw conclusions across several studies. The effect sizes found in each individual experiment can be entered into a statistical analysis so that overall patterns that may not be obvious in any individual study can be investigated. Two comprehensive meta-analyses on the functional neuroanatomy of emotions have been reported (Murphy et al., 2003; Phan et al., 2002).

We will focus on the Murphy et al. (2003) meta-analysis because it includes a larger number of studies ($n = 106$) than the earlier analysis conducted by Phan et al. (2002). Murphy and colleagues directly tested the hypothesis that the pattern of neural activity would differ for the basic emotions of fear, anger, disgust, happiness, and sadness. They examined all of the relevant studies (106 were identified) and then determined the most consistently activated brain region for each emotion. Some support for the basic emotions approach was found, with some brain regions being more consistently activated for particular discrete emotions:

- 1 *fear* – amygdala;
- 2 *disgust* – insula/operculum and globus pallidus;
- 3 *anger* – lateral orbitofrontal cortex (OFC);
- 4 *happiness* – rostral supracallosal ACC/dorsomedial prefrontal cortex (dmPFC);
- 5 *sadness* – rostral supracallosal ACC/dmPFC.

This analysis included studies examining emotion perception as well as those examining the subjective experience of emotion. Further statistical analysis showed that three of the discrete emotions (fear, disgust and anger) could be distinguished from all others, while the pattern of neural activation did not differ between sadness and happiness. A similar pattern of findings was found in a more focused analysis of studies that investigated only the recognition of facial expressions of emotion (i.e., emotion perception). The results of this analysis are shown in Table 4.5.

As can be seen in Table 4.5, the number of studies for each emotion is relatively small. Nevertheless, there seems to be evidence for separate spatial distributions of

TABLE 4.5 The regions most consistently activated when processing facial expressions of the basic emotions

	Fear (8)	Disgust (5)	Anger (4)	Happiness (4)	Sadness (3)
Amygdala	63	19	0	0	25
Insula/operculum	0	100	22	0	0
Globus pallidus	23	80	22	0	0
Lateral OFC	61	19	100	23	0
rsACC	38	19	23	50	0
dmPFC	38	19	23	50	0

The number of studies included in the meta-analysis is shown in brackets.

Source: Adapted from Murphy et al. (2003).

neural activity for the emotions of fear, disgust, and anger. In contrast, no significant difference between the spatial distribution of neural activity for happiness and sadness could be detected. It is important to note that regions of the anterior cingulate and mPFC (rsACC and dmPFC) were activated in most of the discrete emotions studied, suggesting a more general role for these brain areas (see Murphy et al., 2003, for further discussion). It is possible that some brain areas may play a general role in both the perception and experience of emotions, while other regions play a more specific role for individual discrete emotions. On the basis of their meta-analysis, in conjunction with evidence from brain damaged individuals, Murphy et al. (2003) conclude that there are partially separate neural systems underlying fear, disgust, and anger. This conclusion is broadly consistent with the discrete emotions approach that at least some basic emotions can be separated at both psychological and neural levels of representation.

Distinctive antecedent events

Another criterion assumed to be important in determining whether an emotion is 'basic' is that the emotion should be elicited by a distinctive antecedent event (see Table 4.1). If basic emotions evolved to help us deal with fundamental life tasks, then it is clear that there should be some common elements in the contexts in which particular emotions occur. Boucher (1983) argued, for example, that the loss of a significant other was an antecedent to sadness in most cultures. While there may be cultural variations in what person is a 'significant other', the death of that individual will generally result in sadness.

There are two general types of events that elicit specific emotions: biologically primed stimuli and stimuli that elicit responses through learning experiences. For example, we have seen how rats can quickly and easily learn to fear a tone that is associated with an electric shock. However, research also shows that rats will demonstrate a classic fear response to the smell of a cat, even if they have had no prior experience with cats (Panksepp, 1998). In most situations, it is likely that emotional responses

to particular situations are the result of the joint contributions of evolution and social learning. An elegant study by Susan Mineka and her colleagues demonstrates this very nicely. They studied young rhesus monkeys that had been born and raised in the laboratory and had had no prior experience of snakes. Snakes, of course, represent a real danger to monkeys in the wild. In the experiment, the young monkeys were presented with realistic toy snakes, as well as a bunch of flowers as a control. The monkeys showed no particular fear of either the toy snakes or the flowers, showing that the sight of a snake is not hard-wired for monkeys in the way that the smell of a cat seems to be for rats. The researchers had obtained a video of an adult monkey demonstrating a classic fear response to a real snake in the wild. A copy of the video was then edited: the snake was replaced with a bunch of flowers so that it looked like the adult monkey was displaying fear to the bunch of flowers. Both versions of the video were then presented to two groups of naive monkeys who had never seen either snakes or bunches of flowers before. Remember that the video of the adult monkey's fear reaction was identical in both cases, so that if social learning was the *only* factor in eliciting the emotion of fear then the naive monkeys should develop a fear response to *both* the flowers and the snakes. Following the video, the naive monkeys were presented with a toy snake and a bunch of flowers. The naive monkeys developed a strong fear response only to the toy snake, while no fear reaction developed to the bunch of flowers. Moreover, the fear response to the snake was very persistent and difficult to extinguish (Mineka et al., 1984). This experiment nicely demonstrates that just one exposure to an adult exhibiting fear towards a snake is enough to induce a strong fear of snakes in young monkeys. This is clearly a *selective* learning process because the identical fear display to a bunch of flowers did not elicit a fear reaction. Thus, biological evolution seems to have provided us with a variety of stimuli which represented great dangers and/or advantages to our ancestors, and which are still important antecedents to emotional responses today (Mineka and Öhman, 2002; Öhman, 1986). It is no surprise, for example, that the most common phobias are the fear of spiders and the fear of open spaces – neither of which represent a particularly common danger in the modern world.

Appraisal models of emotions

The work of Mineka and others show that there are particular stimuli which are more easily associated with the induction of specific emotions. However, it is also clear that no one set of antecedent events is likely always to elicit the same emotions in everybody (Stein and Trabasso, 1992). Instead, many psychologists have argued that it is the *appraisal* of the situation which gives it a particular meaning, and this, in turn, will elicit a specific basic emotion. For example, Nancy Stein and her colleagues have argued that the *basic emotions* can really be reduced to *basic appraisal scenarios* (Stein and Trabasso, 1992). They argue for the existence of a small set of high-level goals associated with a core set of appraisal and action processes, which relate in a fairly direct way to the attainment of particular goals. These core goals are shared across cultures and, therefore, the appraisals linked to these goals are fundamental cognitive

processes that result in basic emotions. Thus, the evaluation or appraisal of an event (e.g., interpreting somebody's comment as an insult) is seen as the key mechanism that leads to an emotion (e.g., anger).

It was Magda Arnold (1960) who first argued that *appraisal* was the crucial immediate evaluation of a situation that could account for the qualitative differences among emotions. In other words, discrete emotions are produced because of variations in fundamental appraisals of situations. She suggested that people evaluated particular situations on three key dimensions: Is the situation beneficial or harmful? Is an important object present or absent? Is the object difficult to approach or avoid? The idea that emotions are elicited by appraisals is reasonable given that we do not tend to become emotional about situations or people that we do not care about or that have no special significance for us. Therefore, the evaluation or appraisal of the way in which something is significant is an important determinant of the type of discrete emotion that is experienced. Arnold (1960) argued that all organisms constantly evaluate the environment for changes that might have relevance for their own well-being. These appraisals then result in specific action tendencies which are experienced as emotions. The component process model in Figure 4.9 outlines four major appraisal objectives that occur in a particular sequence (Scherer, 2001, 2004). Each type of appraisal – relevance, implication, coping potential, and normative significance – unfolds sequentially over time and receives input from a variety of motivational and cognitive processes such as attention, memory, reasoning and the concept of the self. Thus, various evaluation criteria as well as stored information are considered crucial for the appraisal process (see Scherer, 2001).

The central assumption of an appraisal perspective is that organisms constantly evaluate their environment for personal significance. This means that different emotions are produced by a cumulative sequence of appraisals or stimulus evaluation checks (Ellsworth and Scherer, 2003; Scherer, 1984). Appraisal theories differ from many categorical theories of emotion (Izard, 1977) in that they do not assume that distinct basic emotions are produced by innate hard-wired neural circuits. In contrast, appraisal models assume that there are as many different emotions as there are reliably differentiated appraisals. Nevertheless, many appraisal-based models do argue that a

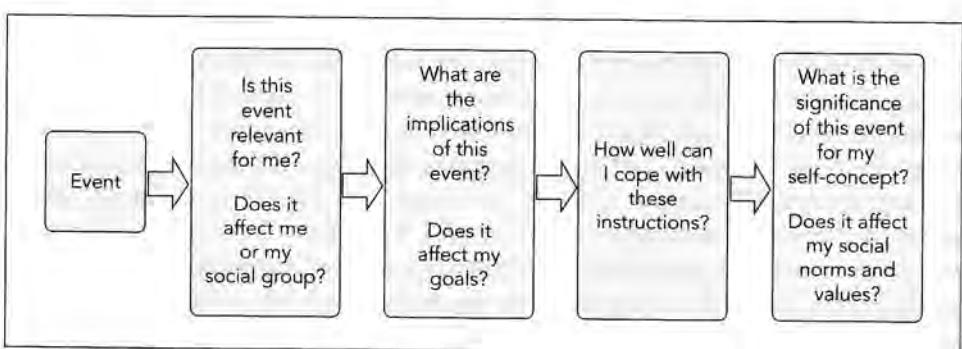


FIGURE 4.9 The component process model

Source: Scherer (2001).

smaller number of emotions are important in helping the organism to adapt to important events that have consequences for survival and well-being. This is the primary reason why Klaus Scherer (1994) has suggested that these should be *modal* emotions, rather than *basic* emotions. This is a useful concept since these are the emotions most commonly experienced across cultures. In addition, most cultures have distinctive verbal labels in their languages to refer to these 'modal' emotions which are elicited by a fundamental appraisal. There are many appraisal-based models of emotion and we do not have the space to provide a comprehensive overview here (for an excellent review see Ellsworth and Scherer, 2003). Instead, we will consider in some detail two influential models of emotion which both hold that cognitive appraisal is at the heart of the emotion process.

Richard Lazarus (1966, 1991)

Richard Lazarus proposed a *cognitive-motivational-relational* theory (1991) in which each discrete emotion is associated with what is called a 'core relational theme'. The core relational themes and the emotions they elicit are outlined in Table 4.6. Each discrete emotion is elicited by an appraisal of one of the core relational themes, all of which are common situations in which we might find ourselves. Few people would object to this list but, as pointed out by Power and Dagleish (1997), the 'core relational themes' are more or less equivalent to a list of dictionary definitions of different emotions. It also seems to be rather circular in the sense that we might define anger as the emotion that occurs when we appraise a situation as being demeaning to us. This is, of course, exactly the core relational theme that Lazarus identifies as leading to anger. Moreover, we might also imagine that anger and aggression are likely to occur in situations where we are in danger (core relational theme associated with fear) and where there is no escape. Indeed, animal research shows that there is a close

TABLE 4.6 Examples of some core relational themes and the discrete emotions with which they are associated

Core relational theme		Resulting emotion
A demeaning offence against you or your family	⇒	Anger
Faced with an uncertain threat	⇒	Anxiety
Faced with an immediate overwhelming danger	⇒	Fright
Faced with a transgression of a moral value	⇒	Guilt
A failure to live up to an ideal	⇒	Shame
Wanting to have what somebody else has	⇒	Envy
Resenting someone for loss of another's affection	⇒	Jealousy
Being faced with an indigestible object (or idea)	⇒	Disgust
Progressing towards a wanted goal	⇒	Happiness
Being moved by another's suffering	⇒	Compassion

Source: Based on Lazarus (1991).

relationship between fear and defensive aggression. Thus, this list does not seem to have a high degree of explanatory power because we can simply keep adding themes or situations that we think might be linked to a specific emotion.

Oatley and Johnson-Laird (1987)

Oatley and Johnson-Laird proposed a cognitive theory of emotions, in which they argued that a primary *function* of discrete emotions is to provide a means by which important life goals can be pursued. An important aspect of Oatley and Johnson-Laird's theory is that they acknowledge the *functional* nature of emotions while also accepting that cognitive evaluation is critical for the elicitation and differentiation of different emotions. The basic idea is that an event is appraised in relation to various goals. These appraisals are considered to occur automatically and without conscious awareness, and are driven by a small set of basic emotions. They argue that relatively complex organisms such as mammals are faced with two major problem areas: personal goals and the unpredictability of their surroundings.

First, every organism has multiple goals: not being injured or killed; finding food; finding a mate; finding shelter and so on. At any given moment each of us has many different goals, all competing for priority. For example, you may have a higher-level goal of passing your exams at the end of the year, but you may also have a lower-level goal of having lunch in an hour or so, and then another goal of going out at the weekend. The problem is that these goals have to be prioritized in some way. You cannot actively pursue all of them at the same time, and it is often the case that different goals may be incompatible with each other. For example, you may hope to gain a place on a college sports team, and this involves training at least three times a week. Thus, going out training is compatible with your goal of getting on the team. However, let us imagine that you have a slight injury that seems to be getting worse the more you train. The goal of staying injury-free would indicate that you should cut back on your training, but this is probably incompatible with the goal of getting a place on the team. Life is full of conflicting goals like this, and, according to Oatley and Johnson-Laird, emotions play a key role in prioritizing and organizing these goals.

A second problem facing every mammal is the fact that the world is an unpredictable place. If everything that happened from moment to moment could be accurately predicted then life would be very simple. However, life is not like this and therefore our cognitive systems need to be highly flexible in order to cope with a changing world. According to Oatley and Johnson-Laird (1987), this is precisely why emotions have evolved: to help us to coordinate competing goals in a flexible way. The emotion signal is very old in evolutionary terms. It sets the entire cognitive system into a specific mode but, when some environmental event indicates that a change in this mode is necessary, then the critical emotion signal forces a change from one mode to another.

On the basis of the work of Ekman (1973) and others, Oatley and Johnson-Laird (1987) propose that at least five basic emotions have evolved to enable complex cognitive systems to assign priorities to specific goals in a flexible way. Emotions are

TABLE 4.7 Junctures and the five basic emotions associated with them

Juncture of goal or plan	⇒	Basic emotion
Sub-goals or goals being achieved	⇒	Happiness
Failure or loss of plan or goal	⇒	Sadness
Self-preservation goal threatened	⇒	Anxiety
Plan or goal frustrated or blocked	⇒	Anger
Gustatory goal violated	⇒	Disgust

Source: Oatley and Johnson-Laird (1987).

important when a key juncture occurs between plans or goals because they allow the system to switch rapidly from one mode to another. The key junctures in goals and plans that are associated with specific basic emotions are outlined in Table 4.7. The important point is that these key junctures are identified by cognitive appraisals or evaluations.

CHAPTER SUMMARY

This chapter has reviewed evidence from a wide variety of sources indicating that, at least some, emotions are 'gifts of nature'. *Discrete emotions approaches* hypothesize that some emotions are crucial for adapting to common and important life events and have evolved to help us deal swiftly with these universal situations. For this reason, these *basic emotions* would be expected to have key expressive signals which are likely to elicit them. These signals may well be universal, fairly unique physiological responses and neural circuits, and common antecedent events. A number of important criteria for basic emotions were outlined and evidence ranging from neurobiology to psychological models of appraisal provide some evidence for the hypothesis.

Many emotion scientists are confident that fear can be categorized as a basic emotion. This chapter has focused on research into fear in both animals and humans because it is the basic emotion that has been studied most intensively. The assumption is that similar evidence will be found for the other basic emotions once the appropriate research has been done.

RECOMMENDED READING

Excellent discussion and commentaries on the question of whether there are basic emotions is provided in:

- Lisa Feldman Barrett (2006) 'Are emotions natural kinds?', *Perspectives on Psychological Science*, 1, 28–58.
- Lisa Feldman Barrett et al. (2007) 'Of mice and men: Natural kinds of emotions in the mammalian brain? A response to Panksepp and Izard', *Perspectives on Psychological Science*, 2, 297–312.

- Paul Ekman and Richard J. Davidson (1994) *The Nature of Emotion*. New York: Oxford University Press. (Question 1: pp, 7–47).
- Carol E. Izard (2007) ‘Basic emotions, natural kinds, emotion schemas, and a new paradigm’, *Perspectives on Psychological Science*, 2, 260–80.
- Jaak Panksepp (2007) ‘Neurologizing the psychology of affects’, *Perspectives on Psychological Science*, 2, 281–96.

An older series of articles published in the journal *Psychological Review* also provide an overview of different opinions on the question of whether basic emotions exist.

- Paul Ekman (1992) ‘Are there basic emotions?’, *Psychological Review*, 99, 550–3.
- Carol Izard (1992) ‘Basic emotions, relations among emotions, and emotion–cognition relations’, *Psychological Review*, 99, 561–5.
- Andrew Ortony and Terence Turner (1990) ‘What’s basic about basic emotions?’, *Psychological Review*, 97, 315–31.
- Jaak Panksepp (1992) ‘A critical role for “affective neuroscience” in resolving what is basic about basic emotions’, *Psychological Review*, 99, 554–60.
- Terence Turner and Andrew Ortony (1992) ‘Basic emotions: Can conflicting criteria converge?’, *Psychological Review*, 99, 566–71.