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3 EDITION

Cognitive Science

An Introduction to the Study of Mind

10

The Emotional Approach

Mind as Emotion

Ninety percent of our lives is governed by emotion. Our brains merely register and act upon what is telegraphed to them by our bodily experience. Intellect is to emotion as our clothes are to our bodies: we would not very well have civilized life without clothes, but we would be in a poor way if we had only clothes without bodies.

—Alfred North Whitehead, 1943

EMOTION AND COGNITIVE SCIENCE

Your boyfriend is late. He said he would pick you up at 7:00 p.m. so that the two of you could go out to dinner at your favorite Italian restaurant. It's 8:00 p.m., and he still hasn't arrived. On top of this, he has not responded to your text or voicemail. You start to get angry and wonder what the matter is. You remember another time when he was late in arriving and begin to think that he doesn't care about you. This gets you thinking about other negative thoughts like that time the two of you got into that argument the previous week. Maybe it is time for a breakup? Just then the phone rings. It is him, and he says he got into a car accident. Immediately you feel sorry for him and perhaps a bit guilty for thinking so poorly of him.

This example shows that we humans are not pure calculating machines. We think yes, but we also feel. We are cognitive, but we are also emotional. Cognition and emotion are complexly intertwined. They are both co-occurring and influencing each other. Our thoughts affect how we feel, and how we feel affects how we think. In this chapter, we will examine emotions and their relation to cognition, but first, we will start by defining what emotions and other related phenomena are. Then, we will discuss the evolutionary forces that created emotions along with the psychological disorders that can arise from them. Following that, we will delve a bit into the anatomy and physiology underlying emotional states. We will conclude with a discussion of affective computing and attempts by researchers in the field of artificial intelligence to artificially create machines capable of emotional behavior.

WHAT IS EMOTION?

The concept of emotion is a slippery one (Solomon, 2003). People use the term in a number of different ways. We will adopt the approach used by Davidson, Scherer, and Goldsmith (2003) and differentiate between emotions, feelings, and moods. An **emotion** is a relatively brief episode of coordinated brain, autonomic, and behavioral changes that facilitate a response to an external or internal event of significance for the organism. Fear is a good illustrative example. Imagine that you are hiking in the woods. Suddenly, you come across a bear. The bear is an external event that has a clear significance for you since it could potentially kill you. Suddenly, you find that your heart is beating faster, you begin to sweat, and a feeling of panic flashes through your mind. You immediately turn around and run back down the trail at full speed. In this case, the physiological changes facilitated the fleeing response.

Feelings correspond to the subjective experience of emotions. They are what it is like to feel afraid, sad, or jubilant. Emotions may be considered public; other people can judge whether or not you seem afraid based on outward appearances, such as trembling hands. Feelings, though, are internal and subjective; they are the way you as an individual experience the emotion. **Moods** are diffuse affective states that are often of lower intensity than emotion but considerably longer in duration. If you received an "A" on your psychology exam, it might put you in a good mood for the rest of the day. Whereas the emotion of happiness would be more intense but short-lived—lasting, say, only a few minutes—the good mood would be more subdued but could stay with you for hours. The term *affective* is sometimes used to signify emotion but can be more broadly construed to refer to emotions, feelings, and moods together (Fox, 2008).

Dolan (2002) believes that, from a psychological perspective, emotions have three characteristics. First, unlike thoughts, emotions are embodied. That is, we experience emotions not just as mental events "in our heads" but also as full-body experiences. Second, and also unlike cognition, emotions are harder to control. We may find that it is easier to change our thoughts than our emotions. Finally, emotions seem less encapsulated than thoughts. In other words, they seem to have a more global impact on our behavior. When we are happy, the entire world seems better. Consequently, this emotion would affect our entire outlook and influence what we remember, what we say to people, and so on.

THEORIES OF EMOTION

Since emotions were first studied psychologically, there has been controversy over how they are caused. According to the **James-Lange theory of emotion**, there is an event that produces arousal and other physiological changes in the body (James, 1884; Lang, 1994). These physiological changes are then interpreted. The result of the interpretation is the emotion. Imagine that you are walking down a city street late at night. A man lurches toward you from an alley, holding what appears to be a gun. According to this view, the sight of the man would cause your heart to beat faster; only then would you be aware of your heart's acceleration and experience fear.

According to the **Cannon-Bard theory of emotion**, the event itself can trigger an emotion (Cannon, 1927). Although the event causes physiological arousal, the arousal is not necessary for the formation of the emotion. So in this view, the event immediately causes both the emotion and the bodily changes. The two do not depend on each other.

The **cognitive theory of emotion** resembles the James-Lange theory but has more to say about the interpretation process. In this view, it is the total situation and not just the arousal that determines emotions. An accelerating heart by itself would not be enough to produce fear, as we find in the James-Lange theory. Instead, it would be the bodily change plus the situation that would produce fear: your heart beating faster and the awareness that the man may want to shoot you.

A study by Schachter and Singer in 1962 is perhaps one of the most classic experiments in psychology. It is a good illustration of the role cognitive appraisal plays in the determination of emotions. In this experiment, two groups of participants were injected with epinephrine, which induces arousal. They were both told that this was a vitamin injection and were told to sit in a waiting room before the rest of the experiment. In the waiting room, there was a confederate, an actor who plays a part in the study. In one condition, the confederate acted happily. He made paper airplanes, played with a hula hoop, and acted silly. The confederate in the second condition, in contrast, acted angrily. He bothered the participant, ultimately storming out of the room. When asked about how they felt, the first group exposed to the happy confederate reported that they felt happy. The second group, who had to sit through the irate confederate, instead, reported that they felt irritable and angry.

The lesson from this study is clear: Both groups were equally aroused but in different contexts, and it was the context that determined how they appraised the situation. When in the presence of the happy confederate, they attributed their arousal to him, resulting in a happy outcome. When the arousal was interpreted in a different situation—with the angry confederate—it instead produced feelings of anger.

The most recent model of emotion formation incorporates elements from the previous three theories. It is called the **emergence synthesis** approach (LeDoux, 1996; Russell, 2003). In this perspective, there are some emotions that are triggered solely by a stimulus and don't require any interpretation. For instance, fear can be caused when a threatening stimulus activates a part of the brain called the amygdala. The amygdala by itself can induce the feeling of being scared without any thought or appraisal.

However, there are some emotions that do require interpretation. For example, guilt seems to result from a combination of bodily changes, cognition, and perhaps memories of previous experiences. So in this model, we have several pathways to emotion. They can be caused by arousal, by interpretation, or by some combination of the two. This more flexible model accounts for a wider range of studies and is the one currently in favor.

BASIC EMOTIONS

How many emotions are there? It seems as if it could be a long list. To simplify the discussion, researchers have introduced the concept of a basic emotion. A **basic emotion** is one that is believed to be mostly innate, and in humans, it ought to be universal or is found in all cultures. Basic emotions may also contribute in various combinations to form other more complex emotions (Plutchik, 1980).

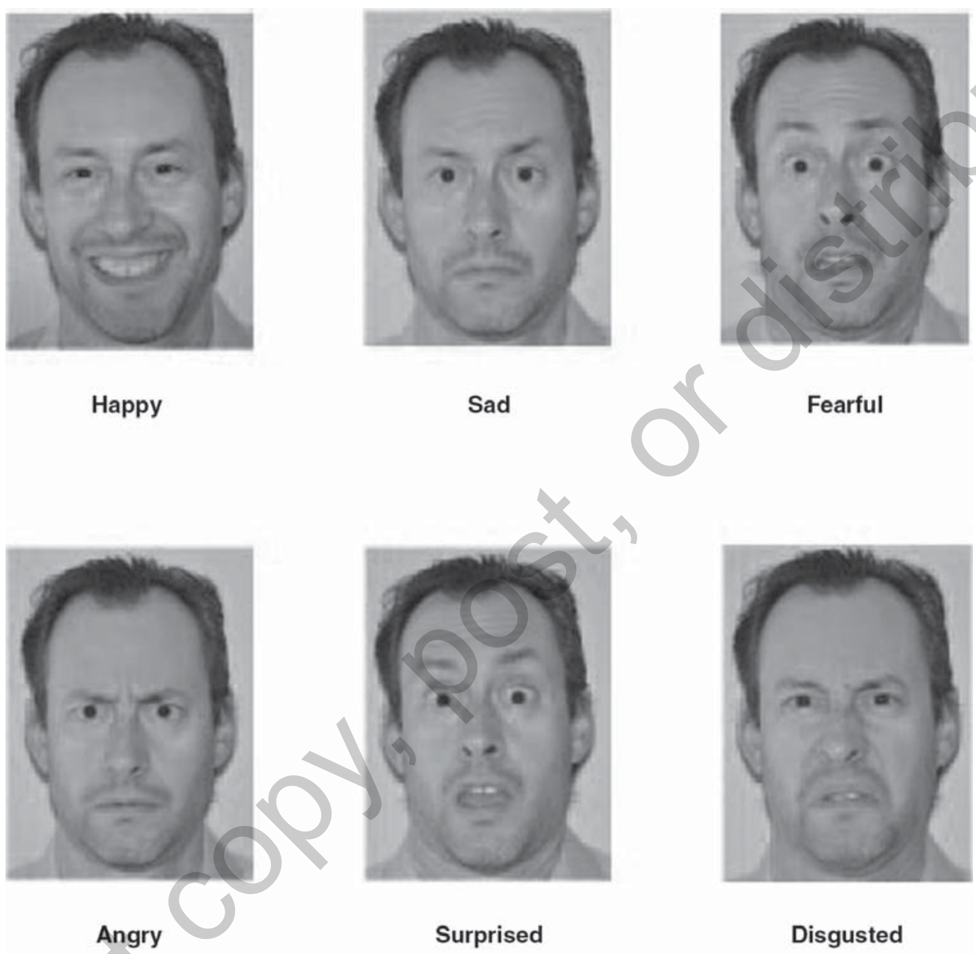
Charles Darwin first suggested that there might be basic emotions not just in humans but in animals as well. He noted that people, regardless of background, use similar facial expressions to convey particular emotions. There is empirical evidence to support this view. Ekman and Friesen (1971) presented photos of Caucasian facial expressions to members of a New Guinea tribe who had little or no exposure to Western faces. The participants could correctly label nearly all the faces, suggesting that the expressions employed correspond to a set of fundamental emotions (Ekman, 1989). The expressions were happy, sad, fearful, angry, surprised, and disgusted (see Figure 10.1). However, there is no complete agreement on these expressions. Other studies have suggested additional emotions, such as pride (Tracy & Robins, 2004). There is also contention as to whether or not these basic emotions can be further subdivided. It has been proposed that there may be three kinds of disgust (Rozin, Lowery, & Ebert, 1994). There also may be several varieties of happiness, such as joy, amusement, love, and interest (Keltner & Shiota, 2003; LeDoux, 1996).

EMOTIONS, EVOLUTION, AND PSYCHOLOGICAL DISORDERS

Emotions clearly serve some adaptive purpose if evolutionary forces have selected for them. Rolls (1999) lists three primary functions of emotion. He divides them into categories servicing survival, communicative/social, and cognitive needs. At the survival level, emotions elicit responses to stimuli important to the organism. The presence of a threat will thus automatically trigger a fight-or-flight response to deal with the potential danger. Running or fighting keeps the organism alive in such situations and so, clearly, is of adaptive value.

Emotions can be thought of as complex, sophisticated reflexes. A reflex is triggered by a very specific stimulus and produces a very specific response. Emotions are much more flexible. Multiple stimuli, such as a spider, a snake, or a bear, can all trigger fear. Emotions also provide for a more varied behavioral reaction. Depending on the context, being afraid

Figure 10.1 The six basic emotional facial expressions.



Source: Adapted from Ekman and Friesen (1971).

can make you jump, scream, run, hide, and so on. They narrow our possible responses, but at the same time, they allow us some measure of choice in determining what to do. Here, we again see a cognition–emotion interaction. Emotions prime our responses, but the actual selection and execution can be left up to more controlled thought processes.

In animals and people, emotions also serve as a form of communication (Darwin, 1872/1998). Facial expressions caused by emotions convey our feelings to others. This guides our interactions with one another. If your best friend looked very angry or sad, your reactions to him or her in each case would differ considerably. You might try to calm him or her down or suggest a relaxing activity that you could do together, such as watching a movie. The perception of sadness, instead, might prompt you to ask him or her to tell you what was wrong and to talk about it.

The third major function is one we have already mentioned—namely, that our emotions can assist us in thinking and problem solving. Emotions guide our attention to what is important, helping us ignore distractions and prioritize our concerns (Picard, 1997). In the rest of this section, we will outline some of the adaptive functions that basic emotions might serve. We will then discuss how these emotions can sometimes "backfire" and contribute to various psychological disorders. Friedenberg (2008) provides a more detailed account.

Disgust

Disgust is the emotional reaction we have to substances that could be a source of viral, bacterial, or parasitic infection. It causes us to be repulsed and, therefore, to avoid these things. There is a possible relationship between this emotion and **obsessive-compulsive disorder**. Marks and Nesse (1994) point out that other animals engage in ritualistic actions to reduce the threat of infection. Birds preening their feathers or cats licking their fur are two examples of this. People suffering from obsessive-compulsive disorder also engage in such behaviors. They count the number of cracks in a sidewalk or wash their hands many times a day. These compulsions temporarily reduce the anxiety they feel in response to a repeated intruding thought or obsession related to contamination, such as believing that their hands are dirty. It could be that this disorder is the result of a disruption in this mechanism.

Fear

When we are afraid, our palms sweat, pupils dilate, and hearts accelerate. The evolutionary advantage of fear is obvious: it causes us to avoid dangerous things. There are a number of distinct fear disorders. A **phobia** is a persistent and irrational fear of a specific object or situation. Fear of spiders (arachnophobia) and heights (acrophobia) are two common examples. The fact that phobias are connected to stimuli commonly found in the natural environment and less often to human-made objects, such as guns or car doors, suggests that they are genetic rather than learned (Marks, 1987). In a **panic attack**, a person is overcome with intense fear accompanied by a strong sympathetic nervous system arousal. The majority of symptoms for this disorder are related to an escape response (Nesse, 1987). Patients with this disorder seem to be hypersensitive to stimuli that signal the state of being trapped.

In a **posttraumatic stress disorder**, an individual has been exposed to a traumatic situation, such as an earthquake or war. Patients manifest anxiety but also continue to psychologically reenact the event in the form of flashbacks and nightmares. This disorder may occur when the memory consolidation mechanism hypothesized to underlie flashbulb memory is activated. The details and feelings experienced during the trauma seem to be encoded so strongly in these people that they come out inappropriately, perhaps in response to subtle retrieval cues.

Anger

Anger is the emotion that motivates fighting, the opposite of a fear response. When angry, we confront and deal aggressively with the inducing stimulus. Anger serves to mobilize and sustain vigorous motor activity (Tomkins, 1963). In this aroused state, we are better able to deal with threats. Aggression also has evolutionary roots. Men are much more aggressive than women. According to one explanation, this is because men must compete for mates, with more aggressive males being able to secure better mates. Manson and Wrangham (1991) studied warfare in 75 traditional societies. They found that in more than 80% of the cases, war involved access to females or to resources necessary to obtain one.

Sadness

All of us may have felt down and discouraged, typically in response to some personal event, such as the loss of a job or the death of a loved one. For most of us, this feeling eventually goes away. For some individuals, though, this sadness can occur without any precipitating incident and can be more intense and longer lasting. This is known as **major depressive disorder** and can be accompanied by interruptions in sleep, appetite, and concentration. Nesse (2000) believes that depression is an evolved strategy for disengaging from unattainable goals. Moods may also regulate the amount of time and energy we put into various activities, with depressed moods causing us to rethink our strategy and abandon fruitless efforts.

Depressed people often ruminate on their life situation. This rumination involves an analytical mode of thinking, which can actually help solve complicated problems. However, to be truly effective, this analysis needs to be done slowly and carefully. According to the **analytical rumination hypothesis**, depression is an evolved response to complex problems (Andrews, Thomson, & Anderson, 2009). In this view, the depressive state induces a focus on the problem while at the same time minimizing distractions that might detour attention, working memory, and other processing resources. Experimental evidence supports the hypothesis. Au, Chan, Wang, and Vertinsky (2003) manipulated mood while participants performed a financial investment task. They found that those in the negative mood condition made the most accurate decisions and invested conservatively. In comparison, those in the positive mood made bad decisions. Their accuracy was lower, and they lost more because they invested more.

Happiness

Being happy may serve as a reinforcer for adaptive responses and encourage us to engage in actions with survival value, such as feeding and mating. Happiness also broadens our scope of attention and may enhance our physical and creative skills (Fredrickson, 1998). It seems to occur more often during times of perceived security and acceptance. Happiness, in this view, stimulates us to learn new skills, establish relationships, and accrue resources that may be needed in leaner times to come. In addition, happiness seems to foster altruism. Studies show that a mood-enhancing experience such as finding money or recalling a happy event can cause people to engage in helping behavior, such as picking up someone's papers or giving away money (Salovey, 1990). This is known as the **feel-good, do-good phenomenon**.

Most disorders involve negative emotions. However, in **bipolar disorder**, individuals alternate back and forth between depressive and manic symptoms. The manic state is characterized by exuberance, a grandiose sense of self, decreased need for sleep, and excessive talkativeness. These symptoms mirror those found in a normal state of happiness and perhaps reflect some defect in the neural mechanisms underlying it. Bipolar individuals are often well educated and are found in large numbers in creative fields such as writing (Westen, 1996). This supports the notion that happiness causes creativity and the development of new skills.

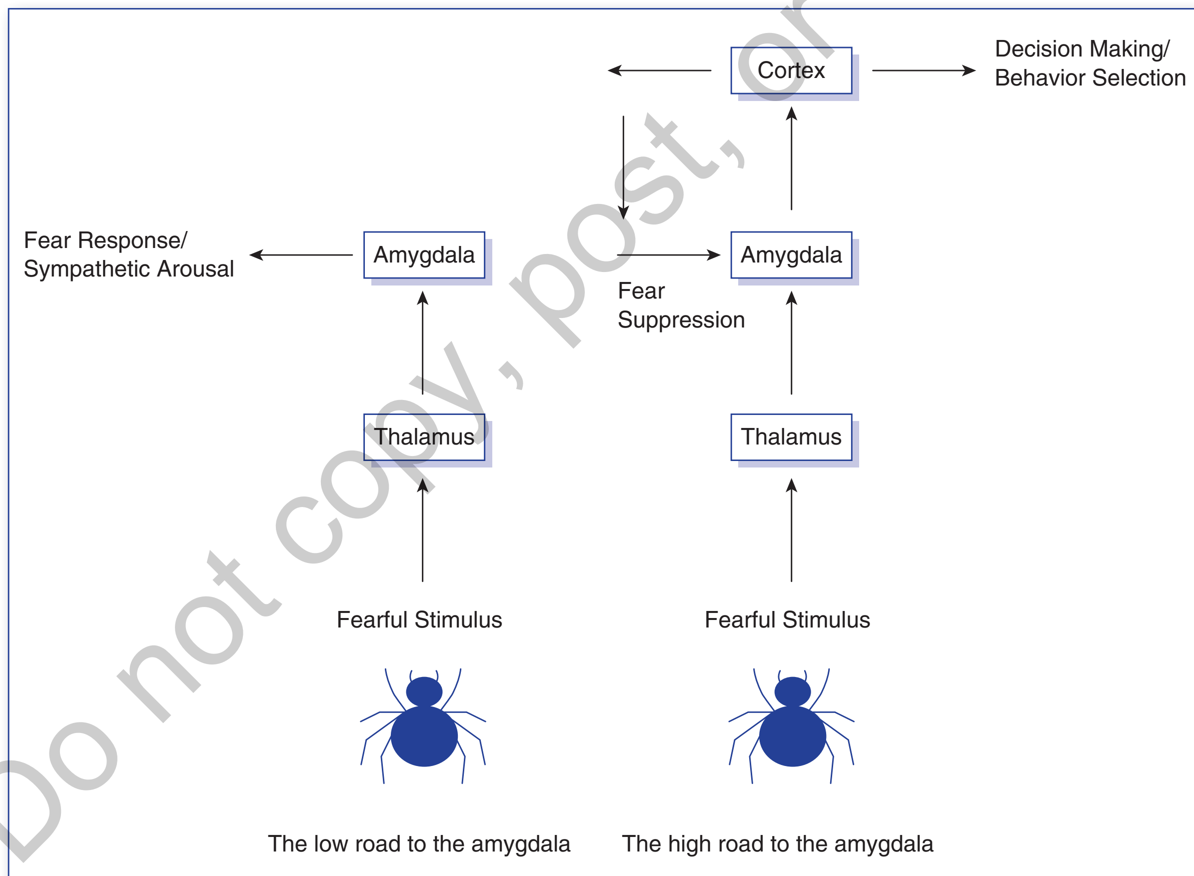
EMOTIONS AND NEUROSCIENCE

Much of the biological research on emotion in humans and animals has centered on the amygdala. This is an almond-shaped structure that belongs to a larger collection of structures called the limbic system, also implicated in emotion. The amygdala has been found to play a key role in learning to associate a particular stimulus with a fear response (Barinaga, 1992). Rabbits can be conditioned to fear an auditory tone by repeated pairing of that tone with an electric shock. This is the classical conditioning paradigm that we presented in the psychology chapter. Animals with lesions to the amygdala cannot be conditioned in this way. They never seem to develop a connection between the shock and the tone.

Brain research has revealed that the amygdala is part of two neural circuits that mediate our fear reactions (LeDoux, 1996). These are shown in Figure 10.2. In the first circuit, a fearful stimulus—such as a spider—is relayed through the thalamus directly to the amygdala. This triggers a fearful emotional response that would include physiological arousal, such as increased heart rate. This has been dubbed the "low road" to the amygdala since it is fast and does not require any thought. It can be thought of as a quick, emergency fear response system that evolved to deal quickly with threatening stimuli. Remember that in the real world, if you stop to think about what to do in a dangerous situation, it may already be too late.

At the same time the thalamus sends this signal to the amygdala, it also sends it to the cortex. Here, the sensory information can be analyzed and evaluated by cognitive

Figure 10.2 The "low" and "high" roads to the amygdala.



Source: Hansen and Hansen (1988).

processes. This is the "high road," since the information is passed upward and takes more time to process. The cortex can now initiate further behaviors if necessary. It could, for instance, get you to brush off the spider or back away from it. The cortex also sends signals back down to the amygdala, further moderating its activity. Fear might be suppressed at this stage if you realized that the spider wasn't poisonous.

The amygdala is also implicated in the perceptual and attentional processing of dangerous stimuli. Several studies show increased activity in the amygdala in response to fearful faces compared with neutral stimuli without any affective content (Morris, Öhman, & Dolan, 1998; Vuilleumier & Schwartz, 2001). Grandjean et al. (2005) found that the sound of an angry voice activated another brain area, the superior temporal sulcus, even when participants weren't attending to it. The results imply that there may be an emotional "early-warning system" that biases perceptual and attentive processes to threatening stimuli. This mechanism appears to be modality independent, since in these studies it was found for both visual and auditory perception.

What about affect and memory? A roundup of the usual suspects reveals that the amygdala again plays a role (McGaugh, 2004). Specifically, it is believed to improve memory for physiologically arousing stimuli. Arousal triggers sympathetic epinephrine and norepinephrine release, which activates the amygdala. It, in turn, sends outputs to the hippocampus. Remember, it is the hippocampus that is responsible for the encoding of new information so that this information gets transferred from short-term storage in working memory to more permanent storage in long-term memory. The hippocampus then ensures that the arousing stimulus is consolidated, making it hard to forget. This mechanism may be responsible for flashbulb memory.

The Chemical and Electrical Basis of Emotional Computation

The neural basis underlying thought is believed to be the electrical communication that occurs among neurons. Action potentials traveling down axons ultimately induce either excitatory or inhibitory postsynaptic potentials that summate in the receiving neuron to determine its firing rate or firing pattern. The result is numerous activation patterns that course through the network. Most researchers believe that cognition is coded for in this activity, in much the same way that electron patterns flowing through silicon chip circuits are the basis for computation in a computer.

What is frequently missing in this "information flow" account of cognition is synaptic action. Between every terminal button and dendrite, there is a synapse. Many different types of neurotransmitters are released at synapses in the human brain. The kind of synaptic action that happens may regulate not only cognition but also emotion. Panksepp (1993) provides a list of neurotransmitters that play important roles in various emotional states. The main excitatory transmitter, glutamate, is linked to anger and fear; gamma-aminobutyric acid, the main inhibitory transmitter, regulates anxiety; norepinephrine is part of sympathetic nervous system arousal, the "fight-or-flight" response; and Serotonin's influence on depression is well documented, as is the influence of dopamine on positive emotional states and also on schizophrenia.

Hormones also underlie much of our emotional responses. The corticotropin-releasing factor is part of the stress reaction and affects our feelings of anxiety and fear; testosterone has been implicated in aggression and social dominance; estrogen in women influences mood and sexual behavior; and oxytocin has been found to promote maternal bonding and affection for offspring, especially during nursing (Nelson & Panksepp, 1998).

One intriguing account of all this is that electrical brain activity in the form of potentials may underlie or contribute more to cognitive processes. Hormonal and synaptic action in the form of neurotransmitter function may then be the basis for or contribute more to emotion. In other words, thought may be *electrical*, while emotion may be *chemical*. If this were the case, then the same pathways that produce thought might also give rise to affect, because axonal and synaptic action are both necessary links in the process of neural information transmission. A particular pattern of neural activity in our brains could then simultaneously convey our experience of thought and affect. This corresponds with the earlier notion that the two are inseparable.

If mental computation—broadly speaking to include both cognition and affect—was expanded to include chemical and electrical activity, then the computing power of the brain may be significantly higher than previously estimated. Rather than 100 billion neurons with 1,000 connections each, we would need to add in a billion or so proteins in each neuron. This would yield a figure of a billion times 100 billion computing units (Thagard, 2008).

HOT AND COLD: EMOTION–COGNITION INTERACTIONS

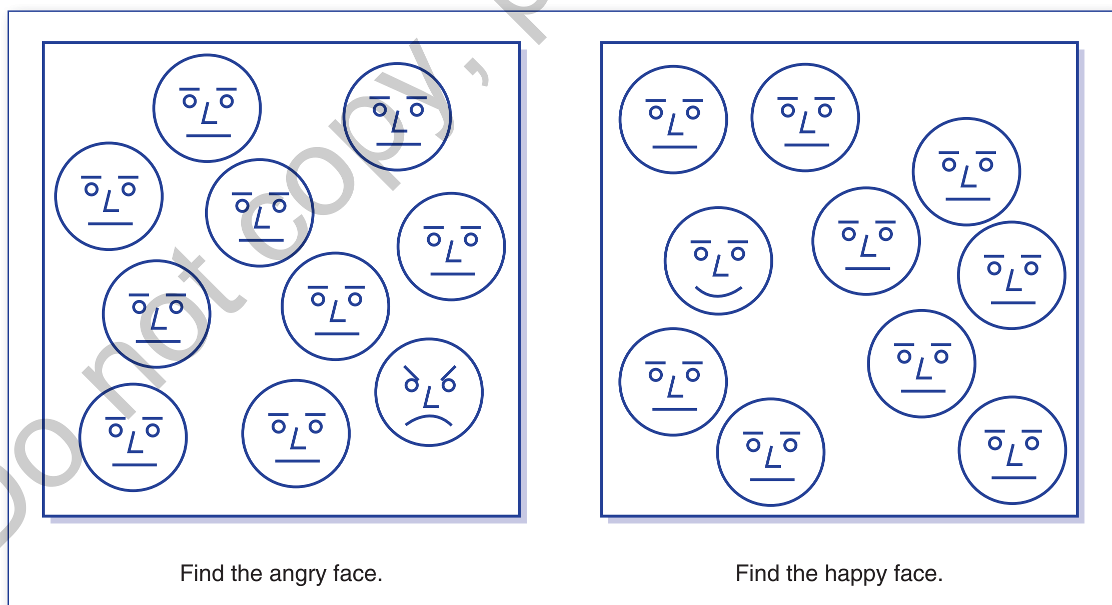
Thoughts and emotions seem different. A thought seems "cool" and is associated with calm, measured deliberation. Emotions, on the other hand, seem "hot." They appear to drive behavior, impelling us to do something right now. However, this distinction may be a false one. A growing body of evidence indicates that emotions are part and parcel of many cognitive processes (Adolphs, Tranel, & Damasio, 1998). It seems that emotion and cognition work together integrally in determining behavior. The neural mechanisms underlying both, for example, are connected at many different levels of organization (Phelps, 2006). In the sections that follow, we wish to show that emotion–cognition interaction is complex. Following Thagard (2008), we reject the classical view that emotions always get in the way of thinking. We also reject the romantic view that emotions are better than reason. Instead, we adopt a critical view that shows how each can facilitate or interfere with the other.

Emotion and Perception/Attention

One of the proper functions of perception is to filter out information that is irrelevant and to focus on what is important. If a tiger is running at you, you certainly don't want to waste time looking at the flowers. Attention serves this function. Items that are allocated attention in the visual field are given priority and get processed more quickly, thereby enabling faster and perhaps lifesaving responses. But how does attention get allocated? There is evidence now to show that emotional processes can help steer attention toward significant stimuli—those that may be crucial for the organism's survival (Vuilleumier, 2005).

Using a visual search paradigm, Hansen and Hansen (1988) found that participants were faster at detecting an angry face hidden among neutral faces than they were at detecting a happy face under the same conditions (see Figure 10.3). These results have since been explained as an example of the **threat-superiority effect**, whereby dangerous items are found to be more perceptually salient. Easier detection of angry faces has since been replicated a number of times (Eastwood, Smilek, & Merikle, 2001; Fox et al., 2000). Notably, easier

Figure 10.3 According to the threat-superiority effect, it is easier to detect an angry face hidden among neutral faces than it is to detect a happy face hidden among neutral faces.



detection is not found for sad faces, indicating that it is the threat value rather than the negative valence that drives the effect (Öhman, Lundqvist, & Esteves, 2001).

Whereas the aforementioned work shows a facilitative effect of emotionally charged stimuli, other work shows that it can interfere as well. Recall the Stroop effect, where it takes longer to name the color of a word spelling out a different color in contrast to that same word printed in the color it spells out. Pratto and John (1991) presented negative and positive adjective words in various colors. Their participants took more time to name the colors in the negative condition compared with the positive condition. In other words, it took more time to respond to a word such as *ugly* than to a word such as *pretty*. The results suggest that our perceptual/attentional systems are oriented toward negative social information.

This slowing down in the Stroop effect implies that we are more sensitive to such information. We, thus, have a harder time ignoring it in the Stroop task. There is additional evidence supporting this notion of increased sensitivity. Phelps, Ling, and Carrasco (2006) presented either fearful or neutral faces and then followed these very quickly with four striped patches. The task was to judge which of the four patches was at a different orientation. Observers were faster at discriminating the orientation following the presentation of the fearful faces in comparison with the neutral ones.

Emotion and Memory

What might be the role of emotion with regard to memory processes? One obvious prediction is that we should remember events surrounding emotional situations better. Since emotional events are important to our survival, it makes sense that our memory systems should be set up this way. Imagine being chased by a tiger. If you climbed up a tree to escape and have a strong recollection of that event, then you would be more likely to employ the same strategy the next time you find yourself in that situation. So there is a clear evolutionary benefit to this type of memory system.

Better recall of personal events during important or emergency situations is known as **flashbulb memory** (Brown & Kulik, 1977). People's recollections of what happened to them during the *Challenger* space shuttle disaster, the O. J. Simpson trial, and the attacks of September 11, 2001, are self-reported as being quite vivid (Reisberg, Heuer, McLean, & O'Shaughnessy, 1988). However, the accuracy of such memories is controversial. People have a high confidence in recalling what happened to them in these situations and report that they were very emotional at the time, but their memories may not actually be any better than during neutral times (Neisser & Harsch, 1992; Talarico & Rubin, 2003).

Flashbulb memories are for what a person was doing at the time of the incident. This includes where they were, whom they were with, and what they did. Such personal recollections are examples of what is called **autobiographical memory**. Whereas semantic memory is for facts, autobiographical memory is for episodes or events. This is, thus, considered a form of an episodic long-term memory, discussed in the chapter on the second cognitive approach.

This means that we can now ask a question: Is memory for the emotional stimuli themselves, rather than the events surrounding them, better? The answer appears to be yes. Ochsner (2000) presented participants with positive, negative, and neutral pictures and words. In a recognition paradigm, they were later asked to judge which of the stimuli they had seen before. If they thought they had seen an item before, they were then asked whether they remembered the context in which it occurred (the "known" condition, more episodic) or simply whether it was familiar (the "remembered condition," more semantic). The negative stimuli were remembered better than the positive or neutral stimuli. The arousing emotional words, positive and negative, were also remembered better than the neutral words. Furthermore, "remember" judgments were made more to negative stimuli.

There are several reasons why emotional items might be better remembered (Fox, 2008). First, it could be that we allocate more attention to such items. Things we pay more attention to are remembered better. Second, it could be because emotional things are more distinctive and unusual. In other words, they stand out more because they are rare and strange. A third alternate account is that we might think about them more often, and thus, rehearse them more. It may be that all three of these contribute to varying degrees, although at least one study has found better recall for negative affect items that cannot be entirely due to distinctiveness (Christianson & Loftus, 1991).

Emotion, Mood, and Memory

In the introduction, we distinguished between emotion and mood, stating that mood was less intense but longer lasting than emotion. A number of studies have examined the influence that mood has on memory (Levine & Pizarro, 2004). The research on this topic has focused on two effects: (1) mood-congruent memory and (2) mood-dependent memory. We will examine each of these next.

Mood-congruent memory is when we remember more stimuli if those stimuli match a mood we were in while learning those stimuli. Studies investigating this induce a particular mood at encoding while a participant is studying items, and then later, at recall, we see if the performance is better for matching items. The results support a mood-congruency effect. People are generally better at recalling negative words such as *death* if they learned them in a negative mood and words such as *flower* if induced into a positive mood at encoding (Rinck, Glowalia, & Schneider, 1992). One explanation for this is that we think more deeply and make more associations to mood-congruent material (Bower, 1981).

In **mood-dependent memory**, recall is better when the mood at recall matches that during learning. Here, the same mood must be present at both occasions for there to be an effect. Note the difference here. In mood congruency, the stimuli match the mood at encoding. In mood dependency, the moods match. Bower, Monteiro, and Gilligan (1978) found that neutral words were better remembered when the mood at encoding matched the mood at recall. The two induced states were happy and sad. In these cases, it may be that mood is acting as a retrieval cue; the learned items became associated with the mood at encoding and reactivated this association at retrieval.

Fiedler (2001) argues that we engage in different information-processing strategies while in different moods. When we are in a good mood, we are more likely to assimilate. In **assimilation**, we take information and interpret it in terms of what we already know. This is a less critical strategy and stands the chance of being wrong. For example, we may incorrectly categorize a scooter as a motorcycle, failing to note the differences between them. On the other hand, when we **accommodate**, we change our internal concepts or schemas to take new information into account. In this example, we would form a new category for "scooter," differentiating it from "motorcycle."

According to Levine and Pizarro (2004), a positive mood corresponds to a motivational state where we have attained a goal and there is no immediate problem to be solved. Under such conditions, our cognitive processing is a bit "looser" and accuracy is not as important. A negative mood, in contrast, corresponds to a situation where we encounter a problem and a goal is threatened. Here, we need to "tighten up" our processing, becoming more analytic and detail oriented.

Emotion and Decision Making

Thagard (2008) outlines some of the differences between emotional (intuitive) and rational (calculated) decision making. Intuitive decisions are fast; they can be made immediately and lead directly to a decision. This is preferable when making less important judgments, such as whether you should order out for pizza or Chinese food. However, they are prone to error because they may be based on inaccurate or irrelevant information. When making calculated decisions, we usually consider more alternatives and goals, understand the pros and cons of each, and make the entire process explicit so that we can go back and rethink it or get somebody else to help. This process is slower but is the way we would want to approach important problems in our lives, such as whether or not we should marry someone or accept a job offer.

Damasio (1999) argues that there are situations where emotion facilitates decision making. Several of his patients suffered damage to the ventral and medial portions of the prefrontal cortex (vmPFC). Following this, they lost the ability to apply rationality to personal and social situations. He believes that the damage prevented them from making emotional evaluations that involve somatic markers. These are bodily states that indicate whether a particular outcome will be good or bad. It is important to note that these patients could still reason well in other contexts and in some cases scored well on cognitive tests.

Bechara, Damasio, Tranel, and Damasio (1997) introduced a clever way to measure the role of emotions in decision making. In the Iowa Gambling Task, players received $2,000 in fake money to spend. They were presented with four decks of cards. In the first two decks, turning over a card resulted in a $100 win. However, these decks also produced large losses. In another two decks, the wins were smaller. Turning over a card in those decks resulted in only a $50 gain, but there were no associated losses. The best way to win and maximize earnings was to pick only from the latter two decks without associated losses.

Normal participants who played this game eventually realized (consciously or subconsciously) that the first two decks were risky, and they eventually stopped picking from them. In comparison, patients with bilateral damage to the vmPFC never stopped drawing from those decks, even when they were aware that they were risky options. This demonstrates that the vmPFC helps us determine whether a particular course of action is worth pursuing based on our past experiences. Normally, if we've done something and it resulted in a positive outcome, we will continue to do it. If another action has negative consequences, we will stop doing it. The emotional processing that enables us to do this is apparently missing in these patients, even if they were consciously aware of the risk.

Other research supports the notion that emotions are part of our normal decision-making process. Rather than believe that emotions are separate from cognition, it is more realistic to say that emotions are an integral part of them and help us choose from among alternatives (Loewenstein, Weber, Hsee, & Welch, 2001). Fazio (2001) reviews literature showing that most concepts have attached emotional attitudes. This certainly seems to be the case. It would be hard to imagine thinking about topics such as sex, politics, religion, and our friends and family without some sort of emotional bias. As we indicate in greater detail in the neuroscience section, the brain's emotional and cognitive centers work together during decision making (Rolls, 1999).

Clore, Gasper, and Garvin (2001) additionally advocate that feelings as well as information are used in decision making. For instance, if you find yourself in a good mood when in the presence of a certain someone, you may take that as evidence that you like him or her and decide to ask him or her out on a date. This suggests a whole new class of process models, ones where feelings are combined with thoughts to determine our decisions and behavior (Fox, 2008).

Emotions and Reasoning by Analogy

Recall from the introductory chapter that analogies can be considered as a type of mental representation. They can be used in problem solving and decision making by applying what we know in one situation to another similar to it. Thagard (2008) lists three types of analogies defined by their relation to emotion. First, there are analogies that are about emotions. Second, there are analogies that involve the transfer of emotion between situations. Third, there are analogies that generate new emotions. We detail each of these types below.

We often use analogies to describe our mental states. Examples include being "as brave as a lion" or "sneakier than a rat." Perhaps this is because it is difficult to describe what a thought or feeling is like in literal terms. Analogies of the second type that are used to transfer emotions are found in persuasion, empathy, and reverse empathy (Thagard, 2008). We often use analogies when we are trying to persuade somebody. These sorts of analogies are quite prevalent in the news media (Blanchette & Dunbar, 2001). Examples include "living on easy street," rumors spreading "like wildfire," and being led "like pigs to a slaughter."

In empathetic analogies, we express our ability to appreciate somebody else's situation by comparing it with another similar situation. For example, we might say, "The Korean war was awful. The war in Vietnam was like it in several ways. So the Vietnam war must have been awful, too." In reverse empathy, we make this relation personal: "I was a victim of the New York City attack. When you were a victim of the Washington, D.C., attack, you felt terrified. So I am feeling terrified as well."

In the third case, analogies are used to generate new emotional states. According to Thagard (2008), these involve humor, irony, and motivation, to name just a few. Here is an example he gives to illustrate humor: "How can a single woman get a cockroach out of her kitchen? Ask him for a commitment." As a joke, this ought to generate feelings of surprise and amusement in the listener. Ironic analogies can be used to evoke negative emotions as well, as when we say that a failing bank's efforts are like "rearranging the deck chairs on the Titanic." We can also use analogies to motivate, as when a father compares his son with Albert Einstein or Mozart.

EMOTIONS AND ARTIFICIAL INTELLIGENCE: AFFECTIVE COMPUTING

Affective computing is computing that relates to, arises from, or deliberately influences emotions and other affective phenomena (Picard, 1997). The goal of such projects is to enable computers and robots with the ability to recognize emotions in people. This capability would facilitate human–machine interactions. For example, your computer could tell when you are tired or frustrated based on your facial expression. It might then recommend that you take a rest break. Secondary, but also interesting, is imbuing machines with the ability to express emotions. Emotionally expressive machines are more satisfying to interact with. The Kismet project is a first step in this direction (Breazeal, 2002). Kismet is capable of expressing a wide variety of facial expressions and can carry out extended, lifelike social interactions. See the "Interdisciplinary Crossroads" section for a detailed description of this project.

A number of computer programs already exist that are capable of recognizing human emotion from spoken auditory information. Petrushin (2000) describes the emotion recognition project that utilizes an artificial neural network program to process features present in the speech stream. Examples of these features are energy, speaking rate, and the fundamental frequency. This program can recognize five emotions—(1) anger, (2) fear, (3) happiness, (4) sadness, and (5) a neutral, emotionless state—with about 70% accuracy. This is equivalent to human-level performance. There are plans to implement this system in automated telephone reservations systems such as those used by airlines to book flights.

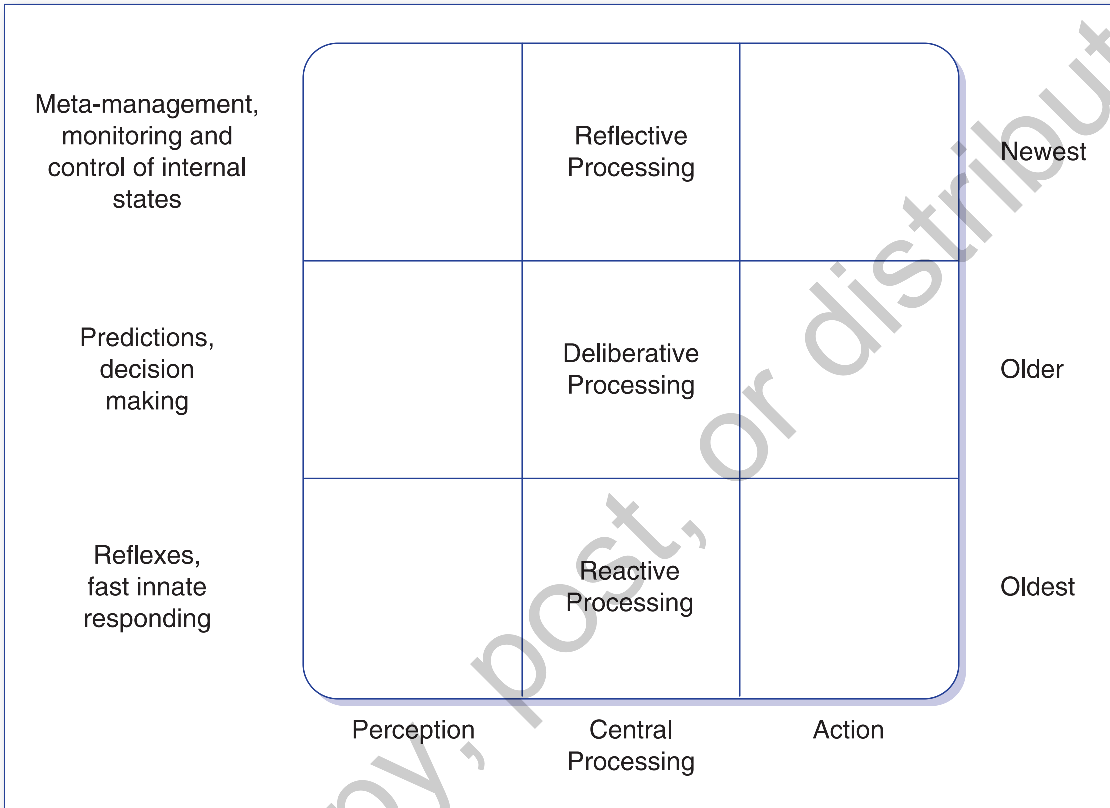
Researchers in the affective computing group at the Massachusetts Institute of Technology are developing a wide variety of affective systems. Their FaceSense program can tag facial expressions, head gestures, and affective–cognitive states from real-time videos for use in human–machine and human–human interactions. The system utilizes a combination of bottom-up visual cues, such as frowns, and top-down predictions of what expected affect should be like given the situation and context. It can be used to evaluate customer satisfaction and as a training tool for autism disorders. Another model this group is developing is called SmileSeeker. It also captures facial cues to help interpret social interactions. The current version specifically looks for smiles in face image data. This program could be implemented for use in bank teller training.

Recognizing and producing emotions is just one facet of affective processing. Other investigators are focusing on what the internal design of an emotional being is like. The **CogAff architecture** is a generic scheme for how cognitive–emotional processing may take place in either a person or a machine (Sloman, Chrisley, & Scheutz, 2005). In this model, there are three distinct levels of processing (shown in Figure 10.4). The first and the lowest level is **reactive**. These are reflex-like responses in which a stimulus automatically triggers a reaction—for example, the fear experienced after bumping into something in the dark.

The second stage involves **deliberative** processes. These involve representations of alternate plans of action. Here, different courses of behavior are generated given the circumstances, and the best one is selected. For instance, one could determine whether or not he or she wants to go on a roller coaster ride at an amusement park. Emotional states such as fear and cognitive factors such as one's medical condition are both taken into consideration.

In the third, **reflective** stage, we see metacognition come into play. Recall that metacognition is the ability to think about and control other mental states. At this level, one is aware of experiencing an emotion but can choose to act on it or not depending on the circumstances and the use of deliberative processes. An illustration of this would be deciding whether or not to speak at a conference. One could be afraid of doing so based on the possibility of being critiqued or evaluated. After reflecting on this fear, though, one might decide to go ahead and do it anyway because it would further his or her career. Alternate options, such as writing a paper, would be considered along with their associated emotions before a decision is reached. When giving the talk, one would then suppress fear but know why he or she is doing it.

Figure 10.4 The CogAff architecture specifies how a machine may exhibit emotional behavior.



Source: Sloman et al. (2005).

Minsky (2006) expands on this type of architecture by inserting a few more levels. Between reactive (what he calls instinctive reactions) and deliberative processes, he places learned reactions—the difference being that the lowest level reactions are genetically hard-wired, while learned reactions are acquired through experience. He then adds two more levels on top of reflective thinking that involve self-reflection. At the self-reflective thinking stage, one can think back to a decision and determine whether it corresponded to one's ethics and values. For example, one value a person might have is to help others. If we made a decision to do volunteer work in the past and it satisfied this value, we would decide to do it again now, even if we have lots of other work to do. Self-conscious emotions could involve those feelings we have from satisfying our values and can serve to motivate self-reflective thinking.

Interdisciplinary Crossroads: Emotion, Robotics, and the Kismet Project

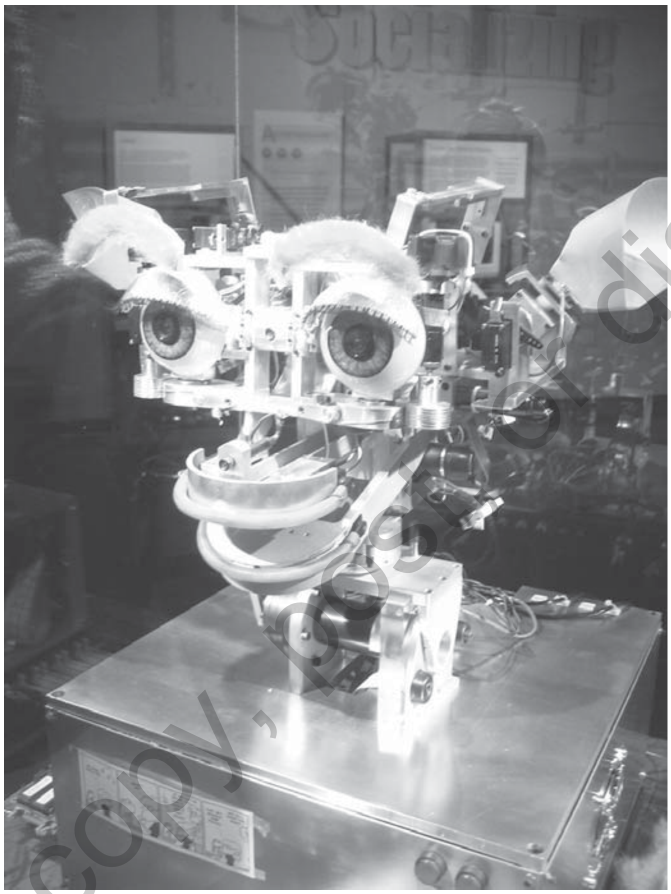
Researchers in robotics are beginning to realize the importance of emotion (Breazeal, 2002). The goal of this new area in robotics is to design robots that both recognize and express emotions in much the same way that humans do. Robots with these capacities will make it easier for us to interact with them. The ***Kismet*** project is the first major step in this direction. It is designed to model the interaction between an infant and its caregiver. Kismet is a cute robotic head capable of sensing others and of expressing a wide range of facial expressions. It is driven by a cognitive and emotional system that work together to govern its interactions with people (Breazeal & Brooks, 2005).

Kismet can "see" using a set of color cameras. It can move its head and eyes to control where it looks and what it pays attention to. Kismet's auditory system is a microphone that can process and recognize certain aspects of human speech. The auditory system allows it to detect basic pitch contours that signal approval, prohibition, attention, and comfort (Fernald, 1989). The detection of this affective information then guides its own emotional state. Kismet can fold back its ears to signal anger or raise them to display a state of interestedness. It can also move its eyebrows up and down or furrow them to communicate surprise, frustration, or sadness. In addition, Kismet is equipped with a vocalization system, allowing it to generate synthesized sounds reminiscent of a young child.

The Kismet robot conveys emotions mostly through its face (see Figure 10.5). The emotions it displays have been formulated to fit within a three-dimensional affect space of valence (good or bad), arousal (high or low), and stance (advance or withdraw). A soothed expression corresponds to high positive valence and low arousal (i.e., a state of being happy but underaroused). A joyous expression instead corresponds to a state of positive valence and moderate arousal. Some of the other expressions Kismet is capable of include anger, disgust, sorrow, surprise, and fear.

Kismet's cognitive system consists of perception, attention, drive, and behavior subsystems. It is motivated by basic drives just as a real biological child would be. These drives are thirst, hunger, and fatigue. A social drive gives it a "need" to interact with people, a stimulation drive provides an impetus to play with toys, and a fatigue drive causes it to rest when it is overstimulated. When these "needs" are met, the drives are in a homeostatic regime and Kismet acts as though it is satisfied. But if the intensity level of a drive deviates from this state of balance, the robot is motivated to engage in behaviors that restore the drive to equilibrium. Kismet's drives don't directly produce an emotional response, but they do, however, bias its overall emotional state or mood.

Figure 10.5 Kismet the robot is designed to interact with people in humanlike ways.



Source: Jared C. Benedict, CC-BY-SA.

If Kismet does not receive enough stimulation and its social drive state is high, it puts on a sorrowful expression. Under typical circumstances, this will elicit increased interaction by a human playmate. For example, a person might try to engage Kismet by waving a toy in front of its face. If the robot is getting too much stimulation, its drive state is lowered, causing it to make a fearful face. In this case, a normal human would back off to reduce the amount of stimulation. If Kismet is receiving a moderate amount of stimulation, it expresses joy to encourage sustained human interaction.

Kismet can use its eyes and vocalize to communicate as well. If it is presented with an undesired stimulus, a disgust response will reorient its gaze to an alternate area in the visual field, where it might locate a more desirable object. This would again serve as a cue to a person to change his or her behavior, perhaps by switching to a different toy. If a person is ignoring Kismet, it can attract the person by first vocalizing. If that doesn't work, it might lean forward and wiggle its ears to attract attention. So, just like a real child, Kismet can utilize a variety of behaviors to get what it "wants."

Kismet's creators programmed it with several basic-level emotional states, including interest, surprise, sorrow, joy, calm, fear, disgust, and anger. The trigger state for one of these particular emotions corresponds to the values of the different motivational drives. The activation of the emotion would then, in turn, trigger the facial expression that goes along with it. A human observer, seeing this display, would then modify his or her actions toward it. People enjoy playing with Kismet and very easily attribute humanlike qualities to it. Future robots with emotionally perceptive and expressive abilities like Kismet will undoubtedly make it easier for us to accept and work with them.

OVERALL EVALUATION OF THE EMOTIONAL APPROACH

The emotional approach is a recent but welcome addition to cognitive science. For too long, researchers have swept emotions "under the rug" and focused exclusively on cognitive factors. It is now generally accepted, though, that most cognitive processes work in concert with affective ones. The research we have reported here is a good start. We are just beginning to understand how emotions affect perception, attention, memory, language, and problem solving. Many questions remain, however. We need a more detailed description of the physiology and information flow that underlies each of the emotions and moods.

Most of the research reported here looks at the influence of emotion on cognition, presumably because these cognitive processes have been studied for some time and are better understood. But the reverse situation, the influence of cognition on emotion, deserves research attention as well. For instance, how do we suppress emotions, and under what conditions is this easier or more difficult? There seem to be large individual differences in this ability, with some people predisposed to be more emotional and others more rational. If we understood the neural mechanisms underlying aggressive behavior, we might be able to reduce theft, murder, spousal abuse, and other crimes.

Understanding the basic emotions is just the tip of the iceberg. There are many other more subtle and complex emotions that remain. If these are created by a combination of the basics, then are there lawful rules governing this process? Perhaps anger and admiration mix to produce envy in much the same way that blue and yellow combine to make green. These "secondary" emotions play a powerful role in our thinking and behavior, but they have yet to be well classified or explained. There may even be "tertiary" emotions that are combinations of affect and cognition. Arrogance and self-esteem seem to fall into this category.

Summing Up: A Review of Chapter 10

1. An emotion is a relatively brief brain and body episode that facilitates a response to a significant event. Feelings correspond to the subjective experience of an emotion. Moods are less intense but longer lasting types of affective states.
2. Theories of emotion all posit a stimulus that triggers physiological changes and some sort of appraisal. However, these theories disagree on the temporal ordering of these events and the exact role that the cognitive appraisal process takes.
3. Some of the basic emotions that may be universal across cultures are happiness, sadness, fear, anger, surprise, and disgust.
4. Each of the major emotions may have played an adaptive role in promoting our survival during the conditions of our ancestral past. However, problems with these emotions can also be linked to psychological disorders.
5. The amygdala is a brain structure that mediates our fear response. It also plays a role in improving our memory for arousing stimuli.
6. More contemporary work in affective science has investigated the role that emotions play in perception, attention, memory, and decision making.
7. Emotions focus our attention on dangerous events. This is known as the threat-superiority effect. They also bias us to remember events of emotional significance. Under certain conditions, emotions can even facilitate decision making.
8. A number of computer models already exist that are capable of recognizing emotions based on cues in speech or facial images.
9. The CogAff architecture is an example of how an organism or machine may integrate emotions into decision making. It utilizes reactive, deliberative, and reflective stages.

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Suggested Readings

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