PART I

A biosocial view of emotion

CHAPTER 1

A developmental-interactionist theory of emotion

As you read the words on these pages, information pours into your brain. You can experience the feel of the constant tug of gravity pulling you into your chair, the pages in your hand, and the clothes and shoes on your body. You can be aware of the lights and noises in your surroundings. Your sensory receptors constantly pick up information physically present in the light, air, and surfaces of the terrestrial environment, and this is automatically correlated with proprioceptive cues about the position of your eyes, ears, and parts of the body. Together, this amalgam of information tells you where you are located relative to your surroundings. However, as you try to concentrate on reading, you do not typically pay attention to these things. If your surroundings are comfortable, it is relatively easy to concentrate. But, if your chair is too hard, or your shoes are too tight, or if it is too dark or noisy in the room, it is difficult to shut this annoying information out. You experience the offending stimulation with a sense of frustration, and are distracted from your task.

Not all of the potentially distracting stimulation comes from your external surroundings. You may be hungry, or thirsty, or too warm or cold, or you may experience sexual urges, or a headache. Also, you may be in a bad mood, or you may feel slightly euphoric and just not "feel like reading." Any of these may interfere with your task, but the source of the distraction is not in the external surroundings, but rather is within your body. Information associated with these feelings and desires is always with you, pouring into your brain just like the information from the external surroundings. Interoceptors monitoring the nutrients, fluids, and tissues of the body inform us of bodily needs; generating a cocktail of *desires*. Also, interoceptive systems generate a cocktail of specific *feelings*: the subjective aspects of emotion. You can always "call up" the experience of these feelings and desires. You can call up the experience of how hungry, or thirsty, or warm/cold, or sexy you feel at the moment; and also how happy, sad, afraid, angry, and disgusted you are; just as you can call up the experience of the feel of your shoes on your feet. You can also call up feelings such as

love or hate, but only if you think of a particular individual with whom you have a personal relationship. Normally, all these feelings are at low levels, whispering, but like the feel of your shoes on your feet *they are always "there."*

You may experience other feelings that do not distract from your reading, but actually nourish and sustain your attention. You may experience excitement in discovery, in seeing the world from another viewpoint, in understanding something about yourself and your relationships with others. Curiosity is one of the fundamental emotions underlying the development and maintenance of the cognitive system: as Albert Einstein put it, "our longing for understanding is eternal."

The essences of emotion

Can we approach these subjective feelings and desires, simultaneously distinct and ineffable as they are, from the viewpoint of objective science? Emotion is at the same time compelling and intimate, and mysterious and enigmatic. Virtually everyone will agree on the direct phenomenal reality of emotion: the subjective reality of our feelings and desires seems self-evident. However, when pressed it becomes difficult to define exactly what emotion is, how we distinguish one emotion from another, or how we even know that an emotion is occurring. For scientists, this difficulty of definition and measurement constitutes a significant challenge. Can one define and measure emotional phenomena in an objective way that is open to public verification, the hallmark of science?

For most of the twentieth century, the answer to this question on the part of most social and behavioral scientists, and many philosophers, was an unequivocal "no!" Emotions have been seen to be ineffable and unobservable, because subjective experience – considered by most to be an essential aspect of emotion – cannot be objectively observed. The originator of behaviorism, J. B. Watson, argued that science must confine its attention to publicly observable events, such as objective stimuli and responses, and that emotions simply do not qualify (1919). Many behaviorists acknowledged that subjectively experienced "private events" may exist, but argued that they cannot be studied by objective scientific methods and are therefore beyond the reach and ken of science; although B. F. Skinner in his 1953 book *Science and Human Behavior* presciently acknowledged that future technology might make private events objectively observable.

Others have gone farther, questioning the very existence of emotion. To the language philosopher Gilbert Ryle (1949), emotion is a "ghost in a machine": a category mistake involving a misuse of language.

The philosopher Ludwig Wittgenstein (1965) noted that often different things named by the same term are often truly different one from the other, and related only by what he termed "family resemblances." Tracing the history of the word "emotion," Dixon (2012) concluded that the word does not name "either a natural kind or any kind of innate or 'folk' psychological concept" (p. 343). An *Annual Review of Psychology* summary of the emotion field current at this writing began by questioning whether scientists can or should study emotion, and concluded that an integrative theory of emotion is impossible because the very definition of the term "emotion" is useful only in the context of a given research program (Niedenthal and Brauer, 2012). So, are different sorts of phenomena named "emotion" actually distinct and only related indirectly, with no fundamental essence?

I suggest that all of the words that refer to feelings and desires can be understood in terms of two related and complementary but distinct "essences" of emotion: at one level of analysis there are neurochemical systems and at another level, ecological demands and functions (Buck, 2010a). At the biological level, neurochemical systems contribute to subjective emotional experiences much like the ingredients to a cocktail or musical instruments to a symphony. At the ecological level, emotions are identified with displays, including facial expressions, body postures, spatiotemporal cues, touches, and pheromone releases. In addition, there are interrelated systems of higher-level social, cognitive, and moral emotions reflecting interactions between biological potential and universal ecological contingencies. Importantly, all of these emotions have publicly observable aspects that can be scientifically investigated – operationalized and objectively measured – including aspects that have heretofore been unobservable.

The biological essence: neurochemical systems

Primes. The subjective aspects of biological emotions – feelings and desires – are associated with specific neurochemical systems. As is described in detail in Chapter 2, neurochemical systems are defined by neurotransmitters and agonists or antagonists that respectively facilitate or impede such transmission. These systems constitute *primary motivational/emotional systems* or *primes* (Buck, 1985): distinct and dissociable but interrelated *modules* that are analogous to ingredients making up the subjectively experienced affective cocktail; or individual instruments contributing to the symphony of feeling.

Specific primes can be identified with specific neurochemical systems that can be located within the brain. They include systems in the brainstem involving arousal and behavioral activation/inhibition;

systems in the hypothalamus involving biological drives such as hunger and thirst; systems in subcortical brain structures involving raw sex and aggression; and systems in paleocortical brain structures involving a variety of individualist and prosocial emotions. The functioning of the primes is increasingly open to observation by advanced biological and physiological techniques, from the investigation of the functioning of specific genetic systems to double-blind studies of the behavioral effects of important neurochemicals to the online functioning of brain systems by advanced electrophysiological and scanning technology.

Voices of the genes. The molecules underlying the primes can be directly linked with specific genetic systems. Peptide neurotransmitters are direct genetic products constructed by DNA in the nuclei of their parent neurons. They are physically transported down the axon of the cell to the synapse, where they are released to carry on the message of the genes. On one hand, these peptide molecules are among the most ancient components of living systems, appearing in virtually unmodified form in microbes (bacteria, slime molds, yeast) and highly developed animals including human beings. On the other hand these molecules are closely related to the subjective experience of emotion, or affect, in human beings, interacting and participating in a cocktail or symphony of feelings whose precise recipe or score is discoverable, and affective neuroscience is hot on the trail to discover recipes for these cocktails or the scores for these symphonies. The feelings and desires so engendered carry the influence of the genes to the behaving organism. Usually whispering and murmuring in pianissimo, sometimes speaking out forcefully, and occasionally screaming and shouting in crescendo, affects function as *voices of the genes* that, acting together, can produce the equivalent to a *symphony of the genes* (Buck and Ginsburg, 1997a).

The ecological essence: display, behavior, and communication

Neurochemical systems evolved in the context of ecological requirements: that is, necessities born from functioning in the terrestrial environment of objects and events, and the social environment of other organisms. This terrestrial/social ecology can require, for example, approach, avoidance, escape, aggregation, separation, exploration, investigation, competition, cooperation, sex, play, and nurturance. These functional requirements took the phenomenon of emotion outside the organism and brain into the communicative social environment. Emotions are displayed as well as felt, and these displays are "picked up" by partners in communicative exchanges that may involve a number of specific primes.

The primes as individual modules are gathered together into "packages" due to their similar ecological implications regarding display, behavior, and communication. For example, the following feeling states can be considered to reflect modular primes based upon specific neurochemical systems: *stress* associated with corticotropin releasing hormone (CRH); *panic* with cholecystokinin (CCK); and *anxiety* with diazepam binding inhibitor (DBI). These are ecologically "packaged together" in that they all relate to similar escape/avoidance behavior patterns and specific displays (e.g. well-described facial expressions, gestures, postures, vocalizations) associated with the emotion that we term *fear*. In this view, fear per se is not associated with any single brain system: rather the feeling of fear represents a cocktail or symphony of neurochemicals whose precise recipe is variable, and, in principle, measurable; and fearful displays and behaviors can reflect any of a number of interacting primes (Buck, 2010a).

An example of a variety of primes underlying a complex emotional state was presented in the February 2011 "Valentine's Day" issue of *Scientific American* summarizing studies of brain systems underlying love (Fischetti, 2011). Neurochemicals at high levels included dopamine (DA) reflecting feelings of pleasure and activation; oxytocin (OXY) reflecting attachment and trust; vasopressin (AVP) reflecting attraction and sexual arousal;, and cortisol (CORT) reflecting stress and alertness. Sadness, fear, anxiety, and pain sensitivity were all low. Interestingly, serotonin (5-HT) was at a low level, reflecting tendencies toward insecurity, jealousy, aggression, and obsessive thinking associated with love. One can imagine how different specific examples of love may be reflected in different levels of these constituent neurochemicals interacting to yield a variable symphony of feelings and desires that nevertheless are all associated with "love" at the ecological level. At the ecological level, love is celebrated in story and song, particularly in "silly love songs" which, despite their ubiquity, are typically overlooked and ignored as inconsequential (Buck, 2010b). As we shall see in Chapter 5, such songs are extraordinarily diverse, ranging from "Some Enchanted Evening"[1] to "If you Want to Keep your Beer Ice Cold (Set it Next to my Ex-Wife's Heart)"[2]: thus the metaphorical symphony of felt love is embodied, as it were, in a plethora of actual songs. These reflect the wide variety of feelings and desires that can be associated with love; and our fascination with these songs reflects our fascination with these feelings and desires.

[1] From the 1949 Rodgers and Hammerstein musical *South Pacific*.
[2] © 1989 by Doug Vaughn and Pete Samson.

The ecological reality of emotion with respect to display, behavior, and communication is just as "real" as are biological neurochemical systems, and just as open to objective observation and investigation. As there has been a revolution in our ability to record, examine, manipulate, and image phenomena at the biological level, there has been a simultaneous and complementary revolution in our ability to image, measure, and time the fleeting nuance of display and expression occurring during social interaction. This involves, for example, using inexpensive low-light video technology and high-speed computer analysis. This revolution in observation has rendered the ephemeral permanent, allowing us objectively to record and examine the "body language" of nonverbal communication in human beings and other animals as never before.

Developmental-interactionist theory

Emotion, then, is based in biological potential inherent in the primes. However, this potential must be realized and actualized in social communication and interaction over the course of development. This interaction between biological potential and social experience is at the heart of the biosocial synthesis and is described by *developmental-interactionist theory*.

Defining motivation and emotion

Motivation and emotion. I begin by defining the fundamental terms, motivation and emotion. Kleinginna and Kleinginna (1981a; 1981b) surveyed definitions of motivation and emotion in the scientific literature, and suggested consensual definitions for each. *Motivation* has been traditionally defined in terms of the control of behavior: that is, the *activation and direction of behavior toward a goal* (Young, 1961). Such control may be manifested at many levels, from simple reflexes such as the knee-jerk reaction, to "instincts" or fixed action patterns including migratory behavior patterns, to drives such as hunger, thirst, and sex, to complex higher-level motives involving power, attachment, exploration, and achievement. *Emotion* has also traditionally been associated with goal-directed behavior, but in contrast with motivation, emotion typically involves *affects*: subjectively experienced feelings and desires. These may involve dimensions of quiescence-arousal and reward-punishment; the specific primary affects such as happiness, sadness, fear, and anger; and also higher-level affects such as pride, guilt, jealousy, trust, and resentment. Kleinginna and Kleinginna noted that emotion is also typically associated with *expressive behaviors*, including

facial expressions, postures, patterns of spacing and eye contact, etc., and *peripheral physiological responses*, including changes in heart rate, sweating, blood pressure, and muscle tension.

Developmental-interactionist theory is consistent with these traditional definitions, but goes beyond them in suggesting that motivation and emotion are functionally linked. Motivation is defined as *potential for the activation and direction of behavior that is inherent in a system of behavior control*; while emotion is defined as the *realization or "readout" of motivational potential when activated by challenging stimuli*. So, motivation is the potential for behavior, and emotion is the readout of motivational potential. In this view, motivation and emotion are seen as two sides of the same coin: aspects of a *motivational-emotional system* (see Buck 1985, p. 9, 1988a, p. 5).

The relationship of emotion and motivation is analogous to that of matter and energy in physics. Energy is a potential that is not seen in itself, but rather is manifested in matter: in heat, light, and force. The potential energy in an explosive is manifested in heat, light, and force when it explodes, and the potential energy in a coiled spring is manifested in force when the spring is released. The energy per se is never seen. Similarly, motivation is conceptualized as potential that is not shown in itself, but rather is manifested in emotion: in physiological arousal, expressive displays, and affective experience.

Levels of motivational-emotional systems. Like motivation, motivational-emotional systems are manifest at many levels. For example, in a simple *spinal reflex* like the knee-jerk reaction, the motivational potential exists in the arrangement of sensory and motor neurons between the knee and spinal cord. The motivational potential is released with the stimulus: the neurologist's tap on the knee. In *fixed action patterns* such as those underlying migratory behavior, the potential exists in a system that activates complex sequences of behavior in response to a specific challenging stimulus (*releaser*) that may involve the day/night cycle, the magnetic fields of the Earth, and other environmental changes. In eating behavior, the motivational potential (the "hunger drive") exists in a complex system of energy regulation and metabolism that is functioning constantly – we always have specific needs for food that vary – and that can respond to environmental stimuli including the presence, sight, and smell of attractive food. Thus, motivational potential is activated by challenging stimuli – a tap on the knee, the day/night cycle, attractive food – in appropriate circumstances. This view of motivation in itself is not extraordinary: what is different is linking the activation of motivational potential with emotion. Reflexes, fixed action patterns, and drives are not traditionally associated with "emotion," but this linkage is an important aspect of developmental interactionist theory.

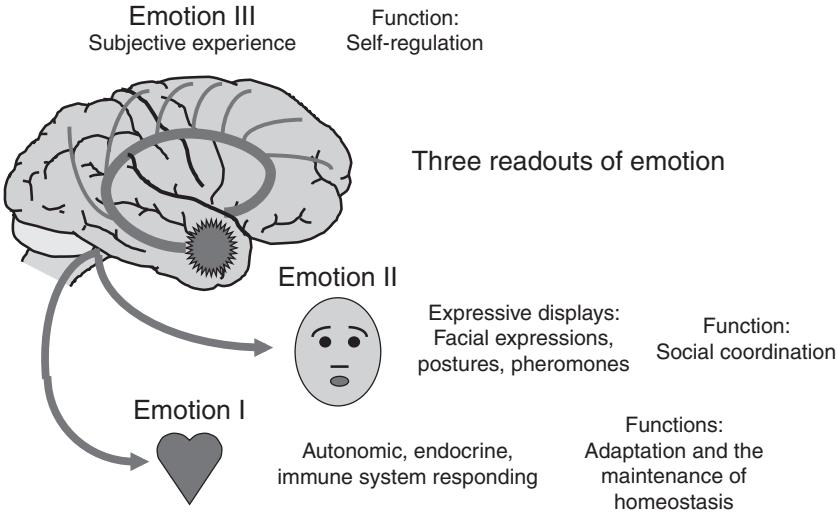

Figure 1.1 Three readouts of emotion. See text for details.

Three readouts of emotion

Emotion includes three aspects identified by Kleinginna and Kleinginna (1981a, 1981b): subjective experience, expressive displays, and physiological arousal. I characterize these three aspects of emotional responding as *readouts* (Buck, 1985, 1994a), and they are illustrated in Figure 1.1. There are ways to measure objectively and directly both physiological arousal and expressive behavior, but the aspect of emotion that in many ways seems most essential – the subjective experience of feelings and desires, or affects – has long seemed impossible to measure directly.

Affect: the subjective readout. In recent years, there has been a revolution in the ability to observe biological processes closely associated with feelings and desires, leading to the potential for what Jaak Panksepp termed an *affective neuroscience* that relates subjectively experienced feelings and desires directly to the activities of specific neurochemical systems (Panksepp, 1991, 1998). Brain scanning and electrophysiological techniques give access to events occurring within the functioning brain. Not only human beings, but also other mammals show evidence of the subjective experience of affects, in that they can demonstrate in their behavior that they have awareness of the states of neurochemical systems that are associated with affects. Moreover, viewing emotional displays of other persons can activate the areas of the brain associated with the experience of those emotions in the viewer: these *mirror neuron* (MN) systems suggest the possibility that even empathy may be observable.