Joseph LeDoux (1996) The Emotional Brain. The Mysterious Underpinnings of Emotional Life. TOUCHSTONE. Simon & Schuster.

CONTENTS

PREFACE

I first started working on the brain mechanisms of emotion in the late 1970s. At that time very few brain scientists were interested in emotions. In the intervening years, and especially recently, the topic has begun to be fairly heavily investigated, and a good deal of progress has been made. I thought it was time to share some of this information with the general public.

The Emotional Brain provides an overview of my ideas about how emotions come from the brain. It is not meant as an all-encompassing survey of every aspect of how the brain produces emotions. It focuses on those issues that have interested me most, namely, issues about how the brain detects and responds to emotionally arousing stimuli, how emotional learning occurs and emotional memories are formed, and how our conscious emotional feelings emerge from unconscious processes.

I tried to write The Emotional Brain so that it would be accessible to readers not trained in science or versed in scientific jargon. But I also tried not to water down the science. I hope I've been successful in making the book readable and enjoyable for lay persons and scientists alike.

I'm extremely grateful to my family for tolerating me while I struggled to write this book. I owe much to my wife, Nancy Princenthal, for her tireless reading of endless drafts of my book proposal, and then of the chapters, and for her many useful suggestions. Our two boys, Jacob and Milo, kept my emotional brain in tip-top shape throughout.

Many students and postdoctoral researchers have helped greatly in my past and current research on emotions in the brain: Akira Sakaguchi, Jiro Iwata, Piera Chichetti, Liz Romanski, Andy Xagoraris, Christine Clugnet, Mike Thompson, Russ Phillips, Maria Morgan, Peter Sparks, Kevin LaBar, Liz Phelps, Keith Corodimas, Kate Melia, Xingfang Li, Michael Rogan, Jorge Armony, Greg Quirk, Chris Repa, Neot Doron, Gene Go, Gabriel Hui, Mian Hou, Beth Stutzmann, and Walter Woodson. I have also had some important collaborators, including Don Reis, David Ruggiero, Shawn Morrison,

Costantino Iadecola, and Terry Milner at Cornell Medical School; David Servan-Schreiber and Jon Cohen at the University of Pittsburgh; Asla Pitkänen in Finland; and Chiye Aoki at NYU. And I will always be grateful to Claudia Farb for her many tangible and intangible contributions to my lab. Some of these people have had to do their work while I was writing the book. I apologize to them for being inaccessible, especially during those last days when it seemed that I might never finish. I also owe a great deal to Irina Kerzhnerman and Annette Olivero, who helped with many aspects of the final preparation of the book. Jorge Armony and Mian Hou assisted with the illustrations.

I also want to thank Mike Gazzaniga, my Ph.D. advisor, for showing me how to have fun while being a scientist, and for teaching me how to think about the mind. He encouraged me to write a book on emotions years before I actually got around to it. I'm also grateful to Don Reis, who took me into his lab as a postdoc, taught me neurobiology, and provided me with the resources I needed to start pursuing the brain mechanisms of emotion.

The Neuroscience Research Branch at the National Institute of Mental Health has generously funded my work. The research that this book is based on could not have been done without this support. New York University, especially the Faculty of Arts and Science Dean's Office, has also been very supportive. And I couldn't ask for better colleagues than those I have in the NYU Center for Neural Science.

Katinka Matson end John Brockman of Brockman, Inc., have been wonderful as literary agents. They were instrumental in helping me shape my proposal and in signing me up with Simon & Schuster, where I'm pleased to have had the opportunity to work with Bob Asahina, who made only good editorial suggestions. I wish him luck in his new job which took him away just as the book went into production. Bob Bender, who took over, has been wonderful as well, and Johanna Li.

Some people go on sabbatical to write books. I'm now going on one to recover.

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1. WHAT'S LOVE GOT TO DO WITH IT? (pp. 11-21, 304-305)

"Our civilization is still in a middle stage, scarcely beast, in that it is no longer guided by instinct, scarcely human in that it is not yet wholly guided by reason."

Theodore Dreiser, *Sister Carrie*[1]

My father was a butcher. I spent much of my childhood surrounded by beef. At an early age, I learned what the inside of a cow looks like. And the part that interested me the most was the slimy, wiggly, wrinkled brain. Now, many years later, I spend my days, and some nights, trying to figure out how brains work. And what I've wanted to know most about brains is how they make emotions.

You might think that this would be a crowded field of research. Emotions, after all, are the threads that hold mental life together. They define who we are in our own mind's eye as well as in the eyes of others. What could be more important to understand about the brain than the way it makes us happy, sad, afraid, disgusted, or delighted?

For quite some time now, though, emotion has not been a very popular topic in brain science.[2] Emotions, skeptics have said, are just too complex to track down in the brain. But some brain

scientists, myself included, would rather learn a little about emotions than more about less interesting things. In this book, I'll tell you how far we've gotten. Skeptics be warned, we've gotten pretty far.
Of course, at some level, we know what emotions are and don't need scientists to tell us about them. We've all felt love and hate and fear and anger and joy. But what is it that ties mental states like these together into the bundle that we commonly call "emotions"? What makes this bundle so different from other mental packages, ones that we are less inclined to use the term "emotion" for? How do our emotions influence every other aspect of our mental life, shaping our perceptions, memories, thoughts, and dreams? Why do our emotions often seem impossible to understand? Do we have control over our emotions or do they control us? Are emotions cast in neural stone by our genes or taught to the brain by the environment? Do animals (other than human ones) have emotions, and if so do all species of animals have them? Can we have unconscious emotional reactions and unconscious emotional memories? Can the emotional slate ever be wiped clean, or are emotional memories permanent?
You may have opinions, and even strong ones, about the answers to some of these questions, but whether your opinions constitute scientifically correct answers can't be determined by intuitions alone. Occasionally, scientists turn everyday beliefs into facts, or explain the workings of intuitively obvious things with their experiments. But facts about the workings of the universe, including the one inside your head, are not necessarily intuitively obvious. Sometimes, intuitions are just wrong—the world seems flat but it is not—and science's role is to convert these commonsense notions into myths, changing truisms into "old wives' tales." Frequently, though, we simply have no prior intuitions about something that scientists discover—there is no reason why we should have deep-seated opinions about the existence of black holes in space, or the importance of sodium, potassium, and calcium in the inner workings of a brain cell. Things that are obvious are not necessarily true, and many things that are true are not at all obvious.
I view emotions as biological functions of the nervous system. I believe that figuring out how emotions are represented in the brain can help us understand them. This approach contrasts sharply with the more typical one in which emotions are studied as psychological states, independent of the underlying brain mechanisms. Psychological research has been extremely valuable, but an approach where emotions are studied as brain functions is far more powerful.
Science works by experimentation, which, by definition, involves the manipulation of some variables and the control of others. The brain is an enormously rich source of variables to manipulate. By studying emotion through the brain, we greatly expand opportunities for making new discoveries beyond what can be achieved with psychological experimentation alone. Additionally, studying the way emotion works in the brain can help us choose between alternative psychological hypotheses—there are many possible solutions to the puzzle of how emotions might work, but the only one we really care about is the one that evolution hit upon and put into the brain.

I got interested in how emotions come from brains one day in New England. It was the mid-1970s, and I was a graduate student doing my Ph.D. research at the State University of New York at Stony Brook. A decade earlier, my advisor, Mike Gazzaniga, had made a big splash with his thesis research

involving the psychological consequences of split-brain surgery in humans, work that he had done at Cal Tech with the late Nobel Laureate Roger Sperry.[3]

Split-brain surgery is a procedure in which the nerve connections between the two sides or hemispheres of the brain are severed in an attempt to control very severe epilepsy.[4] A brand-new series of patients was being operated on at Dartmouth and the surgeon had asked Gazzaniga to study them.[5] We built a laboratory inside a camper-trailer attached to a pumpkin-colored Ford van, and frequently traveled from Long Island to see the patients at their homes in Vermont and New Hampshire.[6]

The earlier studies that Gazzaniga had done showed that when the brain is split, the two sides can no longer communicate with each other. And because language functions of the brain are usually in the left hemisphere, the person is only able to talk about things that the left hemisphere knows about. If stimuli are presented in such a way that only the right hemisphere sees them, the split-brain person is not able to verbally describe what the stimulus is. However, if you give the right hemisphere the opportunity to respond without having to talk, it becomes clear that the stimulus was registered. For example, if the left hand, which sends touch information to the right hemisphere, reaches into a bag of objects, it is able to sort through them and pull out the one that matches the picture seen by the right hemisphere. The right hemisphere can thus match the way the object feels with a memory of the way it looked a few moments earlier and pull out the correct one. The right hand can't do this because its touch information goes to the left hemisphere, which didn't see the object. In the split-brain patient, information put into one hemisphere remains trapped on that side of the brain, and is unavailable to the other side. Gazzaniga captured the essence of this remarkable situation in an early article on the topic called "One Brain—Two Minds."[7]

The split-brain experiment that set my scientific compass in the direction of emotion involved the presentation of stimuli with emotional connotations to the two half-brains of a special patient known as P.S.[8] He was special because unlike most previous patients of this type, he was able to read words in both hemispheres, although, as with the others, he could only speak through his left hemisphere. So vvhen emotional stimuli were presented to the left hemisphere, P.S. could tell us what the stimulus was and how he felt about it— whether it signified something good or bad. When the same stimuli were presented to the right hemisphere, the speaking left hemisphere was unable to tell us what the stimulus was. However, the left hemisphere could accurately judge whether the stimulus seen by the right was good or bad. For example, when the right hemisphere saw the word "mom," the left hemisphere rated it as "good," and when the right side savv the word "devil," the left rated it as "bad."

The left hemisphere had no idea what the stimuli were. No matter how hard we pressed, the patient could not name the stimulus that had been presented to the right hemisphere. Nevertheless, the left hemisphere was consistently on the money with the emotional ratings. Somehow the emotional significance of the stimulus had leaked across the brain, even though the identity of the stimulus had not. The patient's conscious emotions, as experienced by his left hemisphere, were, in effect, being pushed this way and that by stimuli that he claimed to have never seen.

How did this occur? Most likely, the path taken by the stimulus through the right hemisphere forked. One branch brought the stimulus to parts of the right hemisphere that identify what the stimulus is.

The split-brain surgery prevented the identification made by the right hemisphere from reaching the left. The other branch took the stimulus to parts of the right hemisphere that determine the emotional implications of the stimulus. The surgery did not prevent the transfer of this information over to the left side.

The left hemisphere, in other words, was making emotional judgments without knowing what was being judged. The left hemisphere knew the emotional outcome, but it did not have access to the processes that led up to that outcome. As far as the left hemisphere was concerned, the emotional processing had taken place outside of its realm of awareness (which is to say, had taken place unconsciously).

Split-brain surgery seemed to be revealing a fundamental psychological dichotomy—between thinking and feeling, between cognition and emotion. The right hemisphere was unable to share its thoughts about what the stimulus was with the left, but was able to transfer the emotional meaning of the stimulus over.

By the way, this work was not at all about the issue of possible hemisphere differences in emotion.[9] We were simply examiriing the kinds of information that could and could not flow between the hemispheres when the brain was split.

Freud of course told us long ago that the unconscious is the home of our emotions, which, he said, were often dissociated from normal thought processes. However, decades later, we still had little understanding of how this might take place, and whether it was true at all was often questioned. I set as my goal figuring how the brain processes the emotional meaning of stimuli, a goal that I have since pursued.

After completing my graduate work, I decided that the techniques available for studying the human brain were too limited and that I would never be able to understand the neural basis of emotion by studying humans. I therefore turned to studies of experimental animals, rats, for the purpose of trying to unlock the brain's emotional secrets. As important as the human split-brain observations were in getting me going on this topic, it has been the animal studies that have really shaped my view of the emotional brain.

This book will tell you what I've learned from my researching and thinking about brain mechanisms of emotions. It gives a scientific account of what emotions are, how they operate in the brain, and why they have such important influences on our lives.

Several themes about the nature of emotions will emerge and recur. Some of these will be consistent with your common-sense intuitions about emotions, whereas others will seem unlikely if not strange. But all of them, I believe, are well-grounded in facts about the brain, or at least in hypotheses that have been inspired by such facts, and I hope that you will hear them out.

• The first is that the proper level of analysis of a psychological function is the level at which that function is represented in the brain. This leads to a conclusion that clearly falls into the realm of the bizarre at first—that the word "emotion" does not refer to something that the mind or brain really has or does.[10] "Emotion" is only a label, a convenient way of talking about aspects of the brain and its

mind. Psychology textbooks often carve the mind up into functional pieces, such as perception, memory, and emotion. These are useful for organizing information into general areas of research but do not refer to real functions. The brain, for example, does not have a system dedicated to perception. The word "perception" describes in a general way what goes on in a number of specific neural systems—we see, hear, and smell the world with our visual, auditory, and olfactory systems. Each system evolved to solve different problems that animals face. In a similar vein, the various classes of emotions are mediated by separate neural systems that have evolved for different reasons. The system we use to defend against danger is different from the one we use in procreation, and the feelings that result from activating these systems—fear and sexual pleasure—do not have a common origin. There is no such thing as the "emotion" faculty and there is no single brain system dedicated to this phantom function. If we are interested in understanding the various phenomena that we use the term "emotion" to refer to, we have to focus on specific classes of emotions. We shouldn't mix findings about different emotions all together independent of the emotion that they are findings about. Unfortunately, most work in psychology and brain science has done this.

• A second theme is that the brain systems that generate emotional behaviors are highly conserved through many levels of evolutionary history. All animals, including people, have to satisfy certain conditions to survive in the world and fulfill their biological imperative to pass their genes on to their offspring. At a minimum, they need to obtain food and shelter, protect themselves from bodily harm, and procreate. This is as true of insects and worms as it is of fish, frogs, rats, and people. Each of these diverse groups of animals has neural systems that accomplish these behavioral goals. And within the animal groups that have a backbone and a brain (fish, amphibians, reptiles, birds, and mammals, including humans), it seems that the neural organization of particular emotional behavioral systems—like the systems underlying fearful, sexual, or feeding behaviors—is pretty similar across species. This does not imply that all brains are the same. It instead means that our understanding of what it means to be human involves an appreciation of the ways in which we are like other animals as well as the ways in which we are different.

• A third theme is that when these systems function in an animal that also has the capacity for conscious awareness, then conscious emotional feelings occur. This clearly happens in humans, but no one knows for sure whether other animals have this capacity. I make no claims about which animals are conscious and which are not. I simply claim that when one of these evolutionarily old systems (like the system that produces defensive behaviors in the presence of danger) goes about its business in a conscious brain, emotional feelings (like being afraid) are the result. Otherwise, the brain accomplishes its behavioral goals in the absence of robust awareness. And absence of awareness is the rule of mental life, rather than the exception, throughout the animal kingdom. If we do not need conscious feelings to explain what we would call emotional behavior in some animals, then we do not need them to explain the same behavior in humans. Emotional responses are, for the most part, generated unconsciously. Freud was right on the mark when he described consciousness as the tip of the mental iceberg.

• The fourth theme follows from the third. The conscious feelings that we know and love (or hate) our emotions by are red herrings, detours, in the scientific study of emotions. This will surely be hard to

swallow at first. After all, what is an emotion but a conscious feeling; Take away the subjective register of fear and there's not much left to a dangerous experience. But I will try to convince you that this idea is wrong—that there is much more than meets the mind's eye in an emotional experience. Feelings of fear, for example, occur as part of the overall reaction to danger and are no more or less central to the reaction than the behavioral and physiological responses that also occur, such as trembling, running away, sweating, and heart palpitations. What we need to elucidate is not so much the conscious state of fear or the accompanying responses, but the system that detects the danger in the first place. Fear feelings and pounding hearts are both effects caused by the activity of this system, which does its job unconsciously—literally, before we actually know vve are in danger. The system that detects danger is the fundamental mechanism of fear, and the behavioral, physiological, and conscious manifestations are the surface responses it orchestrates. This is not meant to imply that feelings are unimportant. It means that if we want to understand feelings we have to dig deeper.

• Fifth, if, indeed, emotional feelings and emotional responses are effects caused by the activity of a common underlying system, we can then use the objectively measurable emotional responses to investigate the underlying mechanism, and, at the same time, illuminate the system that is primarily responsible for the generation of the conscious feelings. And since the brain system that generates emotional responses is similar in animals and people, studies of how the brain controls these responses in animals are a pivotal step toward understanding the mechanisms that generate emotional feelings in people. Studies of the neural basis of emotion in humans vary from difficult to impossible for both ethical and practical reasons. The study of experimental animals is, as a result, both a useful and a necessary enterprise if we are to understand emotions in the human brain. Understanding emotions in the human brain is clearly an important quest, as most mental disorders are emotional disorders.

• Sixth, conscious feelings, like the feeling of being afraid or angry or happy or in love or disgusted, are in one sense no different from other states of consciousness, such as the awareness that the roundish, reddish object before you is an apple, that a sentence just heard was spoken in a particular foreign language, or that you've just solved a previously insoluble problem in mathematics. States of consciousness occur when the system responsible for awareness becomes privy to the activity occurring in unconscious processing systems. What differs between the state of being afraid and the state of perceiving red is not the system that represents the conscious content (fear or redness) but the systems that provide the inputs to the system of awareness. There is but one mechanism of consciousness and it can be occupied by mundane facts or highly charged emotions. Emotions easily bump mundane events out of awareness, but non-emotional events (like thoughts) do not so easily displace emotions from the mental spotlight—wishing that anxiety or depression would go away is usually not enough.

• Seventh, emotions are things that happen to us rather than things we will to occur. Although people set up situations to modulate their emotions all the time—going to movies and amusement parks, having a tasty meal, consuming alcohol and other recreational drugs—in these situations, external events are simply arranged so that the stimuli that automatically trigger emotions will be present. We have little direct control over our emotional reactions. Anyone who has tried to fake an emotion, or

who has been the recipient of a faked one, knows all too well the futility of the attempt. While conscious control over emotions is weak, emotions can flood consciousness. This is so because the wiring of the brain at this point in our evolutionary history is such that connections from the emotional systems to the cognitive systems are stronger than connections from the cognitive systems to the emotional systems.

• Finally, once emotions occur they become powerful motivators of future behaviors. They chart the course of moment-to-moment action as well as set the sails toward long-term achievements. But our emotions can also get us into trouble. When fear becomes anxiety, desire gives way to greed, or annoyance turns to anger, anger to hatred, friendship to envy, love to obsession, or pleasure to addiction, our emotions start working against us. Mental health is maintained by emotional hygiene, and mental problems, to a large extent, reflect a breakdown of emotional order. Emotions can have both useful and pathological consequences.

As emotional beings, we think of emotions as conscious experiences. But when we begin probing emotion in the brain, we see conscious emotional experiences as but one part, and not necessarily the central function, of the systems that generate them. This does not make our conscious experiences of love or fear any less real or important. It just means that if we are going to understand where our emotional experiences come from we have to reorient our pursuit of them. From the point of view of the lover, the only thing important about love is the feeling. But from the point of view of trying to understand what a feeling is, why it occurs, where it comes from, and why some people give or receive it more easily than others, love, the feehng, may not have much to do with it at all.

Our journey into the emotional brain will take us down many different paths. We start with the curious fact that the study of emotion has long been ignored by the field of cognitive science, the major scientific enterprise concerned with the nature of the mind today (Chapter 2). Cognitive science treats minds like computers and has traditionally been more interested in how people and machines solve logical problems or play chess than in why we are sometimes happy and sometimes sad. We will then see that this shortcoming has been corrected in an unfortunate way—by redefining emotions as cold cognitive processes, stripping them of their passionate qualities (Chapter 3). At the same time though, cognitive science has been very successful, and has provided a framework that, when appropriately applied, provides an immensely valuable approach for pursuing the emotional as well as the cognitive mind. And one of the major conclusions about cognition and emotion that comes from this approach is that both seem to operate unconsciously, with only the outcome of cognitive or emotional processing entering awareness and occupying our conscious minds, and only in some instances.

The next stop along the way takes us into the brain, in search of the system that gives rise to our emotions (Chapter 4). We'll see that there is no single emotion system. Instead, there are lots of emotion systems, each of which evolved for a different functional purpose and each of which gives rise to different kinds of emotions (Chapter 5). These systems operate outside of consciousness and they constitute the emotional unconscious.

We then concentrate on one emotion system that has been extensively studied, the fear system of the brain, and see how it is organized (Chapter 6). The relation between unconscious emotional memory and conscious memories of emotional experiences is then discussed (Chapter 7). The breakdown of emotion systems, especially the fear system, is then considered (Chapter 8). We see how anxiety, phobias, panic attacks, and post-traumatic stress disorders emerge out of the depths of the unconscious workings of the fear system. Psychotherapy is interpreted as a process through which our neocortex learns to exercise control over evolutionarily old emotional systems. Finally, we explore the problem of emotional consciousness, and the relation of emotion to the rest of the mind (Chapter 9). I conclude with the hypothesis, based on trends in brain evolution, that the struggle between thought and emotion may ultimately be resolved, not simply by the dominance of neocortical cognitions over emotional systems, but by a more harmonious integration of reason and passion in the brain, a development that will allow future humans to better know their true feelings and to use them more effectively in daily life.

LeDoux' Footnotes

1. Dreiser (1900).
2. The study of emotions in brain science has gone through cycles. We'll review this history in detail in Chapter 4. For now, I'll just note that neuroscientists have, in recent decades, been much more interested in the intellectual or cognitive aspects of the mind than in emotions. However, this is starting to change. Although there are still relatively few neuroscientists who claim emotions as their main interest, emotional functions of the brain are becoming more popular as research topics. There are several reasons for this shift. One has to do with the recognition that the mind is more than cognition, so that the focus on cognitive processes by neuroscientists only reveals part of the mind. Another is the realization that the subjective states of awareness that accompany emotions are just part of the overall emotion process, and that much can be learned by studying how the brain processes stimuli and controls objectively measured responses in emotional situations. Since stimulus processing and response control can be studied in animals, but subjective awareness cannot, a focus on processing and responses has facilitated research. These notions are developed further in Chapters 2 and 3.
3. Gazzaniga, Bogen, and Sperry (1962); Gazzaniga, Bogen, and Sperry (1965); Gazzaniga (1970).
4. Bogen and Vogel (1962).
5. D. Wilson, et al (1977).
6. Our research on the Dartmouth patients between 1974 and 1978 is summarized in Gazzaniga and LeDoux (1978).
7. Gazzaniga (1972).
8. Studies of this patient are described in Gazzaniga and LeDoux (1978).
9. See Davidson (1992); Heilman and Satz (1983); Gainotti (1972).
10. A similar point was made by E. Duffy in the 1940s [Duffy (1941)]. However, while Duffy wished to do away with talk about emotion, I want to understand what emotions are. The key is the use of the plural rather than the singular. I don't think that there is anything called "emotion" but I do believe that there are lots of "emotions."

2. SOULS ON ICE (pp. 22-41, 305-309)

"Think, think, think." Winnie the Pooh.[1]

"Ahab never thinks, he just feels, feels, feels." Herman Melville, *Moby-Dick.*[2]

The human brain contatns about 10 billion neurons that are wired together in enormously complex ways. Although the electrical sparks within and chemical exchanges between these cells accomplish some amazing and perplexing things, the creation of our emotions stands out as one of their most amazing and perplexing feats.

When we turn our mind's eye inward on our emotions, we find them at once obvious and mysterious. They are the states of our brain we know best and remember with the greatest clarity. Yet, sometimes we do not know where they come from. They can change slowly or suddenly, and their causes can be evident or opaque. We don't always understand what makes us wake up on the wrong side of the bed. We can be nice or nasty for reasons other than the ones we believe are guiding our actions. We can react to danger before we "know" we are in harm's way. We can be drawn toward the aesthetic beauty of a painting without consciously understanding what it is we like about it. Although our emotions are at the core of who we are, they also seem to have their own agenda, one often carried out without our willful participation.

It's hard to imagine life without emotions. We live for them, structuring circumstances to give us moments of pleasure and joy, and avoiding situations that will lead to disappointment, sadness, or pain. The rock critic Lester Bangs once said, "The only questions worth asking today are whether humans are going to have any emotions tomorrow, and what the quality of life will be if the answer is no."[3]

Scientists have had lots to say about what emotions are.[4] For some, emotions are bodily responses that evolved as part of the struggle to survive. For others, emotions are mental states that result when bodily responses are "sensed" by the brain. Another view is that the bodily responses are peripheral to an emotion, with the important stuff happening completely within the brain. Emotions have also been viewed as ways of acting or ways of talking. Unconscious impulses are at the core of an emotion in some theories, while others emphasize the importance of conscious decisions. A popular view today is that emotions are thoughts about situations in which people find themselves. Another notion is that emotions are social constructions, things that happen between rather than within individuals.

A scientific understanding of emotions would be wonderful. It would give us insight into how the most personal and occult aspects of the mind work, and at the same time would help us understand what may go wrong when this part of mental life breaks down. But, as the above comments indicate, scientists have not been able to agree about what an emotion is. The careers of many a scientist have been devoted to, if not devoured by, the task of explaining emotions. Unfortunately, one of the most significant things ever said about emotion may be that everyone knows what it is until they are asked to define it.[5]

This state of affairs might seem to pose a major stumbling block for our attempt to understand the emotional brain. If we can't say what emotion is, how can we hope to find out how the brain does it?

But this book is not about mapping one area of knowledge (the psychology of emotion) onto another (brain function-). It is instead about how studies of brain function allow us to understand emotion as a psychological process in new ways. I believe that we can get a unique and advantageous view of this puzzling part of the mental terrain by peering at it from inside the nervous system.

But I don't intend to ignore the psychology of emotion. Psychologists have had lots of insights. The problem is deciding which are correct and which are clever but wrong. Studies of the emotional brain can give us additional insights, but can also help us pick and choose from the psychological offerings. Aspects of the psychology of emotion are discussed in Chapter 3.

Our pursuit of the psychology of emotion, though, needs to be prefaced with an exploration of how emotion fits into a larger view of the mind—we need to delve into the nature of cognition, emotion's partner in the mind. The study of cognition, or just plain thinking, has advanced amazingly far in recent years. These advances provide a conceptual framework and methodology that is useful as an approach to all aspects of the mind, including emotion. The business of this chapter will therefore be to see what cognition is and how emotion and cognition relate.

Reason and Passion

Since the time of the ancient Greeks, humans have found it compelling to separate reason from passion, thinking from feeling, cognition from emotion. These contrasting aspects of the soul, as the Greeks liked to call the mind, have in fact often been viewed as waging an inner battle for the control of the human psyche. Plato, for example, said that passions and desires and fears make it impossible for us to think.[6] For him, emotions were like wild horses that have to be reined in by the intellect, which he thought of as a charioteer. Christian theology has long equated emotions with sins, temptations to resist by reason and willpower in order for the immortal soul to enter the kingdom of God. And our legal system treats "crimes of passion" differently from premeditated transgressions.

Given this long tradition of separation of passion and reason, it should not be too surprising that a field currently exists to study rationality, so-called cognition, on its own, independent of emotions. This field, known as cognitive science, tries to understand how we come to know our world and use our knowledge to live in it. It asks how we recognize a certain pattern of visual stimulation falling on the retina as a particular object, say an apple, or determine the apple's color, or judge which of two apples is bigger, or control our arm and hand in the act of catching an apple falling out of a tree, or remember where we were or who we were with when we last ate an apple, or imagine an apple in the absence of one, or tell or understand a story about an apple falling out of a tree, or conceive of a theory of why an apple falling out of a tree goes toward the earth instead of the sky.

Cognitive science emerged recently, around the middle of this century, and is often described as the "new science of mind."[7] However, in fact, cognitive science is really a science of only a part of the mind, the part having to do with thinking, reasoning, and intellect. It leaves emotions out. And minds without emotions are not really minds at all. They are souls on ice—cold, lifeless creatures devoid of any desires, fears, sorrows, pains, or pleasures.

Why would anyone want to conceive of minds without emotions? How could such a field focused on emotionless minds be so successful? How do we get emotion and cognition back together? To answer these questions we need to see where cognitive science came from and what it's all about.

Thinking Machines

Throughout much of the first half of this century, psychology was dominated by behaviorists, who believed that the subjective inner states of mind, like perceptions, memories, and emotions, are not appropriate topics for psychology.[8] In their view, psychology should not be the study of consciousness, as had been the case since Descartes said "Cogito, ergo sum,"[9] but instead should be the study of observable facts—objectively measurable behaviors. Being subjective and unobservable (except by introspection), consciousness could not, in the behaviorists' mind, be examined scientifically. Mental states came to be known pejoratively as "ghosts in the machine."[10] Behaviorists were known to ridicule those who dared to speak of mind and consciousness.

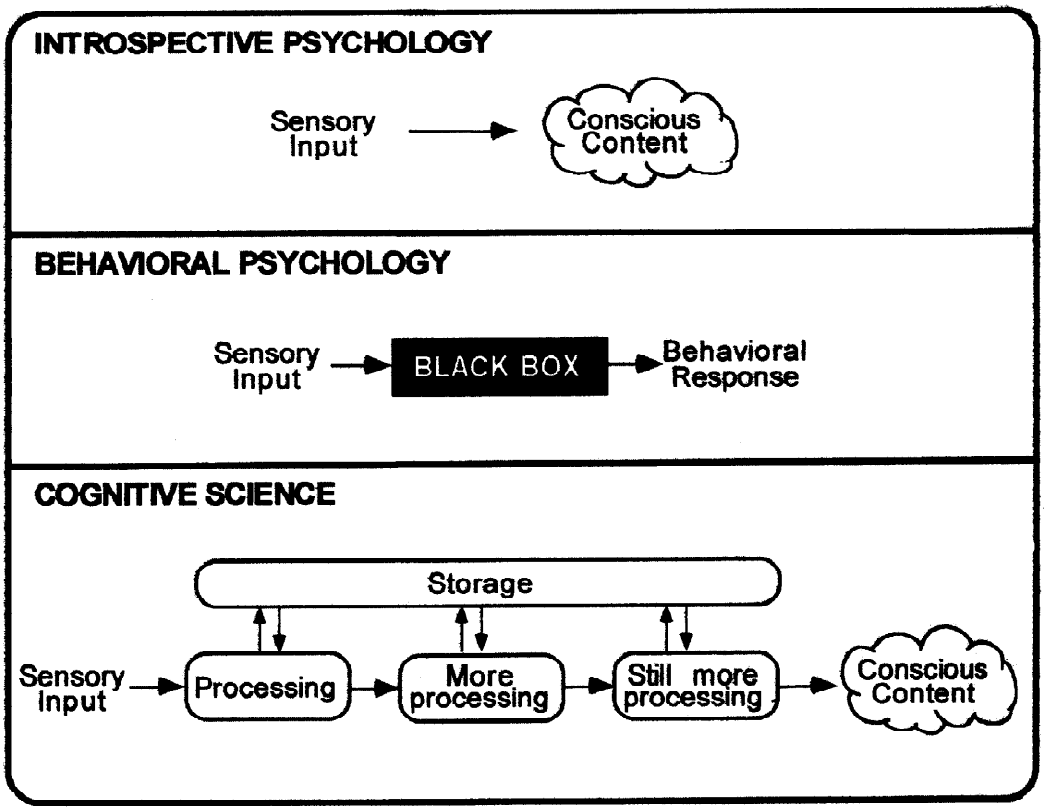


FIGURE 2-1 Three Approaches to the Science of Mind and Behavior.
Introspective psychology is mainly concerned with the contents of immediate conscious experience. Behaviorism rejected consciousness as a legitimate subject matter for psychology and treated the events occurring between stimuli and responses as hidden in a black box. Cognitive science tries to understand the processes that occur inside the black box. These processes tend to occur unconsciously. In focusing on processes rather than conscious content, cognitive science did not exactly revive the view of the mind that the behaviorists rejected. More and more, however, cognitive scientists are beginning to try to understand the mechanisms of consciousness as well as the

unconscious processes that sometimes do and sometimes do not give rise to conscious content. (Bottom panel is based on figure 1 in U. Neisser [1976], Cognition and Reality. San Francisco: W.H. Freeman.)

By mid-century, though, the behaviorist stronghold on psychology began to weaken.[11] Electronic computers had been developed, and engineers, mathematicians, philosophers, and psychologists quickly saw similarities in the way computers process information and the way minds work. Computer operations became a metaphor for mental functions, and the field of artificial intelligence (AI) which seeks to model the human mind using computer simulations, was born. Pretty soon, anyone who bought into the notion of the mind as an information-processing device came to be known as a cognitive scientist. Cognitive science caused a revolution in psychology, dethroning the behaviorists and bringing the mind back home. But the impact of cognitive science reached far beyond psychology. Today, cognitive scientists can be found in linguistics, philosophy, computer science, physics, mathematics, anthropology, sociology, and brain science, as well as psychology.

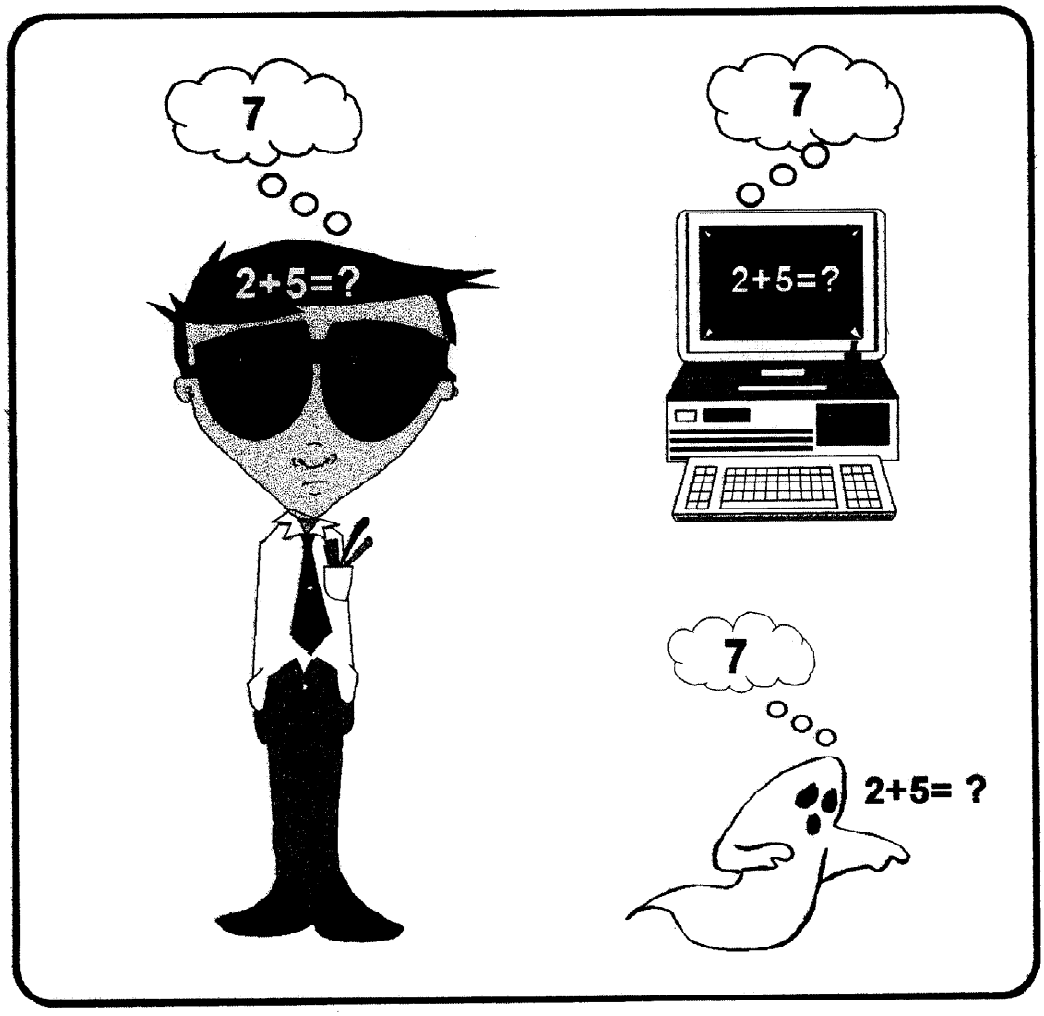
One of the most important conceptual developments in the establishment of cognitive science was a philosophical position known as functionalism, which holds that intelligent functions carried out by different machines reflect the same underlying process.[12] For example, a computer and a person can both add 2 + 5 and come up with 7. The fact that both achieve the same answer cannot be explained by the use of similar hardware—brains are made of biological stuff and computers of electronic parts. The similar outcome must be due to a similar process that occurs at a functional level. In spite of the fact that the hardware in the machines is vastly different, the software or program that each executes may be the same. Functionalism thus holds that the mind is to the brain as a computer program is to the computer hardware.

Cognitive scientists, carrying the functionalist banner, have been allowed to pursue the functional organization of the mind without reference to the hardware that generates the functional states. According to functionalist doctrine, cognitive science stands on its own as a discipline—it does not require that we know anything about the brain. This logic was a shot in the arm to the field, giving it a strong sense of independence. Regardless of whether they do experiments on humans or use computer simulations o the human mind, many cognitive scientists today are functionalists.

It would be natural to presume that the cognitive revolution resulted in the return of consciousness as the number one topic of psychology. But this was not the case. The cognitive movement brought the mind back to psychology, but not exactly the all-knowing conscious mind that Descartes had popularized. For Descartes, if it wasn't conscious it wasn't mental: mind and consciousness became synonymous after him.[13] In contrast, as we'll soon see, cognitive scientists tend to think of the mind in terms of unconscious *processes* rather than conscious contents. And in leaving out consciousness, cognitive science left behind those conscious states called emotions. Later we'll see why this occurred. For now, we want to explore the unconscious nature of cognitive processes.

FIGURE 2-2 Functionalism.

This is a philosophical position which proposes that mental functions (thinking, reasoning, planning, feeling) are functional rather than physical states. When a person and a computer add 2 to 5 and come up with 7, the similar outcome cannot be based on similar physical makeup, but instead must be due to a functionaI equivalence of the processes involved. As a result, it is possible to study mental processes using computer simulations. Minds might in principle even exist without bodies. (Based on J.A. Fodor, The Mind-Body Problem. Scientific American January 1981], Vol. 244, p. 118.)



The Cognitive Unconscious

Rooted in the idea of mind as an information processing device, cognitive science has been geared toward understanding the functional organization and processes that underlie and give rise to mental events, and much less toward understanding the nature of consciousness and its subjective contents. In order for you to consciously perceive an apple in front of you in space, the apple must be represented in your brain and that representation must be made available to the conscious part of your mind. But the mental representation of the apple that you consciously perceive is created by the unconscious turnings of mental gears. As Karl Lashley long ago pointed out, conscious content comes from processing, and we are never consciously aware of the processing itself but only of the outcome.[14] These mental processes are the bread and butter of cognitive science. Cognitive scientists sometimes

speak of consciousness as the end result of processing, but are usually far more interested in the underlying processes than in the contents of consciousness that occur during and as a result of the processing. This emphasis on unconscious processes as opposed to conscious content underlies much work in cognitive science.[15] And for adherents of strong versions of functionalism these processes can be studied equally well in any device that can solve the functional problem at hand, regardless of whether the device is made of neurons, electrical components, mechanical parts, or sticks and stones.[16]

The psychologist John Kihlstrom coined the term "cognitive unconscious" to describe the subterranean processes that have been the main preoccupation of cognitive science.[17] These processes span many levels of mental complexity, all the way from the routine analysis of the physical features of stimuli by our sensory systems, to remembrance of past events, to speaking grammatically, to imagining things that are not present, to decision making, and beyond.

Like Freud before them, cognitive scientists reject the view handed down from Descartes that mind and consciousness are the same. However, the cognitive unconscious is not the same as the Freudian or dynamic unconscious.[18] The term cognitive unconscious merely implies that a lot of what the mind does goes on outside of consciousness, whereas the dynamic unconscious is a darker, more malevolent place where emotionally charged memories are shipped to do mental dirty work. To some extent, the dynamic unconscious can be conceived in terms of cognitive processes,[19] but the term cognitive unconscious does not imply these dynamic operations. We are going to also discuss the dynamic unconscious in some detail in later chapters. But for now we are focused on the tamer cognitive unconscious, which consists of processes that take care of the mind's routine business without consciousness having to be bothered. Let's consider some examples.

The first level of analysis of any external stimulus by the nervous system involves the physical properties of the stimulus. These low-level processes occur without awareness.[20] The brain has, for example, mechanisms for computing the shape, color, location, and movement of objects we see, and the loudness, pitch, and location of sounds we hear. If we are asked to say which of two objects is closer or which of two sounds is louder, we can do so, but we cannot explain vvhat operations the brain performed to allow us to reach these conclusions. We have conscious access to the outcome of the computation but not to the computation itself. The processing of physical stimulus features makes possible all other aspects of perception, including our conscious awareness of perceiving something. It is just as well that we are unaware of these processes, as we would be so busy doing the computations that we would never get around to actually perceiving anything if we had to do it all with deliberate concentration.

On the basis of its analysis of physical features of stimuli, the brain begins to construct meaning. In order to know that the object you are looking at is an apple, the physical features of the stimulus have to find their way into your long-term memory banks. Once there, the stimulus information is matched up with stored information about similar objects and is classified as an apple, allowing you to "know" that you are looking at an apple and perhaps even leading you to remember past experiences you've had that involved apples. The end result is the creation of conscious memories (conscious contents) but through processes that you have little conscious access to. Presumably you can remember what

you had for dinner last night, but you are not likely to be able to explain the machinations your brain went through to pull that information out.

Even that most ghostly of cognitions, the mental image, is the product of unconscious processes. For example, the cognitive psychologist Stephen Kosslyn asked subjects to draw an imaginary island that contained certain objects (tree, hut, rock, etc.).[21] The subjects were then asked to imagine the map and focus on one of the objects. A test word was then given and the subjects had to press a button to indicate whether the word named one of the objects on the map. The amount of time taken to press the button was directly related to the distance between the object named by the test word and the object being imagined. This suggested to Kosslyn that the brain actually computes geometric distances in mental images. But the subjects did not deliberately perform these calculations. They just gave the answers by pressing a button. All the work was done by the brain operating unconsciously.

Just because your brain can do something does not mean that "you" know how it did it. If it seems odd that the brain can unconsciously solve geometric problems, imagine the kinds of automatic calculations that go on in the brain when we turn the steering wheel to navigate a curve at 60 mph, or better yet, the kinds of processes that go on in the nervous system of homing pigeons or honeybees as they fly out into the world in search of food and then effortlessly find their way home using an internal compass.

Speech, consciousness' favorite behavioral tool, is also the product of unconscious processes.[22] We do not consciously plan the grammatical structure of the sentences we utter. There simply isn't enough time. We aren't all great orators, but we usually say things that make sense linguistically. Speaking roughly grammatically is one of the many things that the cognitive unconscious takes care of for us.

The cognitive unconscious also extends to complex judgments about the mental origins of beliefs and actions. In 1977, Richard Nisbett and Timothy Wilson published an extremely interesting paper, "Telling More Than We Can Know: Verbal Reports on Mental Processes."[23] They created a number of carefully structured experimental situations in which people were required to do things and then say why they did what they did. In one study, they lined up several pairs of stockings on a table. Female subjects were then allowed to examine the stockings and to choose which one they liked best.

When the women were questioned, they had all sorts of wonderful answers about the texture and sheerness of the stockings that justified their choices. But unbeknownst to them, the stockings were identical. The subjects believed that they had decided on the basis of their internal judgments about the quality of the stockings. In this and a host of other studies, Nisbett and Wilson showed that people are often mistaken about the internal causes of their actions and feelings. Although the subjects always gave reasons, the reasons came not from privileged access to the processes that underlay their decisions, but from social conventions, or ideas about the way things normally work in such situations, or just plain guesses. Accurate introspective reports, Nisbett and Wilson say, often occur in life because the stimuli involved in causing the behavior or the belief are salient and plausible causes of these. But when salient and plausible stimuli are not available, people make up reasons and believe in them. In other words, the inner workings of important aspects of the mind, including our own understanding of why we do what we do, are not necessarily knowable to the conscious self.[24] We

have to be very careful when we use verbal reports based on introspective analyses of one's own mind as scientific data.

Around the same time that Nisbett and Wilson were performing their studies, Michael Gazzaniga and I were engaged in studies of split-brain patients that led us to a similar conclusion.[25] It was wellknown from earlier work by Gazzaniga and others that information presented exclusively to one hemisphere of a split-brain patient is unavailable to the other.[26] We capitalized on this as a model of how consciousness deals with information generated by an unconscious mental system. In other words, we secretly instructed the right hemisphere to perform some response. The left hemisphere observed the response but did not know why the response was performed. We then asked the patient why he did what he did. Since only the left hemisphere could talk, the verbal output reflected that hemisphere's understanding of the situation. Time after time, the left hemisphere made up explanations as if it knew why the response was performed. For example, if we instructed the right hemisphere to wave, the patient would wave. When we asked him why he was waving, he said he thought he saw someone he knew. When we instructed the right hemisphere to laugh, he told us that we were funny guys. The spoken explanations were based on the response produced rather than knowledge of why the responses were produced. Like Nisbett and Wilson's subjects, the patient was attributing explanations to situations as if he had introspective insight into the cause of the behavior when in fact he did not. We concluded people normally do all sorts of things for reasons they are not consciously aware of (because the behavior is produced by brain systems that operate unconsciously) and that one of the main jobs of consciousness is to keep our life tied together into a coherent story, a self-concept. It does this by generating explanations of behavior on the basis of our self-image, memories of the past, expectations of the future, the present social situation, and the physical environment in which the behavior is produced.[27]

Although a good deal remains uncertain about the cognitive unconscious,[28] it seems clear that much of mental life occurs outside of conscious awareness. We can have introspective access to the outcome of processing (in the form of conscious content), but not all processing gives rise to conscious content. Stimulus processing that does not reach awareness in the form of conscious content can nevertheless be stored implicitly or unconsciously (see chapter 7) and have important influences on thought and behavior at some later time.[29] Further, it is worth emphasizing that information can be simultaneously processed separately by systems that do and do not give rise to conscious content, leading to the conscious representation in some and the unconscious representation in other systems. We may sometimes be able to introspect and verbally describe the workings of the systems that create and use conscious representations, but introspection is not going to be very useful as a window into the workings of the vast unconscious facets of the mind. This will be an especially important point when we consider the emotional unconscious in the next chapter.

The field of cognitive science has been incredibly successful in its stated mission of understanding information processing, which turns out to mean the unconscious processing of information. We now have excellent models of how we perceive the world in an orderly fashion, remember events from the past, imagine stimuli that are not present, focus our attention on one stimulus while ignoring many others, solve logical problems, make decisions on the basis of incomplete information, make

judgments about our beliefs, attitudes, and behaviors, and many other aspects of mental functioning.[30] That much of the processing involved in these functions occurs unconsciously has allowed cognitive science a luxury that earlier forms of mentalism did not have—the field could get on with the business of studying the mind without having to first solve the problem of consciousness.[31] This does not mean that consciousness is irrelevant or unimportant. It is so important that when it has come up in the past it has completely dominated the scientific pursuit of the mind. This time around, though, scientists have figured out that the unconscious aspects of the mind are also important. In fact, it is probably not too far off the mark to say that consciousness will only be understood by studying the unconscious processes that make it possible. In this regard, cognitive science seems right on track. We'll return to the topic of consciousness, and especially emotional consciousness, in Chapter 9.

The Mental Health of Machines

The cognitive mind (the mind being studied by cognitive scientists) can do some very interesting and complicated things. For example, it can play chess so well that real grand masters can be given a run for their money.[32] But the cognitive mind, when playing chess, does not feel driven to win. It doesn't enjoy putting its partner in checkmate, or feel saddened or annoyed if it loses a match. It is not distracted by the presence of an audience at a big game, by sudden anxiety over the realization that a mortgage payment is late, or by the need to go to the little chip's room. The cognitive mind can even be programmed to cheat at chess, but not to feel guilty when it does.

As one thumbs through some of the attempts to define cognitive science it is striking how often this field is characterized by saying that it is not about emotion. For example, in The Mind's New Science: A History of the Cognitive Revolution, Howard Gardner lists the de-emphasis of affective or emotional factors as one of five defining features of cognitive science.[33] In his seminal 1968 textbook, Cognitive Psychology, Ulric Neisser states that the field is not about the dynamic factors (like emotions) that motivate behavior.[34] Jerry Fodor, in The Language of Thought, a groundbreaking book in the philosophy of cognitive science, describes emotions as mental states that fall outside the domain of cognitive explanation.[35] And Barbara von Eckardt, in a book titled What Is Cognitive Science? says that most cognitive scientists do not consider the study of emotions to be part of the field.[36] These cognitive scientists each pointed out that emotional factors are important aspects of the mind, but also emphasized that emotions are just not part of the cognitive approach to the mind.

What is it about emotion that has compelled cognitive scientists to separate it out from attention, perception, memory, and other bona fide cognitive processes? Why was emotion banned from the rehabilitation of the mind that took place in psychology's cognitive revolution?

For one thing, as we have seen, philosophers and psychologists have for millennia found it useful to distinguish thinking and feeling, cognition and emotion, as separate facets of mind. And following the work of philosophers like Bertrand Russell[37] in the early twentieth century, thinking came to be viewed as a kind of logic, now known, thanks to Fodor, as the language of thought.[38] When the computer metaphor came along, it was seen as more applicable to logical reasoning processes than to so-called illogical emotions. But, as we will see, cognition is not as logical as it was once thought and emotions are not always so illogical.

AI researchers realized early on that knowledge was needed in problem-solving machines—problem solvers with impeccable logic but without facts didn't get very far.[39] However, knowledge was a crutch to logic in these models. It is now believed that thinking does not normally involve the pure reasoned rules of logic.[40] This has been demonstrated in research by Philip Johnson-Laird.[41] He examined people's ability to draw logical conclusions from statements like: all artists are beekeepers, all beekeepers are chemists. He found that quite often people draw logically invalid conclusions, suggesting that if the human mind is a formal logic machine, it is a pretty poor one. People are rational, according to Johnson-Laird, they just don't achieve their rationality by following formal laws of logic. We use what Johnson-Laird calls mental models, hypothetical examples drawn from our past experiences in real life or from imagined situations. Other studies by Amos Tversky and Daniel Kahneman led to a similar view, but from a different angle.[42] They showed that people use their implicit understanding of the way the world works, often relying on educated guesswork rather than formal principles of logic, to solve the problems that they face in their daily lives. Economist Robert Frank, however, goes further.[43] He argues that decision making is often not rational at all: "Many actions, purposely taken with full knowledge of their consequences, are irrational. If people did not perform them, they would be better off and they know it." He cites examples such as battling endless red tape to get a small refund on a defective product or weathering a snowstorm to cast a ballot that will on its own have little impact in a race. Jorge Luis gorges' description of the British and Argentine battle over the Falkland Islands, quoted by Frank, says it all: "two bald men fighting over a comb." If cognition is not just logic, and is sometimes illogical, then emotion might not be as far afield from cognition as it was initially thought.

Many emotions are products of evolutionary wisdom, which probably has more intelligence than all human minds together. The evolutionary psychologists John Tooby and Leda Cosmides say that the species' past goes a long way toward explaining the individual's present emotional state.[44] What is irrational about responding to danger with evolutionarily perfected reactions? Daniel Goleman gives lots of examples of emotional intelligence in his recent book.[45] Success in life, according to Goleman, depends on a high EQ (emotional quotient) as much or more than a high IQ. True, derailed emotions can lead to irrational and even pathological consequences, but emotions themselves are not necessarily irrational. Aristotle, for example, saw anger as a reasonable response to an insult, and a number of philosophers have taken this view.[46] Antonio Damasio, a neurologist, also stresses the rationality of emotion in his book Descartes' Error.[47] He emphasizes the importance of gut feelings in making decisions. And while early AI programs were most successful at modeling logical processes, more recent models have gone far beyond this truly artificial approach and some even try to model aspects of emotions. Some programs use emotional scripts or schemas (builti-n information that suggests what is likely to happen in certain situations: for example, in baseball games, classrooms, business meetings) as aids to decision making and action, others try to simulate the processes through which people evaluate or appraise the emotional meanings of stimuli, and still others attempt to make use of our understanding of the emotional brain in order to model how emotions are processed.[48] The logical/illogical or rational/irrational distinction is not a very sharp one when it comes to separating

emotion and cognition, and is certainly not a clean way of defining what a science of mind should be about.

The second reason why emotion was not rehabilitated in the cognitive revolution may have been because emotions have traditionally been viewed as subjective states of consciousness. To be afraid, angry, or happy is to be aware that you are having a particular kind of experience, to be conscious of that experience. Computers process information rather than have experiences (at least by most people's way of thinking). To the extent that cognitive science was the science of information processing, rather than a science of conscious content, then emotion, being an aspect of consciousness, did not necessarily fit comfortably in the program. Recently, though, as we'll see in Chapter 9, consciousness has come to be more and more a part of cognitive science. Consequently, the excuse that emotions are subjective states loses much of its appeal. But the subjective argument should have never carried much weight. There is really nothing more or less subjective about the experience of an emotion than about the experience of the redness of an apple or the memory of eating one. The study of visual perception or memory has not been held back simply because these brain functions have subjective correlates, and neither should the study of emotion.

As we will see in the next chapter, subjective emotional states, like all other states of consciousness, are best viewed as the end result of information processing occurring unconsciously. Just as we can study how the brain processes information unconsciously in perceiving visual stimuli and using visual information to guide behavior, we can study how the brain processes the emotional significance of stimuli unconsciously and uses this information to control behaviors appropriate to the emotional meaning of the stimuli. And just as we hope that studying how the brain processes visual stimuli will help us understand how it creates the accompanying subjective perceptual experiences, we hope that studying how the brain processes emotional information will help us understand how it creates emotional experiences. This does not mean that we will program computers to have these experiences. Instead, it means we can use information processing ideas as the conceptual apparatus for understanding conscious experiences, including subjective emotional feelings, even if such experiences are themselves not computational states of computers.[49] More about this when we get to consciousness in Chapter 9.

So, emotion could have fit into the cognitive framework. The question is whether it should have been included in cognitive science, or, more to the point, whether the boundaries of cognitive science should now be expanded to include emotion, placing all of the mind under one big conceptual tent.

All along some cognitive scientists have recognized that emotion is important. AI pioneer Herbert Simon,[50] for example, argued in the early 1960s that cognitive models needed to account for emotions in order to approximate real minds, and around the same time social psychologist Robert Abelson[51] suggested that the field of cognitive psychology needed to turn toward "hot cognitions," as opposed to the "cold" logical processes that it had been focusing on. Philip Johnson-Laird and George Miller, two leading cognitive psychologists, made a similar point in the 1970s.[52] And recently, Alan Newell, another AI pioneer, writing about emotions, noted, "no satisfactory integration yet exists of these phenomena into cognitive science. But the mammalian system is clearly constructed as an emotional system."[53] These suggestions by leading cognitive scientists have finally begun to have an impact—

more and more cognitive scientists are getting interested in emotions. The problem is, instead of heating up cognition, this effort has turned emotion cold—in cognitive models, emotions, filled with and explained by thoughts, have been stripped of passion (we're going to go into the cognitive theory of emotion and its unfortunate consequences in great detail in the next chapter).

In the final analysis, then, the processes that underlie emotion and cognition can be studied using the same concepts and experimental tools. Both involve unconscious information processing and the generation of conscious content (sometimes) on the basis of this processing. At the same time, though, it does not quite seem right that emotion should be subsumed under cognitive science. The experimental study of the mind should be done in a framework that conceives of the mind in its full glory. The artificial separation of cognition from the rest of the mind was very useful in the early days of cognitive science and helped establish a new approach to the mind. But now it is time to put cognition back into its mental context—to reunite cognition and emotion in the mind. Minds have thoughts as well as emotions and the study of either without the other will never be fully satisfying. Ernest Hilgard, an eminent psychologist, makes the point nicely when he says that sibling rivalry is as important a concept to child development as is the maturation of thought processes.[54] "Mind science" is the natural heir to the united kingdom of cognition and emotion. To call the study of cognition and emotion cognitive science is to do it a disservice.

Minds, Bodies, Emotions

The idea of what the mind is has changed a number of times since the early Greeks, many of whom were preoccupied with rationality, but tended to view the mind as having both knowable and unknowable facets. Descartes redefined the mind to include only what we are aware of, making mind and consciousness the same thing. Since consciousness was viewed as a unique human gift, other animals were treated as mindless creatures. Freud, in formalizing the unconscious as the home of primitive instincts and emotions, helped re-establish a mental link between animals and humans, and began to dethrone consciousness as the sole occupant of the mind. The behaviorists dismissed the whole idea of mind, and took a step that really put animals and people on the same continuum, but one involving behavioral rather than mental functions. Cognitive science resurrected the Greek idea of mind, mind as reason and logic. And because the kind of mental states that were being suggested in the earlier days were based on the rules of logic, which is closely tied up with the human capacity for language, cognitive science was, for some time, not very friendly to the idea of animal minds. The idea of the human mind as a carefully engineered machine seemed more appealing than the idea of the mind as a biological organ with an evolutionary history.

The emergence of ideas about unconscious processing, and the re-realization that mind is more than cognition, again puts major parts of the mental life of humans and other animals on a continuum and encourages cognitive scientists to study mental functions in the context of the machine in which the functions are housed rather than as complete abstractions. Reacting to the functionalist credo that the mind can be modeled independent of knowledge of how the brain works, philosopher Patricia Churchland and computational neuroscientist Terrence Sejnowski have argued, "Nature is more ingenious than we are. And we stand to miss all that power and ingenuity unless we attend to

neurobiological plausibility. The point is, evolution has already done it, so why not learn how that stupendous machine, our brain, actually works?"[55]

The functionalist conception of mind as a program that can run on any machine (mechanical, electronic, biological) has been fairly easy to accept, or at least tolerate, in the area of cognition. The biological machine of relevance to cognition, of course, is the brain. And the idea that the brain is a cognitive computer is now commonplace. However, in emotions, unlike in cognitions, the brain does not usually function independently of the body. Many if not most emotions involve bodily responses.[56] But no such relation exists between cognitions and actions. In the case of cognitively driven responses, the response is arbitrarily linked to cognition. This is partly why cognition is so powerful—cognitions allow us to be flexibile, to choose how we will respond in a certain situation. Such responses are used by but are not essential to the cognition. The capacity to understand language, one of man's highest forms of cognition, and the form of cognition most closely tied to a specific set of expressive responses, works just fine in people who live their lives without being able to express this capacity in speech. In the case of emotion, though, the response of the body is an integral part of the overall emotion process. As William James, the father of American psychology, once noted, it is difficult to imagine emotions in the absence of their bodily expressions.[57]

We know our emotions by their intrusions (welcome or otherwise) into our conscious minds. But emotions did not evolve as conscious feelings. They evolved as behavioral and physiological specializations, bodily responses controlled by the brain, that allowed ancestral organisms to survive in hostile environments and procreate. If the biological machine of emotion, but not cognition, crucially includes the body, then the kind of machine that is needed to run emotion is different from the kind needed to run cognition. Even if the functionalist argument (that the hardware is irrelevant) could be accepted for mind as cognition (and it is not clear that it can), it would not seem to work for the emotional aspects of the mind (since the hardware does seem to make a difference when it comes to emotion).

Programming a computer to be conscious would be an essential first step toward programming it to have a full-blown emotional experience, since the feelings through which we know our emotions occur when we become conscious of the unconscious workings of emotional systems in the brain. However, even if a computer could be programmed to be conscious, it could not be programmed to have an emotion, as a computer does not have the right kind of composition, which comes not from the clever assembly of human artifacts but from eons of biological evolution.

LeDoux' Footnotes

1. This quote was seen on the wall behind the counter at Kim's Underground Video in Greenwich Village in Manhattan.
2. Melville (1930).
3. Bangs (1978).
4. Theories of emotion will be discussed in this chapter and Chapter 3.
5. Fehr and Russell (1984).
6. Plato, Phaedo, cited in Flew (1964).

7. Gardner (1987).
8. Watson (1929); Skinner (1938).
9. Actually, psychology, as a field of science, did not exist until the late nineteenth century, when it emerged in Germany as the experimental study of consciousness [see Boring (1950)]. Before that, mental phenomena were the business of philosophers. And following Descartes' proclamation, "I think therefore I am," mind and consciousness came to be equated in Western philosophical discussions, a trend that was inherited by scientific psychology when it emerged. For a translation of some of Descartes' key writings, see Smith (1958). For a summary of the importance of Descartes' views in forcing the modern equation of mind as consciousness, see Rorty (1979). According to Rorty, mind and consciousness were not such interchangeable ideas before Descartes introduced the notion of an all-knowing soul (consciousness), that had no unknowable (unconscious) aspects. If it wasn't knowable (available to conscious) it wasn't mental. In this way, certain things that we consider mental today (like sensations and some aspects of emotions) were demoted to physical states by Descartes.
10. Ryle (1949).
11. The following summary is based on Gardner (1987).
12. Putnam (1960).
13. Rorty (1979).
14. Lashley (1950b).
15. Neisser (1976); Gardner (1987); Kihlstrom (1987).
16. For example, an abacus is a computer made of sticks and stones. It does calculations using an algorithm or program that is built into its design. For some problems, it is as effective as (and in some instances more practical than) an electronic computer.
17. Kihlstrom (1987).
18. Freud (1925). For a reinterpretation of Freudian concepts in terms of cognitive science, see Erdelyi (1985).
19. Erdelyi (1985).
20. These are sometimes called preperceptual or pre-attentive processes. For example, in visual perception, the determination of the intensity of light reflecting from different parts of a stimulus or the direction of movement of a stimulus occur preconsciously. For a discussion of these processes, see Marr (1982); Ullman (1984).
21. Kosslyn and Koenig (1992); Kosslyn (1983); Kosslyn (1980). For a challenge to Kosslyn's theory, see Pylyshyn (1984).
22. Pinker (1994).
23. Nisbett and Wilson (I 977).
24. However, not everyone agrees with the strong claims made by Nisbett and Wilson. For example, following Nisbett and Wilson's study, Ericcson and Simon (1984) attempted to identify whether there might be some kinds of conscious introspections that could be trusted. After an exhaustive study, they concluded that verbal reports about the state of one's mind can be used reliably to indicate the outcome of a decision (whether one thing is bigger than another, whether you like or dislike something, or

whether you plan to do something) but that such reports are less reliable about the processes leading up to a decision, especially if there is some delay between the occurrence of the process and the report. They emphasized that information in short-term memory is most accessible, allowing for accurate descriptions of processes as they occur or shortly thereafter, but once information decays from or is displaced from short-term memory, accessibility can decline. Some say that since the events that cause a behavior or mental state typically occur right before the behavior or state, we typically have conscious access to causes because the causal events are still in short-term memory, a view sometimes known as folk psychology [see Goldman (1993); Churchland (1984); Arnold (1960); Johnson-Laird and Oatley (1992); Oatley and Duncan (1994)]. However, in my mind, this view is problematic in at least three respects. First, it assumes that all of the stimuli that have significant mental effects occupy short-term memory and thus are noticed and appreciated. As we will see in the next chapter, some things are not noticed but still influence us, and other things are fully noticed but their significance is processed implicitly and not consciously appreciated. This latter point means that stimuli that are consciously perceived can have important unconscious effects, influencing our emotions, goals, and attitudes without our being aware that they are being influenced. Second, it assumes that the stimuli that provoke behavior are what cause it, which is not necessarily the case. Innocuous events can set us off if we are in a bad mood. The mood, more than the eliciting stimulus, is the cause in such situations. Third, it assumes that we can correctly identify from the many stimuli that were available the exact ones that actually elicited the response. Obviously, we are often correct, otherwise life would be chaotic and impossible (incidentally, the chaotic and impossible life of persons suffering from mental illness may represent a breakdown in these mechanisms, either the introspective one, the attribution one, or the balance between them). But whether we are correct about causes because we have introspective access to causal events or because we are very good at attributing cause on the basis of noticing correlations is less clear. Regardless, even if we wholly accept the Ericsson and Simon view, that some aspects of cognition can be characterized on the basis of introspective verbal reports, there remains room for much of the cognitive mind to operate below the tip of the iceberg. For a discussion of some additional issues, see Bowers and Meichenbaum (1984); Miller and Gazzaniga (1984); Marcel and Bisiach (1988). Also, see the June 1992 issue of American Psychologist, which has numerous articles on this topic.

25. Gazzaniga and LeDoux (1978).

26. For summary, see Gazzaniga (1970).

27. These ideas are elaborated on and expanded in Gazzaniga (1985); Gazzaniga (1988); LeDoux (1985).

28. I am grateful to several people for their discussions with me about unconscious processing, including Daniel Schacter, Matthew Erdelyi, John Bargh, and John Kihlstrom. From their comments, and from my own reading of the literature, several methodological problems that plague studies of unconscious processing of stimuli are apparent. One is that much of the work has involved subliminal perception or masking, both of which involve very brief stimulus exposures. This limits the amount of information that can be presented at one time and also limits the amount of cognitive resources that can be dedicated to the processing task. It is likely that the limits of the unconscious found through

such studies reflect, at least to some extent, methodological limitations rather than the real limits of unconscious processing. Another problem with the arguments against the existence of a sophisticated cognitive unconscious is the fact that most of the work has used verbal stimuli (words, sentences) to test processing limits. These are the currency of the systems that are involved in conscious processing, which is an evolutionarily new system. Unconscious processing, on the other hand, is the stock-in-trade of evolutionarily old systems that are likely to be more readily studied with nonverbal measures. Indeed, some of the strongest evidence for unconscious processing comes from studies using pictorial rather than verbal stimuli. These studies will be examined in Chapter 3. Another methodological problem is that of drawing the line between conscious and unconscious processing. Several recent attempts to use more sophisticated analytic techniques to draw the line have been made. Included is work by Merikle, Jacoby, Erdelyi, Bargh, and Kihlstrom (citations below). Each of these concludes that the cognitive unconscious can process significant meanings. Also, as indicated in the text, stimuli that are consciously processed can also be processed by unconscious systems, which may in fact do different things with them; and stimuli that are noticed and attended to can have important unconscious influences because it is their activation of unconscious meanings that is most important, not their physical features. These ideas are elaborated on further in the next chapter. A sampling of citations include: Merikle (1992); Kihlstrom, Barnhardt, and Tataryn (1992); Erdelyi (1992); Bargh (1992); Bargh (1990); Jacoby et al (1992).

29. Bowers (1984); Bowers and Meichenbaum (1984); Bargh (1992); Bargh (1990); Jacoby et al (1992).

30. Posner (1990); Anderson (1990); Kosslyn and Koenig (1992); Gardner (1987).

31. The mind-body problem, the problem of how the mind relates to the brain and the rest of the body, is a deeply troubling philosophical problem. It has always been a thorn in the side of psychology. For a nice summary of the issues involved see Churchland (1984). For a summary of the early impact on psychology, see Boring (1950). The mind-body problem and its relation to cognitive science is discussed in Gardner (1987). Another discussion of the mind-body problem that I like is in Jackendoff (1987).

32. As I was finalizing this book there was a very exciting chess match going on in Philadelphia between grand master Gary Kasparov and a computer. The computer gave Kasparov a run for his money.

33. Gardner (1987).

34. Neisser (1967).

35. Fodor (1975).

36. Von Eckardt (1993).

37. Russell (1905).

38. Fodor (1975).

39. The history of artificial intelligence is nicely summarized in Gardner (1987).

40. The following summary of the work of Johnson-Laird and Kahnemann and Tversky is based on a description in Gardner (1987).

41. Johnson-Laird (1988).

42. Kahneman, Slovic, and Tversky (1982).

43. Frank (1988).

44. Tooby and Cosmides (1990).

45. Goleman (1995).

46. Aristotle (1941); de Sousa (1980); Solomon (1993).

47. Damasio (1994).

48. Dyer (1987); Scherer (1993b); Frijda and Swagerman (1987); Sloman (1987); Grossberg (1982); Armony et al (1995).

49. Johnson-Laird (1988).

50. Simon (1967).

51. Abelson (1963).

52. Miller and Johnson-Laird (1976).

53. Newell, Rosenblum, and Laird (1989).

54. Hilgard (1980).

55. Churchland and Sejnowski (1990).

56. We'll discuss the bodily responses in emotions in Chapters 3—6.

57. James (1884).