CHAPTER

1

History of Learning and Memory

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Learning Objectives

1. Identify the contributions of philosophers to the early study of learning and memory.
2. Understand the basic assumptions of behaviorism.
3. Summarize the major contemporary approaches to the study of learning and memory.
4. Describe the six themes of the textbook.

Overview

Our ability to learn and store what we have learned is a remarkably important capability, pervasive to nearly every aspect of our lives. Consider the following "thought experiment": imagine you had the opportunity to have the vacation of your dreams but would never remember it, or you could have the memory of the vacation but would not have taken the trip at all. Which would you select? Most of us are initially pulled in the direction of wanting the trip but having no memory of it—but, of course, you can see the problem. Having no memory of the trip means the trip will have no influence on us afterwards. No happy memories, no feeling of satisfaction, no photos or videos to share. In fact, we'd probably still be pining to take that trip—the very one we had already had—because we would've forgotten we'd already taken it! It may be counter-intuitive now, but having a memory of the trip, even if a false one, could likely have a larger impact on us than a forgotten journey.

"Buddy O'Dell"

As a young man, my grandfather Delor "Bud" Benoit was a professional boxer who went by the show name "Buddy O'Dell," although he was not Irish (see Fig. 1.1). He credited the violin lessons he was made to take as a child for his early boxing experience—he had to fight off bullies as he was walking to and from lessons while protecting his violin. He fought Jake La Motta in 1942 and lost in a close decision. His boxing experience left him with occasional vision problems, but he was otherwise in very good health. While serving as Seaman Specialist in the US Navy in World War II, his ship, the USS Princeton, was hit by a 500-pound bomb from a Japanese dive bomber. Despite his dislocated shoulder from the blast, he was able to tie a lifeline around a wounded crewmate and lower his body down a stairwell before a lieutenant encouraged Bud to jump off the deck into the ocean. The Princeton continued to burn and secondary explosions began, taking more lives, until rescuing destroyers had to sink it.

FIGURE 1.1 Boxing

Bud was a serious poker player, and (as the family legend goes) he would sometimes travel to Las Vegas and gamble until he had enough money to pay the rent. He was always a smooth, easygoing talker who seemed to be able to hold a conversation with anyone; maybe it was the result of his blue-collar upbringing plus his university experience at Michigan State University on a boxing scholarship. He eventually earned a JD, and spent his career doing administrative work for State Farm Insurance.

Today he is 91 years old and living in a monitored group home for seniors. His health has always been exceptionally good, but gradual

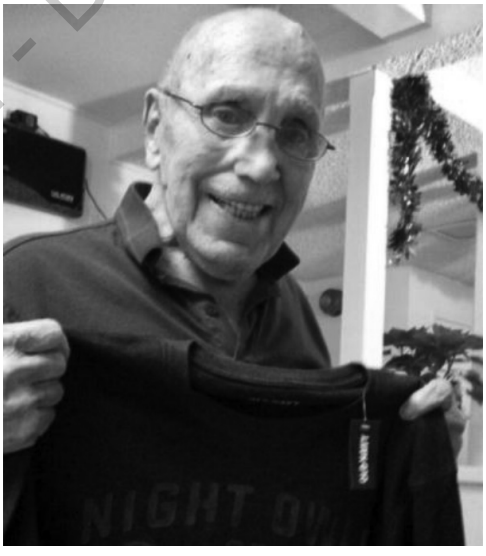
changes to his memory had started to occur. The loss of his memory meant not keeping up with basic home cleanliness. He kept firing the cleaning service his adult daughter (my mother) would hire for him, telling them he could take care of it himself. His dogs would eliminate about anywhere, and he would not remember to clean up after them. His stove had to be replaced after the family found a nest of rats living in the back of it. He came to believe he didn't have enough money to get by, even though he was fairly well off. But he didn't remember. Eventually, scam artists and occasionally his bank would take advantage of his inability to remember his money situation. At one point, family members had to camp outside his house to scare off a woman coming to collect a large sum of money he had promised her as down payment for some future return investment (similar to that Nigerian prince email scam, except that criminals were physically at your home!).

The decision to move Bud from his long-term home was not an easy one for my mother. Even though he adapted to his new surroundings fairly well, he repeatedly asked to return to his old home, since that's what he remembered as his. He once talked a hospital shuttle driver into taking him there instead of his group home. It had been emptied months earlier, and he had no key to get in. By now, despite his acumen for talking people into doing what he wanted, he no longer remembered or recognized family members, including my mother. It's been this way for some time. The loss of memory begins to take away who one was, after a while, and adjusting to new circumstances is difficult.

Recently, my mother arrived at the group home, and Bud met her at the door. He knew her name, and asked her to come in and sit. Once seated, he turned to her and said, "All right. What am I doing here?" In the conversation that followed, my mother and her father had a very lucid conversation about what had been happening to him over the past few years and the decisions that had been made to that point. She explained. He apologized for the trouble he had caused.

It was not to last. By the next visit, he was back to not remembering. He has adjusted to his new home and seems happy, but he remembers little. It is as if, somewhere under the memory loss and likely brain decay, the person I know as my grandfather is still there, unable to get out (see Fig. 1.2).

FIGURE 1.2 Recent



This has become a common story. Many families, particularly those with long-living parents, are running into events like these. While the physical form of the person is still present, and often their habits and even personality remain intact, the loss of memory is catastrophic for individual functioning. The "remembering power" of the brain is so beneficial that its loss is extremely noticeable.

In this book, we will explore what it means to learn and to know. We will explore the vast amount of research on learning and the kinds of memory, the amazing diversity of activities that memory supports, and what happens when memory fails us. My goal is to convince you that, ultimately, we are what we learn and remember. Much of who we are and who we believe ourselves to be is determined not by what precisely has happened to us, but by what we remember of what has happened to us and the stories we believe those remembrances tell. To start our in-depth study of memory, let's examine where the field of study on learning and memory has been and where it is today. We'll start with classic philosophical approaches and then move to more recent, contemporary approaches.

Early Philosophical Approaches

It's understandable to question whether it is worth looking back to earlier centuries to understand what we do today. It doesn't always feel relevant, and instead is like rehashing the past. In this situation though, questions about learning, memory, and the nature of knowledge reach back a long ways. Prior to psychological science, the nature of mind and memory were exclusively in the domain of philosophy and theology. In many cases, the general ideas that philosophers had about learning and memory are still represented in modern theories. So, while delving so far into the past can seem like a detour, what you will find in this section are ideas and relationships that are prescientific, but are around to this day. Having a basic understanding of these ideas will prepare you for the modern research and theory we'll encounter in the next chapters.

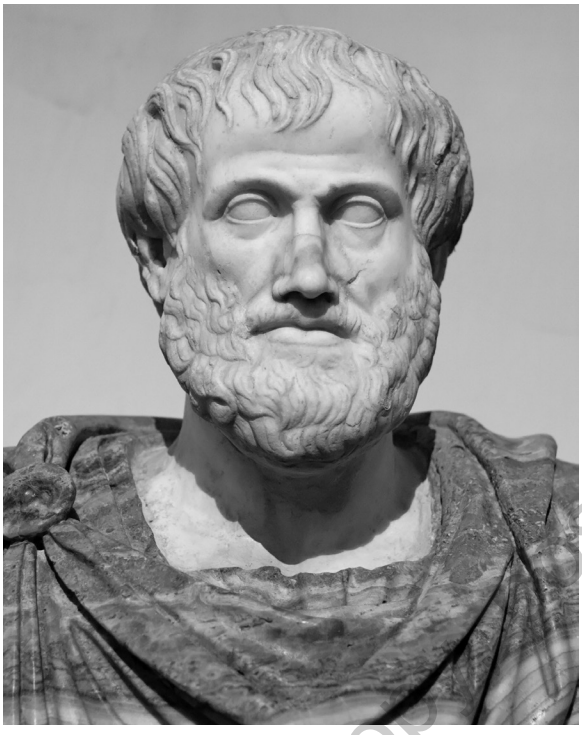
Socrates's Early Functionalism

The Greek philosopher Socrates (469–388 BCE) noted that many objects could be grouped together as "instances" of the same idea even if they do not look alike, such as different chairs. The physical, surface features were not always what mattered. He suggested that objects in our memory are based on their **functions**. That is, objects in memory are stored by the potential function that they may serve. For example, the diversity in what people consider to be "cars" is rather large, but it doesn't seem to take us long to add new models we encounter into a "car" category. Socrates's idea about this conceptualization of how memory for objects works allows that what we remember and know about the world isn't constrained by the physical or material aspects of the real-world objects. Thus, whether a coffee mug is made of ceramic or plastic or steel is irrelevant to our being able to remember what a coffee mug is and to recognize one. Using Socrates's conceptualization of knowledge, one can also recognize a coffee mug as a mug even if it is cracked or chipped. This "functional" approach to explaining how we know what objects are is an approach that is still around today.

Aristotle's Associationism

The Greek philosopher Aristotle (364–323 BCE; see Fig. 1.3) intuited a number of the issues and approaches that were later developed by other philosophers and psychologists.

FIGURE 1.3 Aristotle



He based at least some of his intuitions on the theories of his teacher, Plato (427–347 BCE), who had used various metaphors to try to capture the nature of human memory. Plato had described memory as being like wax, on which impressions could be made. He noted that some people were better at recording memories than others. For some people, it was as if their wax was less pliable. This is an observation that psychologists now often call a matter of "individual differences."

Likewise, Aristotle noted that memory is not particularly static or frozen, but could move; it has a relatively fluid nature. Thinking of one thing can cause one to think of or remember something else. Aristotle proposed that this fluid process of thinking and remembering obeyed a set of rules such as **similarity, contiguity**, and **causal properties**. For instance, remembering one event can remind us of another similar event, hence the term "similarity." We encounter this often in daily life. Thinking of one embarrassing moment makes other related moments seem to come to mind quite readily. Our memories appear to be highly interconnected based on similarity.

Aristotle noted that we tend to associate those events or objects that occur together frequently, which he called his rule of contiguity. Experiencing two events together enough, and we form a connection between them in memory. We associate applause with acknowledgement of a stellar performance. All of marketing is based on this rule: I might like eating cheeseburgers, but with lots of exposure to marketing through billboards and commercials, I have come to associate a large yellow "M" with cheeseburgers.

When we experience an event that reliably produces a certain outcome, we will recall that outcome. This is Aristotle's rule of causal properties. Instead of learning a simple

association between two events, we can decide that one event is causing the other. An infant in a high chair playing with toy keys might be delighted by the sound of dropping the toy keys on the floor (and watching family scurry to pick the toy up). After a while, the infant will become less interested. At that point, the infant presumably can recall the outcome and is less surprised or interested in it.

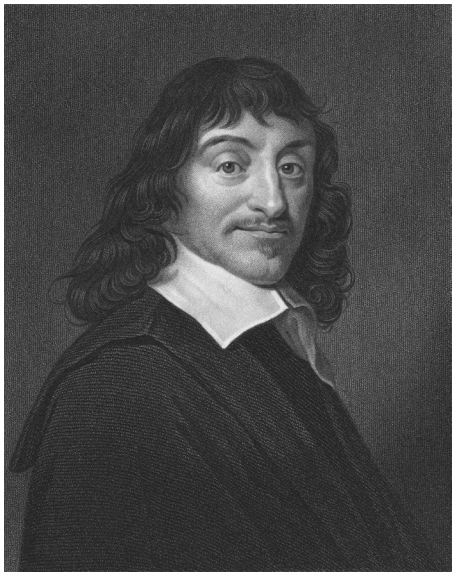
Aristotle also intuited that memory is similar to searching for information—much like clicking around on web pages from the Internet, following from one site to another, following a path between memories. He also believed that concepts were arranged mentally in a hierarchy. That is, there are classes of concepts arranged in levels: some concepts embody a great many other objects, like "furniture," whereas others are of a lower level and are more specific, like "side-table drawer."

In summary, Socrates and Aristotle posited ideas that are foundational to the field today. These include Socrates's idea that the function of what objects do might be what constitutes our knowledge of them, and Aristotle's claim that there are different mechanisms for learning.

Descartes's Dualism

The French philosopher Rene Descartes (1596–1650; see Fig. 1.4) believed that at least some knowledge was innate, that is, with us from birth. In particular, he believed certain abstract concepts could not be sensed directly. For instance, he believed that there is an innate idea of "perfection," and that a supernatural being, "God," embodies all aspects of perfection. He also believed that other abstract concepts we possess—such as time, hope, and infinity—could not be experienced through the senses and, as a result, were most likely innate. Some of these ideas may have been simply capitulations to the powerful Catholic Church system that was present at the time; but other concepts that Descartes believed could not be experienced through the senses, so they had to be internally based.

FIGURE 1.4 Descartes



Hence, he believed that what we sense of the world around us is largely accurate, since our minds have a sense of what perfection is, as well as an understanding of the perfection of the God who created the world.

Descartes famously posited that one could make a distinction between the "mind" and the "body," the physical support for mental activity. He concluded that the human body interacted with an immaterial soul somewhere in the brain. **Neuropsychology**, the study of the workings of the brain and nervous system, is commonly based on prior damage from disease or injury and has a long history that began during this time.

Descartes was a pioneer in his understanding of the mechanical nature of physiology that human and animal bodies function like a kind of machine. During Descartes's time, theory and research into the anatomy began in earnest, mostly through the dissection of animals. The belief that some element of God was embodied in humans did not extend to animals, who were thought not to possess a soul or a consciousness. As a result, animals were primarily thought of as "automata," or machines. This belief was not uncommon in that time. This led to a rise in animal research, primarily to understand the mechanics of physiology and anatomy. Unfortunately, this does mean that little thought or concern was given to the animals that were dissected and cut open, often while awake, during a time when there were no anesthetics.

Locke's *Tabula Rasa*

John Locke, a British philosopher, disagreed with multiple aspects of Descartes's stance on the innateness of ideas (see Fig. 1.5). In contrast to Descartes, Locke (1632–1704) believed all human knowledge comes from experience with the world around us. At birth, we are devoid of ideas—a *tabula rasa*, or blank slate. The mind has two kinds of experiences of the world: sensations of objects and those reflections we have upon our own ideas. We have these impressions immediately in the conscious mind and can recall them later as memories. Locke believed that the same mechanistic approach used to explain

FIGURE 1.5 John Locke

how the human body functions could also be used to explain human thought. In other words, basic or simple ideas could be had by experiencing the world around us—how the sun feels on our skin, or how peanut butter tastes. These simple ideas are like images, are highly sensory in nature, and could not be reduced to any smaller unit of thought since they were just sensory impressions.

If we combine many of these simple ideas or images, they can give rise to more complex ideas, Locke suggested. Experiencing a "book" is the result of a combination of simpler sensory experiences that might involve shape, texture, weight, and temperature. All mental content he believed to be the result of adding different sensory units. The basic view Locke advocated is not terribly different from how a child might build a fairly complex house or space ship from toy building blocks. The simple ideas combined together form more advanced, complex ones. In every instance, however, the idea is made up of sensory elements and is not an abstraction. Locke was not specific about how these ideas were combined or associated, although he clearly believed contiguity and similarity played large roles, as Aristotle had proposed.

So, from Locke's perspective, memories are a copy of earlier sensations. Normal memories, therefore, are fairly accurate since they are a replication of what was experienced. There is an interesting theoretical consequence to this view: if memories are exact copies of direct sensations, then no change or distortion can occur. There can be no misconceptions if memory is simply a copy of a sensory event, like a photocopy made from a copier machine. It is also unclear if memories can have gaps—missing pieces of information—under Locke's approach.

Locke's ideas were extremely influential inside of philosophy. Locke was considered to be an **empiricist**, meaning one who relies on observation and experimentation to support his or her ideas. His beliefs on empiricism drove much of the developing science of the day. Locke's ideas and approach had an impact on psychology as well. His brand of philosophy, **associationism**, that learned connections between different ideas and events are the basis for all thought and meaning, was the foundation for a movement in psychology known as "behaviorism" in early 20th century America. We'll discuss behaviorism as a movement in the next major section (p. XXX), and Chapter 4 is devoted to a major theory of the movement.

In summary, Descartes and Locke exist in a kind of philosophical chokehold. Descartes proposed the existence of innate knowledge for understanding the world and distinguished between the functions of mental activity and the structure of the physical body. Locke, however, took a hard-line, sensory-only approach to learning and memory.

Kant's Interactionism

German philosopher Immanuel Kant (1724–1804; see Fig. 1.6) provided a compromise between Descartes's and Locke's views, seeing both approaches as partially right and partially wrong. A child doesn't have innate, genetic concepts like "car," or "bottle," or "ball" at birth, Kant reasoned; but the child certainly has the biological underpinnings to form those concepts at the right time. The biological structure may include unconscious reasoning skills (like understanding time and space) that allow the child to form these concepts when he or she is ready to understand and learn them. In what is known as Kant's *interactionism*, mind and body interact and influence each other. In modern terms, this is like having the computer hardware and an operating system to allow software and apps to run on it.

From Kant's perspective, we have the biological capacity to interpret the world around us (e.g., eyes, ears, touch, the nervous system). This means the biological system that

FIGURE 1.6 Kant

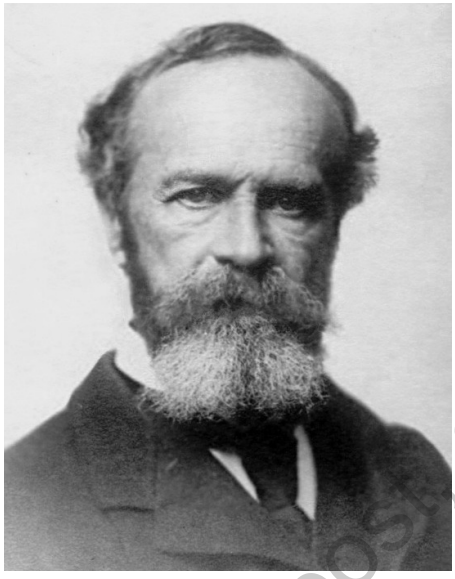
makes up the human body grants the ability to form abstract ideas like "ball" when the human is ready. Of course, if people can interpret stimuli in the environment, then that also means people can misinterpret what goes on around them. I'm reminded of my oldest son, who, as a toddler, refused to eat vegetables. I tried to introduce him to vegetable juice through a colored sippy cup. When I handed the cup to him, he saw the dark-colored liquid in the transparent cup. He announced "Chocolate milk!" and—before I could correct him—proceeded to drink. He was immediately disgusted, and I could never get him to try vegetable juice again. Our interpretations of the external world are, on the whole, quite accurate, but not always perfect. This is a distinct advantage to Kant's ideas over Locke's, which didn't permit distortions based on expectations or misunderstandings.

What one knows of the world, according to Kant, is what one can perceive of it. Our knowledge of the world is constructed in a generally accurate way, but it is not a perfect copy. Kant's view also tolerates those gaps in knowledge that develop from time to time, perhaps when someone is distracted or too fatigued. Additionally, Kant expected that when there are gaps in what is learned and remembered, people could make inferences about what should be there. These ideas are still popular within the field today. Kant used the term **schema** for the abstract knowledge that we mentally form of the external world, and a considerable number of theories have been developed to try to explain the mental structure of the abstract knowledge of the world.

William James's Functionalism

Our last philosopher is, in many ways, at the transition point between philosophy and psychology. Considered to be the founder of American psychology, William James (1842–1910; see Fig. 1.7) wrote one of the most popular textbooks on psychology in his day, although he himself did not like to think of himself as a psychologist. Many of his

FIGURE 1.7 **William James**



topic choices for chapters were prescient of modern topics in psychology despite the coming wave of behaviorism in America. He had a particular view of how people learn that incorporated biological change with development, much like psychologists attempt to do today.

James believed that the nervous system is adaptable and can be modified by experience. Particular motor skills become associated within the nervous system over time as a sequence is learned, so practice is important for learning a particular skill or habit. While he believed the nervous system was flexible, it was so only until age 30. After that, habits become rigid (he was not correct in this regard). Therefore, he believed it was necessary to teach all young people good habits at an early age. He believed that learning the right set of habits could eliminate many social ills, including war, famine, and ugliness. He encouraged all youth to be drafted into the military to develop the necessary habits for later. The idea that learning a particular set of habits will instill a better life is a value many parents encourage in their children, and it is the basis of many self-help books and websites on productivity and happiness.

James was able to clearly define what he meant by a "memory": "knowledge of an event, or a fact which is out of conscious awareness currently," and the awareness "that we have thought or experienced it before" (James, 1890, p. 648). We use memory, according to James, to reproduce those earlier events and facts. These events and facts leave paths or **traces** between nerve centers in the brain. Experience adds to the traces of a memory and strengthens it.

In summary, Kant and James began the process of modernizing conceptualizations of the act of learning and language around the phenomenon of memory. Kant proposed that the biological structure of the human body gives rise to our mental activities, and that we perceive our world around us and build what we know. James successfully promoted the field through a popular textbook on psychology, which included and defined modern topics such as learning through experience and memory.

For the remainder of this chapter, we'll examine the major movements that have contributed to our understanding of how learning and memory work, beginning with the movement that was inspired by Locke's theories, behaviorism.

A Twentieth-Century Approach: Behaviorism

Locke's ideas had an impact on psychology some time later. The behaviorist movement in psychology began in the early part of the 20th century, lasted well into the 1960s, and primarily occurred in the United States. The name **behaviorism** was applied to the movement precisely for how it sounds: the study of how people and animals changed their behaviors due to interactions with their environment. It was strictly focused on observable behaviors as part of a desire to make psychology as a field more of a true science. If a behavior was unobservable, it was unmeasurable, and therefore not worth pursuing. This meant that highly popular topics today, such as consciousness, motivation, dreams, personality, thought, and memory, were not considered to be topics that could be successfully researched.

The behaviorists used Locke's ideas of a blank slate and of associations as the bases of thought and reframed them as **stimulus-response associations**. People form a connection between an event in the environment, like seeing a plate of cooked food, and a response such as hunger. Often the responses of interest were negative emotions: fear, disgust, or anxiety. Behaviorists would not have studied emotions directly, however. Rather, they would have considered them to be merely the words we use to anthropomorphize those situations, at worst, or phenomena that couldn't be studied, at best.

For a major part of the 20th century, research into the mental aspects of the human experience were set aside as American psychologists focused primarily on systems of stimulus-response associations through reinforcements and punishments, with a heavy focus on refining research methodology (primarily through experimentation). While many of the findings that came out of this period have been abandoned as psychology moved on, the techniques for rigorous research design have not been left behind. Behaviorist theories are still applied in a variety of situations, including advertising and marketing, animal training, classroom management, and in therapeutic settings. We'll take a closer look at behaviorists and their approach to learning in Chapter 4.

Contemporary Approaches

Besides the behaviorist tradition, there are three main approaches to the study of learning and memory today. By the 1970s, a renewed interest within American psychology on mental activities meant a shift in focus away from strict behaviorism. First, psychologists took a greater concern for how the social situation affects how we learn. **Social learning theory** (sometimes referred to as **social cognitive theory**) was developed to describe how people learn by watching what happens to others and by imitating the successes others have. The expectations people form for themselves became of interest, since they affect how much effort people will put into an activity.

Second, psychologists began to reconsider whether abstract, unobservable human activities like thought, memory, and attention could be systematically studied after all. **Cognitive psychology** is the study of higher mental activities, such as attention, memory, and thinking.

Finally, technological advances to enable imaging the brain and its functions have led to a greater understanding of the physical basis underlying learning and memory,

or **cognitive neuroscience**. Cognitive neuroscience has the benefit of not necessarily requiring subjects who have suffered brain injury in order to be studied, as **neuropsychology** often does. For just the practical implications of being able to use healthy subjects alone, cognitive neuroscience has generated a lot of excitement for its scientific potential. Because it's important to be able to see where the distinctions between each approach lie, let's take a closer look at each approach.

Social Learning

Social theories of learning advanced past behaviorism by including those aspects of learning that involve the presence of other people, whether real or imagined. For example, **social comparison** is the act of comparing how we performed to the performance of others. From a strict behaviorist perspective, how others perform shouldn't affect our learning, but often it does. When the first exam scores of a class are handed out, people will, sometimes quite surreptitiously, find a way to see how they did in relation to other students. The comparison shouldn't really matter, but it often does. If everyone received a high score, then your score isn't as revealing about your mastery of the material or your capabilities in that area—-it just shows that as a whole, everyone understands the material similarly. On the other hand, if you were the highest or lowest scorer in the class, that tells you something about your situation as well.

A sense of fairness or **equity** can be quite important in situations in which we are evaluated too. Did the students who put in a lot of time and effort in on an assignment tend to earn higher scores than those students who did not? Or do the results appear to be independent of the effort people put in? Both situations send a message about the class.

Expectations also play a large role in motivation to learn and remember. When a parent promises a reward to a child for earning high grades and then reneges on the arrangement later, claiming to have forgotten, this broken promise is remembered. How will the child respond to the next promise? How about a younger sibling, who has watched this exchange play out? When people form expectations about the time and effort involved in doing a task, they examine the outcome with a critical eye to see if it matched what they were hoping for.

One major barrier to learning is the learner's belief about whether or not material can be learned at all. Our **self-efficacy** for the activity, the belief we have about our own ability to perform a task, is highly predictive of whether we will attempt the task, how hard we will persist, and how creative we are at completing it (Pajares & Urdan, 2006). If someone does not believe he or she can accomplish a particular task, then why bother trying?

In sum, social learning theories are those that try to explain human behavior by incorporating not just the component of thought but the social component as well.

Cognitive Psychology

Cognitive psychology is the study of higher mental activities. Cognitive psychology encompasses all psychological research that involves the study of language, attention, acquiring and representing knowledge in the mind, judgment, and decision making. The overarching question of cognitive psychology might be, "How does the mind use information?"

Cognitive psychologists often approach human learning and memory from the perspective of how people process information, **information-processing theories**, or how people think about their own thinking, called "metacognition." Of particular interest for

us is how people try to control their own learning and assess their own memory abilities, a subfield known as *metamemory*.

Information-Processing Theories

A long-standing, fundamental assumption in cognitive psychology is that we can approach the human mind as a high-powered computer, examining its capacity, speed, and abilities in a fairly similar way to how one might talk about technical specification of some hardware for sale in a store. How much can we remember? What helps us to store more information? What helps us to remember, and what gets in our way when we can't? In the past, the information-processing approach was the only option for studying memory in people with normal functioning, since the brain imaging technology simply wasn't developed enough to answer the questions people had. Nowadays this approach often works in tandem with the cognitive neuroscience approach.

Hermann Ebbinghaus (1850–1909) was a pioneer in this approach to mental activity. He took the study of learning and memory from the realm of philosophers and moved it into the realm of psychological science. Adopting an attitude that remains prevalent in psychology today, he explored learning and memory by collecting data on how well people can perform a task, instead of solely theorizing about it. Ebbinghaus's methods are fairly simple by today's standards, but his approach was thorough enough that his results provided insights that are still talked about today. Briefly, Ebbinghaus used lists of "nonsense syllables" in a consonant-vowel-consonant pattern as the stimuli to memorize and try to recall later, such as CEG, TIB, and PAH (Ebbinghaus, 1885/1964). He would monitor how many tries it took to learn a list of nonsense syllables and quiz himself over a period of days to track his forgetting. We'll return to Ebbinghaus and his work in Chapter 7.

Today, modern memory researchers often rely on three key functions or processes to describe aspects of human memory (see Fig. 1.8). **Encoding** is the act of sensing some stimuli in our environment, like light or sound, and extracting the meaning from it in your mind. An example is sensing the shape, color, and texture of an object in a parking lot and then realizing that it is a car that is moving toward you too quickly to be safe. Encoding is a critical process if we are encountering something for the first time. **Storing** is the act of retaining information for a period of time. The information can come in many forms, including images, knowledge, impressions, and feelings. The duration of time can be relatively short, such as a second or two, or it could be a lifetime. As we move forward through this book, we will encounter many instances of memory researchers attempting to study what kinds of information we store, where in the brain, and how the information is organized in the mind. **Retrieval** is the act of attempting to remember some information. Often researchers are interested in trying to understand why some memories are easily recalled, whereas other memories are not. Often researchers will use the word *cues* for those hints that we use to try to retrieve a particular memory, like the search term we might enter into a search engine to find a website.

FIGURE 1.8 **Diagram of the 3 key processes**

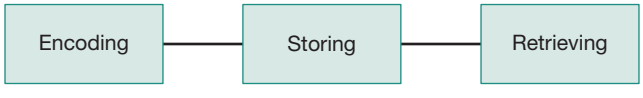
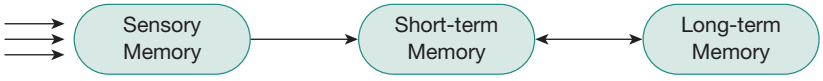


FIGURE 1.9 Diagram of basic Atkinson-Shiffrin model



So, when watching a movie for the first time, we can expect a fair amount of encoding the characters and the plot of the movie, and storing the parts that really caught our attention. Later, we can retrieve some of that information when a friend asks what the movie was like. If these three processes sound like using a computer—that is, entering information, saving a document, and later, opening the file again—that's by design. This analogy of the mind as a computer has been a tremendous benefit to memory research and has stimulated much work and theory over the past few decades.

One particular model of how human memory works emerged from verbal learning research in the 1960's and became so well known that it has been called the "modal" model of memory, meaning the most commonly talked about and referenced. While it is not an active focus of research today, the terms used in this model are now a part of our cultural vernacular. The *Atkinson-Shiffrin model* (Atkinson & Shiffrin, 1968; see Fig. 1.9), named after the people who described it, claims that memory for some stimulus or information will reside in one of three states: a sensory buffer, a short-term memory store, or long-term memory. The sensory buffer is essentially the beginning of the encoding process as a person registers some stimulus within his or her sense systems, such as a voice, and the information is briefly held. Should attention be given to that particular sensation, it will move into what was called short-term memory, where it can be kept mentally active for as long as desired by continually thinking about it. Finally, with enough continual thinking, it could end up being stored for a long period of time, in long-term memory.

Besides its general popularity, the Atkinson-Shiffrin model is a good example of many information-processing theories. First, information is assumed to pass through stages, sequentially. Additionally, these theories may not necessarily be expected or required to have direct mapping onto parts of the brain. These kinds of models are meant to be diagrams of abstract functioning that people seem to do when they think. Of primary interest to cognitive psychologists is what information a person uses when he or she wrestles with an important decision. The mechanics of brain functioning are usually of secondary interest.

The Atkinson-Shiffrin model is still a useful framework for talking about human memory in broad terms. Most, if not all, modern research today targets particular memory phenomena more specifically than this model. Essentially, the field has incorporated it and moved beyond it.

Metamemory Awareness and Strategies

Metamemory is part of an area in cognitive psychology called **metacognition**, or thinking about one's own thinking. Metamemory includes the acts of knowing what our strengths are for learning and remembering, and strategies we might use to help us study. It includes knowing when to stop studying material because we have learned something well enough, as well as when to stop because of frustration. It is an activity we do all the time, yet we may not realize it. Mental activities such as deciding whether

we are better at spelling than grammar, or that to study for a history quiz you need to make flashcards, or that you might have to email the professor to ask for more time on your paper are all examples of thinking about your own thinking in order to decide what to do next. Whenever we are making judgments about different strategies we could use for handling a situation or problem, we are thinking metacognitively.

Miller, Galanter, and Pribram's (1960) test-operate-test-exit model (TOTE) was the model of metacognition that broke cleanly away from behaviorist approaches to learning and remembering. Behaviorists had assumed that learning was primarily a matter of learning a particular response to some external stimulus; little or no evaluation or thought was required on the part of the individual at all. The TOTE model claims that what people do when engaging in an activity is to see whether the situation is currently what we want (a "test"), then make a change ("operate"), check again to see if we have arrived at the goal state (another "test"), and if so, leave this process ("exit"). This is repeated as long as necessary. For example, when using an automatic car wash, the act of driving the car to the right spot within the facility (where the front tires stop at the bumper and the electric signs change to a red "STOP") requires some monitoring: "Am I there yet? How about now?" TOTE models metacognitive activity. It's easy to imagine how the TOTE model might be used while learning. "Do I understand this chapter?" or "How much of this to I need to memorize?" or "What really are the main points of this section?" are all metacognitive questions relating to memory and are metamemory questions.

Flavell, Friedrichs, and Hoyt coined the term "metamemory" in 1970. Research questions for metamemory studies include investigating people's confidence for learning material. Are we ever too confident? What strategies, if any, do people use to remember important information? How does our ability to judge our memories change from childhood, to adulthood, to old age? Any time you talk to other students about strategies for succeeding in a particular class or for a particular assignment, metamemory is involved.

Cognitive Neuroscience

Research into the mechanics of the brain and nervous system, essentially the hardware that "runs" the human mind, has continued well past the techniques Descartes used. Instead of exclusively relying on patients or animals who had suffered injuries, researchers can now take images of the brain in action. Neuroscientists study the brain at the cellular and molecular levels in order to describe theoretical, metabolic structures of the brain that give rise to different brain functions. Neuroscientists focus on (1) neurons, the primary building blocks of the central nervous system; (2) the gaps between the neurons; and (3) the chemicals that are used to facilitate communication between neurons.

Neuroscientists use a variety of techniques. The use of **neuroimaging** to see the brain as it operates is relatively new, but it has much potential for altering the course of study for learning and memory research. Sometimes neuroscientists will activate single neurons to study how they behave, a technique called **single-cell recording**—although usually their focus is on how groups of neurons work together. In some studies, **mind-altering drugs** are used to study how neurons communicate across synapses.

Integrating the Approaches

A major challenge for psychologists and neuroscientists has been attempting to integrate across fields. Social learning and cognitive psychology research have been mutually reinforcing, since both use behavioral assessments for data, and researchers in each area have

similar training. Neuroscience and cognitive psychology have been more challenging to integrate, for philosophical and practical reasons, which are discussed next.

Descartes's theorizing about the mind-body problem has had one unexpected ramification. By conceptually splitting the functions of the "mind" from the actions of the "body" and hence the brain, psychologists have pursued describing the mind in their own fashion while cognitive neuroscientists have pursued documenting brain activity in theirs. One major issue stemming from these two focal areas is that cognitive psychologists and neuroscientists tend to have different educational backgrounds and training. This is a broad generalization, but neuroscientists approach the study of the brain from a metabolic "systems" perspective. They are looking to see what the neural underpinnings of mental activities are by identifying where they are housed and how those mental activities are supported. Cognitive psychologists, while interested in the neural basis for their theories, tend to take a "process" approach—looking for theories that focus on how the mind allows people to function. Today, with the ability to image the brain, there is a greater desire to **map** or connect cognitive models of learning and memory to an underlying neural structure. This has presented new challenges in the incongruence between how the two camps study and theorize about their ideas.

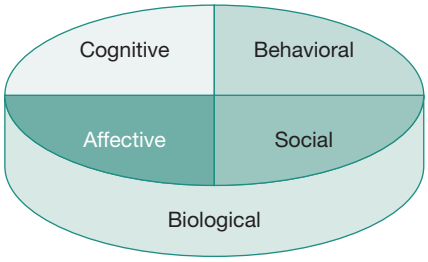
Consider the Atkinson-Shiffrin model of memory stores, described above. This model of cognitive processes behind memory has similarities with other cognitive models (Weldon, 1999). The flow of information through the model is sequential. That is, information works in a stepwise fashion. Information is stored in one stage at a time, and not spread out across different stages simultaneously. Information is transferred from one stage to the next, computationally, as a computer might be programmed to do. This model is primarily constructed to describe at an abstract level the functioning that should be going on in the mind based on behavioral data. No assumptions about the biology underneath the model are claimed.

For a period of time, cognitive neuroscientists were hoping to find one-to-one connections between the models that cognitive psychologists were creating and their own findings. But our understanding of the brain has evolved in the past several decades quickly. While the psychological functioning of the brain can be described in sequential models like the Atkinson-Shiffrin model, the mechanical functioning of the brain itself isn't sequential or as easily compartmentalized as cognitive models tend to be. The brain is a fairly dynamic and interconnected processing machine, which makes finding a neural basis for sequential, stage-like cognitive theories difficult, if not completely impossible.

So, the role that neuroscience plays in psychological science and the relationship between it and cognitive psychology are still being clarified. Perhaps the cognitive psychologists are best at identifying *what* the mind does, and the neuroscientists uncover *how* the brain affords what the mind can do. Some cognitive psychologists believe that the behavioral research that they do must come first, with the neuroscience following it later (Toth & Hunt, 1999).

Overall, neuroscience techniques are contributing to psychological science in three major ways. First, human abilities to learn and remember can be mapped to specific parts of the brain, documenting the mechanisms behind existing theories. Second, neuroscience techniques can provide constraints or limits to existing theories. Using behavioral research, such as experiments, psychologists are relatively free to propose whatever brain functioning they might imagine is operating behind a particular theory. With neuroscience evidence, it's possible to find that a theory is either physically impossible or that the brain is not activating in accordance to the theory, which is fairly strong evidence that

FIGURE 1.10 The four primary approaches to learning, with a biological basis underneath



the theory is flawed. Third, neuroscience techniques can be used to generate new theories of human functioning based on patterns of brain activity that existing theory may not have accounted for.

This simple diagram may help clarify matters when thinking about the state of psychological science. There have been four general approaches or "frames" to the study of human and animal behavior in psychology. Psychologists approach human behavior from either behavioral, cognitive, social, or affective perspectives (see Fig. 1.10). Each of these approaches dictates the pertinent variables of interest and occasionally the most preferred kinds of research. There are no firm boundaries between them; each acts as a kind of shorthand for grouping related theories and concepts.

Behavioral approaches to learning focus solely on the actual movements of a learner. Social learning takes into account the presence of others and to whom we give the credit for our learning (ourselves or the situation). Cognitive theories of learning focus entirely on the mental processing that occurs to encode, retain, and retrieve information. Emotions and our motivations play a clear role in learning as well. Underlying each of these approaches, of course, are the biological structures that support the organism's capabilities.

Ultimately, each approach has strengths and limitations to what it can bring to describe and explain the range of activities that make up what we call "learning." In fact, it's not uncommon to see modern theories try to bridge more than one approach, and they will often be called "social-cognitive" or "cognitive-behavioral" theories.

Themes in the Book

These themes will be reoccurring throughout the textbook, and they give an indication of what we will find as we take a closer look at the immense amount of research on learning and memory.

1. There are different kinds of learning (cognitive, behavioral, social), and our emotions and motivations play a role in what we learn and store.
2. We are constantly learning, even when we are not aware of doing so. That is, learning occurs at multiple levels of awareness.
3. The brain is the basis of and gives us several separate memory systems.

4. Complex memories are stored all over the brain, across layers as well, not in any one spot, or even in one system.
5. The human memory system's best trait—learning the gist or "take away" message of an event or some material—can be its biggest weakness.
6. The context of learning helps us to remember, but it can limit our ability to recognize when our knowledge will be useful.

CHAPTER SUMMARY

Philosophers posited a number of ideas that are still with us today. One is the distinction between memories of sensory experiences and abstract ideas. Some philosophers proposed that the purpose or meaning of a particular object, its function, is what defines an object, more than its actual structure. Ideas may be formed through the association or connection of several events or ideas to each other. Descartes was responsible for making the distinction between the mind and the body, a distinction between mental function and physical structure; but it was Kant who reconnected them by explaining how the physical form gives rise to the capabilities for mental abilities and understanding. Locke believed that all knowledge was a combination of sensory experiences in some form; but Kant asserted that we construct our understanding of the world instead, which means it is an interpretation and can be inaccurate. William James defined memory as knowledge of an event that we currently do not have in conscious awareness, and he used the term "traces" to describe the paths of memories across centers of the brain.

The approaches that will be the focus of this book are: **behavioral theories of learning** (Chapter 4), **social learning theories** that examine the role of others (Chapter 5), **cognitive learning theories** that take either an information-processing approach or metamemory approach (Chapter 7), **emotional and motivational influences** on learning and memory (Chapter 6), and **cognitive neuroscience** attempts to account for the biological underpinnings of human learning and memory (Chapter 3).

REVIEW QUESTIONS

1. Of the following philosophers, which do you think were the most far apart in their views about memory? Aristotle, Descartes, Locke.
2. Which of the philosophers seemed to represent the most contemporary view of what you know about learning and memory so far?
3. What is the single defining idea behind "behaviorism" and its approach to learning and memory?
4. How are social learning theories an advance from behaviorism?
5. What is the single defining idea behind an "information-processing" approach to learning and memory?

KEY TERMS

Associationism 000
Behavioral theories of learning 000
Behaviorism 000
Causal properties 000
Cognitive learning theories 000
Cognitive neuroscience 000
Cognitive neuroscience 000
Cognitive psychology 000
Emotional and motivational influences 000
Empiricist 000
Encoding 000
Equity 000
Expectations 000
Functions 000
Information-processing theories 000
Map 000
Metacognition 000
Metamemory 000
Mind-altering drugs 000
Neuroimaging 000
Neuropsychology 000
Retrieval 000
Schema 000
Self-efficacy 000
Similarity, contiguity 000
Single-cell recording 000
Social cognitive theory 000
Social comparison 000
Social learning theories 000
Social learning theory 000
Stimulus-response associations 000
Storing 000
Traces 000

FURTHER RESOURCES

- Weblink: A large collection of materials about and by William James
- Weblink: The William James Society
- Weblink: B. F. Skinner, Interviews on YouTube

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