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1 INTRODUCTION

LEARNING OBJECTIVES

1. Explain the growth of cognitive psychology as a field of study, including the differences between behaviorism, the information-processing perspective and the early development of artificial intelligence.
2. Discuss the benefits of close cooperation between the fields of cognitive psychology, cognitive neuroscience, and artificial intelligence.

Cognition can be defined simply as the study of the mental operations that support people's acquisition and use of knowledge. Both the acquisition and the use of knowledge involve a variety of mental skills. If you glanced at the table of contents at the beginning of this book, you saw a list of some of these skills. Psychologists who study cognition are interested in topics such as how people recognize patterns, store information in memory, use language, solve problems, and make decisions.

The purpose of this book is to provide an overview of the field of **cognitive psychology**. The book summarizes experimental research in cognitive psychology, discusses the major theories in the field, and relates the research and theories to situations that people encounter in their daily lives—for example, reading, driving, studying, designing products, solving problems in the classroom, and making decisions.

Most students are surprised to learn how much of their everyday lives is driven by cognitive processes. One major area of interest to both students and cognitive psychologists is how to improve learning—a topic that will run throughout several chapters in the text. Another important area of interest is marketing applications of cognitive psychology. For example, manufacturers spend a great deal of time trying to make their products visually distinctive and therefore easier to find on a store shelf—a direct extension of research conducted in *visual attention*.

cognitive psychology The study of the mental operations that support people's acquisition and use of knowledge

Further business applications include manipulating pricing and discounts to influence *decision-making* in purchasing—in fact, a great deal of economics is based on decision-making research.

A great deal of law and public policy has also been formulated directly from research in cognitive psychology. In a dramatic instance of law extending from cognitive research, the New Jersey Supreme Court set down a decision outlining the only legal ways in which police officers can interrogate eyewitnesses that is based entirely on research regarding the fallibility of memory (*State v. Henderson,* 2011). In the 21st century, cognitive psychology research has had other wide-ranging impacts, from the operation of airport screening checkpoints to the safe operation of subway systems to the design of roadways and sidewalks. A section on the applications of cognitive psychology occurs at the end of every chapter.

In addition to the important ways in which cognition influences our everyday lives, how we live our lives has equally important implications for our cognitive functioning. We are learning more every year about how our diet, exercise, and sleep influence critical cognitive functions such as memory and our risk for cognitive decline as we grow older. Stress, anxiety, and depression are all influenced by our lifestyles, and these in turn can have negative effects on cognition. Similarly, both prescribed and recreational drugs can influence cognition in a variety of ways that are both positive and negative.

Cognitive skills are needed in a wide variety of professions that I discuss in my book *Cognitive Skills You Need for the 21st Century* (Reed, 2020b). The book begins with the World Economic Forum's *Future of Jobs Report 2018* that asked executives at some of the world's largest employers to report on the latest skills and human investment trends in their industries (www.weforum.org). The industries include advanced materials and biotechnology, consumer and financial services, healthcare, information and communication technologies, infrastructure and urban planning, mining and minerals, transportation, travel and tourism, and professional services. Skills that will be trending in 2022 include analytical thinking and innovation, learning strategies, creativity and originality, critical thinking and analysis, reasoning, and complex problem solving. I analyze these skills in greater depth in this text. Before delving into these topics, let's take a brief look at the history of cognitive psychology.

THE GROWTH OF COGNITIVE PSYCHOLOGY

It is difficult to pinpoint the exact beginning of any field of study, and cognitive psychologists would likely offer a wide variety of dates if asked when cognitive psychology began. James's *Principles of Psychology*, published in 1890, included chapters on attention, memory, imagery, and reasoning. Kohler's *The Mentality of Apes* (1925) investigated processes that occur in complex thinking. He and other Gestalt psychologists emphasized structural understanding—the ability to understand how all the parts of a problem fit together (the Gestalt). Bartlett's book *Remembering: A Study in Experimental and Social Psychology* (1932) contained a theory of memory for stories consistent with current views. There are some other important articles or books that seemed modern but did not cause a major shift in the way cognitive psychology is currently studied.

One book that had a major impact on psychological research was Watson's *Behaviorism* (1924). The book's central theme was that psychologists should become more objective by studying only what they could directly observe in a person's behavior. Watson's argument lent support to a **stimulus-response (S-R)** approach, in which experimenters record how people respond to stimuli without attempting to discover the thought processes that cause the response. The S-R approach is consistent with Watson's view because the stimulus and the response are both observable. Watson's book contributed to basing psychology on a more objective foundation of scientific observations. A limitation of the S-R approach, however, is that it does not reveal what the person does with the information presented in the stimulus.

By contrast, the information-processing approach seeks to identify how a person transforms information between the stimulus and the response. The acquisition, storage, retrieval, and use of information comprise separate stages, and the information-processing approach attempts to identify what happens during these stages (Haber, 1969). Finding out what occurs during each stage is particularly important when a person has difficulty performing a task because the psychologist can then try to identify which stage is the primary source of the difficulty. Information-processing models continue to have a major impact on our understanding of cognitive processes (Jarecki et al., 2020).

Information Processing Gathers Momentum

Changing allegiance from a behavioral to a cognitive perspective required taking risks, as Miller (2003) points out in his personal account of the early years of the cognitive revolution. Miller (1951) wrote in the preface to his own book on language (*Language and Communication*) that the bias of the book was behavioristic. In 1951, he still hoped to gain scientific respectability by swearing allegiance to behaviorism. His later dissatisfaction with behaviorism resulted in the 1960 creation, with Jerome Bruner, of the Center for Cognitive Studies at Harvard. The cognitive emphasis at the center reopened communication with distinguished psychologists abroad, such as Sir Frederic Bartlett in Cambridge, England; Jean Piaget in Geneva, Switzerland; and A. R. Luria in Moscow, Russia. None of these three had been influenced by the behaviorism movement in the United States and therefore provided inspiration for the cognitive revolution.

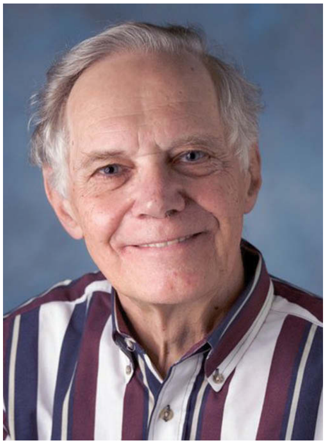

PHOTO 1.1 Ulric Neisser's 1967 book *Cognitive Psychology* contributed to establishing the field of cognitive psychology.

Credit: Cornell University

Ulric Neisser's 1967 book *Cognitive Psychology* provided a clear explanation of the information-processing perspective. He defined cognitive psychology as referring "to all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used." This definition has several important implications. The reference

stimulus-response (S-R) The approach that emphasizes the association between a stimulus and a response, without identifying the mental operations that produced the response to a sensory input implies that cognition begins with our contact with the external world. Transformation of the sensory input means that our representation of the world is not just a passive registration of our physical surroundings but an active construction that can involve both reduction and elaboration. Reduction occurs when information is lost. That is, we can attend to only a small part of the physical stimulation that surrounds us, and only a small part of what we attend to can be remembered. Elaboration occurs when we add to the sensory input. For example, when you meet a friend, you may recall many shared experiences.

The storage and the recovery of information are what we call memory. The distinction between storage and recovery implies that the storage of information does not guarantee recovery. A good example of this distinction is the "tip of the tongue" phenomenon. Sometimes we can almost but not quite retrieve a word to express a particular thought or meaning. Our later recall of the word proves the earlier failure was one of retrieval rather than one of storage. The word was stored in memory; it was simply difficult to get it back out. The last part of Neisser's definition is perhaps the most important. After information has been perceived, stored, and recovered, it must be put to good use—for example, to make decisions or to solve problems.

Neisser's *Cognitive Psychology* (1967) brought many of these ideas together into a single source; other books on cognition followed as cognitive research and theories began to gather momentum in the 1970s. For instance, research on categorization in the 1960s had focused on a concept identification paradigm in which categories were defined by logical rules, such as category members consist of all geometric forms that are either circles or large.

The predominant criticism of the concept identification paradigm was that real-world categories, such as clothes, tools, and vehicles, are unlike the categories studied in the laboratory. A dramatic change in how psychologists viewed real-world categories had to wait until the 1970s when Eleanor Rosch (Photo 1.2) and her students at the University of California, Berkeley, began to study the characteristics of real-world categories (Rosch, 1973). Her ideas and research were so important that they deserve the extensive coverage they receive in Chapter 9 on Categorization.

PHOTO 1.2 Eleanor Rosch made major contributions to our understanding of the organization of real-world categories.

Source: Photo of Eleanor Rosch available at https://en.wikipedia.org/wiki/Eleanor_Rosch#/media/File:Eleanor_Rosch.jpg, licensed by CC0 1.0 Universal (CC0 1.0) Public Domain Dedication

Cognitive psychology currently has widespread appeal among psychologists. Almost all psychologists studying perception, attention, learning, memory, language, reasoning, problem solving, and decision-making refer to themselves as cognitive psychologists, even though the methodology and theories vary widely across these topics. A caveat is that most of the initial contributions to the cognitive revolution were made by men because of the lack of women psychologists in academia during the time this revolution occurred. There are important exceptions, such as Eleanor Gibson's (1969) contributions to perception discussed in Chapter 2 on Pattern Recognition and Anne Treisman's (1960) theory discussed in Chapter 3 on Attention (Photo 1.3).

As a whole, the psychology field has also historically lacked racial and ethnic diversity. American Psychological Association data from 2015 showed 86% of psychologists in the U.S. workforce were white. In contrast, only 14% were from other racial or ethnic groups. Psychology is becoming more diverse as more racial and ethnic minorities enter the field, and cognitive psychology in particular is diversifying as it becomes more international, but more progress needs to be made.

PHOTO 1.3 Anne Treisman's theory of attention advanced the information-processing approach for studying cognitive processes. Here, she is pictured receiving the National Medal of Science from President Obama.

UPI / Alamy Stock Photo

Higher Cognitive Processes

The information-processing analysis of perception and memory was accompanied in the late 1950s by a new approach to more complex tasks. The development of digital computers after World War II led to active work in **artificial intelligence**, a field that attempts to program computers to perform intelligent tasks, such as playing chess and constructing derivations in logic (Hogan, 1997). A seminar held at the RAND Corporation in the summer of 1958 aimed at showing social scientists how computer-simulation techniques could be applied to create models of human behavior. The RAND seminar had a major impact on integrating the work on computer simulation with other work on **human information processing**.

One consequence of the RAND seminar was its influence on three psychologists who spent the 1958–1959 academic year at the Center for Advanced Study in the Behavioral Sciences at Stanford University. The three—George Miller, Eugene Galanter, and Karl Pribram—shared a common dissatisfaction with the then-predominant theoretical approach to psychology, which viewed human beings as bundles of S-R reflexes. Miller brought with him a large amount of material from the RAND seminar, and this material—along with other recent work in artificial intelligence, psychology, and linguistics—helped shape the view expressed in their book, *Plans and the Structure of Behavior* (Miller et al., 1960).

The authors argue that much of human behavior is planned. A **plan**, according to their formulation, consists of a list of instructions that can control the order in which a sequence of operations is to be performed. A plan is essentially the same as a program for a computer. Because the authors found it difficult to construct plans from S-R units, they proposed a new unit called TOTE, an abbreviation for Test-Operate-Test-Exit. A plan consists of a hierarchy of TOTE units. Consider a very simple plan for hammering a nail into a board. The goal is to make the head of the nail flush with the board. At the top of the hierarchy is a test to determine whether the goal has been accomplished. If the nail is flush, one can exit. If the nail sticks up, it is necessary to test the position of the hammer to determine which of two operations, lifting or striking, should be performed.

The ideas expressed by Miller, Galanter, and Pribram were influenced by earlier work in two areas outside psychology. The work of Newell et al. (1958a) in the area of artificial intelligence identified strategies that people use to perform complex tasks such as playing chess. A second major influence came from linguist Noam Chomsky, who argued that an S-R theory of language learning could not account for how people learn to comprehend and generate sentences (Chomsky, 1957). His alternative proposal—that people learn a system of rules (a grammar)—was consistent with Miller, Galanter, and Pribram's emphasis on planning.

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artificial intelligence The study of how to produce computer programs that can perform intellectually demanding tasks

human information processing The psychological approach that attempts to identify what occurs during the various stages (attention, perception, short-term working memory) of processing the stimulus

plan A temporally ordered sequence of operations for carrying out some task

cognitive science The multidisciplinary study of cognition through such fields as psychology, philosophy, artificial intelligence, neuroscience, linguistics, and anthropology

COGNITION'S RELATION TO OTHER FIELDS

Cognitive psychology is part of a broader field of study labeled cognitive science. **Cognitive science** is the study of intelligence in humans, computer programs, and abstract theories, with an emphasis on intelligent behavior as computation (Simon & Kaplan, 1989). It attempts to unify views of thought developed by studies in psychology, linguistics, anthropology, philosophy, artificial intelligence, and the neurosciences (Hunt et al., 1989).

There are several landmarks in the development of the field (Nunez et al., 2019). The journal *Cognitive Science* began publication in 1977, and the Cognitive Science Society was formed in 1979. In 1986, the first PhD-granting cognitive science department was created at the University of California, San Diego. Don Norman played a major role in the creation of the journal, the Cognitive Science Society, and the first PhD-granting cognitive science department.

Nunez and his coauthors nonetheless argue that the field as a whole has lost impetus, focus, and recognition. Instead of becoming an interdisciplinary field, it has become a multidisciplinary field. A multidisciplinary field makes use of the theoretical perspectives of the different

PHOTO 1.4 Don Norman at the University of California, San Diego, helped establish the multidisciplinary field of cognitive science.

Don Norman.

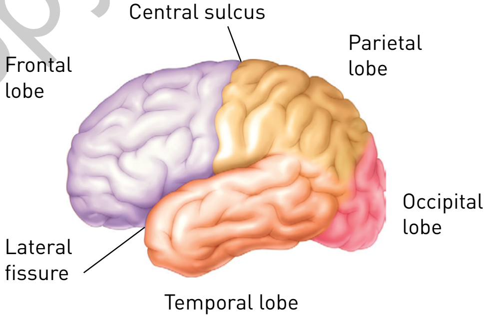
disciplines without integration. In contrast, interdisciplinary theories are more coherent and integrated. A multidisciplinary field refers to a collection of disciplines without cohesive interaction among them (Nunez et al., 2019).

Gentner (2019) agrees that the field has not converged on unified theories but argues that this is not a departure from the goals of its founders. She applauds the multidisciplinary approach to cognitive science and believes that it should be preserved and celebrated. Both the multidisciplinary and interdisciplinary approaches have made valuable contributions to cognitive science, as documented in the remainder of this chapter.

Cognitive Neuroscience

An exception to a lack of integration among fields within cognitive science is the field of cognitive neuroscience, which combines the methodology and theories of cognitive psychology with the methods of neuroscience. Throughout the text, we will examine the relationship between specific brain areas and cognitive functions. Much of this will focus on the **neocortex,** which consists of the four lobes of the brain shown in Figure 1.1. Processing of visual information occurs in the *occipital lobe*, which is the sole function located in this brain region. The *parietal lobe* is specialized for dealing with the body and spatial information (where things are in the world, including the body). Damage to this area can result in difficulty with movement as well as loss of attention. The *temporal lobe* is essential for understanding language and contributes to recognizing complex visual patterns, such as faces. The *frontal lobe* receives sensations from all the sensory systems and contributes to planning motor movements. Damage to this area can also interfere with memory.

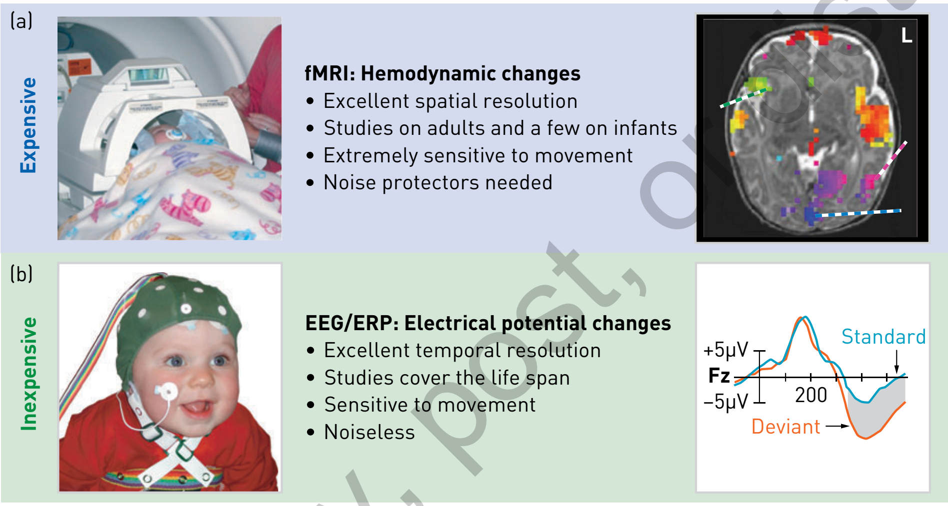
FIGURE 1.1 ■ Some Major Subdivisions of the Left Hemisphere of the Neocortex.



neocortex Layers of the cerebral cortex that are involved in higher-order brain functions, such as perception, cognition, motor commands, and language

As technology has advanced, the ability of scientists to measure brain activity has also advanced. **Positron emission tomography (PET)** uses radioactive tracers to study brain activity by measuring the amount of blood flow in different parts of the brain (Posner & Rothbart, 1994). A more recent and widely applied method, **functional magnetic resonance imaging (fMRI)**, uses magnetic fields to measure blood flow (Figure 1.2a). It is a popular method of neuroimaging in adults because it provides high spatial-resolution maps of neural activity across the entire brain. However, the loud noises and sensitivity to movement limit its use with infants (Kuhl & Rivera-Gaxiola, 2008).

FIGURE 1.2 ■ Functional Magnetic Resonance Imaging (fMRI) and Event-related Potentials (ERP) Provide Spatial and Temporal Measures of Brain Activity.



Source: From "Neural substrates of language acquisition," by P. K. Kuhl & M. Rivera-Gaxiola, 2008, *Annual Review of Neuroscience, 31*, 511–534.

A limitation of spatial imaging techniques such as PET and fMRI is that they do not provide the precise temporal information that is necessary for analyzing many cognitive processes in which fractions of a second are theoretically important. Recording electrical activity from the scalp provides temporal precision on the order of milliseconds. The use of these **event-related potentials (ERPs)** allows scientists to study the time course of mental operations. The vertical axis of the graph in Figure 1.2b displays voltage changes and the horizontal axis displays time in milliseconds (Kuhl & Rivera-Gaxiola, 2008).

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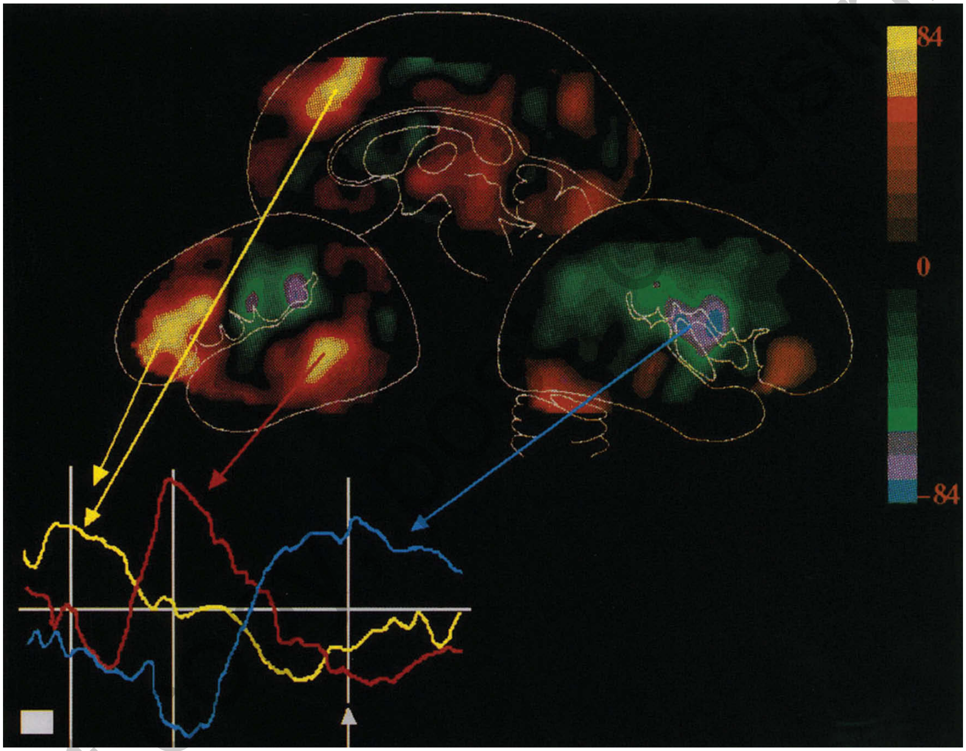
positron-emission tomography (PET) A diagnostic technique that uses radioactive tracers to study brain activity by measuring the amount of blood flow in different parts of the brain

functional magnetic resonance imaging (fMRI) A diagnostic technique that uses magnetic fields and computerized images to locate mental operations in the brain

event-related potential (ERP) A diagnostic technique that uses electrodes placed on the scalp to measure the duration of brain waves during mental tasks

By combining PET and ERP studies, it is possible to take advantage of the more precise spatial localization of imaging techniques and the more precise temporal resolution of electrical potentials (Posner & Rothbart, 1994). Figure 1.3 illustrates how both techniques help scientists comprehend how people understand written words (Snyder et al., 1995). The red and yellow areas show increases in blood flow, indicating that the frontal and temporal areas of the left hemisphere are important for understanding the meaning of the words.

FIGURE 1.3 ■ A PET Scan Showing Changes in Blood Flow in the Left Hemisphere During a Cognitive Task. Brain Waves Show When Activation Occurs.

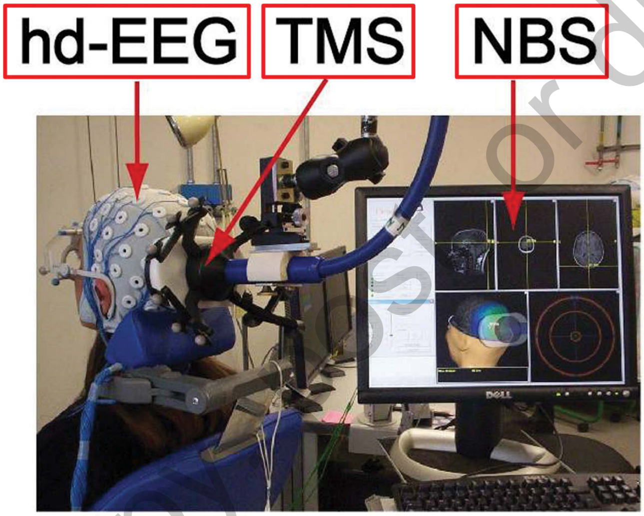


Source: From "Scalp electrical potentials reflect regional cerebral blood flow responses during the processing of written words," by A. Z. Snyder, Y. G. Abdullaev, M. I. Posner, & M. E. Raichle, 1995, *Proceedings of the National Academy of Sciences USA*, *92*, 1689–1693.

The arrows connect PET blood-flow changes with the ERP waveforms recorded at the nearest overlying electrode on the scalp. The activation in the frontal part of the left hemisphere (yellow) leads the activation in the temporal part (red) by several hundred milliseconds. These findings imply that the earlier frontal activation is important for encoding the meaning of individual words and the later temporal activation may be more important for the integration of word meanings to understand phrases and sentences (Snyder et al., 1995). This hypothesis is consistent with the finding that damage to the temporal area of the left hemisphere often produces a language deficit that leaves the person unable to combine words to produce meaningful ideas.

Remarkably, it is possible to not only record ERPs but to directly change them (Widhalm & Rose, 2019). Transcranial magnetic stimulation produces a high-intensity magnetic field that passes through the scalp and causes neurons to fire. The effects of the stimulation are observed not only through changes in behavior but through changes in brain activity that reflect cognitive processes that contribute to that behavior (Widhalm & Rose, 2019). Figure 1.4 displays a brain stimulation system that navigates and targets **transcranial magnetic stimulation** on a 3D construction of the participant's brain. An EEG cap measures the electric field induced by transcranial stimulation and estimates its intensity on the cortical surface (Rosanova et al., 2012).

FIGURE 1.4 ■ A Navigation Brain Stimulation System (NBS) Measures Brain Waves (EEG) Produced through Transcranial Magnetic Stimulation (TMS).



Source: From "Combining transcranial magnetic stimulation with electroencephalography to study human cortical excitability and effective connectivity," by M. Rosanova, S. Casarotto, A. Pigorinni, P. Canali, A. G. Casali, & M. Massimini, 2012, *Neuromethods, 67*, 435–457.

Cognitive neuroscience is particularly interesting to cognitive psychologists when it helps them evaluate cognitive theories (Yarkoni et al., 2010). For instance, we will see in Chapter 8 that one of the classic debates in cognitive psychology is the role of visual imagery in cognition. How do we know when people are using visual imagery to perform a task? Cognitive neuroscience has helped answer this question by allowing psychologists to study which part of the brain is active when people perform spatial reasoning tasks. Evidence for the use of visual imagery occurs when the same part of the brain is activated (the occipital lobe) as is activated during visual perception.

transcranial magnetic stimulation (TMS) A brain stimulation technique in which electrical pulses produced by a magnetic field cause neurons to fire in a focused region of the brain

Artificial Intelligence

In their chapter on artificial intelligence (AI) in *The Cambridge Handbook of Intelligence,* Goel and Davies (2020) propose that, from an AI perspective, the construct of intelligence is not limited to humans or even animals but includes any type of intelligent system including computers. AI implements information-processing theories that describe intelligence in terms of the content, representation, access, use, and acquisition of information. It is helpful for exploring the benefits and limitations of different ways of representing and organizing knowledge in memory. It is also helpful for exploring how robots interact with the physical world through perception and action.

There are two major paradigms for designing intelligent computers, according to the authors. Engineering AI attempts to design the smartest possible intelligent systems regardless of whether the systems reflect intelligence found in people. The vast majority of AI research on robotics and machine learning falls into this category. In contrast, psychological AI attempts to design systems that think like people.

Goel and Davies (2020) describe a paradox in which tasks that are relatively easy for computers, such as producing logical proofs and playing chess, are difficult for humans. Tasks that are relatively easy for humans, such as perceiving, walking, and talking, are difficult for computers. The goal of general AI is to make computers proficient at a wide range of tasks, including those that are easy for humans.

There are at least three benefits of close cooperation between cognitive psychologists and people working on AI (Reed, 2019). The first is that computational programs in AI can serve as potential theoretical models in cognitive psychology. An early collaborative effort between a cognitive psychologist (Alan Collins) and a computer scientist (Ross Quillian) resulted in the hierarchical network model described in Chapter 10 to represent semantic organization in human memory (Collins & Quillian 1969). But it was human problem solving (Newell & Simon, 1972) that introduced many new ideas into cognitive psychology that is described in Chapter 13.

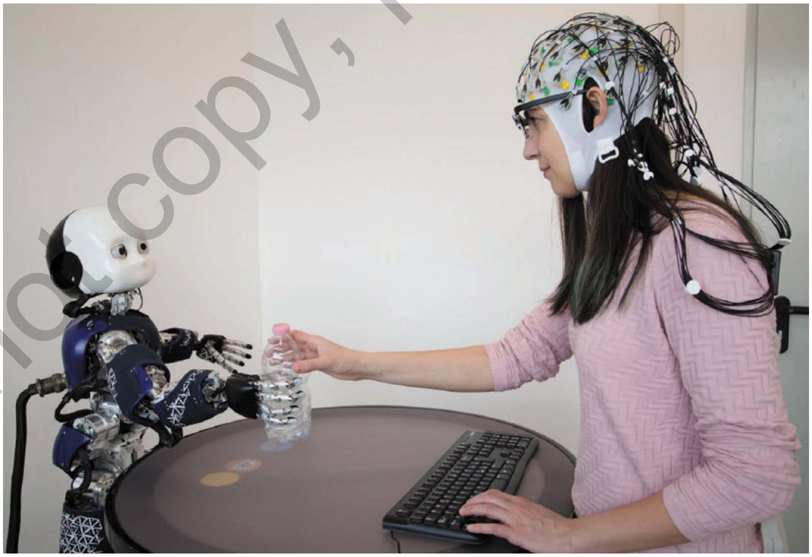
A second benefit is that AI and cognitive psychology share common interests, such as developing methods for categorizing patterns. In his book *The Master Algorithm: How the Quest for the Utimate Learning Machine Will Remake Our World,* computer scientist Pedro Domingos (2015) explains different methods used in machine learning. Cognitive psychologists have developed similar methods to evaluate models of how people categorize patterns (Reed, 2019). The *Master Algorithm* asks how these different methods can be combined to improve performance, a challenge for both AI and cognitive psychology.

A third benefit of building bridges between AI and cognitive psychology is that the increasing impact of AI in our lives requires understanding how technology and people can work together. For instance, it is likely that robots will soon enter our lives as assistants in workplaces, shops, airports, healthcare, and classrooms (Wykowska, 2021). They will also serve as tools for generating new hypotheses, predictions, and explanations regarding human cognition. Robots offer the possibility of greater experimental control over initiating and responding to interactions with people (Figure 1.5).

PHOTO 1.5 Alan Newell (left) and Herb Simon (right) at Carnegie Mellon University applied concepts in artificial intelligence to model human cognition.

Getty Images/Bill Pierce

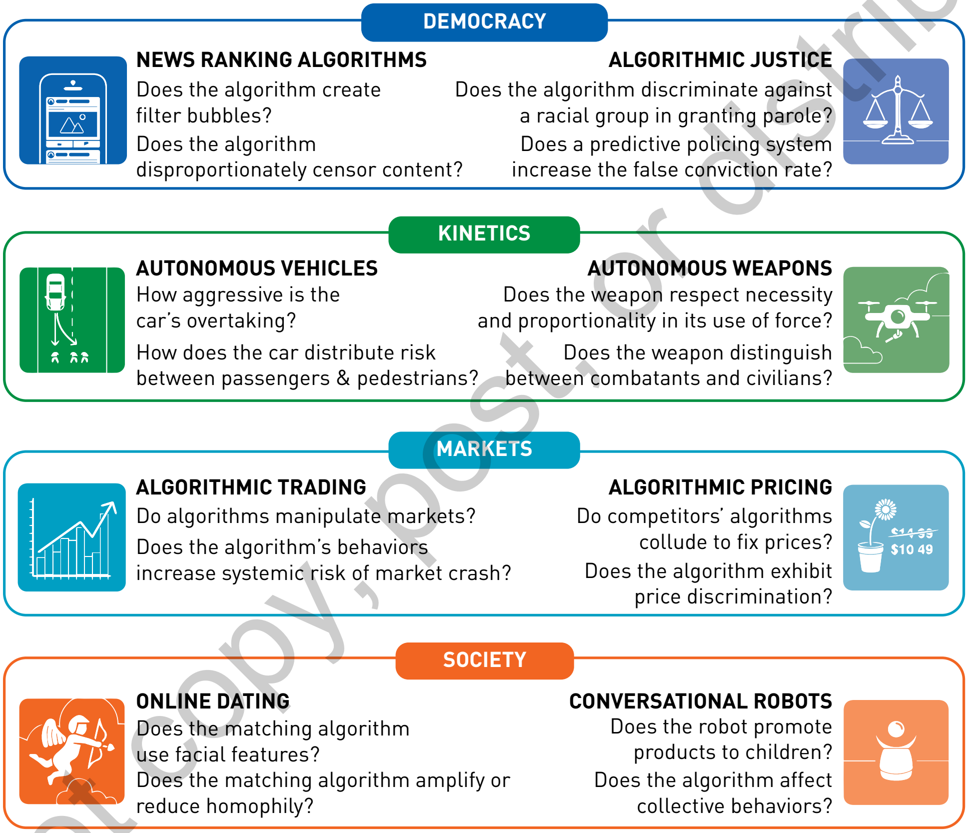
FIGURE 1.5 ■ An Experiment that uses Behavioral Measures, Evoked Potentials, and Eye Tracking to Record the Interactions between a Participant and the Robot iCub.



Source: From "Robots as mirrors of the human mind," by A. Wykowska, 2021, *Current Directions in Psychological Science, 30*, 34–40.

Although AI is already having a major positive impact on our lives, it can also have a negative impact, which has raised concern about its ethical usage. Many of the questions raised in Figure 1.6 are concerns about the social consequences of algorithms (Rahwan et al., 2019). Do they disproportionally censor content? Do they discriminate against racial groups? Do weapons use appropriate amounts of force? Do competitors collude to fix prices? These types of questions are increasingly being asked in and out of courtrooms.

FIGURE 1.6 ■ AI Algorithms that Impact People's lives.



Source: From "Machine behavior," by I. Rahwan et al., 2019, *Nature*, *568*, 477–486. https://doi.org/10.1038/s41586-019-1138-y

Cognitive Architectures

A landmark in the history of artificial intelligence was a book published by Alan Newell (1990) titled *Unified Theories of Cognition*. Unified theories should ideally be able to explain all aspects of cognition, including perception, learning, memory, problem solving, and decision-making. Such explanations require specifying interactions among the various components of cognition.

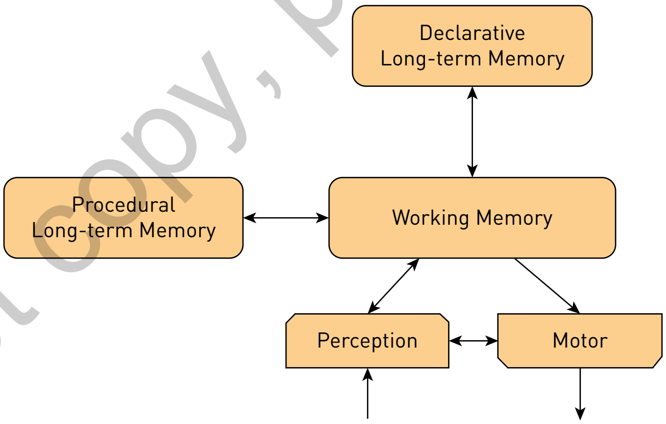
Newell proposed a theory of how these components interact by developing a **cognitive architecture** called Soar (Newell, 1990).

Soar continues to be developed by the AI community (Laird, 2012), but its greatest contribution to cognitive psychology has been its influence on the development of ACT-R (Anderson, 1983)—a cognitive architecture for modeling human cognition. ACT-R assumes that cognitive architectures should be a theory of how behavior is generated through information processing that includes perception and action (Ritter et al., 2019). It has demonstrated how many aspects of cognition are intertwined, such as perception, memory, and problem solving. A manual, summer school, and workshops have supported building a community of cognitive scientists who have used the architecture to model cognition.

A limitation of ACT-R is its complexity; hence the need for summer school and workshops. Participants in a 2013 symposium on integrated cognition, sponsored by the Association for the Advancement of Artificial Intelligence, therefore met to develop a standard model of the mind based on a stripped-downed cognitive architecture. A standard model would be helpful because artificial intelligence, cognitive psychology, cognitive neuroscience, and robotics all contribute to our understanding of intelligent behavior but each from a different perspective. A standard model would provide a common framework for unifying these disciplines and guide practitioners in constructing a broad range of applications.

Figure 1.7 shows the components of the proposed standard model (Laird et al., 2017). Perception converts sensory stimuli into representations that can be stored in working memory or directly converted into actions by the motor component. Attention limits the amount of

FIGURE 1.7 ■ The Standard Model of the Mind.



Source: From "A standard model of the mind: Toward a common computational framework across artificial intelligence, cognitive science, neuroscience, and robotics," by J. E. Laird, C. Lebiere, & P. S. Rosenbloom, 2017, *AI Magazine*, *38*, 13–26.

cognitive architecture An integrated system of cognitive components for modeling cognition available perceptual information in both situations. Working memory provides a temporary storage space where perceptual information can be integrated with information from long-term declarative and long-term procedural memory. Declarative memory is the store for facts and concepts. Procedural memory contains knowledge about actions. The motor component uses the body to execute the actions.

You will learn much more about each of these components as you progress through the book, and the standard model will help relate these components. The authors of the standard model propose that it has the potential to provide a platform for the integration of theoretical ideas across different disciplines. I hope that including it in this text will help fulfill that goal.

SUMMARY

One reason for studying cognitive psychology is that cognitive processes influence many aspects of our lives. It differs from behaviorism by its emphasis on mental representations and procedures, such as replacing stimulus-response associations with hierarchical plans. Cognitive psychology is a member of a multidisciplinary field labeled "cognitive science," which also includes linguistics, anthropology, philosophy, artificial intelligence, and cognitive neuroscience. The interaction between cognitive psychology and cognitive neuroscience is the best example of an attempt to create an interdisciplinary field in which disciplines interact with each other. The objective of the standard model of the mind is to encourage more interdisciplinary interactions based on a shared cognitive architecture. The next five chapters discuss the components of this architecture—perception, working memory, long-term declarative memory, long-term procedural memory, and action.

RECOMMENDED READING

Readers interested in how major theoretical approaches influenced the history of psychology should read Heidbreder's (1961) *Seven Psychologies.* The book contains chapters on prescientific psychology, the beginning of scientific psychology, the psychology of William James, functionalism, behaviorism, dynamic psychology, Gestalt psychology, and psychoanalysis. *The Mind's New Science: A History of the Cognitive Revolution* (Gardner, 1985) and *How the Mind Works* (Pinker, 1997) provide very readable accounts of the evolution of cognitive psychology. The article "A framework for building cognitive process models" (Jarecki et al., 2020) demonstrates how information-processing models continue to influence the field. Chipman's (2016) introduction to cognitive science appears in the *Oxford Handbook of Cognitive Science*, which she edited. *Cognitive Skills You Need for the 21st Century* (Reed, 2020b) contains 20 short chapters on themes related to this topic. *How We Learn: Why Brains Learn Better Than Any Machine... for Now* (Dehaene, 2020) an overview of many issues discussed in this textbook.