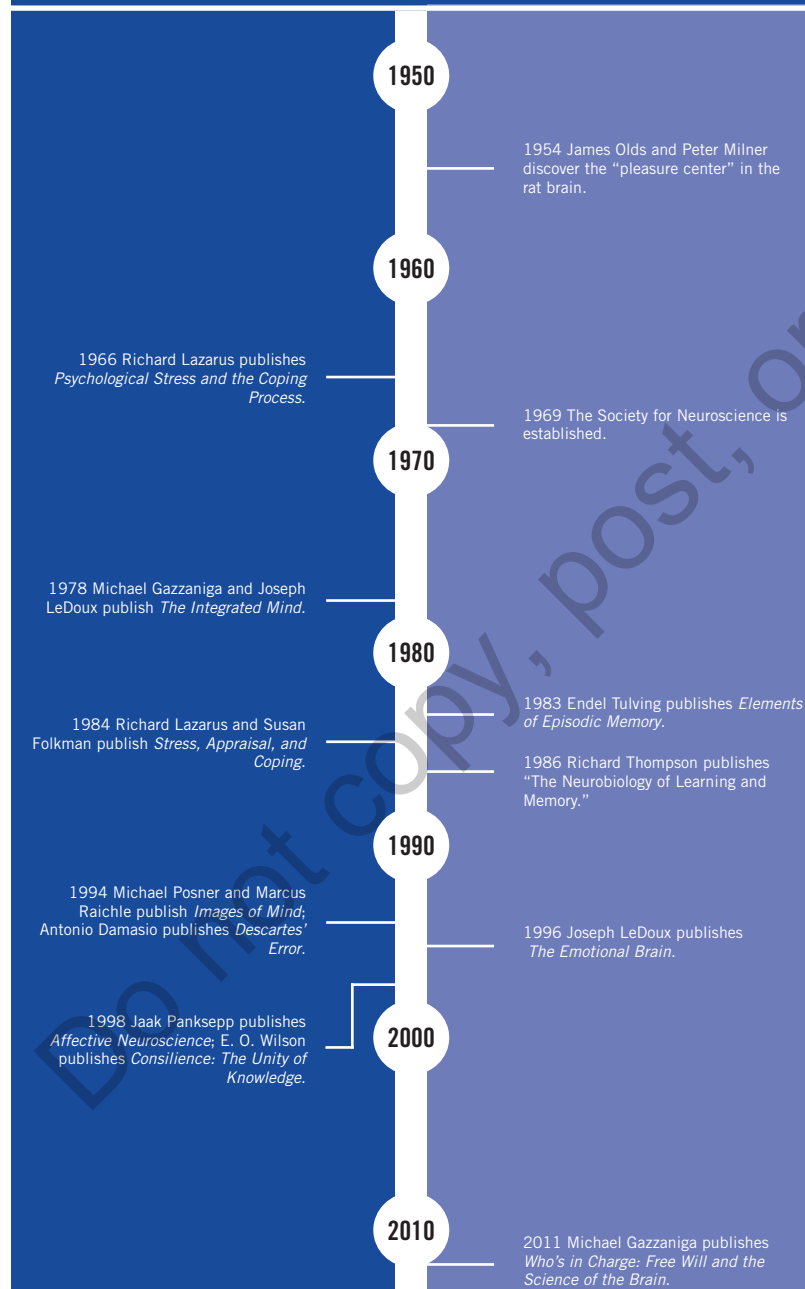


Timeline



Learning Objectives

After reading this chapter, you should be able to:

- Evaluate the contributions of behavioral neuroscience to our understanding of the brain processes that underlie motivation and learning.
- Appraise the merits of cognitive neuroscience in revealing associations between localized brain activity and cognitive processes such as memory and attention.
- Assess the potential for affective neuroscience to contribute to the fields of clinical and health psychology.
- Critique the various scenarios that philosophers of science have envisioned for the future of neuroscience and psychology.

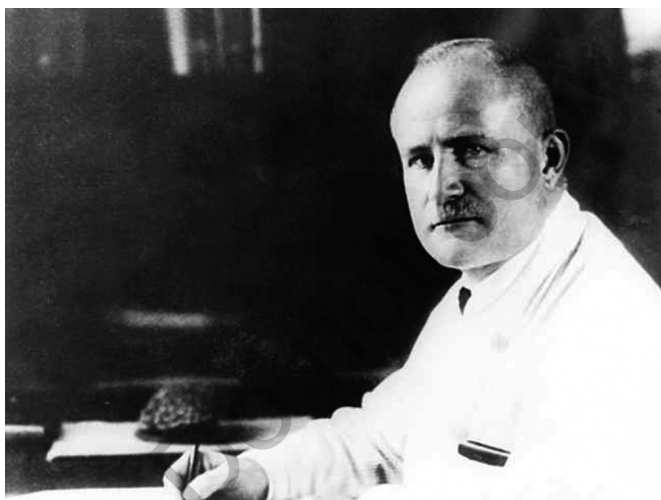
Looking Back

The scientific study of brain functioning goes back at least to the middle of the nineteenth century (Borck, 2016). As medical knowledge advanced, patients who suffered traumatic brain injuries often survived for years afterward, and changes in their cognitive or behavioral abilities were associated with the location and extent of their lesions. In the middle decades of the twentieth century, physiological psychologists created surgical brain lesions in rats and other animals to test hypotheses about brain functioning. But what they lacked was a method of observing brains as they functioned in real time. Thus, it was the invention and diffusion of brain recording and brain imaging techniques after World War II that led to the birth of modern-day neuroscience.

Many historians credit the German psychiatrist Hans Berger (1873–1941) as the first researcher to directly observe activity in a normally functioning human brain (Sannita, 2017). Working alone in the early decades of the twentieth century, Berger invented **electroencephalography**, or EEG. This is *a technique for recording electrical activity produced in the brain by placing a set of electrodes on the scalp*. At the time, physiologists were already making recordings by surgically inserting electrodes into the brains of animals, but the general consensus was that no meaningful patterns of activity could be observed at the scalp. In fact, Berger did find meaningful patterns, even with the crude instruments he had available. For instance, he found one rhythm of activity in brains at rest (which he called *alpha waves*) and a different pattern in brains at work (which he called *beta waves*). When Berger published his findings in 1929, they were ignored at first, but eventually physiologists replicated his findings, and this generated great excitement in the scientific community. At this point, however, World War II broke out, and EEG research was set aside.

After the war, researchers turned their attention once again to the EEG, making some important discoveries (Borck, 2005). For instance, it was found that the brain cycles through a series of distinct stages during sleep, each marked by a specific rhythm of electrical activity, including a special stage in which we dream. Moreover, the EEG proved useful in detecting anomalies in brain functioning, and today it's a standard diagnostic tool in cases of brain trauma. However, as an instrument for exploring how the brain worked, EEG left much to be desired. Although it produced a continuous readout of brain activity as it occurred, it was virtually impossible to tease out specific processes or locations. Nevertheless, it held out hope that more effective brain recording and brain imaging techniques could be developed as technology advanced.

The term “neuroscience” was first used in the name of an interdisciplinary research program started at MIT in the 1960s (Borck, 2016). The idea quickly caught on, and the Society for Neuroscience was established in 1969, thus marking the establishment of the new discipline. Early studies in neuroscience mainly relied on the standard physiological techniques of making lesions and inserting electrodes into the brains of animals, but by the 1980s brain imaging technologies such as PET and MRI were being developed that enabled neuroscientists to observe human brains in action. As these techniques were perfected, they led to what can only be called the Neuroscience Revolution, raising the discipline to the dominant position it holds in psychology today.



Wikimedia Commons

Photo 16.1
Hans Berger

Behavioral Neuroscience

When the interdisciplinary field of neuroscience was first created, behaviorism still dominated American psychology. Thus, it should come as no surprise that the early work in

this field focused on *the study of the brain processes underlying motivation and learning*. This approach became known as **behavioral neuroscience**. Relying mostly on lesions to disrupt brain tissue and electrodes to stimulate it, the early behavioral neuroscientists demonstrated that a science of brain and behavior was feasible.

Richard Thompson

Karl Lashley was the scientific hero of **Richard Thompson** (1930–2014) ever since he first learned about his work in an introductory psychology class (Shors, 2015). Lashley (Chapter 10) had devoted much of his career in search of the engram—the hypothetical location in the brain where a memory is stored. In the end, Lashley failed to find the engram and came to the conclusion that it didn't exist. With the benefit of better technology, however, Thompson picked up the search for the engram, and after decades of dedicated research he and his students finally isolated the complete neural path for a conditioned response. Furthermore, he found it in a part of the brain Lashley would never have suspected. For this, Richard Thompson is remembered as the *American behavioral neuroscientist who isolated the engram and demonstrated the role of the cerebellum in learning and memory*.

Thompson earned his Ph.D. at the University of Wisconsin in 1956, working with a number of notable physiological psychologists, including Harry Harlow (Patterson, 2011). From the beginning, his research interests focused on how the structure of the nervous system changes as a result of learning. For more than a decade, he studied the processes of habituation and sensitization in spinal reflexes. Although they're innate responses, reflexes can either decrease in strength (habituation) or increase in strength (sensitization) due to repeated stimulation. While these studies were important contributions, even more important was that they gave Thompson the experience he needed to embark on a search for the engram, which dominated the middle decades of his career. This shift in research direction occurred when one of the postdoctoral fellows in his lab introduced him to a new technique for studying classical conditioning.

In 1986, Thompson published the research article “The Neurobiology of Learning and Memory” in the prestigious journal *Science* (Knowlton, 2016). He made two bold claims in this article. The first claim was that he'd traced the neural pathway of a conditioned response from sensory inputs to motor output, including the exact location that linked the stimulus with the response. In other words, he'd located an engram. The second claim was that this engram was situated in a most unexpected location, namely the cerebellum. Until that time, it was believed that the cerebellum played a role in maintaining balance and locomotion, and no one suspected that it was also involved in the higher processes of learning and memory. However, Thompson provided overwhelming evidence for his claims, and his critics were soon convinced. The story of this discovery is fascinating in its own right, and furthermore it illustrates how research was conducted in the early days of behavioral neuroscience.

In Search of the Engram

As we learned in Chapter 5, a common technique for studying learning in both human and nonhuman animals is eyelid conditioning (Foy & Foy, 2016). This is a classical conditioning procedure that pairs an auditory tone with a puff of air that makes the subject blink. In 1962, Isidore Gormezano, a former classmate of Thompson's at Wisconsin, constructed a device for conditioning the blink response in rabbits. It consisted of a narrow cage that held the rabbit so it couldn't move. A tube to deliver puffs of air was adjacent to one of the rabbit's eyes, and a loudspeaker above the cage played the tone. A sensor was also attached next to the rabbit's eye to measure blinks. This device could automatically condition the rabbit to blink to the tone by repeatedly pairing it with air puffs.

A few years later, a postdoc named Michael Patterson worked with Gormezano using the device (Patterson, 2011). Sometime later, Gormezano introduced Patterson to Thompson, who offered him a fellowship in his lab. After he joined Thompson's lab, Patterson told him

about the eyelid conditioning device and offered to construct one for him. Once Thompson saw how efficiently it worked, he understood this could be the tool he needed to search for the engram—that is, the exact location in the brain where the memory of the eyeblink response was stored.

Thompson's approach was quite straightforward (Foy & Foy, 2016). He assigned a different part of the brain to each research assistant in his lab, who trained rabbits on the eyeblink response and then used various techniques to see which parts of the brain became active during the task. This was largely accomplished with electrodes inserted into the brain that measured electrical activity at the target area.

When a region of interest was identified, it was further tested with a **lesion study** (Foy & Foy, 2016). This is *a research technique that involves damaging a specific portion of the brain and observing any subsequent deficits*. In addition to brain surgery, lesions could be created by passing a strong electric current through the target area, injecting a poisonous chemical, or even through a blast of air passed through a narrow tube inserted into the brain. The disadvantage of creating lesions was that the animal was permanently damaged. However, by the 1970s neuroscientists had several methods for producing “temporary” lesions. One technique involved surgically introducing a small tube into the target area of the brain. When chilled water was run through the tube, the target area shut down, but warm water brought it back to working temperature. Another technique used a chemical that temporarily numbed the brain. Either technique provided the researcher with a “switch” to turn a specific portion of the brain on and off at will. Electrodes inserted into the site could also be used to stimulate the region of interest, and any resulting behavior was noted.

A brain region that originally looked promising was the hippocampus (“Gold Medal,” 2010). Neuroscientists already knew from the work of Brenda Milner (Chapter 10) with the patient H.M. that the hippocampus was involved in the formation of long-term memories. Thompson's lab found that the hippocampus was quite active during eyeblink conditioning. However, even rabbits whose hippocampus had been removed were still able to learn the response without problems. Only in the case of long delays between the conditioned stimulus (the tone) and the unconditioned stimulus (the air puff) was the hippocampus necessary for learning the response. Eventually, this promising lead turned into a dead end.

Other members of Thompson's team found activity in the cerebellum during eyelid conditioning, and it soon became the focus of research in the lab (Foy & Foy, 2016). During the early 1980s, Thompson published a number of articles reporting on his lab's findings that the engram for the blink response seemed to be in the cerebellum. However, it took several years—and many rabbits—to pinpoint the exact location. Eventually, they found the engram was located in the interpositus nucleus of the ipsilateral cerebellum—that is, the same side as the conditioned eye. In addition, Thompson's team traced the neural pathway of both the conditioned tone stimulus and the unconditioned air puff stimulus from sensory input to the interpositus nucleus, as well as the neural pathway from the interpositus nucleus to the motor centers that generate the blink response.

In follow-up studies, Thompson's team found that they could create a conditioned eyeblink response without learning (Shors, 2015). Using electrodes, they repeatedly stimulated the neural pathways of the conditioned and unconditioned stimuli. Afterward, the rabbit blinked when it heard the tone, without having the prior experience of a subsequent air puff. This result provided further evidence that the interpositus nucleus was indeed the engram of the conditioned eyeblink response.

Thompson's research on the conditioned eyeblink response breathed life into the nascent field of behavioral neuroscience (Baudry & Swanson, 2011). He demonstrated that it was possible through painstaking and methodological testing to discover the biological links between brain and behavior. As a result, he inspired a generation of fledgling neuroscientists to commit to research careers with the goal of unraveling the mysterious connection between learning and the nervous system. Finally, Thompson gave psychologists hope that the age-old mind-body problem could be solved at last.

James Olds and Peter Milner

As a graduate student at Harvard, **James Olds** (1922–1976) studied motivation with Richard Solomon (Thompson, 1999). When he read Donald Hebb's *The Organization of Behavior*, he asked to do a postdoctoral fellowship with him at McGill University in Montreal. Hebb gave him free rein, but the person who most influenced Olds was Peter Milner, a graduate student in the lab. Working together, they made a chance discovery that helped define the field of behavioral neuroscience for decades. Today, James Olds is known as the *American psychologist who discovered the reward center in the brain along with Peter Milner*.

When Olds arrived at McGill, Milner showed him a device he'd constructed for administering mild electric currents to the brains of freely moving rats (de Haan, 2010). For several decades, physiological psychologists had electrically stimulated the outer surface of the brain to map its functional areas. More recently, some researchers had also been experimenting with surgically implanting needle-thin electrodes deep into the brains of rats. Using sensitive equipment to guide the electrode into place, the rat was left with a small piece of metal protruding from its skull, to which a wire could be attached for delivering the current. Prior research using this method had established the hypothalamus as a drive center for hunger, thirst, and sex. Olds and Milner thought they would explore a brainstem region known as the reticular formation, which was believed to be involved in arousal.

The skill with electrical devices that **Peter Milner** (1919–2018) displayed had come from his previous career as an electrical engineer (White, 2018). Born in England, he served during World War II on a project developing radar, and his assistant was a young psychologist from Cambridge named Brenda. The two fell in love, and when Peter was offered a position in Canada, they got married so she could accompany him. As you already know from Chapter 10, Brenda Milner did her Ph.D. with Donald Hebb and gained fame as the neuroscientist who studied the patient H.M. After learning about the fascinating work his wife was doing, Milner decided that he'd rather spend his career studying the brain than designing electrical components. Hebb accepted Peter Milner as a graduate student after he'd completed a year of undergraduate psychology, and he was in his third or fourth year when James Olds arrived. Today, Peter Milner is known as the *British-Canadian psychologist who discovered the reward center in the brain along with James Olds*.

As Olds (1956) tells the story, he and Milner had surgically implanted the electrode into their first rat early in the week, and they planned to begin testing the following Monday. On Sunday morning, Olds stopped by the lab to make that sure the rat had fully recuperated and that the equipment was working properly. He hooked the rat up to the wire and placed it in the test box, which had four corners labeled A through D. When the rat wandered into corner A, Olds pressed the button to release a brief electric current. The rat stayed put for a moment, wandered away from the corner, and then quickly returned. Olds zapped it again each time it approached corner A. Soon, it was staying put in that corner, but Olds coaxed it over to corner B by electrical stimulation each time it moved in that direction. It was almost as if he had a remote control for the rat. When the electricity was turned off, the rat lay down and went to sleep.

The next day, Olds (1956) showed Milner what he'd discovered. After that, they ran the rat through a series of tests. For instance, they found they could train the rat to navigate a maze simply by giving it a jolt each time it turned correctly. They also trained it to run down an alleyway to get a piece of food. But as the rat was running, they zapped it at the halfway point. The rat stopped there and never went for the food.

After that, they put the rat into an operant conditioning chamber so that the rat could press a lever to stimulate itself (Olds, 1956). Once the rat learned what the lever did, it self-stimulated at a rate of around 2,000 presses per hour, greatly exceeding typical rates when the lever press dispensed food. When the researchers turned off the electricity, the rat pressed the lever six or seven times, then curled up in a corner and went to sleep. Later when the rat awoke, they gave it one free jolt, after which it returned to its previous lever pressing rate. Finally, they found they could get the rat to run across a painful electrified grid to get to the lever to self-stimulate. Clearly, these mild electric currents applied deep inside

its brain were strongly rewarding. Olds and Milner first published these results in 1954, and they reported a number of follow-up studies over the next few years.

As it turns out, the electrode bent during insertion, and it didn't go into the reticular formation as intended (Baumeister, 2006). Instead, it had landed in the hypothalamus. Olds and Milner tested a number of sites in this region, and they found that stimulating the nucleus accumbens led to the highest rates of self-stimulation. And in brazen defiance of behaviorist dogma, Olds even referred to this site as the brain's "pleasure center."

Neuroscientists now recognize the identification of the reward center in the brain by Olds and Milner as perhaps the single most important discovery in the field (Baumeister, 2006). Certainly we can argue that it marked the point where traditional physiological psychology transitioned into the newly conceived field of behavioral neuroscience. Olds and Milner had demonstrated that the technique of deep-brain electrical stimulation was a useful tool for studying the relationship between brain and behavior. Their work also inspired a whole generation of young researchers who built the field of behavioral neuroscience. Furthermore, the discovery led to a much greater understanding of important psychological issues such as drug addiction. Finally, this incident demonstrates the powerful role of serendipity in science. Had the electrode made it to its intended target, Olds and Milner may never have discovered the brain's reward center. No doubt someone else would have eventually found it, but the take-home lesson is the importance of keeping an open mind to unexpected possibilities when doing research—sometimes mistakes lead to the most important discoveries.

Mark Rosenzweig

As an undergraduate, **Mark Rosenzweig** (1922–2009) developed a lifelong passion for physiological psychology (Pawlik & Breedlove, 2010). He then entered Harvard, where he worked under the supervision of Edwin Boring (Chapter 3) studying the auditory system of cats. The electrophysiological techniques he used involved placing electrodes on the scalps of cats to detect patterns of brain activity. Although he made important advances in the application of this technology, he gave it up after accepting a position at Berkeley. There, he took up the question of how learning and memory are instantiated in the brain. Today, he's best known as the *American psychologist who discovered that neural plasticity continues even in adulthood*.

Edward Tolman (Chapter 5) spent the 1948–1949 academic year at Harvard while his challenge of Berkeley requirement that all faculty members sign loyalty oaths worked its way through the courts (Pawlik & Breedlove, 2010). Rosenzweig was just finishing his dissertation, and Tolman recommended him for a position at Berkeley, where he remained for the rest of his career. At Berkeley, Rosenzweig befriended David Krech (1909–1977), who pointed him in the direction that would define his research career. A Berkeley colleague had developed two strains of rats, known as "maze-bright" and "maze-dull," by interbreeding the best performers together and the worst performers together for several generations.

Krech suggested that there might be structural differences in the brains of these two strains of rats, and this proved to be a fruitful line of research ("Mark R. Rosenzweig," 1983). First, Rosenzweig and Krech found chemical differences in the brains of these two strains of rat. Specifically, the maze-bright rats had more of an enzyme known as acetylcholinesterase. However, follow-up studies showed that this difference wasn't just due to genetics. They found that rats raised in enriched environments with plenty of toys and other rats to interact with also had more of this enzyme in their brains than did those raised under impoverished circumstances. Furthermore, they found that the "enriched" rats had larger brain masses as well, suggesting that the brain actually changes its structure as a result of experience. The idea that the brain was plastic even in adulthood was met with criticism at first, since it was generally believed that brain structure was set after childhood. Nevertheless, the evidence that Rosenzweig, Krech, and their colleagues presented was overwhelmingly convincing, and today the notion of neural plasticity throughout the lifespan is generally accepted among neuroscientists.

Rosenzweig and his colleagues continued with an investigation of the neurochemistry of learning and memory (“Mark R. Rosenzweig,” 1998). They discovered a cascade of chemicals involved in the formation of both short-term and long-term memories. Furthermore, they found that enriched environments can help even adult organisms overcome deficits due to brain lesions.

In addition to his research, Mark Rosenzweig was an international traveler (“Mark R. Rosenzweig,” 1998). He spent several sabbaticals in France, and he visited a number of foreign countries as guest speaker. During one semester in France, he met Alexander Luria (Chapter 9) and accepted an invitation to Moscow to give a series of lectures. As a result, he was widely recognized for his efforts to help psychologists around the world connect and exchange ideas.

The notion that the brain’s structure was fixed in adulthood has been dispelled thanks to the work of Mark Rosenzweig (Carey, 2009). We now understand that the brain continues to change and grow throughout the lifespan, and this knowledge has inspired a generation of researchers to further understand the principles of neural plasticity and the promise that idea holds for humanity.

Cognitive Neuroscience

With the rise of the Cognitive Revolution in the 1960s, neuroscientists turned their attention to *the study of the brain processes underlying memory and attention*. This approach was given the name **cognitive neuroscience**. Early studies examined the cognitive deficits of humans with brain damage and animals with induced lesions, but the advent of neuroimaging technologies has been a great boon to this field.

Endel Tulving

Growing up in Estonia, **Endel Tulving** (born 1927) suffered from the horrors of World War II, including time in a German prisoner-of-war camp (Habib, 2009). After the war, he immigrated to Canada, where he finished a bachelor’s degree in psychology at the University of Toronto before enrolling in the doctoral program at Harvard. There, he interacted with many of the most important experimental psychologists of the twentieth century, including Edwin Boring (Chapter 3) and B. F. Skinner (Chapter 5), as well as George Miller and S. S. Stevens (Chapter 11), his thesis adviser. Earning his Ph.D. in 1956, Tulving returned to Toronto as a faculty member and remained there for the rest of his career. During his long career, he developed a reputation as an *Estonian-Canadian psychologist who advocated for episodic memory as a separate memory system*.

At the time, most psychologists viewed memory as a singular construct (Tulving, 2002). They recognized that it was often useful to distinguish different types of learned information, but they still maintained that all memories were stored in the same way and likely used the same brain processes. One common distinction was between **procedural memory**, which is *knowledge of how to do something*, and semantic memory, which is knowledge of facts and concepts about the world in general. In a nutshell, this is the difference between “knowing how” and “knowing what.” In his 1983 book *Elements of Episodic Memory*, Tulving proposed a third distinction. As the title of the book implies, he called it **episodic memory**, by which he meant *the recollection of personal experiences*. According to Tulving, episodic memory wasn’t just “knowing what” happened, but also “when” and “where.” Psychologists saw this as a useful philosophical distinction while insisting on the underlying unity of all memory as a single system in the brain or mind.

Tulving (1985b) challenged the received wisdom by proposing that the three-way division of procedural, semantic, and episodic memory was more than just a convenient philosophical distinction (Table 16.1). Rather, he contended, these were three semi-independent memory systems that stored information in different ways and likely involved separate brain networks.

Table 16.1 Tulving's Three Memory Systems and Associated Levels of Consciousness

Memory System	Description	Associated Level of Consciousness
Procedural memory	Ability to learn new responses to environmental or internal stimuli	"Non-knowing" consciousness as the organism interacts with the environment in the moment
Semantic memory	Ability to learn facts about the world	"Knowing" consciousness in which the organism recognizes familiar situations and responds accordingly
Episodic memory	Ability to perceive oneself as separate from the environment	"Self-knowing" consciousness in which the organism has a sense of self, enabling it to engage in mental "time travel" into the past or future

His reasoning was based on both evolutionary and clinical evidence. Furthermore, he maintained that each type of memory was associated with a different sort of consciousness:

- *Procedural memory* is associated with a "non-knowing" consciousness in which the organism can sense and respond to stimuli in the environment or even internal stimulation. Tulving acknowledged that simple animals such as insects have procedural memory and "non-knowing" consciousness. For instance, a honeybee can learn how to navigate to a new source of nectar. But it doesn't know any facts about the world, and doesn't have any sense of self.
- *Semantic memory* is associated with a "knowing" consciousness in which the organism has knowledge of facts about the world that it can use to guide its behavior. For example, your dog knows she'll get punished if she pees on the carpet. She also knows you'll open the door if she scratches at it. Tulving believed that at least birds and mammals have semantic memory and "knowing" consciousness, but he also insisted it was unlikely they had a clear sense of self as separate from the rest of the world.
- *Episodic memory* is associated with a "self-knowing" consciousness. To experience personal recollections, you need to first have a sense of self. This is because your episodic memories are inherently about you. After all, you can know about another person's life experiences, but you can't experience them as your own personal memories. Thus, Tulving reserves the term "remembering" for episodic memory and "knowing" for semantic memory. Tulving also insisted that only humans have episodic memories.

According to Tulving (1985b), episodic memory emerged fairly recently in the evolutionary history of humans. It also develops late, around three or four years of age. Furthermore, it's the memory system that's most easily disrupted, as in cases of brain trauma or dementia. Although Tulving cited a number of case studies reporting a loss of episodic memory while other forms of memory remained intact, most of his evidence came from a patient known by his initials K.C., who Tulving worked extensively with.

K.C. was born in 1951 and suffered a severe head injury due to a motorcycle accident (Tulving, 2002). As a result, K.C. suffered both retrograde and anterograde amnesia. **Retrograde amnesia** refers to *the loss of memories that have already been stored*, while the term **anterograde amnesia** indicates *the inability to form new memories*. K.C. suffered anterograde amnesia for both semantic and episode memories, meaning that he could learn no new facts and that he had no recollection of any events in his life after the crash. But the symptoms were different when it came to retrograde amnesia. K.C. still knew all the facts he'd accumulated up to the time of the accident, but he had no personal memories of his life at all. For instance, he knew the address of the house where he grew up, but he had no recollection of ever being there. Here was a clear-cut case in which semantic memory had been spared but episode memory was lost, implying that these were two separate systems.

Tulving (2002) found that K.C. also had an unexpected impairment. He clearly understood the concept of time, but if you asked him what he was doing later that day or the day after that, he had no idea. Apparently, he'd also lost the ability to imagine himself in a future scenario. Tulving's insight was to see that this was related to K.C.'s loss of recollections for past events. In other words, episodic memory wasn't a record of the personal past, which was already known to be quite unreliable. Rather, it was about the ability to subjectively travel in time, whether it's into the past or into the future. But to do either one, you have to have a self that gets projected in time, and this sense of self as separate from his conscious experience of the world appeared to be what K.C. had lost.

As functional neuroimaging became available toward the end of the twentieth century, Tulving was one of the first psychologists to make use of this new technology for observing the brain in action (Habib, 2009). In a series of experiments, he demonstrated that the learning and recall of semantic and episodic memories take place in different brain networks. These studies have provided even more compelling biological evidence for his contention that these are two separate memory systems.

Although Tulving's argument for three separate memory systems was controversial when it was first proposed, the theory is now widely accepted among cognitive neuroscientists (Habib, 2009). For more than six decades, Tulving has been at the cutting edge of memory research, contributing many ideas that are now standard fare in introductory psychology textbooks. Perhaps more than any other psychologist, Endel Tulving has shaped our understanding of the nature of memory in the twenty-first century.

Michael Posner

As an undergraduate, **Michael Posner** (born 1936) majored in physics (Keele & Mayr, 2005). His first job was as a research engineer at Boeing, studying ways to reduce aircraft noise to levels tolerable by humans. This work in human-machine interactions led to an interest in psychology, and he pursued his Ph.D. at the University of Michigan. After accepting a position at the University of Oregon, he studied the process of reading, which piqued his interest in attention, and this became the dominant theme of his career. Today, Posner is recognized as a leading *American cognitive neuroscientist who studies the biological basis of attention*.

Along with other colleagues and graduate students, Posner set up what was perhaps the first computerized psychology laboratory in the world ("Michael I. Posner," 1981). Computers allow for the precise timing of stimuli presentation and response measurement, and they're ubiquitous in cognitive psychology laboratories today, but Posner and his associates were pioneers in this approach. One of the first projects in this computerized lab involved the study of the reading process. Posner broke down the reading task into what seemed to be its component parts and investigated how long on average it took participants to execute each task. *The measurement of the time course of cognitive events* is known as **mental chronometry**, and it was first pursued in the lab of Wilhelm Wundt in the late nineteenth century. But with the help of computers, Posner could make far more accurate measurements. For instance, in one experiment he asked participants to indicate whether two figures on the screen represented the same or different letters. He found that the reaction time was longer for upper and lower case pairs that were dissimilar, such as "A" and "a," compared with pairs that were similar, such as "C" and "c." The results of studies such as these convinced Posner that the time course of basic mental processes could be measured accurately.

Mental chronometry studies led to the development of the **Posner cueing task** (Keele & Mayr, 2005). This is a *laboratory procedure that is used to measure people's abilities to make*



Photo 16.2
Magnetic resonance
imaging scanner

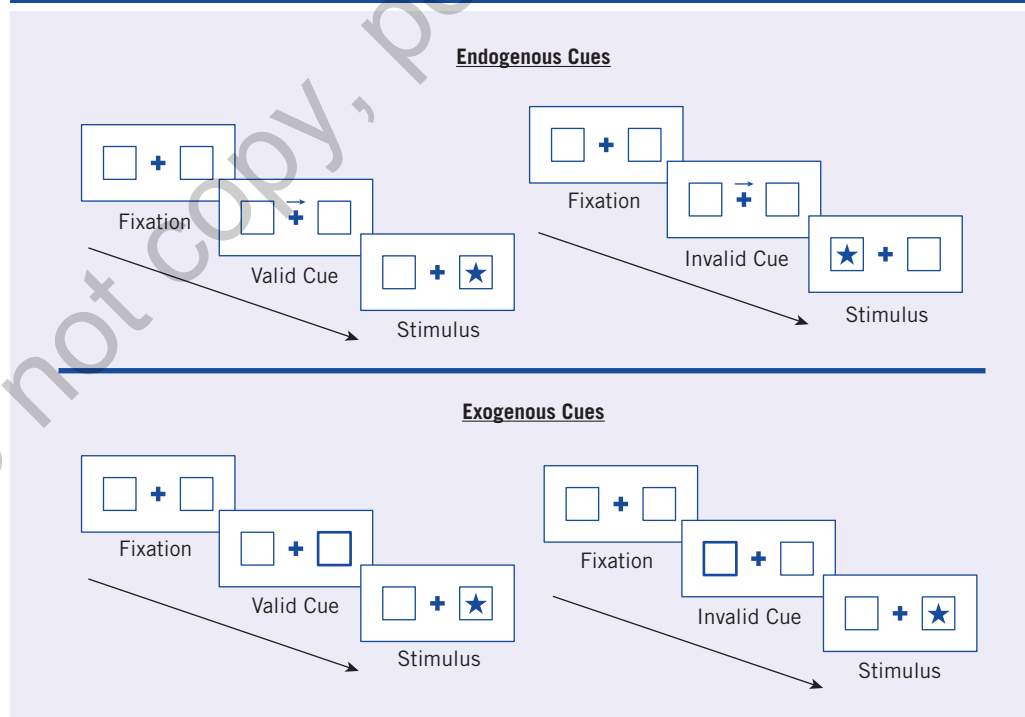
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<https://creativecommons.org/licenses/by/4.0/>

rapid shifts of attention. At the beginning of each trial, the participant stares at a fixation point marked by a cross at the center of the screen, with a box on each side (Figure 16.1). A cue such as an arrow briefly appears, either above the fixation point or in the periphery of the visual field. A target stimulus such as a star then appears in one of the two boxes, and the participant's task is to press a button as soon as it does so. In half of the tasks, the cue is invalid, meaning that it points away from, rather than toward, the target location. In these trials, the participant needs to make an attentional shift to perceive the target, so reaction time is delayed. This simple procedure has been used to test a number of hypotheses regarding the mechanics of attention in both healthy and patient populations.

Two counterintuitive findings came out of Posner's work with the cueing task (Keele & Mayr, 2005). The first was the observation that adults can shift attention within their visual field even though their eyes are fixated on a point. The second was the discovery of a phenomenon known as **inhibition of return**, which is *a delay in an attentional shift back to a previously attended location.* It's believed that this is an evolved feature of visual systems. In the real world, organisms need to constantly scan their visual fields for sudden changes in the environment, and this inhibition keeps them from repeatedly looking at the same location. It was the ability of computers to accurately control the presentation of stimuli and measure the timing of responses that enabled Posner and his team to make these discoveries.

Behavioral approaches to mental chronometry have an inherent weakness that was recognized even in the Wundt laboratory ("Michael I. Posner," 1981). Namely, this was that the measured reaction time includes the time course of both the mental processing of the stimulus and the motor programming of the response. In the late 1960s, Posner spent a yearlong postdoctoral fellowship at the Applied Psychology Unit of Cambridge to learn *a technique for measuring the time course of mental events based on EEG recordings.* This new method measured what was called an **event-related potential**, or ERP for short. The EEG, or electroencephalogram, measures electrical activity diffusing from the brain to the scalp,

Figure 16.1 Posner Cueing Task



Source: Local870, via Wikimedia Commons, CC BY 3.0, <https://creativecommons.org/licenses/by/3.0/>.

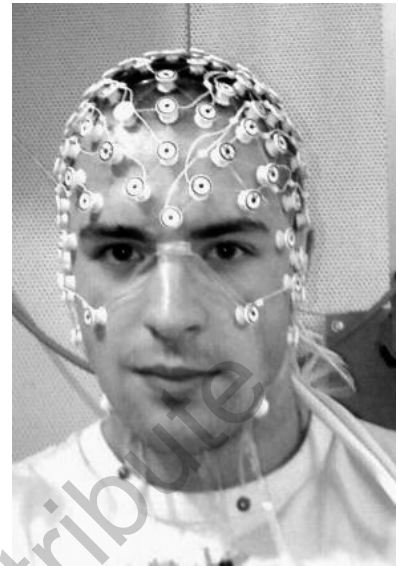
and it can be thought of as the summation of all of the brain's electrical processes. However, the brain activity of a specific activity can be extracted through the averaging of EEG waveforms over many trials. Although the first ERP studies were conducted before World War II, the advent of computers made the complex calculations necessary to average waveforms much easier. Posner now had a noninvasive technique for accurately measuring the processing of mental events in the brain without having to take motor responses into account. In fact, ERP research doesn't require the participant to do anything at all. This technique became an important tool in Posner's lab after he established his lab at Oregon.

The strength of the ERP technique is that it yields a precise measure of the time course of brain activity ("Michael I. Posner," 1981). However, its weakness is that it gives little indication of the region where that activity is occurring. In an attempt to identify brain structures responsible for regulating attention, Posner spent six months with George Miller testing patients with brain damage. There was already a long history of lesion studies with the following rationale: If a patient with a lesion in area X has a deficiency performing cognitive task Y, then area X must somehow be involved in the production of task Y. By identifying patients who had difficulties in executing specific attentional processes, Posner could then correlate those processes with the damaged brain regions of those patients. Lesion studies in humans tend to yield only tentative results, since naturally occurring brain damage, such as from head injuries or stroke, is often diffuse and can involve multiple brain areas. Nevertheless, lesion studies can provide clues at least to the general brain regions that are involved.

In the 1980s, neuroimaging techniques became available, and Posner was one of the first neuroscientists to make use of them (Denis, 2008). Neuroimaging has complementary strengths and weaknesses compared with ERP. Although it doesn't provide a good measure of time course, it does pinpoint exact regions where brain activity occurs. The first technique to become available was PET, which measured blood flow as an indicator of brain activity. The disadvantage of this approach is that it requires the injection of mildly radioactive substances into the participant. Posner first conducted studies searching for attention areas in the brain using PET, but he switched to functional MRI (fMRI) when it became available. This technique uses the magnetic properties of water to track blood flow, and hence brain activity. But unlike PET, fMRI has no known health risks to the participant. When these brain imaging techniques first became available, many psychologists were skeptical that specific cognitive processes could be linked to specific brain regions. Yet Posner and his colleagues demonstrated that this was indeed possible, laying out the case in the 1994 book *Images of Mind*, which he coauthored with Marcus Raichle. Thus, Posner blazed the trail for neuroimaging research in the twenty-first century.

Posner next turned his research focus to the development of attentional processes in infants, considering both genetic and environmental influences (Denis, 2008). He found that newborns had limited control over attentional processes, which came online in a piecemeal fashion over the first few months of life. Although he was able to outline a typical developmental timeline, he also identified cultural and parenting influences as well as specific genetic factors that could speed up or slow down the development of attentional control.

For more than three decades, Posner's lab at the University of Oregon has been at the forefront of cognitive neuroscience research (Keele & Mayr, 2005). As a result, he's attracted a large number of graduate students, not just from across the United States but also from around the world. In fact, Posner has been a major proponent for the internationalization of psychology in the twenty-first century. He's trained many of the next generation of psychologists, who've gone on to positions in universities and research institutions around the globe. He was a pioneer in the use of many of the techniques that are now staples in the toolkit of scientists studying the interface between brain and mind, such as ERP and fMRI. For these reasons, he's rightfully called the father of cognitive neuroscience.



Thuglas at English Wikipedia, via Wikimedia Commons

Photo 16.3
Electrode cap used in ERP
research



Photo 16.4
Patricia Goldman-Rakic

Patricia Goldman-Rakic

When she graduated from Vassar College, **Patricia Goldman-Rakic** (1937–2003; pronounced *rah-KEESH*) found there were few opportunities for women in academia (Aghajanian, Bunney, & Holzman, 2003). Nevertheless, she defied expectations and earned her Ph.D. in experimental psychology from the University of California, Los Angeles (UCLA) in 1963. Offered a position as a research scientist at the National Institute of Mental Health (NIMH), she began the program that would occupy her for the rest of her life. In 1974, she met the neuroscientist Pasko Rakic, who became her research partner and eventually her husband. The couple accepted positions at Yale, where they built a noted program in neurobiology. During this time, Patricia Goldman-Rakic earned a reputation as an *American cognitive neuroscientist whose research on the prefrontal cortex in primates led to a better understanding of the neural substrates of working memory*.

Throughout her career, Goldman-Rakic had a passion for the prefrontal cortex, the part of the forebrain that's most pronounced in humans and other primates (Levitt, 2003). It was believed to be the part of the brain responsible for complex thought processes, and many psychologists at the time thought there was no way it could be studied in a scientific fashion. But Goldman-Rakic

was undeterred. She knew that a thorough investigation of the anatomy and physiology of the prefrontal cortex would require the use of invasive techniques such as surgical lesions and the insertion of electrodes, so human-subject research was out of the question. Instead, she chose to work with the rhesus monkey as a close proxy to humans.

Contrary to the received wisdom of the time, Goldman-Rakic demonstrated that the prefrontal cortex was anatomically and functionally similar to other areas of the brain that were better understood. To study the structure of the prefrontal cortex, Goldman-Rakic used a method known as **autoradiography** (Fuster, 2004). This is *a method of producing an X-ray image by injecting a radioactive substance into the body*. This technique allowed her to trace the neural circuitry of the prefrontal cortex. She found that its neurons were arranged in columns, just as they were in the well-studied sensory and motor areas of the cerebral cortex. And since each column in those areas had a specific task to perform, she reasoned the same must be true of the prefrontal cortex. Goldman-Rakic then used lesion studies to test hypotheses about the functions of specific portions of the prefrontal cortex (Aghajanian et al., 2003). At the same time, she also discovered the remarkable plasticity of this area, especially early in development. She found that adult monkeys with lesions rarely regained lost functions, but young ones often did. It seemed that those lost functions could be taken on by other areas of the prefrontal cortex while the brain was still developing.

Evidence from human patients suggested that the prefrontal cortex played a role in **working memory** (Selemon, 2015). This is *the ability to hold on to information while it is being used to complete a task*. Working memory is usually tested in humans by giving them a list of words or digits to repeat back after a short delay. But since monkeys don't have language, Goldman-Rakic had to find a different approach. She decided on the **delayed-response task** as an operational definition of working memory. This is *a laboratory procedure in which the subject observes a desired object being hidden in one of two containers and is then distracted for a brief time, after which it is allowed to retrieve it*. This task is often used to measure working memory in both primates and young human children. She found that healthy monkeys completed this task easily, while those with lesions to the prefrontal cortex performed at chance. However, the monkeys with lesions could successfully retrieve the desired object as long as they could keep the container in sight the whole time.

Around this time, Goldman-Rakic was also investigating the neurochemistry of the prefrontal cortex (Aghajanian et al., 2003). She found that the predominant neurotransmitter in this area was dopamine. Furthermore, when she injected drugs that depleted dopamine into the brains of healthy monkeys, they lost their ability to complete the delayed-response task, just like those whose prefrontal cortex had been removed. It was already known at the time that dopamine was implicated in a number of psychological disorders, such as Parkinson's

disease, schizophrenia, and Alzheimer's disease. Goldman-Rakic's investigations provided new insights into the underlying brain abnormalities involved in these conditions.

Late in the twentieth century, Goldman-Rakic made use of a new technology known as **microelectrode recording** (Fuster, 2004). This is a *brain recording technique in which an ultrathin electrode is inserted to a position where it can measure the activity of a single neuron*. Using this method, Goldman-Rakic found that certain neurons are only active during the delay portion of the delayed-response task in which the container holding the desired object isn't in view. She proposed that this activity represented the memory for the target that was being kept alive until the desired object could be obtained. This finding was also controversial because at the time many psychologists believed memory to be a singular process not generally associated with the frontal lobe. Thus, she challenged the received wisdom by demonstrating that working memory was situated in a separate structure of the brain from long-term memory.

Goldman-Rakic was at the height of her career when she was struck by a car while crossing a street on a summer afternoon (Selemon, 2015). She died two days later of her injuries. She and her team of researchers had so many ongoing projects at the time that papers including her name as an author were still being published five years after her death. By defying the rampant sexism of her time and establishing a career as one of the most influential neuroscientists of the twentieth century, Patricia Goldman-Rakic has become a role model for a new generation of scientists, both male and female, who are now working in a field that is just beginning to shed its tainted past of gender discrimination.

Michael Gazzaniga

When the first split-brain patient arrived at Roger Sperry's (Chapter 10) lab in 1961, he assigned the task of examining him to his newest graduate student, **Michael Gazzaniga** (born 1939; "Interview," 2011). The split-brain surgical technique, in which the corpus callosum connecting the two halves of the forebrain was severed, showed promise as a means of controlling severe epilepsy. It was also believed that the procedure had no negative effect on the patient's cognitive abilities, and in everyday interactions it was impossible to distinguish a split-brain patient from a person with an intact brain. However, Gazzaniga devised a number of tests that demonstrated the existence of two separate streams of consciousness within these patients. Continuing this line of research, Michael Gazzaniga built a reputation as the *American neuroscientist whose work with split-brain patients has led to our understanding of hemispheric specialization in the brain*.

Gazzaniga's first split-brain patient was known as W.J., who he tested both before and after surgery ("Interview," 2011). The key test involved the flashing of images onto either the left or the right visual field. Because the brain is organized contralaterally, images on the left are processed in the right hemisphere, and vice versa. The participant's job was simply to name the object. Before the operation, W.J. performed this task without difficulty. After the operation, though, he could only name objects viewed in the right visual field. In the case of objects projected to the left, he could still point to a copy of it on a sheet of paper in front of him, thus indicating that he was aware of which image he'd seen. This pattern of results confirmed evidence from brain-damaged patients that language processing takes place in the left hemisphere, yet it also suggested a kind of language-less consciousness on the right side of the brain.

Split-brain research showed that each hemisphere has a separate stream of consciousness, and yet our experience is of a unified self ("Michael S. Gazzaniga," 2008). Gazzaniga puzzled over this mystery for years, but some clues to an answer came when he was working with his graduate student Joseph LeDoux, whom we'll meet in the next section. Rather than relying on the behavioral data alone to understand what was going on in the minds of split-brain patients, Gazzaniga and LeDoux decided to ask the patients why they'd responded the way they did. They soon discovered that the patients made up plausible stories to account for their bizarre behaviors. In other words, their language-based left hemisphere was trying

to interpret what the silent right hemisphere was doing. In healthy brains, Gazzaniga and LeDoux surmised, the left side has access to the right and thus can report on what its other half is doing, thus giving rise to a unified sense of self. The two researchers laid out their view of the left brain as “interpreter” in their 1978 book *The Integrated Mind*.

It’s said that Michael Gazzaniga and George Miller (Chapter 11) were sharing a taxicab in New York City when they coined the term “cognitive neuroscience” to describe the newly emerging field relating mental functions to brain processes (“Interview,” 2011). Whether this story is true or not, there’s no doubt that Gazzaniga has been a major proponent of the field. In addition to building cognitive science programs at Dartmouth College and the University of California, Davis, he founded the *Journal of Cognitive Neuroscience* and the Cognitive Neuroscience Society. He’s also written a number of popular books on topics in cognitive neuroscience, thus spreading knowledge of this exciting field to the general public. He also served on the Bioethics Committee convened by President George W. Bush to discuss important issues such as cloning and cognitive enhancement. In addition, he served on a national committee considering the relevance of neuroscience research to the law, grappling with questions such as whether brain scans should be admissible as evidence in criminal trials.

In his 2011 book *Who’s in Charge: Free Will and the Science of the Brain*, Gazzaniga tackled the question of free will (Nair, 2012). In this work, he argues—much like his mentor Roger Sperry—that the apparent contradiction between a mechanistic brain and the existence of free will can be resolved. Whereas Sperry conjectured that free will arose as the brain gave rise to mind, Gazzaniga argues that, for centuries, philosophers and psychologists have been looking in the wrong place. The key issue in free will, he contends, is personal responsibility, and yet that is a social issue, not a characteristic of any individual. Even though we’re biological machines, the social contract we share with others holds us responsible for our actions, and this is where free will arises.

Michael Gazzaniga is rightly viewed as one of the founders of cognitive neuroscience. Both in his compelling research exploring the specializations of the left and right hemispheres of the brain and in his service to the field, he remains one of the shakers and movers of this burgeoning enterprise exploring the interface between brain and mind.

Affective Neuroscience

The Cognitive Revolution broke the behaviorist stranglehold on American psychology, but it also imposed new restrictions on what was considered an acceptable topic for research. For instance, the computer metaphor of cognition gave little room for a discussion of emotion. But by the end of the twentieth century, more and more psychologists were recognizing the central role that affect, or emotion, plays in human lives. Building on the success of behavioral and cognitive neuroscience, these researchers have created the new field of **affective neuroscience**, which is *the study of the brain processes underlying emotion*. This endeavor holds promise to provide answers to important questions regarding mental health and disease.

Richard Lazarus

During World War II, **Richard Lazarus** (1922–2002) served as a military psychologist, evaluating inductees to see which ones were emotionally unfit for service (Whatmore, 1999). He also devised methods for detecting malingerers who feigned psychological disorders to avoid the draft. After the war, he earned his Ph.D. in 1948 from the University of Pittsburgh. Although behaviorism still dominated psychology, the New Look movement gave him the courage to pursue a cognitive-based research program in stress and emotions. Today Richard Lazarus is known as the *American psychologist who developed the transactional model of stress*.

Early in his career, he studied the unconscious nature of emotional responses (Hyman, 2002). He found that a visual stimulus previously associated with an electric shock would elicit a negative response even when it was presented for such a short interval of time that

the participant had no conscious awareness of having seen it. Lazarus referred to the unconscious perception of an emotional stimulus as *subception*. The idea that perception could take place without conscious awareness was a novel—and controversial—idea at the time. However, subception is now a well-documented phenomenon.

As a military psychologist, Lazarus had studied the effects of stress on soldiers (Robinson, 2018). At the time, stress was viewed as a purely physiological response, but Lazarus believed it also contained a psychological component akin to emotions. Moreover, he noticed that people responded differently to similar stressors. In a series of classic experiments, he tested the hypothesis that the level of stress experienced depended on the way in which the individual appraised the stressful situation. Participants viewed a movie of an emotionally charged event such as a painful circumcision rite. The film was narrated in a calm, manner-of-fact manner in one condition, but the soundtrack emotionally emphasized the painful experience of the suffering person in the other. Those who watched the movie with the calm narration showed reduced stress indicators compared with those who heard the emotional soundtrack.

These findings led Lazarus to posit the **transactional model of stress**, which is *the proposal that stress is moderated by cognitive appraisal of the situation* (Robinson, 2018). In other words, it's not just the degree of stress that's important. Rather, the way in which the person thinks about the stress also matters. Lazarus presented this model and the evidence for it in his 1966 work *Psychological Stress and the Coping Process*. In this book, he proposes that appraisal takes place in two stages. On the one hand, primary appraisal involves an assessment of the potential effect of the stressful situation on the individual. Is this a challenging but potentially beneficial stressor? Or is this stressor likely to lead to physical or psychological harm? Our assessment of the stressor as potentially beneficial or harmful greatly influences our perception of its effect. On the other hand, secondary appraisal involves an assessment of our ability to cope with the stressful event. Even a potentially beneficial stressor can be perceived negatively if we feel we don't have the means to cope with it, while a potentially harmful stressor will have little impact if we believe we have the resources to handle it.

With a move to the University of California, Berkeley, Lazarus established the UC Berkeley Stress and Coping Project, which used both laboratory and field studies to investigate the ways in which people deal with stress (Robinson, 2018). The findings of this project were presented in the 1984 book *Stress, Appraisal, and Coping*, which he coauthored with his graduate student Susan Folkman. In this work, Lazarus and Folkman distinguished two types of coping. When people believe they have control over the situation, they engage in *problem-focused coping*, which is a direct attempt to solve the problem. For example, spouses who talk about their problems and find mutually agreeable solutions are engaging in problem-focused coping. However, when people believe they have no control over the situation, they use *emotion-focused coping*. Accepting the loss of a loved one as God's will would be an example of this second approach. Since there's no way to change the situation, we change our attitudes toward the situation instead as a means of reducing stress.

Richard Lazarus was a pioneer in the study of stress and emotions, challenging his colleagues to open up their field to research on this vital aspect of human psychology (Ekman & Campos, 2003). His experiments provided fresh insights for researchers in the areas of clinical and health psychology. But more importantly for us in this chapter, he also gave inspiration to a third wave of neuroscience that would attempt to find the underlying brain processes that give rise to conscious emotions.

Jaak Panksepp

At the height of his career, **Jaak Panksepp** (1943–2017) became famous as “The Rat-Tickler,” doing the rounds of talk shows and interviews on popular media (Cromwell, 2018). In a career spanning nearly five decades, Panksepp explored the evolutionarily deep roots of emotions. By chance, he discovered that rats laugh when tickled just like humans, hence the nickname. It's just that no one had noticed this before because rat laughter consists of a series



Photo 16.5
Jaak Panksepp (seated
on right)

of chirps at a frequency above the range of human hearing. As the man who dared to challenge the standard view that emotional experience couldn't be studied scientifically, Jaak Panksepp is remembered today as the *Estonian-American psychologist who founded the field of affective neuroscience*.

Panksepp was born in Estonia in 1943, but the following year his family fled the country to escape the invading Russian Army (Eberle, 2017). They spent the next five years in refugee camps until they finally immigrated to the United States in 1949. While the adults of the camp struggled to survive, the children were left alone, and this experience of unsupervised rough-and-tumble play with same-aged children made a lasting impression on him, eventually becoming one of his key research interests.

Panksepp started his graduate studies in clinical psychology, but working in a mental hospital led him to the insight that emotional disturbances lay at the root of all psychological disorders (Davis & Montag, 2019). He was also convinced that emotions arose from deep within the mammalian brain. To study the neural substrates of emotion, he used the brain-stimulating technique pioneered by James Olds and Peter Milner. For his dissertation research, Panksepp found that he could elicit two types of attack in rats, depending on the deep brain region he stimulated. Moreover, he demonstrated that the rats experienced these two attack modes differently, in that they could be conditioned to turn on the stimulation for one mode and turn it off for the other. Further research showed that the “unpleasant” attack mode was related to predation, while the “pleasant” one was a key element in rough-and-tumble play.

In 1972, Panksepp accepted a faculty position at Bowling Green State University in Ohio (Eberle, 2017). This was a time when emotion research was generally off limits, especially at the prestigious universities, but at BGSU he had the freedom to pursue his research interests. Through a series of nearly 300 journal articles, he established himself as one of the leaders in the field of neuroscience.

Much of Panksepp's early work looked at the role of neurochemicals in mediating social emotions (Cromwell, 2018; Davis & Montag, 2019). During his student years working at a mental hospital, he noticed that many of the drug addicts he dealt with came from dysfunctional families, and he wondered if they took drugs as a substitute for the social bonding they lacked at home. Rat pups are distressed when they're separated from their mothers, emitting ultrasonic cries. But Panksepp found they were soothed when they were given small doses of morphine. This finding led to the **opioid hypothesis**, which was *the conjecture that the formation of social attachment and contact comfort is mediated by endogenous opioids*. Later, he also established the role of the neuropeptides oxytocin and vasopressin in mother-infant attachment formation as well as in sexual attraction among adults.

Using a three-pronged research approach of electrical stimulations, chemical injections, and brain lesions, Panksepp mapped out what he believed were the seven primary emotional systems in the mammalian brain (Davis & Montag, 2019). Each of these had a specific location deep within the brain, not on the cerebral cortex as had previously been assumed. Furthermore, each system had a specific repertoire of behaviors, and through operant conditioning studies they could be assessed as either a pleasant or an unpleasant experience for the animal. Panksepp cast the names of the seven primary emotion systems in all capital letters to distinguish them from the common meanings we associate with emotional words:

- SEEKING, which pushes animals to search for resources.
- RAGE, which drives them to compete for and defend those resources.
- FEAR, which impels them to escape bodily danger.

- LUST, which prods them to seek out mates and reproduce.
- CARE, which provides the desire to nurture offspring.
- PANIC, which is a feeling of distress at loss of social contact.
- PLAY, which helps the young to learn the rules of social interaction.

By demonstrating that neural processes could be linked not only to emotional expressions but also to their subjective experiences, Panksepp paved the way for a neuroscience of emotion (Cromwell, 2018). He presented his view of this new field in his aptly named book, *Affective Neuroscience*, which he published in 1998. While his arguments are cogent, they've also challenged the human-centric biases of many psychologists. In placing the seat of emotions deep within the brainstem, he makes the case that emotional experience is evolutionarily old and shared by a wide range of species. This position is simply a reiteration of Charles Darwin's continuity thesis, in which he contends that humans are no different from any other animals. It seems however that even neuroscientists in the twenty-first century are still influenced by the "mindless" behaviorism that dominated the twentieth as well as by a lingering Cartesian belief in the uniqueness of humans. Nevertheless, a younger generation has been convinced by Panksepp's contention that a science of emotion is the pathway to understanding human experience, both in its mundane and in its disordered states. These are the pioneers in the brave new field of affective neuroscience.

Joseph LeDoux

Some have called him "Dr. Fear" (Behar, 2008). **Joseph LeDoux** (born 1949) is an *American neuroscientist who studies the brain mechanisms that are responsible for fearful memories*. He also believes he can find a way to erase painful memories as a potential cure for post-traumatic stress disorder.

LeDoux earned his Ph.D. in 1977, working with Michael Gazzaniga at New York Stony Brook ("Joseph E. LeDoux," 2010). His dissertation research explored questions of cognition, emotion, and consciousness in split-brain patients. The findings from this project led to the book *The Integrated Mind*, which he coauthored with Gazzaniga. While his mentor's interests were clearly on the cognitive side of neuroscience, LeDoux found himself drawn to the interactions between cognition and emotion, and especially how they're processed in the brain. To get at these issues, he knew that human research was out of the question, so he turned to animal models instead.

During twelve years at Cornell, LeDoux investigated the brain mechanisms of emotion and memory using fear conditioning in rats ("Joseph E. LeDoux," 2010). In this method, the rats first heard a tone and then received a painful shock to the foot. Sometimes even after a single pairing of the tone with the shock, the rats became fearful whenever they heard the tone. Once the association was learned, LeDoux traced the neural connections that constituted the learned fear response. Not surprisingly, he found they converged on the amygdala, long thought to be the fear center of the brain. He later moved to New York University, where he has continued this line of research. There he discovered that drugs blocking the growth of new synapses prevented the rat from learning the fear response.

LeDoux published the book *The Emotional Brain* in 1996 (Almada, Pereira, & Carrara-Augustenberg, 2013). In that work, he laid out his dual-route theory of emotional processing in the brain. The "low road" constitutes a rapid emotional appraisal of the situation by subcortical structures such as the amygdala. This processing occurs outside of consciousness, and even the behavioral responses they evoke can occur before we're aware of what's going on. That feeling of chills running down your spine as you walk alone on a dark street would be an example of this. In contrast, the "high road" involves processing in the cerebral cortex as well as subcortical structures. This processing is slower and is to some degree accessible to consciousness. The disappointment you feel at failing a test would involve the high road, since there's no threat of bodily danger at the moment.

LeDoux had already found that some drugs block the formation of emotional memories (“Joseph E. LeDoux,” 2010). However, an even more surprising discovery was that certain of these drugs could also erase specific memories. After conditioning rats on the learned fear response, he injected them with one of these drugs and then repeatedly played the tone, but this time without the electric shock. The next day, these rats showed no fear when they heard the tone. This finding suggests that long-term memories are unstable not only during formation but also during recall. LeDoux believes this research could eventually lead to a cure for post-traumatic stress disorder. Such a treatment is still a long way off, however, and LeDoux concedes that there are considerable ethical issues to work out with regard to memory erasure in humans.

“Dr. Fear” also has a life outside the laboratory (“Joseph E. LeDoux,” 2010). LeDoux is a rock musician who plays with a band called the Amygdaloids. The band performs at various venues in New York City and has already produced a couple of albums. Just as you would expect, the band sings songs about adventures in neuroscience.

Antonio Damasio

The patient had damage to his ventromedial frontal lobe, and he showed no signs of feeling any emotions, even though he performed well on standard reasoning tasks (Pontin, 2014). It seemed a clear-cut case of losing emotion but sparing reason. That is, until it came time for the patient to make his next appointment, when he pondered the advantages and disadvantages of two possible dates for half an hour until someone else made the choice for him. This observation led **Antonio Damasio** (born 1944) to suspect that everyday decision making involves both reason and emotion, a topic he’s studied now for decades, building a reputation as the *Portuguese-American neuroscientist who proposed the somatic marker hypothesis*.

Born in Portugal, Damasio earned a medical degree at the University of Lisbon before immigrating to the United States in 1976 to pursue a career as a neuroscientist (“Virtue in Mind,” 2003). He’s spent much of his career at the University of Iowa, with joint appointments at several other leading institutions. His research mainly involves working with stroke patients, mostly through the administration of behavioral tests early in his career but with more emphasis on neuroimaging techniques as these became available.

Damasio noticed that when a stroke occurred in certain areas of the brain, such as the ventromedial frontal lobe or the amygdala, the patient seemed to lose the ability to feel emotions (Johnson, 2004). They also exhibited alterations in their personalities, making poor decisions that wrecked their marriages and cost them their jobs. Although they could perform well on abstract reasoning tasks, their ability to make good decisions in everyday life was compromised.

Working with his colleagues, Damasio developed the **Iowa gambling task** as a laboratory procedure for assessing decision-making abilities in brain-damaged patients (Schmitt, Brinkley, & Newman, 1999). The task centers on four decks of cards (marked A, B, C, and D), each of which indicates a monetary win or loss. Patients select one card at a time from any deck, and they’re instructed to try to maximize their winnings. Unknown to them, the game is rigged. Decks A and B offer large rewards but even larger punishments, while the gains and losses in Decks C and D are moderate. Normally functioning participants soon learn they’ll maximize their earnings if they stick to Decks C and D. In contrast, patients with damage to emotional areas of their brains are attracted to the big gains of Decks A and B and discount the even bigger losses. The Iowa gambling task has now become a standard test of decision-making abilities in brain-damaged patients.

In the seventeenth-century, René Descartes had proposed a clear distinction between rational and emotional faculties, and this dichotomy has persisted into modern times (Brinkmann, 2006). But by the last decade of the twentieth century, Damasio began wondering if the French philosopher may have been



Photo 16.6
Antonio Damasio

Fronteiras do Pensamento, via Wikimedia Commons, CC BY-SA 2.0, <https://creativecommons.org/licenses/by-sa/2.0/deed.en>

wrong. These musings led to the publication of his 1994 book *Descartes' Error*, in which he lays out *the proposal that emotions play an essential role in everyday decision making*, which he calls the **somatic marker hypothesis**. According to Damasio, emotions are body states that arise in response to particular situations—hence the term “somatic,” meaning “bodily.” These emotions are perceived as either positive or negative, and they “mark” the situation as either beneficial or dangerous. Somatic marking occurs not only in real time, as we encounter potential opportunities and threats in our environment, but also when we generate possible future scenarios. Thus, whether you’ll study for tomorrow’s test or party with your friends depends on which scenario—the bad feeling of failing a test or the good feeling of having fun—produces the stronger somatic marking.

In addition to his numerous scholarly works, Antonio Damasio has also published a series of popular press books on topics in affective neuroscience for the general public. His somatic marker hypothesis has created a lot of excitement among professional and lay readers alike, but it has likewise generated considerable controversy in the fields of philosophy, psychology, and neuroscience. At present, the jury is still out on whether the error lies with Descartes or Damasio.

Neuroscience: The Future or the End of Psychology?

In the early twenty-first century, neuroscience has become the dominant field in psychology. From the start of experimental psychology, there was always the assumption that mind and behavior were products of brain activity, although how that occurred was anybody’s guess. Now neuroscience holds the promise of finally solving the mind-body problem.

A strong bias toward neuroscience is clear in both hiring and funding practices (Schwartz, Lilienfeld, Meca, & Sauvigné, 2016). A recent survey found that between one-third and one-half of advertised positions for psychologists at top research universities were for neuroscientists. Likewise, funding agencies are allocating more and more of their resources to projects involving a neuroscience component. Indeed, the rising generation of experimental psychologists will find it difficult to obtain a job or grant if they don’t include neuroimaging techniques as part of their research toolkit.

This state of affairs has led philosophers of science to speculate on the future of psychology in the coming decades (Sharp & Miller, 2019). Some believe that neuroscience will eventually become a grand unifying framework for a science that has been plagued with disunity from its inception. In other words, the future of psychology is neuroscience. Still others believe that neuroscience will finally provide answers about the ultimate causes of mind and behavior, making all other disciplines of psychology unnecessary. That is to say, neuroscience will spell the end of psychology.

Unifying Theory

The natural sciences all have unifying theories that give them cohesion and guide them toward new discoveries (Green, 2015). Newton’s laws unified physics three centuries ago, giving it a framework for exploring the physical world. This led to rapid progress in the field, the fruits of which include the many technological wonders of the modern era, such as cars, airplanes, and even robotic missions to Mars. Likewise, Mendeleev’s periodic table brought order to chemistry. And finally, the synthesis of Darwinian evolution with Mendelian genetics in the early twentieth century transformed biology from a descriptive to a predictive science.

Psychology has no such unifying theory, no doubt in part because it’s such a new science (Henriques, 2013). It’s often said that psychology is a science unified not by a theory but rather by its commitment to the scientific method. Yet even this view of unity is flawed. First, psychology is far from the only discipline studying human behavior that employs the scientific method, as sociologists, anthropologists, economists, and even political scientists do so as well. Furthermore, there are fields of psychology where commitment to the scientific

method is weak. For instance, counseling psychologists trained under the practitioner-scholar model and holding doctor of psychology (Psy.D.) degrees have limited use for the scientific method in their profession, and yet we still count them as psychologists.

Philosophers of science also warn of what they call the unification trap (Schwartz et al., 2016). This happens when one school or discipline dominates the field to the extent that research outside a circumscribed area is discouraged or even thwarted altogether. The unification trap often comes in the guise of the “one true” approach to the field. In the early twentieth century, advocates of both psychoanalysis and behaviorism maintained that their schools represented the “true” psychology, predicting that their approach would eventually win out over all others. Of course, in neither case did this come to pass. In the early twenty-first century, proponents of neuroscience view their field as finally bringing order to psychology, but there are still plenty of skeptics who see it as yet another fad that will eventually pass, just like psychoanalysis and behaviorism.

Psychology suffers from an identity crisis of sorts (Zilio, 2016). One identity is that of a natural science, with a strong pull toward biology. This is especially true for those who study lower-level processes such as sensation, perception, and attention. But it's also the case for clinical psychologists who seek an understanding of disorders in terms of structural anomalies in the brain or imbalances of neurochemicals. The other identity is that of a social science. Those who study higher-level processes, such as decision making or interpersonal attraction, often collaborate with social scientists in related disciplines. It should come as no surprise that the two cognitive psychologists who won the Nobel Prize (Herbert Simon and Daniel Kahneman, Chapter 10) did so for their work in bridging psychology and economics.

Because of its dual identity, psychology may never find a single framework that can unify the field (Green, 2015). Instead, the tension between the social-science side and the natural-science side may eventually fracture psychology in two. According to this scenario, the gravitational pull of neuroscience will attract the natural-science side of psychology into its orbit, leaving the social-science side to either coalesce into a unified whole of its own or perhaps to be absorbed in the other social sciences. This is just one way that neuroscience could spell the end of psychology.

Reductionism

It could also be the case that neuroscience replaces psychology altogether (Zilio, 2016). In fact, some neuroscientists, such as Michael Gazzaniga, have already declared that psychology is dead. Such a stance is based on a belief in **eliminative reductionism**, which is *the notion that higher levels of explanation become unnecessary once lower levels of explanation have been fully developed*. After neuroscience has come up with a complete description of how brain activity produces mental states, these proponents claim, higher levels of explanation will become superfluous. In other words, we'll no longer need disciplines such as cognitive, social, developmental, or personality—or even clinical, for that matter—because neuroscience will explain the entire range of psychology from the bottom up. Thus, all of psychology will reduce to neuroscience, and so psychology itself will be eliminated.

Eliminative reductionism is certainly a seductive point of view, especially if you're a neuroscientist, since it's your field that wins out in the end (Schwartz et al., 2016). Sympathy toward this attitude is also revealed by the current bias in funding and hiring toward neuroscience. Skeptics, however, point to the natural sciences to confirm their doubts. We know that biological processes are built on chemical interactions, and that these in turn are determined by the laws of physics. Nevertheless, it simply isn't the case that explanations at the biological or chemical level are unnecessary, just because at bottom it's all physics. Rather, the biological and chemical levels provide additional explanatory power not found at the physical level. Another tack is to grant eliminative reductionism in principle but not in practice. If only we knew the position and velocity of every particle in the universe, we certainly could predict behavior even at the macroscopic level. But we don't have this information, and we never will, so the question of eliminative reductionism is moot.

This doesn't mean that psychologists should never resort to explanations at a lower level when studying a particular phenomenon (Sharp & Miller, 2019). For instance, a complete understanding of vision necessitates an investigation down to the level of the neurochemicals that interact with light from the environment during visual sensation. In contrast, if we want to make good predictions about consumer behavior, we probably only need to examine the issue at the social and cognitive levels. Going any deeper than that, say to the neurochemical level, is unlikely to yield any additional useful information. Certainly, neurochemical reactions are occurring inside the brain of the consumer, but for current purposes they're irrelevant.

Even if neuroscience can someday eliminate the need for psychology, it's still too early to sound its death knell (Schwartz et al., 2016). At present, all neuroscience can do is find correlations between brain activity and mental or behavioral processes, and we need to guard against the premature conclusion that the first causes the second. Nevertheless, since brain activity is objectively observable while mental processes are not, it's easy to slide into the assumption that data from neuroimaging are more real or more reliable than those from traditional psychology experiments.

This attitude percolates down even to the general public, who are enchanted with the promises of neuroscience (Schwartz et al., 2016). For instance, researchers have found that just adding the words "brain scans show" to a science report leads people to judge it as convincing, even though it contains logical errors and circular reasoning. Although neuroscientists know better than to fall for such fallacious reasoning, those who control the funding and hiring for psychology may not. Such a state of affairs could lead to a premature elimination of the rest of field, not because neuroscience has conclusively answered all the questions of psychology but rather because it's no longer supported with financial or human resources.

Levels of Analysis

Some philosophers of science maintain that the basic premise of eliminative reductionism is flawed (Sharp & Miller, 2019). They argue that even complete knowledge of the processes and interactions at the bottom level is insufficient to explain phenomena at the next higher level. Specifically, they take a **levels-of-analysis approach**, which is *the position that explanations at one level are unrelated to explanations at a higher or lower level*. Those with the levels-of-analysis viewpoint believe that the current hierarchy of sciences—ranging from physics to chemistry, and from biology to psychology—exist because the world itself is ordered in such a hierarchy. Since lower-level phenomena cannot explain higher-level phenomena, the idea of eliminative reductionism is unsound.

Evidence in support of the levels-of-analysis approach comes from observations of what is called an **emergent property** (Schwartz et al., 2016). This is *a phenomenon that arises from processes at a lower level but is not fully explicable in terms of those processes*. The classic example of an emergent property is that of liquid water as a product of the chemical combination of two gases, hydrogen and oxygen. According to this view, emergent properties delineate the levels of analysis, separating each of them and breaking the causal chain that supposedly links them. Thus, neuroscience can never eliminate other disciplines in psychology because it only provides explanations at its own level. This doesn't mean that we can't have recourse to explanations at other levels—water certainly is composed of hydrogen and oxygen, but it's more than just a combination of these two elements. In other words, phenomena at a higher level can never be fully explained by processes at a lower level.

The levels-of-analysis approach doesn't preclude the possibility that neuroscience will come to play a central organizing role in psychology (Schwartz et al., 2016). In fact, it's already assuming that position. In this chapter, we've seen how the study of behavior, cognition, and emotion have become well integrated into neuroscience. Hybrid fields such as developmental, social, and even clinical neuroscience are on the

rise as well. But we need to be clear what these terms mean. For instance, “behavioral neuroscience” doesn’t mean behavior explained solely in terms of brain activity. Rather, the term refers to an interdisciplinary approach in which a phenomenon is studied at two different levels simultaneously. In this sense, neuroscience wouldn’t be a unifying theory for psychology, but it could serve as a backbone that connects with all of the disciplines.

Consilience

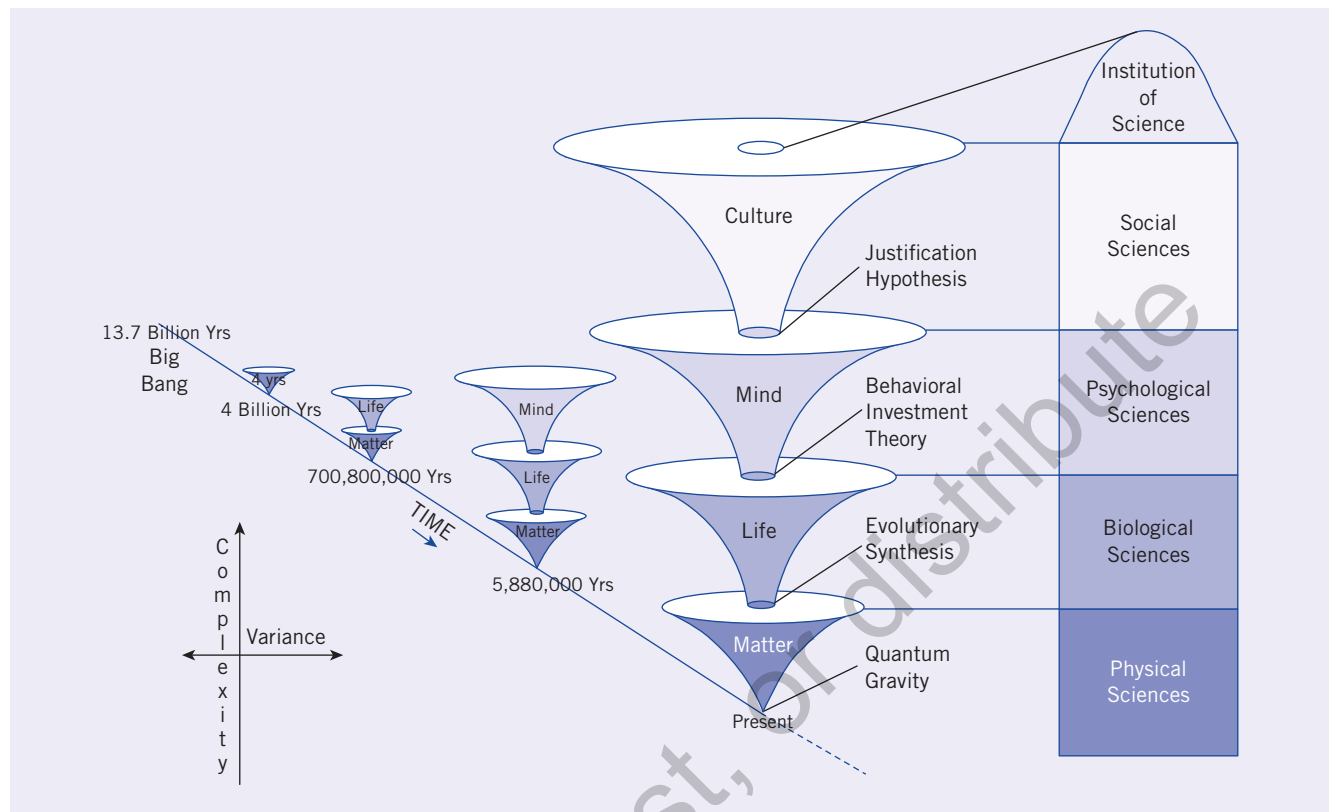
Finally, we need to consider the position of psychology in relation to the other social and natural sciences (Wilson, 1998). In his 1998 book *Consilience: The Unity of Knowledge*, biologist E. O. Wilson contends that the divisions we currently have in the sciences are getting blurred as our range of knowledge expands. The boundaries between physics and chemistry, between chemistry and biology, and between biology and psychology have all become fuzzy, and often the most exciting work in the twenty-first century is in the borderlands between the established sciences. Eventually, Wilson argues, there will be *a convergence of all knowledge into a single scientific structure*, a phenomenon he called **consilience**. It’s important to note that consilience is not at all the same thing as eliminative reductionism. The higher levels don’t get explained away by the lower levels. Rather, the gaps between the levels get filled in, so that scientists can move smoothly from one level to another. In Wilson’s view, all intellectual endeavors, whether the natural or social sciences, philosophy or history, art or literature, have the same goal—a greater understanding of ourselves and of the world in which we live. As our knowledge expands, then, it’s inevitable that the disparate pathways of knowledge we follow now will eventually converge.

In recent years, the psychologist Gregg Henriques (2013) has proposed a framework for situating psychology within the sciences that takes the entire history of the universe into account. According to his Tree of Knowledge System, the universe has undergone four great transitions since the beginning of time, each leading to a greater level of complexity. At the Big Bang 14 billion years ago, the first level of complexity was attained when Matter was created. Somewhat less than 4 billion years ago saw the emergence of Life, thus bringing on the second level of complexity. But this consisted only of single-celled organisms, and it wasn’t until the Cambrian explosion 600 million years ago that multicellular organisms emerged. And among these, of course, were animals that moved about and so needed nervous systems, thus giving rise to the third level of complexity, Mind. Only in the last hundred thousand years did the fourth level of complexity arise, namely Culture, driven by the human ability to use language.

In Henriques’s (2013) view, each of these levels of complexity is the purview of a particular type of science. Matter, the first level of complexity, is studied by the physical sciences. Life, the second level of complexity, is the realm of biology, while the third level, Mind, is the subject of psychology. Finally, Culture as the fourth level of complexity is the scope of the social sciences. Thus, the Tree of Knowledge System explains why the sciences divided up the way they did, in that the four levels of complexity provided natural boundaries for these different approaches to knowledge (Figure 16.2). At the same time, the framework also exhibits consilience, in that it shows how the various intellectual endeavors relate to one another. On this view, psychology is in no danger of becoming eliminated by neuroscience. Instead, the two will become more interconnected as time goes by, just like all the other sciences.

So much for gazing into the crystal ball. Predictions of the future are notorious for their failures to foresee even a few years ahead. Likewise, a new invention or discovery can quickly turn the trajectory of a science in an unexpected direction. But what we can say for sure is that psychology in the middle of the twenty-first century will be built by the current cohort of students. And that means you, the reader of this book, will be part of that exciting endeavor.

Figure 16.2 Tree of Knowledge System



Source: Henriques, G. (2013). Evolving from methodological to conceptual unification. *Review of General Psychology*, 17, 168–173.

Looking Ahead

At the beginning of the twentieth century, experimental psychology was an international endeavor. Arising in Germany in the late nineteenth century, it attracted students from around the world, who learned the methods of this new science of the mind and took them back to their own countries. Within a couple of decades, a second center of psychology had emerged in the United States, where it was widely accepted because it gave the promise of finding solutions to pressing social problems.

The world of 1900 was highly interconnected, thanks to great strides in long-distance communication and transportation. But there were also significant geopolitical stresses that endangered this new world order, such as great powers jockeying for preeminence and growing unrest in the underdeveloped regions of the world. These stresses led to a world war, the rise of nationalism and fascism, a second world war, a cold war, and numerous wars of independence. By the middle of the twentieth century, Europe lay in ruins, divided into American and Soviet spheres of influence. Likewise, Japan was struggling to rebuild, and China was recovering from decades of foreign invasion and civil war. Meanwhile, political instability plagued much of the southern hemisphere. As the only world power to have been spared the destruction of World War II, it's no surprise that the center of the scientific enterprise, including psychology, shifted to the United States. This rise to global dominance was also bolstered by the mass immigration of European scientists in the 1930s.

During the middle decades of the twentieth century, very little psychological research was being conducted anywhere in the world outside of North America (Adair & Huynh, 2012). However, by the 1980s the rest of the developed world was well on the road to

economic recovery, and we see a renewed international interest in experimental psychology around this time. In the last decades of the twentieth century, there was a large influx of graduate students to the United States, hinting at the growing internationalization of psychology that was to come.

When measured in terms of research publications, we first see a steady increase in the number of paper submissions to American journals from other English-speaking countries (Adair & Huynh, 2012). These include Australia, Canada, the United Kingdom, and Israel. By the turn of the twenty-first century, more and more contributions were also coming from other European countries, such as Germany, the Netherlands, Belgium, Switzerland, and Spain. Since 2010, we've also seen a considerable growth in research from East Asia, especially Japan, Hong Kong, and China. With the tremendous economic growth of this region in recent decades, some scholars predict that the center of science will shift to East Asia by the middle of the century.

The internationalization of psychology is imperative if we truly want to build a science of human experience (van de Vijver, 2013). There's an inherent bias in psychology constructed by Euro-American psychologists testing their theories on Euro-American populations. Centered as it is on Western individualistic culture, it's unrealistic to expect findings from a lab in Massachusetts to necessarily apply in Madagascar or Malaysia. And it's not enough for American psychologists to conduct cross-cultural studies to see whether their homegrown theories still work abroad. Rather, a truly universal psychology will have to be built by scholars from around the world representing the full array of diversity on the planet. Only through deep and continuous cultural exchange can we ever hope to understand the universal core of humanity.

The twenty-first century offers both opportunities and obstacles to the internationalization of psychology (van de Vijver, 2013). No doubt the most important opportunity is the internet, which has vastly increased our access to knowledge and our ability to communicate with colleagues around the globe. The rise of English as the international language of business, government, and science presents both an opportunity and an obstacle to full globalization. Communication is greatly enhanced, but the benefits accrue mainly to those for whom English is their native language, and those working with English as a second language will be disadvantaged as they interact on the global stage. Another obstacle to internationalization is the lack of scholarly mentorship in developing countries. Established researchers in the West will have to do their part to help guide young psychologists into mature scholars, in many cases through multinational collaborations. Finally, the greatest obstacle to internationalization is the same as it was at the turn of the previous century, namely geopolitical tensions that threaten once again to tear the global order asunder. We can only hope that our world leaders will act with more prudence than their predecessors did.

The same processes of integration are underway in the United States as well. Women are now taking leadership roles in psychology, and the barriers to entry by minorities are breaking down. These people will bring with them fresh perspectives that will enrich our understanding of the human experience. Perhaps as psychologists, we can even lead the way by example, showing how to build a diverse society where all are welcomed as equals and appreciated for the contributions they make. Despite the dangers we must all face together, there's certainly good reason to hope for a bright future.

CHAPTER SUMMARY

Neuroscience is built on previous work of the physiological psychologists in the middle of the twentieth century, but with support from new technologies that enabled scientists to record brain activity and create images of brain processes. The field got its name in the 1960s, but early work in what became known as behavioral neuroscience

started a decade before that. Some of the key discoveries of behavioral neuroscience included the role of the cerebellum in learning, the reward center in the brain, and neuroplasticity, namely the ability of the brain to reorganize and even regenerate after injury. The Cognitive Revolution of the 1960s led researchers in the following decades to

investigate relationships between cognitive functions and the brain processes that underlie them. Around the turn of the twenty-first century, researchers extended the reach of neuroscience to include the study of the brain processes that underlie emotion, in a field they called affective neuroscience. In the first decades of the twenty-first century, neuroscience has come to dominate psychology. Some philosophers of science speculate that neuroscience

will become a unifying theory or framework that draws together the fractured disciplines of psychology. Others, however, believe that advances in neuroscience will eventually make standard approaches to psychological experimentation obsolete. With the growth of interdisciplinary research, it's also important to consider psychology's relationship to the other sciences as traditional boundaries become blurred.

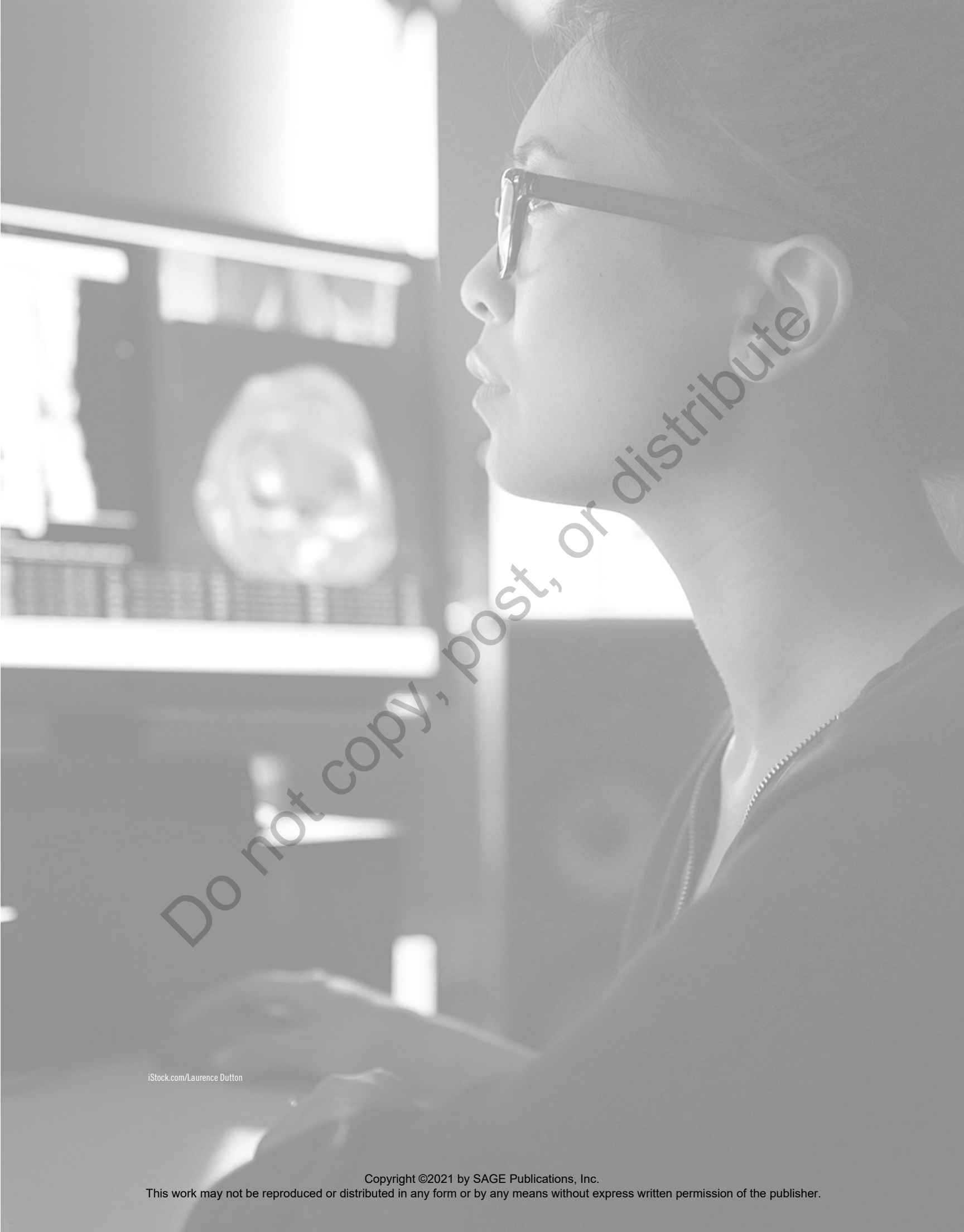
DISCUSSION QUESTIONS

1. Outline the steps Richard Thompson took to locate the engram for the eyeblink response. Consider how this project serves as a model for brain research.
2. Describe the manner in which James Olds and Peter Milner discovered the reward center in the brain. Consider how this project illustrates the role of serendipity in research and the need for scientists to be open to unexpected findings.
3. Mark Rosenzweig demonstrated the brain's ability to reorganize and even regenerate after injury. If we could learn how to control neural plasticity, what sorts of applications might this technology have? Consider also any ethical issues regarding neural regeneration.
4. Endel Tulving proposed that there are three types of memory, each with an associated level of consciousness. As you review this theory, consider what it implies about the relationship between memory and consciousness. Can you come up with examples or counterexamples to the model?
5. Michael Posner was one of the pioneers in the use of both ERP and fMRI. Compare the strengths and weaknesses of each technique, explaining how the two serve as complementary methodologies.
6. Patricia Goldman-Rakic studied the biological basis of working memory by experimenting on rhesus monkeys. How confident are you that her findings can be extended to humans? Defend your position with evidence and arguments.
7. Michael Gazzaniga has lamented that his work on hemispheric specialization has led to many popular misconceptions about how the brain works. What are some of the left-brain/right-brain myths you've heard, and how would you counter them?
8. After describing Richard Lazarus's transactional model of stress, consider some of the stress-coping strategies it suggests. Illustrate these with real-life examples.
9. Outline Panksepp's seven primary emotion systems, evaluating how each maps onto our experience of emotion in daily life. Try to think of common emotions that aren't included in this list, and consider whether these might be complex emotions that can be broken down into a combination of basic emotional systems.
10. Joseph LeDoux thinks it may one day be possible to erase traumatic memories that lead to psychological disorders such as PTSD. What are the ethical implications of memory removal?
11. In the *Star Trek* universe, Captain Kirk is the emotional human and Mister Spock is the rational Vulcan. According to Damasio's somatic marker hypothesis, which would likely be the better decision maker? Explain.
12. How do you see the relationship between psychology and neuroscience progressing during your lifetime? Consider the various scenarios presented in this chapter, evaluating the likelihood of each.

ON THE WEB

Search **Richard Thompson eyeblink conditioning** for a short video of him demonstrating how this research was done. You can also search **James Olds and Peter Milner rat experiment** for a video showing the discovery of the reward center in the brain and self-stimulation by rats. YouTube hosts a brief documentary on the work of **Endel Tulving**, including snippets of an interview with him. Search **Michael Posner psychology** to find a twenty-minute interview with

this neuroscientist. The work of **Michael Gazzaniga**, and especially that of **split-brain patients**, is portrayed in a number of YouTube videos. You can also find a TED Talk by **Jaak Panksepp** as well as several interviews with him. Finally, both **Joseph LeDoux** and **Antonio Damasio** have a number of videos posted on YouTube. While you're surfing the web, don't forget to check out the official website of the **Amygdaloids**.



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Concept Glossary

ABX model. Newcomb's description of the forces that come into play as two people attempt to align their attitudes toward a third entity. (12)

Accommodation. The process whereby new information leads to the construction of novel cognitive structures. (8)

Act psychology. An early school of psychology which held that mental phenomena are active rather than passive processes. (6)

Action research. Experimental investigations aimed at finding effective methods for social change. (6)

Activity theory. The theoretical position that physical activity during social interactions is the basis for cognitive development. (9)

Actor-observer effect. The tendency to make dispositional attributions of others' behaviors and situational attributions of our own. (12)

Affective neuroscience. The study of the brain processes underlying emotion. (16)

Affordance. What the environment offers to an organism. (11)

Age of Enlightenment. A period during the eighteenth century when religious dogma was questioned and reason was held as the ultimate authority. (1)

Agentic shift. A process in which individuals transfer responsibility for their own actions to an authority figure. (12)

Agoraphobia. The fear of leaving home or going into public places. (13)

Allegory of Meno's slave. A story in which Plato shows how Socrates draws out knowledge of geometry from an uneducated boy. (1)

Allegory of the cave. A story in which Plato argues that knowledge can only come from reason because the senses can deceive us. (1)

Anal stage. A time in psychosexual development when a child derives pleasure from the anus and buttocks. (7)

Analytical psychology. Jung's approach to depth psychology emphasizing the role of the collective unconscious and archetypes. (7)

Anchoring and adjustment. A way of estimating a value by moving away from a potentially arbitrary starting point. (11)

Anima. The ideal feminine image. (7)

Animus. The ideal masculine image. (7)

Anterograde amnesia. The inability to form new memories. (16)

Anxious attachment. A mother-infant bond in which the baby is distressed by its mother's departure but isn't soothed by her return. (13)

Aphasia. Loss of language functions due to brain damage. (9)

Apperception. The ability to reflect on one's own perceptions. (1)

Applied psychology. A field that uses psychological research to solve practical problems in daily life. (3)

Approach-avoidance conflict. A situation in which an organism simultaneously experiences a drive to obtain a desired object and a fear compelling it to flee the object. (5)

Archetypes. The primitive ideas contained in the collective unconscious. (7)

Artificial conditioned reflex. The association of an innate reflex with a novel stimulus. (9)

Artificial selection. The intentional breeding of desired characteristics in domestic animals and plants. (2)

Assimilation. The process whereby new information is incorporated into existing cognitive structures. (8)

Associated motor reflex. A muscle movement in response to a signal that a pain stimulus is about to occur. (9)

Associationism. The theory that knowledge develops as simple ideas combine to form complex ideas. (1)

Attachment. The deep emotional bond that develops between an infant and its mother. (13)

Attachment theory. The proposal that the kind of caregiver-infant bond that develops in the first year has significant consequences for later social, emotional, and personality development. (13)

Attenuation model. Treisman's proposal that attention increases the intensity of a wanted stimulus and decreases the intensity of an unwanted stimulus. (11)

Attribution. An inference about the cause of a behavior. (6)

Attribution theory. A framework for explaining the types of inferences people make about the causes of behavior. (6)

Autokinetic effect. A perceptual phenomenon in which a stationary point of light on a dark background appears to move. (12)

Automatism. A behavior that is performed without conscious awareness. (8)

Autoradiography. A method of producing an X-ray image by injecting a radioactive substance into the body. (16)

Availability heuristic. A way of judging the probability of an event by how easily examples come to mind. (11)

Avoidant attachment. A mother-infant bond in which the baby isn't distressed by its mother's departure and shows little interest in her return. (13)

Balance theory. A description of how people adjust their sentiments toward others to achieve a stable cognitive state. (6)

Baldwin effect. The observation that even though learned behaviors of parents cannot be inherited by offspring, the ability to quickly learn adaptive behaviors can be. (3)

- Basic anxiety.** Horney's term for a profound feeling of isolation and helplessness in an uncaring world. (7)
- Behavioral neuroscience.** The study of the brain processes underlying motivation and learning. (16)
- Big Five.** A model of personality consisting of five factors. (14)
- Biofeedback.** The process of gaining insights into physiological functions with the assistance of instruments that monitor them. (5)
- Bit.** The basic unit of information in communication and computing. (11)
- Bounded rationality.** The notion that humans make logical decisions within the limitations of their cognitive capacities and the availability of information. (11)
- Brass instrument psychology.** An early period in experimental psychology when stimuli were presented and responses were recorded by mechanical means. (3)
- Cannon-Bard theory.** The theory that stimulation of the thalamus leads to both physiological arousal and the psychological experience of emotion. (10)
- Cartesian dualism.** The proposal that the mind and the body are separate but interact with each other. (1)
- Catastrophism.** The idea that the Earth's geological features were formed during a small number of major cataclysms during the last few thousand years. (2)
- Categorical imperative.** Kant's fundamental moral law that we must always act in such a way as to respect the humanity of other people. (1)
- Catharsis.** The release of pent-up emotions that cause psychological distress. (7)
- Cell assembly.** A group of neurons that tend to fire together. (10)
- Chemoaffinity hypothesis.** The idea that developing nerve tracts find their destinations by following chemical trails. (10)
- Child Study Movement.** A late nineteenth-century campaign to reform educational practices based on the scientific study of child development. (4)
- Chunk.** A meaningful unit of information held in short-term memory. (11)
- Clinical method.** The investigative technique of asking probing questions and recording responses without judgment. (8)
- Cocktail party effect.** The ability to focus on one environmental stimulus while ignoring others. (11)
- Cognitive dissonance.** The mental discomfort that occurs when a person holds contradictory beliefs or when there is a mismatch between attitudes and behaviors. (12)
- Cognitive map.** A mental model of the spatial layout of a location. (5)
- Cognitive neuroscience.** The study of the brain processes underlying memory and attention. (16)
- Cognitive science.** An interdisciplinary approach to studying the mind and how it works. (1)
- Collective unconscious.** In Jungian theory, a storehouse of innate ideas that have been passed down through human evolutionary history. (7)
- Combined motor method.** An experimental procedure in which participants squeeze a rubber bulb as they give word-association responses. (9)
- Common fate.** The Gestalt principle that items moving together are perceived as a single object. (6)
- Commonsense psychology.** The set of beliefs about human behavior that people use to guide their interactions with others. (6)
- Comparative psychology.** The study of the origin, control, and consequences of behavior across a wide range of species. (10)
- Comparison level.** A consideration of the quality of the relationship in the current interaction as compared with past interactions. (12)
- Comparison level of alternatives.** A consideration of the other relationship options available to each partner. (12)
- Compatibilism.** The argument that human free will can still exist even in a fully deterministic world. (1)
- Complex.** Interrelated set of unconscious memories and emotions on a common theme. (7)
- Computer metaphor.** The notion that the mind is an information-processing device much like an electronic computer. (11)
- Concrete operational stage.** A period in which grade schoolers have the ability to think logically with the aid of manipulated objects. (8)
- Conditioned emotional response.** A process in which a person develops an emotional reaction to a previously neutral stimulus. (5)
- Conditioned taste aversion.** Learned avoidance of a food associated with illness. (10)
- Confederate.** A collaborator with the experimenter whose job it is to create a specific social situation in which to observe the participant's behavior. (12)
- Congruence.** A genuine and authentic relationship between the therapist and the client. (15)
- Connectionism.** The view that learning is fundamentally about forming new associations or connections. (4)
- Conservation.** The understanding that the mass of a substance remains the same even when its shape changes. (8)
- Consilience.** A convergence of all knowledge into a single scientific structure. (16)
- Contiguity theory.** The proposal that stimulus-response associations are created in a single instance when the stimulus and response co-occur at about the same time. (5)
- Controversial Discussions.** A series of meetings of the British Psychoanalytic Society in the early 1940s that pitted supporters of Anna Freud and Melanie Klein against each other. (7)
- Corpus callosum.** The band of nerve fibers connecting the left and right hemispheres of the cerebrum. (10)
- Correspondence bias.** The tendency to assume that behaviors reflect the true intentions of the people who perform them. (12)
- Counter-attitudinal advocacy.** A self-persuasion technique in which people are asked to take a public position on an issue that differs from their privately held beliefs. (12)

- Covariation model.** The proposal that people make attributions by considering which potential cause best predicts the behavior. (12)
- Creationism.** The idea that the various species existing today were created in their present form. (2)
- Crisis.** A turning point in life that will set the direction for future personality development. (15)
- Cronbach's alpha.** A statistical technique for estimating the reliability of a psychometric test. (13)
- Crystallized intelligence.** The accumulation of knowledge over a lifetime. (14)
- Cultural-historical psychology.** Vygotsky's theoretical approach emphasizing the role of social interaction in cognitive development. (9)
- Culture-free intelligence test.** An instrument that measures fluid intelligence. (14)
- Curiosity and manipulation drives.** Motivation to seek out novel experiences and explore new things. (10)
- Deduction.** A method of reasoning that applies general rules to specific cases. (1)
- Defense mechanisms.** Unconscious responses to anxiety-provoking situations. (7)
- Delayed-response task.** A laboratory procedure in which the subject observes a desired object being hidden in one of two containers and is then distracted for a brief time, after which it is allowed to retrieve it. (16)
- Dichotic listening.** A laboratory task in which the participant hears two different streams of speech through left and right headphones and is asked to only attend to one of them. (11)
- Direct perception.** The argument that we perceive the world as it is without having to process the sensory stimulus. (11)
- Discrimination learning.** The process of learning to respond differently to stimuli that differ in some particular aspect. (5)
- Dissociation.** A phenomenon in which persons become detached from their perceptions, memories, or behaviors. (8)
- Doctrine of the idols.** Bacon's assertion that the human mind is beset with biases that lead it to predictable errors. (1)
- Double dissociation.** The demonstration that two independent variables have different effects on two dependent variables. (10)
- Double-aspect monism.** The view that mind and body are two facets of the same universal substance. (1)
- Drive reduction theory.** The proposal that learning occurs when a behavior is impelled by an unpleasant state that is reduced after that the behavior is performed. (5)
- Dualism.** The philosophical stance that mind and body consist of distinct substances and are subject to different laws. (1)
- Dynamic psychology.** The position that behavior can only be explained if the motivations of the organism are first understood. (4)
- Ego.** The sense of self or agency. (7)
- Egocentrism.** A lack of awareness that other people have points of view different from one's own. (8)
- Elaboration principle.** The process in which members of the core group invite additional persons to join in, forming a larger social network. (12)
- Electroencephalography.** A technique for recording electrical activity produced in the brain by placing a set of electrodes on the scalp. (16)
- Eliminative reductionism.** The notion that higher levels of explanation become unnecessary once lower levels of explanation have been fully developed. (16)
- Emergent property.** A phenomenon that arises from processes at a lower level but is not fully explicable in terms of those processes. (16)
- Empiricism.** The philosophical stance that knowledge can only be obtained through experience. (1)
- Engram.** The hypothetical location in the brain where a memory is stored. (10)
- Environment of evolutionary adaptedness.** The stable period of about 200,000 years during which humans lived as hunter-gatherers. (13)
- Epiphenomenalism.** The position that consciousness is nothing more than a byproduct of brain activity. (3)
- Episodic memory.** The recollection of personal experiences. (16)
- Epistemology.** The study of knowledge, which asks questions such as what it means to know something and how knowledge can be acquired. (1)
- Equilibration.** The process of aligning cognitive structures with current environmental conditions. (8)
- Equipotentiality.** The observation that any part of a functional area of the brain is able to carry out the function of the whole area. (10)
- Ethology.** The study of animal behavior in natural settings. (10)
- Eudaimonia.** The view of happiness as resulting from a life in which persons pursue self-actualization and the fulfillment of their potential. (15)
- Eugenics.** The idea that the human race can be rapidly improved through artificial selection techniques. (2)
- Event-related potential.** A technique for measuring the time course of mental events based on EEG recordings. (16)
- Evolution.** The idea that species change over time as they adapt to new environments and challenges. (2)
- Existentialism.** A mid-twentieth-century school of philosophy claiming the central problem that humans face is coming to terms with the anxiety of living in a meaningless world. (15)
- Expected utility theory.** The standard mathematical model of decision making under risk. (11)
- Eyelid conditioning.** A classical conditioning procedure in which a light or tone is paired with a puff of air to the eye, causing the subject to blink. (5)
- Facial efference.** The observation that facial expressions and emotions may be linked through blood flow to the brain. (12)
- Factor analysis.** A statistical technique for reducing a large number of observed variables to a small number of underlying variables. (4)

- Feature integration theory.** Treisman's proposal that the role of attention is to bind features of objects, such as color or shape, into coherent wholes. (11)
- Fechner's law.** The proposal that the intensity of the sensation is related by a logarithmic function to the intensity of the stimulus. (2)
- Field theory.** Lewin's idea that an individual's behavior is determined by personal and situational forces. (6)
- Fight-or-flight response.** The body's arousal reaction to a dangerous situation. (10)
- Figure-ground organization.** The distinction between foreground and background. (6)
- Filter model.** Broadbent's description of attention as a bottleneck that limits the amount of information coming into the organism. (11)
- First signal system.** Pavlov's conceptualization of conditioned reflexes as adjustments to a changing environment. (9)
- Fistula.** A surgical opening that provides access for inserting tubes into internal organs. (9)
- Fixed idea.** A subconscious memory of a traumatic event. (8)
- Fixed mindset.** The belief that a person's intelligence is a fixed quantity that cannot change. (15)
- Flashbulb memory.** A vivid and detailed recollection of events after an emotionally charged experience. (11)
- Flow.** A peak experience in which skilled practitioners report a sense of ecstasy and a loss of time and self. (15)
- Fluid intelligence.** The ability to solve novel problems quickly. (14)
- Flying man argument.** A thought experiment intended to demonstrate the existence of self-awareness outside of the body. (1)
- Forensic psychology.** The application of psychological principles to the legal system. (3)
- Formal operational stage.** A period when adolescents acquire the ability to think logically about abstract or hypothetical situations. (8)
- Framing effect.** The observation that the way a problem is presented influences the decision that is made. (11)
- Free association.** A psychotherapy technique in which patients are encouraged to say whatever comes to mind without attempting to censor their thoughts. (7)
- Freudian slip.** A lapse of memory or an error in speech due to interference from a repressed memory. (7)
- Frustration-aggression hypothesis.** The proposal that people turn to aggression when they are frustrated in reaching their goals. (5)
- Functionalism.** An early American school of psychology that studied mental processes in terms of their adaptive value. (4)
- Fundamental attribution error.** The tendency to discount situational factors and to assume that behavior is driven by personal dispositions. (12)
- Game theory.** A framework for analyzing the costs and benefits of a social exchange to predict whether the partners will cooperate with each other or defect from the relationship. (12)
- Genetic epistemology.** In Piaget's terms, the study of the origin of knowledge. (8)
- Genital stage.** The period of mature psychosexual development in adulthood. (7)
- Gestalt.** German word for "configuration." (6)
- Gestalt quality.** An aspect of a configuration as a whole that none of its parts possesses. (6)
- Group dynamics.** The ways in which social organizations respond to changing circumstances. (6)
- Growth mindset.** The belief that intelligence is a mutable quantity that can increase over time. (15)
- Habit.** A behavioral pattern that develops as the nervous system reorganizes through repeated action. (4)
- Hebbian learning.** The proposal that when two adjacent neurons are repeatedly activated at the same time, the connection between them is strengthened. (10)
- Hedonism.** The view that happiness is the product of pleasurable experiences. (15)
- Heritability.** A statistic indicating the degree to which genetic factors account for the observed variation in a population. (14)
- Heuristics.** Intuitive decision-making processes that are fast and easy but prone to error. (11)
- Hierarchy of needs.** Maslow's contention that the more basic needs will dominate a person's thoughts and feelings until they are met, at which point higher-order needs will emerge. (15)
- Higher nervous activity.** Pavlov's term for the nervous system functions that coordinate the organism's interactions with its environment. (9)
- Homeostasis.** The processes by which the body maintains stable internal conditions. (10)
- Humanistic psychology.** The view that humans have an innate drive to grow toward fulfilling their potential in life. (15)
- Hypothetico-deductive method.** The scientific approach of generating falsifiable hypotheses that are then tested in experiments. (5)
- Hysteria.** An antiquated diagnosis for patients suffering from symptoms such as numbness and paralysis even though there's no damage to the nervous system. (7)
- Id.** The repository of innate drives or instincts. (7)
- Idealism.** The philosophical stance that the world consists solely of minds and the ideas they produce. (1)
- Identity crisis.** The time during adolescence when emerging adults consolidate their sense of who they are as individuals. (15)
- Idiographic approach.** A research style of examining individual persons in great depth. (14)
- Imageless thought controversy.** An extended debate between Titchener and his rivals about the nature of consciousness. (3)
- Imprinting.** A behavioral phenomenon in which a newly hatched chick identifies the first moving object as its mother. (10)

Inattention blindness. A phenomenon in which persons fail to see something directly in front of them because their attention is focused elsewhere. (11)

Individual psychology. Adler's version of psychotherapy that emphasized the centrality of social functioning in mental health. (7)
Binet's term for the study of individual differences in personality and intelligence. (8)

Individuation. A process in which unconscious complexes are brought into consciousness and integrated with the ego. (7)

Induction. A method of reasoning that examines specific cases in order to discover general rules. (1)

Industrial and organizational psychology. The application of psychological principles to business, manufacturing, and other large-group settings. (3)

Inferiority complex. A lifestyle dominated by a sense of helplessness and unworthiness. (7)

Ingratiation. The kinds of behaviors people engage in to get others to like them. (12)

Inhibition of return. A delay in an attentional shift back to a previously attended location. (16)

Instinct. A complex behavioral response to a specific stimulus or situation that doesn't require learning. (4)

Intelligence quotient. The ratio between the mental age and the chronological age of the test taker. (4)

Intentionality. The quality of being about something. (6)

Interdependence theory. A description of how the costs and benefits of particular interactions lead to decisions about whether to cooperate or compete and whether to continue or leave the relationship. (12)

Internal versus external control of reinforcement. The belief that life events are the outcome either of personal effort or of outside forces. (14)

Internal working model. An infant's mental framework for understanding how relationships work based on interactions with caregivers. (13)

Intervening variables. The internal states of the organism mediating between stimulus and response. (5)

Introspection. The careful observation of one's own mental states. (3)

Iowa gambling task. A laboratory procedure for assessing decision-making abilities in brain-damaged patients. (16)

Isomorphism. The idea that the structure of conscious experience is mirrored by similarly structured physical events in the brain. (6)

James-Lange theory. The idea that emotional experience is an interpretation of bodily arousal within a given situation. (4)

Jigsaw classroom. A pedagogical technique in which each member of a group has a different piece of information needed to complete the assignment. (12)

Judgment. The estimation of the likelihood of an event. (11)

Just-noticeable difference. The amount a stimulus has to be increased or decreased before a change in the stimulus can be detected. (2)

Lamarckism. A theory of evolution proposing that characteristics acquired during an organism's lifetime can be passed on to its descendants. (2)

Latency stage. A time in psychosexual development when a child's sexual feelings remain dormant. (7)

Latent content. The unconscious meaning of the dream. (7)

Latent learning. A type of learning that occurs without reward or drive reduction and without any overt expression of behavior. (5)

Law of effect. The observation that learning is strengthened when it is accompanied by a pleasant feeling and weakened when it is accompanied by an unpleasant feeling. (4)

Law of exercise. The observation that learning increases with the number of repetitions. (4)

Law of Prägnanz. The assertion that perceptual organization will be as good as the prevailing conditions allow. (6)

Law of readiness. The observation that individuals learn best when they are motivated and prepared to do so. (4)

Laws of association. Hume's description of how simple ideas adhere to each other to form complex ideas. (1)

Learned helplessness. A phenomenon in which an organism fails to escape a painful situation even when it is capable of doing so. (15)

Learning set. Understanding of how to approach a solution to a particular type of problem. (10)

Lesion study. A research technique that involves damaging a specific portion of the brain and observing any subsequent deficits. (16)

Levels of aspiration theory. The proposal that successful completion of a task depends not only on ability but also the motivation to complete it. (14)

Levels-of-analysis approach. The position that explanations at one level are unrelated to explanations at a higher or lower level. (16)

Lewin's equation. $B=f(P,E)$, meaning that behavior (B) is a function (f) of both personal (P) and environmental (E) variables. (6)

Lexical hypothesis. The proposal that words for personality traits should be common in any language because they serve an important role in social interactions. (14)

Life space. Lewin's term referring to the totality of forces acting on an individual, including personality and motivation as well as social and environmental influences. (6)

Lifestyle. Adler's term for an individual's typical approach to dealing with the world. (7)

Little Albert experiment. A case study in which John Watson demonstrated a conditioned fear in a young boy. (5)

Locus of control. Another term for internal versus external control of reinforcement. (14)

Lost-in-the-mall technique. A laboratory procedure for implanting false memories. (11)

Lower nervous activity. Pavlov's term for the nervous system functions that regulate the internal organs. (9)

Manifest content. The narrative of a dream as recalled by the dreamer on awakening. (7)

Mass action. The observation that an impairment in functioning depended on the amount of brain tissue destroyed. (10)

Materialism. The view that there is only matter and that no separate substance is needed to explain the mind. (1)

Maternal deprivation hypothesis. The proposal that prolonged separation from the mother in early childhood leads to pathological personality development in adolescence. (13)

Maternal sensitivity. The degree to which the mother is attentive and responsive to her infant's needs. (13)

Maturationism. The belief that development unfolds according to a set schedule of milestones. (4)

Mean length of utterance (MLU). The average number of meaningful units per sentence, used as a measure of language development. (13)

Means-ends analysis. The problem-solving method of searching for ways to close the distance between the current state and the goal state. (11)

Mental chemistry. Mill's argument that complex ideas can have features not found in any of its components. (1)

Mental chronometry. The measurement of the time course of cognitive events. (16)

Mental test. An indirect assessment of intelligence based on simple measurements such as reaction time and memory span. (3)

Mere exposure effect. The observation that people tend to like familiar items more than unfamiliar ones. (12)

Metaphysics. The philosophical inquiry into the nature of the universe. (1)

Method of doubt. Descartes's way of avoiding unwarranted assumptions by questioning everything that cannot be logically verified. (1)

Method of dual stimulation. An experimental technique in which a child is first asked to solve a problem alone and then with the help of an adult. (9)

Methodological behaviorism. The position that psychology should ignore questions of consciousness and focus on behavior instead. (5)

Microelectrode recording. A brain-recording technique in which an ultrathin electrode is inserted to a position where it can measure the activity of a single neuron. (16)

Mill argument. Leibniz's thought experiment demonstrating that mental processes cannot be produced by mechanical means. (1)

Millisecond. A thousandth of a second. (3)

Mind-body problem. The question of how psychological experience is related to the physical world. (1)

Misinformation effect. The distortion of memory due to exposure to false or misleading information after the event. (11)

Modern synthesis. An explanation of Darwinian evolution in terms of Mendelian genetics. (2)

Molar behavior. The behavior of the organism as a whole, especially as directed toward a particular purpose. (5)

Molecular behavior. The movements of the individual muscles that make up a behavior. (5)

Monism. The philosophical stance that mind and body consist of the same substance and are subject to the same laws. (1)

Multiform method. A procedure for diagnosing a personality by subjecting the participant to a battery of tests conducted by a group of examiners who then discuss the case to reach a consensus. (14)

Natural selection. A theory of evolution proposing that individuals which are better suited to current circumstances are more likely to survive and reproduce. (2)

Nature and nurture. A catchphrase to describe the respective impact of biological inheritance and environmental upbringing on human development. (2)

Need-press theory. The view that personality is shaped by psychodynamic processes as the individual is driven by internal motivations and constrained by situational factors. (14)

Neo-behaviorism. An approach that sought to explain behaviors that could not be described as conditioned responses. (5)

Neurasthenia. An antiquated diagnosis for patients suffering from symptoms such as fatigue, headache, heart palpitations, anxiety, and depressed mood. (7)

Neurology. The branch of medicine that treats disorders of the nervous system. (7)

Neuropsychology. A field of study that seeks to find connections between brain locations and behavioral or cognitive functioning. (9)

Neurosis. A relatively minor psychological disorder that interferes with the patient's ability to lead a happy and productive life but without a loss of contact with reality. (7)

Nomothetic approach. A research style of examining many examples to derive generalizations. (14)

Normative model. A description of how people should act rather than how they really behave. (12)

Object permanence. The understanding that objects continue to exist even when out of sight. (8)

Object-relations theory. The proposal that relationships with significant others in infancy shape patterns of relating in adulthood. (7)

Oedipus complex. The proposal that all young children develop a sexual longing for their opposite-sex parent and a sexual jealousy toward their same-sex parent. (7)

Operant behavior. An action that is performed by an organism without being elicited by a stimulus in the environment. (5)

Operant conditioning. The process of an organism learning about the consequences of its behavior. (5)

Operation. Piaget's term for a logical thought process. (8)

Operationalization. The practice of defining variables in terms of the way in which they will be measured. (3)

Opioid hypothesis. The conjecture that the formation of social attachment and contact comfort is mediated by endogenous opioids. (16)

- Optic flow.** The observation that the visual scene appears to expand from a central point in front of a moving observer. (11)
- Oral fixation.** A behavior involving the mouth that is engaged in to relieve anxiety. (7)
- Oral stage.** A time in psychosexual development when an infant derives pleasure from nursing at the breast or bottle. (7)
- Outcome matrix.** A diagram that lays out the costs and benefits of an interaction for each participant. (12)
- Paired-associates task.** A test of learning in which the participant memorizes pairs of unrelated words. (4)
- Panpsychism.** The belief that all things in the universe, whether animate or inanimate, have consciousness. (2)
- Peak experience.** A deeply emotional experience in which the person comes to see the world in a new way. (15)
- Penis envy.** Freud's contention that women naturally feel inferior to men because they know they lack a penis. (7)
- Perceptual learning.** The process of becoming more sensitive to the meaningful aspects of a visual scene. (13)
- Person versus situation debate.** An argument among psychologists during the 1970s about whether personalities or situations were the main determinant of behavior. (14)
- Persona.** Jung's term for the self that each person presents to others. (7)
- Personal conscious.** The part of the mind that a person is aware of. (7)
- Personal construct theory.** Kelly's proposal that people actively interpret the situations they encounter in order to control and predict the events in their lives. (14)
- Personal unconscious.** A repository of repressed memories accumulated over a lifetime. (7)
- Personality.** An individual's characteristic ways of feeling, acting, and thinking. (14)
- Personality paradox.** The observation that people's behaviors are inconsistent across a wide range of situations even though our intuitions tell us that individuals display enduring personality traits. (14)
- Personology.** Henry Murray's theory of personality formation throughout the lifespan by psychodynamic processes. (14)
- Phallic stage.** A time in psychosexual development when a child derives pleasure from rubbing the genitals. (7)
- Phi phenomenon.** The apparent motion of stationary but rapidly changing objects. (6)
- Physiological psychology.** The study of how behavior is generated and guided by the nervous system. (10)
- Physiology.** A subfield of biology that studies the processes and functions of living organisms. (2)
- Polymath.** A scholar who makes important contributions to several different fields. (2)
- Positive psychology.** The scientific study of happiness and the features of a life well lived. (15)
- Positivism.** The philosophical stance that scientists can only know what they can directly observe through their senses or instruments. (5)
- Posner cueing task.** A laboratory procedure that is used to measure people's abilities to make rapid shifts of attention. (16)
- Pragmatism.** The philosophical stance that the truth of an idea should be judged according to its practical consequences. (4)
- Preoperational stage.** A period in which the reasoning of preschoolers is dominated by magical thinking rather than rational thought. (8)
- Primary mental abilities.** The seven basic forms of intelligence proposed by Thurstone. (4)
- Principles of perceptual grouping.** Descriptions of how features such as similarity and proximity guide the organization of sensory elements into Gestalten. (6)
- Procedural memory.** Knowledge of how to do something. (16)
- Prospect theory.** A model of human decision making under risk that is based on evidence from experimental psychology. (11)
- Proximity principle.** The observation that people tend to like others who share the same environment with them. (12)
- Psychic secretion.** Salivation at the expectation of food. (9)
- Psychoanalysis.** Freud's theory of the origin of psychological disorders and his method for curing them. (7)
- Psychological analysis.** Janet's approach to treating psychological disorders by identifying and eliminating fixed ideas. (8)
- Psychometrics.** The field involved in the measurement of an individual's psychological characteristics. (4)
- Psychophysical parallelism.** The idea that mind and body act in harmony even though they do not interact. (1)
- Psychophysics.** The study of the relationship between physical stimuli and the sensations associated with them. (2)
- Psychosexual development.** The proposal that infants progress through a series of stages, each centered on a body part that is a source of sensual pleasure. (7)
- Psychosis.** A severe psychological disorder involving hallucinations, delusions, and a general loss of contact with reality. (7)
- Purposive behaviorism.** The position that organisms engage in behaviors to achieve particular goals. (5)
- Puzzle box.** An enclosure from which a test animal can escape if it performs the correct behavior. (4)
- Radical behaviorism.** The philosophical stance that internal experiences of the organism are behaviors just like outwardly observable actions. (5)
- Radical empiricism.** The philosophical stance that we don't just perceive sensations but rather objects in relations with other objects. (4)
- Rationalism.** The philosophical stance that knowledge can only be obtained through reason. (1)
- Recapitulation theory.** The idea that a developing organism repeats all the stages of the evolution of its species. (4)

Recency principle. The proposal that a familiar stimulus will evoke the most recent response to it. (5)

Reflexology. Bekhterev's approach of using associated motor reflexes to make inferences about the nature of mental processes in the brain. (9)

Regnancy. The central motivation in an individual's life that subordinates all other motives and brings unity to the personality. (14)

Reinforcement. A consequence of a behavior that increases the likelihood it will be repeated. (5)

Reinforcement history. An organism's past experience with a behavior and its consequence. (5)

Representativeness heuristic. A way of judging the probability of an event by how typical it appears. (11)

Repression. The exclusion of an unwanted or traumatic memory from consciousness. (7)

Respondent behavior. An action that is performed by an organism in response to a stimulus. (5)

Retrograde amnesia. The loss of memories that have already been stored. (16)

Reversibility. The mental undoing of a process to demonstrate conservation. (8)

Satisficing. The practice of making choices that are good enough for current needs. (11)

Savings during relearning. A process that occurs when a person learns something, forgets it, but then learns it again at a faster rate. (2)

Scientist-practitioner model. An approach to training clinical psychologists both as researchers and as therapists. (14)

Second signal system. Pavlov's conceptualization of language as a means for adjusting each other's behavior. (9)

Secure attachment. A mother-infant bond in which the baby is distressed by its mother's departure but soothed by her return. (13)

Secure base. The conceptualization of the caregiver's role as providing a safe zone from which the child can explore the world and to which it can retreat when frightened. (13)

Security theory. The proposal that infants need to develop a secure dependence upon their caregivers in order to develop the coping skills necessary for navigating a complex adult world. (13)

Seduction theory. The proposal that psychological disorders in adulthood are caused by sexual abuse in childhood. (7)

Self-actualization. The innate drive to reach one's fullest potential in life. (15)

Self-efficacy. A set of beliefs about one's ability to cope with particular challenges. (13)

Self-psychology. The position that the proper subject of psychology is the study of conscious selves as they interact with their social and physical environments. (4)

Self-transcendence. The highest level in the hierarchy of needs in which self-actualized persons seek to become part of something greater than themselves. (15)

Semantic memory. Knowledge of facts and concepts about the world in general. (11)

Sensorimotor stage. A period in which babies learn how the world works by experiencing it through their own bodily sensations and muscle movements. (8)

Separation fear. An infant's distress at its caregiver's departure. (13)

Sexual selection. A theory of evolution proposing that traits can be selected through competition for mates and the preferences of mating partners. (2)

Shadow. An unconscious entity in Jungian theory that contains those aspects of the self which the person doesn't like and so represses. (7)

Sham feeding. A process in which a fistula is cut into the throat and a tube inserted so that everything eaten is diverted from the stomach. (9)

Shaping. Arranging the consequences so that desired behaviors are reinforced. (5)

Similarity principle. The observation that people tend to be attracted to those who have interests in common with them. (12)

Social cognition. The typical thought patterns that people engage in as they interact with others. (6)

Social cognitive approach. A model of personality proposing that behavior is driven by the individual's unique interpretation of a given situation. (14)

Social cognitive theory. The proposal that people construct their own lives by choosing for themselves which models to emulate and which to reject. (13)

Social comparison theory. The proposal that people evaluate their own opinions and abilities by comparing themselves to other people who are similar to them. (12)

Social exchange theory. The view that people enter into relationships in order to trade goods and services for mutual advantage. (12)

Social facilitation. The effect that the presence of others has on an individual's ability to perform a task. (12)

Social influence. The ways in which the social situation shapes a person's behavior. (12)

Social interest. Active engagement in meaningful relationships with others and a desire to make positive contributions to society. (7)

Social learning theory. The proposal that children learn strategies for dealing with the world by copying the behaviors of their parents. (13)

Social learning theory of personality. Rotter's account of individual differences as developing through divergent life histories. (14)

Social perception. The ways we make inferences about the motivations and intentions of those we interact with. (12)

Socratic ignorance. The argument that true wisdom comes from knowing the limits of one's knowledge. (1)

Socratic Method. The instructional technique of asking questions to guide students in a self-exploration of their own thoughts. (1)

Somatic marker hypothesis. The proposal that emotions play an essential role in everyday decision making. (16)

- Somatosensory homunculus.** A diagram illustrating how specific areas of the brain map onto specific body parts. (10)
- Stage model of cognitive development.** Piaget's theory that children's understanding of the world goes through a series of transformations as they reorganize their mental structures to adapt to new experiences. (8)
- Stanford-Binet.** The first successful English-language test of intelligence. (4)
- Stevens' law.** The observation that a power function best describes the relationship between physical stimuli and psychological sensation. (11)
- Stimulus error.** The error of describing the object of perception instead of the conscious experience of that object. (3)
- Stimulus sampling theory.** The proposal that stimulus-response associations are learned in a statistical, not absolute, manner. (5)
- Strange Situation.** A laboratory procedure designed to test an infant's attachment style in which the mother briefly leaves her child alone in an unfamiliar room. (13)
- Stream of consciousness.** A conception of the mind as a continuous, dynamic process. (4)
- Striving for superiority.** Adler's term for people's natural desire to improve themselves. (7)
- Structuralism.** An early school of psychology that sought to decompose consciousness into its component parts. (3)
- Structure-of-intellect theory.** The proposal that mental abilities could be organized in three dimensions, depending on the kinds of operations, contents, and products involved. (3)
- Subconscious.** A level of consciousness in which perceptions are experienced and behaviors are performed without being aware of them. (8)
- Subjective well-being.** The view that happiness is a person's overall assessment of life satisfaction. (15)
- Subliminal consciousness.** Cognitive processes occurring below the threshold of awareness. (4)
- Superego.** An internalization of social and moral rules. (7)
- Superiority complex.** A lifestyle dominated by a sense of being better than other people. (7)
- Syllogism.** A logical argument that uses deductive reasoning to reach a conclusion. (9)
- Synchronicity.** The idea that shared archetypes in the collective unconscious enable the occurrence of meaningful coincidences. (7)
- Syndrome analysis.** The process of breaking down higher cognitive functions into their component parts. (9)
- Synesthesia.** A perceptual phenomenon in which sensations from different modalities become automatically associated. (8)
- Systematic introspection.** A method of accurately reporting sensory experiences under carefully controlled experimental conditions. (3)
- Tachistoscope.** An instrument that displays images for precise durations of time. (6)
- Teleology.** An emphasis on the final result in a process as opposed to its initial conditions. (1)
- Temperament.** The behavioral profile that is present in the infant at birth. (13)
- Texture gradient.** A repeating pattern in the environment that conveys information about distance and relative size. (11)
- Thematic Apperception Test.** A projective personality test consisting of a series of ambiguous pictures that the subject is asked to describe. (14)
- Theory of correspondent inferences.** A normative description of the circumstances in which we should make personal rather than situational attributions about another's behavior. (12)
- Theory of Forms.** Plato's idea that the world as we experience it is but a poor reflection of the world as it truly is. (1)
- Theory of psychosocial development.** The proposal that all people pass through eight distinct stages that shape their sense of identity as they go through life. (15)
- Theory of scales.** The argument that scales of measurement should be categorized by the types of mathematical operations that can be performed on them. (11)
- Think-aloud protocol.** A laboratory procedure in which participants verbally reported their thought processes as they solved puzzles. (11)
- Third force.** A catchphrase indicating that humanistic psychology stood in opposition to both behaviorism and psychoanalysis. (15)
- Three needs theory.** The proposal that an individual's personality is shaped by the three basic needs of achievement, power, and affiliation, one of which will dominate. (14)
- Three-step model of change.** Lewin's process for reshaping the culture of a group by changing the attitudes and behaviors of its members. (6)
- Tinbergen's four questions.** A set of guidelines for interpreting observations of animal behavior. (10)
- Tip-of-the-tongue phenomenon.** The experience of knowing that you know a word without being able to name it. (13)
- Trait.** A stable internal characteristic of an individual that is a determinant of behavior. (14)
- Trait theory.** The proposal that personalities can be analyzed into a finite number of measurable traits. (14)
- Transactional model of stress.** The proposal that stress is moderated by cognitive appraisal of the situation. (16)
- Transcendental idealism.** Kant's contention that human experience consists solely of appearances and not of things in themselves. (1)
- Transfer of training.** The idea that learning in one subject will aid learning in a different subject. (4)
- Transference.** The placing of feelings for one person or object onto another. (5)

Transformational-generative grammar. A theory of sentence structure based on phrase-structure and transformational rules. (11)

Two-factor theory of emotion. The proposal that emotions consist of general physiological arousal and a cognitive evaluation based on the situation. (12)

Two-factor theory of intelligence. Spearman's proposal that any cognitive ability consists of both general intelligence common to all tasks and the specific intelligence required for that particular task. (14)

Two-point threshold. A measure of skin sensitivity in which two points are gradually brought closer together until they are experienced as a single point. (2)

Tyranny of the shoulds. Horney's term for the tension between the real and the ideal self. (7)

Unconditional positive regard. Complete acceptance and non-judgment of another person. (15)

Unconscious inference. Helmholtz's position that perception is a rational process of finding the best interpretation of the sensory input. (2)

Uniformitarianism. The idea that the Earth's geological features were formed gradually over hundreds of millions of years through uniform processes still occurring today. (2)

Variability hypothesis. The notion that men display more extremes in high and low intelligence, whereas women tend to cluster around average abilities. (4)

Verbal learning. A behavioral field of study that investigated the retention and recall of language-based materials such as word lists and word pairs. (5)

Vicarious trial and error. The hesitation that occurs when an organism is uncertain which choice to make. (5)

Visual cliff. An apparatus for testing depth perception consisting of a glass surface spanning a drop of several feet. (13)

Vivisection. The cutting open of a live animal to study the functioning of its internal organs. (9)

Vygotsky boom. A period in the 1980s and 1990s when both Western and Russian psychologists took a renewed interest in Vygotsky's theory of cognitive development. (9)

Weber's law. The finding that the just-noticeable difference is always a proportion of the original stimulus. (2)

Working memory. The ability to hold on to information while it is being used to complete a task. (16)

Yerkes-Dodson law. The observation that there is an optimal level of arousal, neither too high nor too low, for best performance on a complex task. (4)

Zeigarnik effect. The observation that the details of uncompleted tasks are better remembered than are those of completed tasks. (6)

Zeitgeist. German expression for "spirit of the times," referring to the currency of ideas in a given time period. (3)

Zone of proximal development. The difference between a child's actual and potential development. (9)

Person Glossary

Abraham, Karl. (1877–1925). German psychoanalyst who laid the groundwork for object-relations theory. (7)

Adler, Alfred. (1870–1937). Austrian psychologist who emphasized overcoming feelings of inferiority and maintaining active social interest as the keys to mental health. (7)

Ainsworth, Mary. (1913–1999). Canadian-American psychologist who developed the Strange Situation, a laboratory procedure for testing attachment style. (13)

Al-Kindi. (801–873). Islamic philosopher who tried to integrate Greek philosophy with Islamic theology. (1)

Allport, Floyd. (1890–1978). American psychologist who pioneered the experimental approach to social psychology. (14)

Allport, Gordon. (1897–1967). American psychologist who is recognized as the founder of modern personality psychology. (14)

Angell, James Rowland. (1869–1949). Early American psychologist who, with John Dewey, was one of the founders of the Chicago school of functionalism. (4)

Aristotle. (384–322 BCE). Ancient Greek philosopher who argued that all knowledge comes from experience. (1)

Aronson, Elliot. (Born 1932). American social psychologist who has used cognitive dissonance theory for the purpose of effecting positive social change. (12)

Asch, Solomon. (1907–1996). Polish-American social psychologist who studied conformity in a series of famous experiments. (12)

Averroes (1126–1198). Islamic philosopher who reintroduced Aristotelian philosophy to Europe. (1)

Avicenna (980–1037). Islamic philosopher who provided an influential thought experiment regarding the nature of self-awareness known as the “flying man” argument. (1)

Bacon, Francis. (1561–1626). English philosopher and the father of British empiricism who introduced the method of induction. (1)

Baldwin, James Mark. (1861–1934). Early American psychologist who was a pioneer in the fields of developmental and comparative psychology. (3)

Bandura, Albert. (Born 1925). Canadian-American psychologist best known for his Bobo doll experiments exploring the social learning of aggression in young children. (13)

Bartlett, Frederic. (1886–1969). Early twentieth-century British psychologist who argued for the reconstructive nature of memory. (11)

Beach, Frank. (1911–1988). American comparative psychologist who was instrumental in helping the European ethologists gain acceptance in North America. (10)

Bekhterev, Vladimir. (1857–1927). Russian neurologist who founded an approach to psychology known as reflexology based on the associated motor reflex. (9)

Berkeley, George. (1685–1753). Irish philosopher who did groundbreaking research on depth perception and promoted the philosophy of idealism. (1)

Bernal, Martha. (1931–2001). First Hispanic-American woman to earn a Ph.D. in psychology. (13)

Berscheid, Ellen. (Born 1936). American social psychologist who studies the dynamics of close interpersonal relationships. (12)

Binet, Alfred. (1857–1911). French psychologist who collaborated with Théodore Simon to produce the first reliable intelligence test. (8)

Blatz, William. (1895–1964). Canadian developmental psychologist noted for his security theory, which was a precursor to attachment theory. (13)

Boring, Edwin. (1886–1968). Early American psychologist who was a noted historian of psychology. (3)

Bower, Gordon. (Born 1932). American psychologist who developed influential mathematical and computational models of human learning and memory. (5)

Bowlby, John. (1907–1990). British psychologist who studied the impact of mother-child separation and proposed attachment theory to explain its effects. (13)

Brentano, Franz. (1838–1917). Austrian philosopher who advocated for a scientific approach to studying the mind that he called act psychology. (6)

Breuer, Josef. (1842–1925). Austrian neurologist who pioneered the use of the cathartic method to treat hysteria. (7)

Broadbent, Donald. (1926–1993). British psychologist who developed the filter model of attention. (11)

Brown, Roger. (1925–1997). American developmental psychologist who studied language acquisition in the early years of childhood. (13)

Bruner, Jerome. (1915–2016). American developmental psychologist who was one of the founders of the Cognitive Revolution. (11)

Bühler, Charlotte. (1893–1974). German developmental psychologist and one of the founders of the humanistic psychology movement. (15)

Burlingham, Dorothy. (1891–1979). American psychoanalyst and partner of Anna Freud who studied early childhood development. (7)

Burt, Cyril. (1883–1971). British psychologist who pioneered the use of twin studies to test the heritability of intelligence. (14)

- Calkins, Mary.** (1863–1930). Early American psychologist who is best known as the first female president of the APA. (4)
- Cannon, Walter.** (1871–1945). American physiological psychologist best known for his concepts of flight-or-flight and homeostasis. (10)
- Carr, Harvey.** (1873–1954). Early American psychologist who led the functionalist movement during its transition into behaviorism. (4)
- Cattell, James McKeen.** (1860–1944). Early American psychologist who brought experimental methods from Germany and pioneered the field of mental testing. (3)
- Cattell, Raymond.** (1905–1998). British-American psychologist who proposed an influential sixteen-factor model of personality. (14)
- Charcot, Jean-Martin.** (1825–1893). French neurologist who first described the symptoms and possible causes of hysteria. (8)
- Chomsky, Noam.** (Born 1928). American linguist who helped start the Cognitive Revolution by demonstrating that language cannot be learned through operant conditioning alone. (11)
- Claparède, Édouard.** (1873–1940). Swiss developmental psychologist who nurtured Piaget's career. (8)
- Clark, Kenneth.** (1914–2005). African American psychologist whose research was cited in the Supreme Court decision that declared segregation unconstitutional. (13)
- Clark, Mamie.** (1917–1983). African American psychologist who developed the doll studies that were cited by the Supreme Court regarding the need for school desegregation. (13)
- Cronbach, Lee.** (1916–2001). American educational psychologist noted for his contributions to psychological testing and measurement. (13)
- Csikszentmihalyi, Mihaly.** (Born 1934). Hungarian-American psychologist who is one of the founders of positive psychology and who discovered a kind of peak experience known as "flow." (15)
- Damasio, Antonio.** (Born 1944). Portuguese-American neuroscientist who proposed the somatic marker hypothesis. (16)
- Darwin, Charles.** (1809–1882). Nineteenth-century English scientist who proposed the theory of evolution by natural selection. (2)
- Dembo, Tamara.** (1902–1993). Russian-American psychologist who was a pioneer in the field of rehabilitation psychology. (6)
- Descartes, René.** (1596–1650). French philosopher who was one of the first thinkers of the early Modern Period to provide a detailed model of how the mind and body interact. (1)
- Dewey, John.** (1859–1952). Early American psychologist who, with James Rowland Angell, was one of the founders of the Chicago school of functionalism. (4)
- Downey, June Etta.** (1875–1932). American psychologist who was the first woman chair of a psychology department at a major university. (3)
- Dweck, Carol.** (Born 1946). American psychologist who maintains that people's attitudes about the nature of intelligence or willpower influence the amount of effort they put into difficult tasks. (15)
- Ebbinghaus, Hermann.** (1850–1909). Nineteenth-century German psychologist whose memory research demonstrated that higher mental processes could be studied using rigorous experimental methods. (2)
- Ehrenfels, Christian v.** (1859–1932). Austrian philosopher who introduced the concept of Gestalt quality. (6)
- Ellis, Albert.** (1913–2007). American psychologist best known as the founder of rational emotive behavior therapy. (15)
- Erikson, Erik.** (1902–1994). German-American psychologist who maintained that development is a lifelong process and proposed the eight stages of psychosocial development. (15)
- Estes, William.** (1919–2011). American psychologist who developed influential mathematical models of learning and memory. (5)
- Eysenck, Hans.** (1916–1997). German-British psychologist who advanced a three-factor theory of personality. (14)
- Fechner, Gustav.** (1801–1887). Nineteenth-century German scientist who founded the field of psychophysics. (2)
- Festinger, Leon.** (1919–1989). American social psychologist who developed social comparison theory and cognitive dissonance theory. (12)
- Freud, Anna.** (1895–1982). Austrian-British psychoanalyst who conducted pioneering research on early childhood development. (7)
- Freud, Sigmund.** (1856–1939). Austrian neurologist who developed the theory and therapy known as psychoanalysis. (7)
- Frisch, Karl von.** (1886–1982). Austrian ethologist noted for his work on perception and communication in bees. (10)
- Galton, Francis.** (1822–1911). Nineteenth-century English scientist who developed data gathering and analysis methods and who coined the term "nature and nurture." (2)
- Gantt, Horsley.** (1892–1980). American medical doctor who studied conditioned reflexes with Pavlov in Russia. (9)
- Garcia, John.** (1917–2012). First Hispanic-American psychologist and discoverer of conditioned taste aversion. (10)
- Gazzaniga, Michael.** (Born 1939). American neuroscientist whose work with split-brain patients has led to our understanding of hemispheric specialization in the brain. (16)
- Gesell, Arnold.** (1880–1961). Early American psychologist who measured developmental norms in infants and young children. (4)
- Gibson, Eleanor.** (1910–2002). American developmental psychologist who used the visual cliff procedure to test depth perception in human infants. (13)
- Gibson, James.** (1904–1979). American cognitive psychologist who developed the theory of direct perception. (11)
- Gilligan, Carol.** (Born 1936). American psychologist who challenged Kohlberg's theory of moral development for its neglect of the kinds of moral decisions that women face. (15)
- Goldman-Rakic, Patricia.** (1937–2003). American cognitive neuroscientist whose research on the prefrontal cortex in primates led to a better understanding of the neural substrates of working memory. (16)

- Goldstein, Kurt.** (1878–1965). German neurologist who coined the term self-actualization to describe the way an organism recovers after injury. (15)
- Goodenough, Florence.** (1886–1959). Early American developmental psychologist who pioneered field methods for studying children's behavior over time. (4)
- Guilford, Joy Paul.** (1897–1987). American psychologist who proposed the structure-of-intellect theory. (3)
- Guthrie, Edwin.** (1886–1959). American behaviorist who explained learning in terms of contiguity theory and the recency principle. (5)
- Hall, G. Stanley.** (1846–1924). Early American psychologist who pioneered developmental psychology. (4)
- Harlow, Harry.** (1905–1981). American comparative psychologist best known for his studies on the effects of social isolation in monkeys. (10)
- Harrower, Molly.** (1906–1999). British-American clinical psychologist best known for her study of Nazi personality. (6)
- Hebb, Donald.** (1904–1985). Canadian physiological psychologist who developed a highly influential theory of how learning takes place in the brain. (10)
- Heider, Fritz.** (1896–1988). German-American Gestalt psychologist who pioneered the field of social cognition with his attribution theory and balance theory. (6)
- Helmholtz, Hermann von.** (1821–1894). Nineteenth-century German scientist who made important contributions to the physiology of the nervous system and the senses. (2)
- Hippocrates.** (About 460–370 BCE). Greek physician who proposed a theory of personality based on four “humors” or bodily fluids. (14)
- Hobbes, Thomas.** (1583–1679). British philosopher who argued that the mind is nothing more than the product of a mechanical brain. (1)
- Hollingworth, Leta.** (1886–1939). Early American psychologist known for studies on the psychology of women and gifted children. (4)
- Holt, Edwin.** (1873–1946). Early twentieth-century American psychologist who proposed the motor theory of consciousness. (11)
- Homskaya, Evgenia.** (1929–2004). Russian neuropsychologist known for her studies on the role of the frontal lobes in regulating behavior. (9)
- Horney, Karen.** (1885–1952). German-American psychoanalyst who was a pioneer in feminist psychology. (7)
- Howard, Ruth.** (1900–1997). Second African-American woman to receive a Ph.D. in psychology. (4)
- Hull, Clark.** (1884–1952). American neo-behaviorist who emphasized the role of drives and motivation in learning. (5)
- Hume, David.** (1711–1776). Scottish philosopher who developed laws of mental association. (1)
- Hypatia.** (355–415 CE). Woman Greco-Roman philosopher who has become a symbol for the struggle between science and religion. (1)
- Inhelder, Bärbel.** (1913–1997). Swiss psychologist who discovered the formal operational stage in cognitive development. (8)
- James, William.** (1842–1910). Harvard philosopher who inspired the first generation of American psychologists. (4)
- Janet, Pierre.** (1859–1947). Clinical psychologist who became recognized as the father of French psychology. (8)
- Jones, Edward.** (1926–1993). American social psychologist who developed correspondent inference theory and discovered the correspondence bias. (12)
- Jones, Mary Cover.** (1896–1987). American developmental psychologist who pioneered behavior modification therapy. (5)
- Jung, Carl.** (1875–1961). Swiss psychologist noted for his theory of personality types and his idea of the collective unconscious. (7)
- Kagan, Jerome.** (Born 1929). American developmental psychologist who has argued for the role of temperament in the formation of attachment style in infancy and personality in adulthood. (13)
- Kahneman, Daniel.** (Born 1934). Israeli psychologist who won the Nobel Prize for his work on the heuristics and biases approach to judgment and decision making. (11)
- Kant, Immanuel.** (1724–1804). German philosopher who sought to reconcile the rationalist and empiricist approaches by arguing that knowledge is acquired through experience but ordered by innate rational processes. (1)
- Kelley, Harold.** (1921–2003). American social psychologist who played important roles in developing interdependence theory and attribution theory. (12)
- Kelly, George.** (1905–1967). American psychologist who proposed personal construct theory. (14)
- Klein, Melanie.** (1882–1960). Austrian-British psychoanalyst known for her development of object-relations theory. (7)
- Koffka, Kurt.** (1886–1941). German-American psychologist who introduced Gestalt theory to English-speaking psychologists. (6)
- Kohlberg, Lawrence.** (1927–1987). American psychologist who proposed an influential theory of moral development. (15)
- Köhler, Wolfgang.** (1887–1967). German-American Gestalt psychologist who studied intelligence and problem solving in chimpanzees. (6)
- Külpe, Oswald.** (1862–1915). Early student of Wundt who was one of the founders of experimental psychology in Germany. (3)
- Kuo, Zing-Yang.** (1898–1970). Chinese behaviorist who rejected the concept of instinct and maintained that development occurs through an interaction of nature and nurture. (5)
- Ladd-Franklin, Christine.** (1847–1930). Early American psychologist who developed the modern evolutionary theory of color vision. (2)
- Lashley, Karl.** (1890–1958). American physiological psychologist whose studies on how memories are formed in the brain led to his laws of equipotentiality and mass action. (10)
- Lazarus, Richard.** (1922–2002). American psychologist who developed the transactional model of stress. (16)

- LeDoux, Joseph.** (Born 1949). American neuroscientist who studies the brain mechanisms that are responsible for fearful memories. (16)
- Leibniz, Gottfried.** (1646–1716). German philosopher who argued for psychophysical parallelism as an alternative to Cartesian dualism. (1)
- Leontiev, Alexei.** (1903–1979). Russian developmental psychologist who revised Vygotsky's cultural-historical psychology into activity theory. (9)
- Lewin, Kurt.** (1890–1947). German-American Gestalt psychologist who was one of the founders of experimental social psychology. (6)
- Likert, Rensis.** (1903–1981). American social psychologist best known for inventing the five-point rating scale that now bears his name. (13)
- Locke, John.** (1632–1704). British empiricist philosopher who developed a mental philosophy known as associationism. (1)
- Loftus, Elizabeth.** (Born 1944). American psychologist who studies the unreliability of eyewitness testimony and personal memories. (11)
- Lorenz, Konrad.** (1903–1989). Austrian ethologist best known for his studies of imprinting in birds. (10)
- Luria, Alexander.** (1902–1977). Russian psychologist who was one of the pioneers in neuropsychology. (9)
- Lyell, Charles.** (1797–1875). Early nineteenth-century geologist who argued that the Earth was very old. (2)
- Maccoby, Eleanor.** (1917–2018). American developmental psychologist best known for her work on sex differences, gender identity, and parent-child relationships. (13)
- Main, Mary.** (Born 1943). American developmental psychologist who has constructed methods for assessing attachment style during the early school years, adolescence, and in adulthood. (13)
- Maslow, Abraham.** (1908–1970). American psychologist who proposed an influential theory of motivation that included a hierarchy of needs and the concept of self-actualization. (15)
- May, Rollo.** (1909–1994). American psychologist who developed a form of counseling known as existential psychotherapy. (15)
- McClelland, David.** (1917–1998). American psychologist best known for his “three needs” theory of personality. (14)
- McDougall, William.** (1871–1938). Early twentieth-century British psychologist and pioneer in social psychology. (11)
- Meinong, Alexius.** (1853–1920). Austrian philosopher who founded the Graz school of Gestalt psychology. (6)
- Milgram, Stanley.** (1933–1984). American social psychologist who conducted controversial experiments on obedience to authority. (12)
- Mill, John Stuart.** (1806–1873). British empiricist philosopher who declared that psychology was ready to become a natural science that could be used to improve individual lives and society as a whole. (1)
- Miller, George.** (1920–2012). American psychologist who led the Cognitive Revolution with his description of the mind as a limited-capacity information processor. (11)
- Miller, Neal.** (1909–2002). American learning theorist who sought to redefine Freudian concepts in behavioral terms. (5)
- Milner, Brenda.** (Born 1918). British-Canadian psychologist who studied memory in patients with brain damage. (10)
- Milner, Peter.** (1919–2018). British-Canadian psychologist who discovered the reward center in the brain along with James Olds. (16)
- Mischel, Walter.** (1930–2018). Austrian-American psychologist who advocated for a social cognitive approach to personality. (14)
- Motora, Yujiro.** (1858–1913). First Japanese psychologist to earn his doctorate at an American university. (4)
- Münsterberg, Hugo.** (1863–1916). Early German-American psychologist who was a pioneer in applied branches of psychology. (3)
- Murphy, Gardner.** (1895–1979). American social psychologist who advocated for a biosocial approach to personality. (12)
- Murray, Henry.** (1893–1988). American personality psychologist mostly known for his development of the Thematic Apperception Test. (14)
- Neisser, Ulric.** (1928–2012). German-born American cognitive psychologist who investigated the unreliability of flashbulb memories. (11)
- Newcomb, Theodore.** (1903–1984). American social psychologist who studied attitude formation and the acquaintance process through longitudinal field studies. (12)
- Newell, Allen.** (1927–1992). American psychologist who used computer simulations to study human problem solving. (11)
- Nisbett, Richard.** (Born 1941). American social psychologist known for his studies of cognition across cultures. (12)
- Olds, James.** (1922–1976). American psychologist who discovered the reward center in the brain along with Peter Milner. (16)
- Panksepp, Jaak.** (1943–2017). Estonian-American psychologist who founded the field of affective neuroscience. (16)
- Pavlov, Ivan.** (1849–1936). Russian physiologist who discovered the conditioned reflex. (9)
- Pearson, Karl.** (1857–1936). British statistician who developed the methods of correlation and regression. (2)
- Penfield, Wilder.** (1891–1976). Canadian neurosurgeon who mapped the somatosensory cortex. (10)
- Piaget, Jean.** (1896–1980). Swiss psychologist who developed a very influential theory of cognitive development. (8)
- Plato.** (427–347 BCE). Ancient Greek philosopher who argued that all knowledge comes from reason. (1)
- Posner, Michael.** (Born 1936). American cognitive neuroscientist who studies the biological basis of attention. (16)
- Postman, Leo.** (1918–2004). American cognitive psychologist who developed the interference theory of forgetting. (11)
- Prosser, Inez.** (1895–1934). First African American woman to earn a doctorate in psychology. (4)

- Rank, Otto.** (1884–1939). Austrian psychoanalyst who argued that the normal course of a human life is a process of growth. (15)
- Rogers, Carl.** (1902–1987). American psychologist who proposed client-centered therapy and founded the humanistic psychology movement. (15)
- Rosenzweig, Mark.** (1922–2009). American psychologist who discovered that neural plasticity continues even in adulthood. (16)
- Ross, Lee.** (Born 1942). American social psychologist who discovered the fundamental attribution error. (12)
- Rotter, Julian.** (1916–2014). American psychologist who developed the social learning theory of personality and the concept of locus of control. (14)
- Rumelhart, David.** (1942–2011). American psychologist who developed the parallel distributed processing model of perception. (11)
- Schachter, Stanley.** (1922–1997). American social psychologist who developed the two-factor theory of emotion. (12)
- Sears, Robert.** (1908–1989). American developmental psychologist who was a pioneer in social learning theory. (13)
- Sechenov, Ivan.** (1829–1905). Russian physiologist who argued that all behavior, no matter how complex, can be broken down into simple reflexes. (9)
- Seligman, Martin.** (Born 1942). American psychologist who is one of the founders of positive psychology and is best known for his research on learned helplessness. (15)
- Sherif, Muzafer.** (1906–1988). Turkish psychologist who studied the spread of social norms and the dynamics of intergroup conflict. (12)
- Simon, Herbert.** (1916–2001). American psychologist who studied decision making in humans and modeled those processes on computers. (11)
- Simon, Théodore.** (1872–1961). French psychologist who collaborated with Alfred Binet to produce the first reliable intelligence test. (8)
- Skinner, Burrhus Frederic.** (1904–1990). Prominent American psychologist who is best known for developing the methods of operant conditioning and for promoting radical behaviorism. (5)
- Socrates.** (469–399 BCE). Ancient Greek philosopher who was one of the first to turn philosophy toward questions about the nature of the mind. (1)
- Solomon, Richard.** (1918–1995). American comparative psychologist noted for his work on avoidance learning. (15)
- Spearman, Charles.** (1863–1945). British psychologist who developed the theory of general intelligence. (14)
- Spence, Janet Taylor.** (1923–2015). American clinical psychologist who was a leader in gender studies during the last half of the twentieth century. (5)
- Spence, Kenneth.** (1907–1967). American neo-behaviorist who was the major proponent of Hull's drive reduction theory. (5)
- Sperry, Roger.** (1913–1994). American psychologist who won the Nobel Prize for his research on split-brain patients. (10)
- Spielrein, Sabina.** (1885–1942). Russian psychoanalyst who made important contributions to the study of childhood development. (9)
- Spinoza, Baruch.** (1632–1677). Dutch philosopher who argued that mind and matter are but two aspects of the same underlying nature. (1)
- Stern, William.** (1871–1938). German psychologist who developed the concept of intelligence quotient, or IQ. (6)
- Stevens, Stanley Smith.** (1906–1973). American psychologist who developed the power law in psychophysics and an influential theory of scales of measurement. (11)
- Strickland, Bonnie.** (Born 1936). American psychologist who studied the mental health of persons and groups who are marginalized from mainstream society. (14)
- Stumpf, Carl.** (1848–1936). German philosopher who trained the first generation of Gestalt psychologists. (6)
- Sumner, Francis Cecil.** (1895–1954). First African American to earn a Ph.D. in psychology. (4)
- Szemińska, Alina.** (1907–1986). Polish psychologist who investigated the development of mathematical knowledge in children with Piaget. (8)
- Taft, Jessie.** (1882–1960). American social worker who developed an early form of client-centered psychotherapy known as relationship therapy. (15)
- Terman, Lewis.** (1877–1956). Early American psychologist who popularized the use of intelligence tests and performed landmark studies on gifted children. (4)
- Thibaut, John.** (1917–1986). American social psychologist who collaborated with Harold Kelley on interdependence theory and with Edward Jones on attribution theory. (12)
- Thompson, Richard.** (1930–2014). American behavioral neuroscientist who isolated the engram and demonstrated the role of the cerebellum in learning and memory. (16)
- Thorndike, Edward.** (1874–1949). Early American psychologist who pioneered learning theory and educational psychology. (4)
- Thurstone, Louis Leon.** (1887–1955). Early American psychologist who proposed that intelligence can be broken down into seven primary mental abilities. (4)
- Tinbergen, Nikolaas.** (1907–1988). Dutch ethologist best known for his field studies on the nature and function of instinctive behaviors. (10)
- Titchener, Edward.** (1867–1927). Early British-American psychologist who developed a school of experimental psychology known as structuralism. (3)
- Tolman, Edward.** (1886–1959). American neo-behaviorist who studied latent learning and cognitive maps in rats. (5)
- Treisman, Anne.** (1935–2018). British psychologist who proposed the attenuation model and the feature integration theory of attention. (11)

Tulving, Endel. (Born 1927). Estonian-Canadian psychologist who advocated for episodic memory as a separate memory system. (16)

Tversky, Amos. (1937–1996). Israeli psychologist who collaborated with Daniel Kahneman on the heuristics and biases approach. (11)

Vinh Bang. (1922–2008). Vietnamese psychologist who collaborated with Piaget and Inhelder for nearly half a century. (8)

Vygotsky, Lev. (1896–1934). Russian psychologist who emphasized the role of social interaction in cognitive development. (9)

Wallace, Alfred Russel. (1823–1913). Nineteenth-century British naturalist who was working on the problem of natural selection around the same time as Darwin. (2)

Washburn, Margaret. (1871–1939). Early American psychologist who was the first woman to earn a Ph.D. in psychology and a pioneer in animal research. (3)

Watson, John. (1878–1958). American psychologist best known as the founder of the behaviorist movement. (5)

Weber, Ernst. (1795–1878). German physiologist best known for his discovery that human sensory systems are limited in their ability to detect differences. (2)

Wertheimer, Max. (1880–1943). German-American psychologist who was the founder of Gestalt psychology. (6)

Witmer, Lightner. (1867–1956). Early American psychologist who pioneered the field of clinical psychology. (3)

Woodworth, Robert. (1869–1962). Early American psychologist whose dynamic psychology emphasized the role of motivation in behavior. (4)

Woolley, Helen Thompson. (1874–1947). Early American psychologist who made important contributions to the psychology of women and child development. (4)

Wundt, Wilhelm. (1832–1920). German physiologist who established the world's first psychology laboratory in 1879. (3)

Yerkes, Robert. (1876–1956). Early American psychologist who was a pioneer in the fields of comparative psychology and intelligence testing. (4)

Zajonc, Robert. (1923–2008). Polish-American social psychologist who explained social facilitation and discovered the mere exposure effect. (12)

Zeigarnik, Bluma. (1901–1988). Russian psychologist who studied memory for completed and uncompleted tasks. (6)

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