FOURTH EDITION

COGNITIVE PSYCHOLOGY

APPLYING THE SCIENCE OF THE MIND

Bridget Robinson-Riegler · Gregory L. Robinson-Riegler

Cognitive Psychology

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Cognitive Psychology

Applying the Science of the Mind

Fourth Edition

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Brief Contents

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Preface

To the Student

The text you're about to read is about something with which you're intimately familiar yet haven't really stopped to think about. It's about something you engage in every single day, but you rarely give it notice unless something goes wrong. You couldn't live day to day without it, but you seldom stop to truly appreciate it. Is it TV? No. Coffee? No. Sleep? Nope. It's ***thinking***. Ironically, although the mind is in constant use, most people take it for granted, only noticing it when it misfires. Consider the following examples of annoying little disturbances in thought:

- Why did I just put the cereal in the refrigerator and the milk in the cabinet?
- Why did I just get a D on an exam when I thought I knew everything cold?
- Why do I always find that answers to exam questions are right on the tip of the tongue, but I can't quite spit them out?
- Why do I find it so difficult to listen to a professor lecture and take notes (not to mention stay awake) at the same time?

Your average Joe/Jane understands relatively little about how "thinking" works or how to improve it. But take heart! Thousands of scientists who call themselves cognitive psychologists have performed countless investigations on the thinking processes that we engage in every day, shedding tremendous light on the mechanics of thought. After reading this text, you will not be the average Joe/Jane.

What Is Cognitive Psychology?

Cognitive psychology is the subdiscipline of psychology that employs the scientific method to answer fundamental questions about how the mind works. By using controlled research (mostly experiments), cognitive psychologists attempt to explain the thinking processes that we use every day. A cognitive psychologist would have a more analytic view of the problems just described and would view them more technically, through the lens of a scientist. The following questions are how a cognitive psychologist might rework each of the questions posed:

- What are the cognitive factors that underlie action slips? How does this relate to automatic processing?
- Why do people sometimes fail to monitor their own level of comprehension? What are the components of successful *metacognition*?
- What factors play a role in *retrieval failures*, and how can retrieval failures be successfully overcome?
- How do people successfully *divide their attention* between multiple sources of stimulation, given the limited nature of attention?

Why Study Cognition?

The study of cognition has tremendous ramifications for an overall understanding of how you tick on a day-to-day basis; it is in some ways the most applied (and applicable) of psychology's subdisciplines. As noted, cognitive psychologists are attempting to understand the processes that you use every day: perception, attention, memory, language, and reasoning. It's important for gaining a basic understanding of how people think and behave, which is the focus of psychology. And it's important for improving our lot in everyday life—who hasn't been frustrated by the (sometimes more than) occasional "brain lapse" and other difficulties in attention, memory, and the like?

Let's broaden the issue a bit. A full understanding of cognition is critical to an understanding of other subdisciplines in the field of psychology. This makes sense—psychology is typically defined as the scientific study of thinking and behavior, and questions of thinking are at the core of every other subdiscipline of psychology. Consider the following questions from other arenas of psychology:

- **Clinical Psychology:** Do depressed people remember events from their lives differently than nondepressed people?
- **Neuropsychology:** What's happening in different areas of the brain's cortex as people engage in cognitive processes like memory and problem solving?
- **Developmental Psychology:** How do cognitive processes like memory and problem solving change with age?
- **Personality:** Does a person's personality play a role in the types of decisions they make?
- **Social Psychology:** What factors influence our ability to remember an individual?

These questions have quite a range, but there are two common threads. First, they are fundamental psychological questions, and second, they all involve cognition.

Unlocking and understanding the mechanisms that are involved in cognition is fundamental to psychological explanation.

Cognitive psychology can be a bit of a challenge to master for a number of reasons. First, the subject matter of cognitive psychology (mental processes) can be difficult to grasp—you can't really see or touch them, and most often they take place quickly and outside of conscious awareness. As a result, the discussion of mental processes often takes place on a rather abstract level, and discussions of findings from research on cognition are full of jargon that can be difficult to decipher. Second, cognitive psychology's roots are firmly in experimental methodology. So to understand cognitive psychology, you need to understand experimental methodology. Third, cognitive psychology is a sprawling field; no one has provided the one unifying theory of cognition or even of a simpler subprocess, like memory. Findings and theories tend to conflict with one another due to the relative youth of the field (experimental cognitive psychology has only been around for about 60 years). As a result, students don't gain a good sense of "the big picture." Fortunately, this text offers a number of features designed to help you organize, integrate, and apply the material you'll be reading about cognition research.

First, the overall structure of the text parallels the progression of thinking. Take a simple cognitive process—looking at an animal at a zoo and realizing it's a duck-billed platypus. This involves (a) perceiving the animal, (b) paying attention to the animal, (c) retrieving the matching label for the animal from our store of concepts in memory, and (d) saying "duck-billed platypus." Then, we may remember the summer when we had a duck-billed platypus for a pet and, when it got too big, having to decide what to do with it. In line with this intuitive progression through the cognitive system, our text (after an initial foray into the history of cognitive psychology), proceeds from perception (initial perception of the animal), to attention and immediate memory (paying attention to the animal), to pattern recognition and concept representation (retrieving the label "duck-billed platypus" from memory). From there it's on to higher-level mental processes, including autobiographical memory, language, decision making, and problem solving (relating the story of the summer when we had a duck-billed platypus for a pet, and when it got too big, having to decide what to do with it, and then actually carrying out the solution).

A second feature that will help you integrate the material is our inclusion of a number of recurring empirical threads in each chapter. These "threads" are topics that cut across all areas of cognition and will be highlighted throughout the text:

- **Emotion:** How does affect, or feeling, impact basic cognitive processes like memory and attention?
- **Embodied Cognition:** The mind is just one element of an interactive system that includes the body and the situation. Thinking is inextricably tied to body and action.
- **Evolution:** How might cognitive processes serve as adaptations that aid us in everyday functioning?
- **Culture:** It's probably not a big surprise to you that not everyone thinks exactly the same way; what are the differences and similarities in thinking across cultures?

In addition to features that assist you in organizing, integrating, and applying cognitive psychology research, our text provides several tools that we hope will help you in understanding and remembering the material.

As noted earlier, the newness, complexity, and breadth of cognitive psychology make it a challenging topic. However, these characteristics also make cognitive psychology an exciting and dynamic topic of study. Its newness means that there are many more exciting areas to explore and an endless array of questions waiting to be answered. Its complexity makes learning about it a great exercise in critical thinking. In reading this text, we hope that you gain a firm understanding of how seemingly vague questions about mental processes can be translated into experiments that provide concrete empirical answers. The breadth of cognitive psychology makes it one of the most interesting and applicable of psychology's subdisciplines. Topics included in the text range from visual perception to eyewitness memory to language comprehension to problem solving, with many fascinating stops in between. Our sincere hope is that you enjoy learning about cognitive psychology as much as we enjoy talking and teaching about it.

To the Instructor

As in our previous three editions, our goal in this text is to engage students in cognitive psychology with a lively, entertaining, and (most important) accessible presentation of the fascinating research in cognitive psychology. Cognitive psychology can be technical, dry, and more than a little intimidating, and students aren't always as grabbed by the field as we feel they should be. So our goal always has been to combine the engaging with the rigorous. We attempted to continue this approach in the present edition.

Organizational Structure

In organizing the chapters of the text, we attempted to follow the flow of a piece of information that enters the cognitive system. The information is perceived, attended to and placed in immediate memory, identified, and committed to

memory. Later, the information serves as the basis for the higher-level processes of language, decision making, and problem-solving. Admittedly serial, but we think it provides for a nice intuitive description of cognition that will enhance understanding.

Although our text does feature a fairly standard approach to explaining the flow of cognition, there are some notable exceptions. One is that work on attention spans two chapters. Basic work on both visual and auditory attention is discussed in Chapter 3. We continue the discussion of attention in Chapter 4, in the context of short-term/working/immediate memory. It always struck us (and our students) that when we're discussing the control processes of attention and the control processes used in short-term/working/immediate memory, we were talking about many of the same things. The two seem to be (in many ways) flip sides of the same coin. This view is certainly not new—indeed, much of the research on immediate memory has characterized it in terms of attentional control (i.e., executive attention). We thought it highly appropriate to discuss attention and immediate memory together. Another distinctive feature of our layout is that object recognition occurs *after* discussion of attention and immediate memory. We placed it here because conscious recognition of a stimulus only occurs as the stimulus is processed by immediate memory. In other words, pattern recognition can be viewed as the first task of attention/immediate memory. In this edition, we've re-ordered the material on memory a bit, placing the discussion of memory editing and distortion after discussion of basic memory processes and followed it with discussion of autobiographical memory, which serves as a sort of applied "laboratory" for examining the basic processes of encoding and editing memories.

We've also tried to provide some organizational structure by referring to several different research themes in each chapter, including evolution, embodiment, emotion, metacognition, and culture. These themes capture some of the most interesting and dynamic questions that currently define the field. We hope that their inclusion will enhance students' sense of some of the overarching issues that currently define the field.

Everyday Relevance

Cognition is constant; thinking is what we do. Despite the obvious relevance of thinking to our everyday lives, we sensed that students didn't appreciate this relevance as fully as they should. To enhance this appreciation in class, we make liberal use of everyday examples and give students thought-journaling assignments and experiments to do outside of class. The students really enjoy these and often are surprised at how interesting this stuff can be (needless to say, we're never surprised). We've adopted this tactic in our text, sprinkling the discussion with numerous examples and sprinkling each chapter with exercises—titled Try it Out!—to entice students to do just that. These exercises could serve as homework assignments, as discussion generators for the classroom, or both.

Cool Experiments

We were never completely satisfied with the research presented in cognition texts. There are classic findings that merit extensive discussion, to be sure. But there are also some really intriguing empirical investigations, perhaps a little more off the beaten track, that merit mention and analysis. These investigations might be distinctive in their setting or in their empirical question (out-of-body experiences in touch caused by visual stimuli), but they still address fundamental questions of cognition. We've tried to include a good number of studies like this because they're likely to pique student interest and still convey the critical points.

Thanks for taking a look at our text. We hope your students enjoyed reading it as much as we enjoyed putting it together. We'd love to get your feedback and suggestions. If you spot errors or misrepresentations, know of an interesting study that may merit discussion, or otherwise want to comment on the text, please feel free to e-mail us (robinson@augsburg.edu and/or glriegler@stthomas.edu).

New to the Edition

This fourth edition has been expanded and updated to provide interactive features including writing assessments with an emphasis on critical thinking, hands-on experience, and application. There is special emphasis across all units on research themes of emotion, embodied cognition, and cultural differences.

- Expanded and updated coverage of perception, including global/local processing, synesthesia and multisensory integration, embodiment and perception and its connection to weapon focus, perception and sport, subliminal perception, scene recognition, and object recognition through touch.
- Expanded and updated coverage of attention and immediate memory, including inattentional blindness, distracted driving, load theory, theories of immediate memory, and applied issues in immediate memory–mind-wandering, enhancing and training executive function.
- Expanded and updated coverage of memory, including effective techniques for student learning, survival-related processing, metacognition, implicit memory, eyewitness memory and identification, flashbulb memories and

memories for 9/11, childhood amnesia, and functions of autobiographical memory.

- Expanded and updated coverage of language, problem solving and decision-making, including work on parent-child interaction and language learning, active involvement in problem solving, dual processes in problem solving and decision making, reasoning biases, and improvement of decision-making.

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Available Instructor Resources

The following resources are available for instructors. These can be downloaded at http://www.pearsonhighered.com/irc. Login required.

- **PowerPoint**—provides a core template of the content covered throughout the text. Can easily be added to customize for your classroom.
- **Instructor's Manual**—includes chapter outlines; exercises and their elaborations; and Internet resources.
- **Test Bank**—includes additional questions beyond the REVEL in multiple choice and open-ended—short and essay response—formats.
- **MyTest**—an electronic format of the Test Bank to customize in-class tests or quizzes. Visit: http://www.pearsonhighered.com/mytest.

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About the Authors

Bridget Robinson-Riegler is Professor of psychology at Augsburg College in Minneapolis, Minnesota, where she has been teaching cognitive psychology for the past 22 years. She received her B.S. degree in psychology at Indiana University in 1988. While there, she met Dr. David Pisoni who sparked her interest in cognitive psychology. And as they say, the rest is history. She went on to receive her Ph.D. in cognitive psychology at Purdue University in 1994 (where she and Greg met), and has been at Augsburg since then, serving in both administrative and faculty roles. She teaches introductory psychology, cognitive psychology, and supervises experiential learning courses, giving her a particular interest in psychology's application to everyday life. She has published research primarily in the area of memory, specifically bizarre imagery effects and prospective memory. In addition, she has served as an expert witness in legal cases on the fallibility of eyewitness testimony. At Augsburg, she is an active mentor of undergraduate research. Her current research interests include attention and mindfulness.

Greg Robinson-Riegler is Professor of psychology at the University of St. Thomas in St. Paul, Minnesota, where he has been teaching cognitive psychology for the past 26 years. By his math, he has taught cognition to more than 2,000 students. He received his B.A. degree in psychology at the University of Cincinnati in 1984. He was inspired to pursue a career in experimental psychology by Dr. Joel Warm. He received his Ph.D. in cognitive psychology at Purdue University in 1990. He has been at St. Thomas since then, serving in both administrative and faculty roles. He has taught courses in introductory psychology, memory, and cognitive psychology. He also has extensive experience in interdisciplinary teaching, having offered seminars co-taught with colleagues in economics, philosophy, theology, and English. His published research is primarily in the area of memory, specifically the generation effect and implicit memory. His current research interests include autobiographical memory, effects of technology and multi-tasking on attention, and mindfulness. He is an active mentor of undergraduate research.

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Chapter 1

Cognition as the Study of Information Processing

Learning Objectives

1.1 Describe cognitive science as a multidisciplinary approach to understanding cognition

1.2 Recall the work done by some of the early researchers to understand cognitive processes

1.3 Identify the challenges to standard behaviorist explanations that led to the emergence of cognitive psychology

1.4 Report the modern approaches to understanding cognition after the decline of the behaviorist theory

Psychology is generally defined as the scientific study of mental processes and behavior. Cognitive psychology can be defined by eliminating the last two words of that definition, leaving us with "the scientific study of mental processes." Behavior is examined by cognitive psychologists, but primarily as an avenue into the underlying mental processes, in the same way that physicists infer the force of gravity from the behavior of objects in the world. And the study of mental processes covers a lot of ground. These processes include attending, remembering, producing, and understanding language; solving problems; and making decisions. It is hard to imagine that we take such vital processes for granted. Thinking is something that is constantly happening, yet we rarely stop to . . . well . . . think about it. However, for the past six decades, cognitive psychologists have done exactly that, applying the methods of science to answer questions about the mind. With the experimental method as their primary tool, these researchers approach the mind as a type of machine, attempting to elucidate its inner workings. Given that thinking is at the heart of everything we do on a day-to-day basis, it's difficult to imagine a more important field of study.

1.1: What Is Cognition?

1.1 Describe cognitive science as a multidisciplinary approach to understanding cognition

One of our goals is to help you appreciate and understand the importance of the cognitive processes in which you are constantly engaged. As an exercise in thinking about thinking, consider the mental processes that you go through on the first day of class.

(RELATIVELY) EARLY COGNITIVE PROCESSES

Perception Based on a quick glance of the room, you immediately separate the tables from the chairs and make out the back row, your area of choice. Scanning the room, you spot a couple of friends from last semester. You take your seat and listen to the professor outline the thrilling experience you're about to have in their course. This scenario involves perception—the set of front-end processes through which you organize and interpret incoming information.

Attention Should you drift off in one of your classes, you may hear your professor bellow, "Pay attention!" Attention is the set of processes through which you focus on incoming information. Your ability to attend is flexible—you can divert your attention to that juicy gossip being discussed behind you. But it's also limited—if you shift your attention, you're not likely to remember much of what the professor has said.

Immediate Memory It's not enough to simply "zero in" on what the professor is saying at any given moment in time. In order to fully process and understand the information being discussed in class, you've got to perform a sort of mental juggling act. As the material is being presented, you've got to repeat it to yourself and/or jot it down in your notes. The online processing that makes this possible is immediate memory.

Object Recognition Two of the most important (and most easily taken for granted) sets of cognitive processes are the acts of identifying and classifying objects. Without thinking, you distinguish the professor from the students, you pull out your notebook rather than your planner to take notes, and you (without looking) reach into our backpack to turn off that infernal cell phone. How do these acts of identification occur so seamlessly?

(RELATIVELY) LATE COGNITIVE PROCESSES

Long-Term Memory Let's go back to your juggling act. It's not over when the class winds to a close. When the class is finished, you must catch the balls you're juggling and put them in your pocket until the next juggling act. In cognitive psychology lingo, you have to store the information for later use. In our discussion of memory, we'll examine some of the processes involved in remembering, both when you're studying information and when you're trying to retrieve it.

Memory Distortions Memory's not perfect; far from it. It serves us well most of the time, but there are systematic ways in which it fails. We're sure you've had the exasperating experience—especially on tests—of completely blanking on or misremembering information that you thought you knew. Part of our discussion of memory will involve the processes involved in forgetting and memory.

Autobiographical Memory Chances are good that the first day of classes will be one of the better-remembered days of your entire school year. You can probably think of some reasons for this: you meet new professors, hear about new classes, get reacquainted with old friends, and make new ones. Research on how we remember our personal past has exploded, and the study of autobiographical memory has become one of the most dynamic and interesting topics within the field of cognitive psychology.

Language Your seamless processing of all the information from your first day is a testament to your skill in yet another important set of cognitive processes—those involved in the use of language. As the professor speaks, your implicit knowledge of and practice with sentence structure allows you to follow along just fine. What would happen if the professor came into class and said, "Class, and textbook turn your get page out OK to 28"? How about, "Pretty textbooks fly to the bookstore"? No doubt you'd be calling campus security. Your implicit knowledge of syntax (word arrangement rules) and semantics (rules for expressing meaning) allows you to comprehend instantly what makes sense and what doesn't. This knowledge also allows you to ask questions that professors just love to hear, like "Do we have to know this?" or "Will this be on the test?" Implicit principles of language use also allow you to interpret the blank stare you receive in turn.

Decision Making You're going to have to make many decisions throughout the semester. "How much time should I devote to studying for each of my classes?" "If I miss class once in a while, am I going to pay for it in my final grade?" (Do you really need an answer to that one?) The process through which you arrive at decisions involves a complex interplay among other cognitive processes, such as attention, memory, and knowledge retrieval.

Problem Solving After you've been to all of your classes, you've got another juggling act to perform. Somehow, you're going to have to fit studying for 15 to 20 tests, writing for 15 to 20 papers, and attending class for about 150 one-hour periods all into the space of 14 or so weeks. And you've got to do it well. This is an example of (some fairly hefty) problem solving. Problem solving involves operating within constraints (such as time and the professor's paper requirements) and reaching a goal from a starting state that is nowhere in sight.

WRITING PROMPT

Thinking About Thought Processes

Consider the cognitive processes we just discussed (perception, attention, immediate memory, object recognition, long-term memory, memory distortions, autobiographical memory, language, problem solving, and decision making). You engage each of these processes in some manner almost every day. Pick two of these processes and come up with an example of each of these from your daily life.

▶ **The response entered here will appear in the performance dashboard and can be viewed by your instructor.**

Submit

1.1.1: An Interdisciplinary Perspective

Not only is cognitive psychology central to everything we do in our day-to-day lives, it is also central to psychology's quest to understand how people think and act. As noted above in the definition of psychology, cognition comprises half of the subject matter! Because cognition is so fundamental to understanding how humans "tick," it is crucial to psychology's other sub-disciplines. Social psychologists investigate the mental processes involved in thinking about others. Clinical psychologists investigate the role that mental processes play in psychopathology. Developmental psychologists are interested in the ways cognitive processes change throughout the lifespan. Neuropsychologists are interested in the association between mental processing and brain activity. Industrial/organizational psychologists are interested in how cognitive processes such as remembering and decision making play out in the workplace. Understanding the fundamental mechanisms of human cognition provides critical insights into the other sub-disciplines that define psychology.

The study of cognition also lends insights beyond psychology. Cognitive psychology is a key player within the interdisciplinary field of study termed *cognitive science*. Cognitive science, simply defined, is an interdisciplinary effort to understand the mind. It includes a number of (seemingly disparate) disciplines, five of them plus cognitive psychology lying at its "core" (Gardner, 1985).

- Philosophy, the first discipline to systematically examine the mind, helps to formulate and examine the fundamental questions that define the field.
- Neuroscience attempts to specify the relationship between mind and brain.
- Artificial intelligence addresses issues of mind by modeling human thought processes with computer hardware and software.
- The field of linguistics investigates the structure of language and the specifics of language use and what they tell us about the mind.
- Anthropology explores the mind through quite a different lens—the lens of culture. How do our physical and cultural surroundings impact our thinking?

Given that each of these disciplinary approaches is reflected to some degree in the work of cognitive psychologists, you'll be getting a taste of most of these disciplines in this text.

Stop & Review: What Is Cognition?

- Cognitive psychology can be defined as the scientific study of mental processes.
- Cognitive psychologists study a wide range of abilities—perception, attention, working memory, object recognition, long-term memory, language, problem solving, and decision making.
- Cognitive psychology lies at the core of an interdisciplinary approach termed *cognitive science*. Cognitive science attempts to bring together research from the fields of philosophy, neuroscience, artificial intelligence, linguistics, and anthropology in an effort to understand the mind.

1.2: Psychology B.C. (Before Cognitive Psychology)

1.2 Recall the work done by some of the early researchers to understand cognitive processes

As pioneering cognitive psychologist Hermann Ebbinghaus observed, psychology has a long past but a short history. Thinking has long been a topic of interest—no doubt since we, as humans, started thinking. It shouldn't be a surprise that philosophy is generally considered to be the primary disciplinary "parent" of psychology, particularly cognitive psychology. Ancient philosophers such as Aristotle were interested in the mechanics of mind. He (and others) sought to establish laws of association to explain why the activation of some concepts seems to automatically lead to the activation of others.

> Consider a word association task: What is the first word that pops to mind when we say "black"? How about "chair"? We'd be willing to bet that you thought of the concepts "white" and "table." Aristotle assumed, as do modern-day cognitive psychologists, that mental processes are lawful and predictable.

Although philosophers have long been interested in the mind, the subject was not thoroughly examined with the scientific method of controlled observation until the 1800s. At that point, a second disciplinary "parent" of psychology, physiology, had begun to establish itself as a legitimate area of scientific inquiry. Physiologists looked at the body as a sort of machine and employed scientific methods to understand it. How do nerve impulses travel? How does information from the outside world enter into our sensory systems? How is this information interpreted? These latter two questions bring physiology right to the doorstep of psychology because they are questions of human experience and thinking. Once physiologists started applying their methods to these types of questions, a complete science of mind was inevitable.

WRITING PROMPT

Comparing Cognitive Psychology to Its Forerunners

Philosophy and physiology are generally recognized as the parent disciplines of psychology. Do you consider cognitive psychology to be more like philosophy or more like physiology? Why do you think so?

> The response entered here will appear in the performance dashboard and can be viewed by your instructor.

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1.2.1: Psychophysics

The scientific study of mental processes can be traced back to a number of origins, none more important than the work of early psychophysicists. *Psychophysics* refers to the study of the relationship between the physical properties of a stimulus and the properties taken on when the stimulus is filtered through subjective experience. For instance, suppose we see two lights in succession. The first light is double the luminance of the second light. Does the first light seem twice as bright? Note that while luminance is a physical measure of light intensity, seem is a subjective term and brightness is a psychological dimension, not a physical one.

Mapping out the relationship between the physical and the psychological was a primary concern of early psychophysicists such as Gustav Fechner (1801–1878). One of Fechner's major contributions was his quantification of the relationship between incoming stimuli and corresponding perceptions. Fechner demonstrated that there is not a one-to-one relationship between changes in the physical intensity of a stimulus and changes in its psychological (or perceived) intensity. Think about it. If someone snaps their fingers at a rock concert, no one would notice. If somebody snaps their fingers in a quiet room, you notice it easily. Clearly, there is some process of translation occurring between the presentation of the physical stimulus and the actual experience of that stimulus.

Hermann von Helmholtz (1821–1894) influenced the newly developing science of mind primarily through his work on visual perception, which Helmholtz argued involved a process of *unconscious inference*. An inference is a conclusion that we arrive at through some type of evidence.

According to Helmholtz, our visual systems are constantly making inferences about the external world based on the information gathered as well as on the "evidence" of previous experience. Consider what happens when you pick up your alarm clock in the morning and hold it close enough to read it (leaving aside the revulsion you feel that it's 7:30 and you have to get up for an 8:00 class). The image picked up by the retina in the back of your eye gets larger as you move the clock close to your face.

Do you recoil in horror at the sight of a giant clock? Perhaps so, if you had a particularly rough evening the day before, but we're betting not. Based on life experiences, you make an unconscious inference that alarm clocks (and other objects) do not spontaneously increase in size. Therefore, you know that the clock is closer, not larger.

Three important principles are highlighted by Helmholtz's concept of unconscious inferences.

1. First, the perceiver plays an interpretive role in what is perceived. Perception is not just a passive process of registering incoming physical energy.
2. Second, perceptual and cognitive processes are influenced by previous experience.
3. Third, perceptual and cognitive processes often occur outside of conscious awareness (as implied in the term "unconscious inference").

WRITING PROMPT

Cognitive Processes: Conscious or Unconscious

In proposing the concept of unconscious inference, Helmhotz helped make it clear that many cognitive processes occur outside conscious awareness. Think back to the cognitive processes we discussed at the beginning of the module (perception, attention, immediate memory, object recognition, long-term memory, memory distortion, autobiographical memory, language, decision making, and problem solving). Pick two from the list and rate each of them on the following continuum? Explain your rating.

1 ← 2 — 3 — 4 → 5
mostly unconscious — mostly conscious

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THE FIRST STEP TOWARD COGNITIVE PSYCHOLOGY

Early psychophysicists provided an important step toward a science of cognition, as they were among the first to apply the scientific method to bridge the physical and the mental. Both psychophysicists and cognitive psychologists are interested in how information in the outside world is translated by internal processes to produce conscious experience.

While psychophysicists tend to focus on the initial stages of information processing as it's registered by the senses, cognitive psychologists focus on all stages of information processing. Let's turn our attention back to that blasted alarm clock that shatters your night-time reverie. Psychophysicists might be interested in how bright the LED read-out on the clock needs to be for you to read it, or on how loud the alarm has to be for you to hear it, or on whether you think the light is as bright as the alarm is loud—in other words, your psychological interpretation of physical experiences.

A cognitive psychologist, on the other hand, would be interested in those processes and more:

- How you focus your attention on the clock
- How you recognize and understand the sound coming from it
- What the processes are that may lead to your decision to get up and go to class

1.2.2: Structuralism

Although psychophysics may have helped lay the foundation, modern experimental psychology is generally traced back to 1879, when Wilhelm Wundt (1832–1920) established the first psychological laboratory at the University of Leipzig in Germany. Wundt believed that a science of psychology should be concerned with how people consciously experience the world. Given that psychology was a fledgling scientific enterprise, some thought it wise to model psychology after a well-established science—chemistry. Simple chemical elements combine to form complex compounds.

The structuralists, as they would later be dubbed, wondered whether this approach could be applied to

conscious experience. Perhaps the complexities of how we experience everyday events could be broken down into distinct and basic elements of consciousness. According to the structuralists, these elements could likely be classified into three broad categories:

1. Sensations (the basic sensory dimensions of a stimulus)
2. Feelings (emotions aroused by a stimulus)
3. Images (purely mental impressions that seem sensory in nature)

Consider an example: Wundt and his colleagues might characterize looking at a sunrise as a complex experience made up of simpler ones. These would include simple sensations (e.g., warmth on the skin), simple images (e.g., hearing bird calls), and simple feelings (e.g., contentment). Wundt attempted to identify these simple components of complex experiences through the use of *introspection*, a procedure that requires participants to provide a rigorous, unbiased report of every element of their conscious experience when presented with a stimulus (e.g., a tone). It was hoped that applying this method of thorough, objective analysis to a wide range of everyday experiences would yield the elemental sensations, images, and feelings that combine to produce everyday consciousness. One of Wundt's students, Edward Titchener (1867–1927), popularized this approach in the United States, terming it *structuralism*.

While this early approach to the study of psychology may seem simplistic at best, you must remember the context in which it emerged. Psychology was new and trying to establish itself as a scientific discipline, so it made sense to emulate the approach used by another science.

1.2.3: Functionalism

At about the same time that structuralists were attempting to distil consciousness into its basic elements, a decidedly different approach was evolving. William James (1842–1910) and others were highly critical of the structuralist approach (see Kimble, 1985), contending that their atomistic approach to consciousness was wrong-headed. James invoked the well-known phrase "stream of consciousness" to capture the continuous, ever-changing nature of our experience. Analyzing it at any discrete point in time (as the structuralists did with introspection) violates its very nature. A related point is that the mere act of scrutinizing and analyzing one's conscious experience changes the experience. You're no longer studying consciousness.

Rather than using introspection to provide moment-to-moment snapshots of what was currently in mind, James thought psychology should devote itself to figuring out the functions of the mind—what it does in everyday life (hence the name given to this approach—*functionalism*). While a structuralist would attempt to determine the basic images, feelings, and sensations that comprise the conscious experience of being angry, a functionalist would study anger by trying to determine the purpose or function of being angry. Given its emphasis on mental processing rather than mental structure, functionalism ultimately had a more profound influence on cognitive psychology than did structuralism. Indeed, the table of contents of James's famous text *Principles of Psychology* reads like a "what's what" of the study of cognition, including chapters on attention, memory, emotion, and thinking.

1.2.4: Behaviorism

While the structuralists and functionalists were debating the proper focus of a scientific study of consciousness, a storm was brewing. The study of the mind and conscious experience was entering what might be termed a sort of "dark age." Psychologist John B. Watson (1878–1958), intensely dissatisfied with psychology's lack of progress, suggested a shift that he believed would make the fledgling enterprise of psychology truly scientific. Watson's radical notion was the banishment of consciousness from scientific study. Why would he propose such a radical move?

The hallmarks of scientific study are observation, measurement, and repeatability. The study of consciousness lends itself to none of these. It cannot be reliably observed or measured, and the results of an introspective analysis cannot be reliably reproduced. But behavior can be observed, measured, and repeated; hence, it should serve as the focus of scientific psychology. Watson's approach, termed *behaviorism*, discarded both the subject matter and the approach of the structuralists and functionalists, instead emphasizing the study of observable responses and their relation to observable stimuli.

Given its emphasis on observable **s**timuli and **r**esponses, it makes sense that behaviorism is sometimes referred to as *S-R psychology*. According to behaviorists, psychology should dedicate itself to discovering these S-R connections. Between stimulus and response is a "black box" that houses consciousness (Figure 1.1). Investigation of the contents of the black box is a futile enterprise, according to the behaviorists, because the contents do not lend themselves to scientific investigation.

Figure 1.1 Stimulus/Response

The behaviorists were not denying that we experience consciousness; for example, they wouldn't have a problem with acknowledging that people have an inner,

subjective experience of hunger. They simply rejected the idea that this conscious experience could be meaningfully studied, owing to its inherently subjective nature. They also gave consciousness no causal role in producing behavior; we don't eat because we feel hungry. Eating is an observable response that occurs in the presence of some verifiable stimulus, such as low insulin levels or a plate of fresh-out-of-the-oven cookies. The complete rejection of consciousness from scientific study was a radical move, but it struck a resounding chord with other scientists interested in psychology. In the United States, the behaviorist approach dominated experimental psychology for the first half of the 20th century.

Stop & Think

Thinking About Behaviorism

The behaviorists believed that all behavior and action could be understood purely in terms of observable stimuli and responses. Consider each of the following everyday activities:

– Hanging out with a friend
– Getting lunch
– Feeling nervous over an upcoming test
– Screaming for your team at a football game
– Going out see the latest gross-out comedy film
– Working a crossword puzzle
– Telling a joke
– Going for a half-hour jog

For each activity, apply an S-R analysis by answering the following questions:

– What would fit into the S box?
– What would fit into the R box?
– What would fit into the "black box" (that behaviorists would want to ignore)?

WRITING PROMPT

Behaviorism in Terms of Stimuli and Responses

Did you have any difficulties explaining these behaviors solely in terms of the Ss and Rs? If so, what were the difficulties? Which of the activities are most difficult to account for with an S-R view? (In other words, which activities involve a great deal of activity in the black box?)

▶ `The response entered here will appear in the performance dashboard and can be viewed by your instructor.`

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1.2.5: Laying the Foundation for Cognitive Psychology

The rejection of consciousness as a topic for scientific study was not without good intent. The behaviorists wanted to establish psychology as a rigorous experimental science alongside other disciplines more readily acknowledged as "scientific," such as biology and chemistry. Their sincere belief was that the study of mind was never going to get us there. But scientists throughout the short history of psychology have demonstrated time and time again that rigorous observation and measurement of mental processes is possible. In fact, even before the behaviorists "threw down the gauntlet" to scientists interested in human behavior, Hermann Ebbinghaus was quietly conducting a strikingly methodical and precise series of experiments on remembering.

EBBINGHAUS' PIONEERING EXPERIMENTS ON MEMORY

Methodology: In the late 1800s, Ebbinghaus embarked on an investigation of his own memory—an investigation that demonstrated convincingly that complex mental processes could be submitted to experimental test. Ebbinghaus was a truly dedicated researcher; he served as his only participant, tirelessly testing and retesting his own memory under rigorously controlled conditions of presentation and testing. He did this by memorizing list after list of nonsense syllables—letter strings that do not form words (e.g., DBJ). For a given list, he would record the number of study trials it took to learn the list to perfection. Then, after varying periods of time, he would attempt to relearn the list to perfection again.

Result: As you might imagine, it took him fewer trials to relearn a list than it initially did to learn it. Ebbinghaus coined the term *savings* to refer to this reduction in the number of trials it took to relearn a list. His previous experience in perfectly learning the material saved him some trials the second time he tried to learn it. This makes sense; if you've already learned to do something well and then take some time off, you're not going to have to start from scratch when you attempt to redo or relearn the task.

Using the method of savings, Ebbinghaus revealed a number of fundamental principles of memory. He found that as list length increased so did the difficulty of recall, a harbinger of later research that would investigate the limited nature of immediate memory. He found that his ability to retain the nonsense syllables increased with the frequency of repetitions (if you study more, you'll remember more). And he captured a pattern of forgetting that has been termed the *forgetting curve*; memory performance declines over the time interval since study. Early in the time interval, forgetting occurs rapidly, then slows down considerably. This pattern

has been replicated in countless investigations of memory but the precise function depends on a myriad of variables.

Ebbinghaus' research was significant for a number of reasons.

- First, it demonstrated that precise and well-controlled experimental methods could be applied to study complex mental processes, setting the stage for the experimental approach to cognition that was to follow.
- Second, it provided a well-conceived research paradigm for the study of memory that inspired a legion of later researchers.
- Finally, as noted above, it established a number of core principles of memory that are still being replicated and extended in laboratory research today.

BARTLETT'S MEMORY RESEARCH Sir Frederick Bartlett objected to the use of tightly controlled laboratory procedures for studying memory. He believed that if psychological research was to be generalizable, it should be as naturalistic as possible. Following this principle, his procedure involved the presentation of materials that were meaningful rather than nonsensical (e.g., Ebbinghaus' nonsense syllables). In assessing participants' memory for stories and folk tales, Bartlett (1932) discovered a fair amount of reconstruction. Some details were left out of the story; other details were inserted.

Based on his results, Bartlett characterized memory as a reconstructive process rather than a reproductive one. This reconstruction was guided by what Bartlett termed schemata, generalized knowledge structures about events and situations that are constructed based on past experience.

Note that in contrast to the behaviorist explanations of the day, Bartlett was postulating that mental structures (schemata) exerted a causal influence over behavior. Bartlett's work was distinctive and important in a couple of ways.

- First, it provided an alternative to the mechanistic, S-R view of remembering as a group of simple verbal associations.
- Second, it showed incredible prescience, foreshadowing some major concerns that have taken center stage in present-day cognitive psychology—the reconstructive nature of memory.

A social anthropologist at heart, Bartlett was interested in remembering as a dynamic, social process that helps us make sense of our daily lives. His classic book was titled "Remembering: A Study in Experimental and *Social* Psychology" (emphasis added). Cognitive psychology's current emphasis on the study of cognition within natural contexts owes much to Bartlett's early investigations.

It's interesting to note the strong contrast between the methods used by Ebbinghaus and those used by Bartlett to study remembering. Ebbinghaus' method involved the precisely controlled presentation and remembering of lists of nonsense syllables, while Bartlett's method (though somewhat controlled) left more to chance, as participants were exposed to stories and asked to remember them. In cognitive psychology research, there is often a tension between precise control and realism in procedures and materials. As you increase control (i.e., internal validity), you decrease realism (i.e., external or ecological validity). Both are important aspects of the research process, so cognitive researchers need to find the right balance between them. There is no wrong or right answer. It depends on the research question.

WRITING PROMPT

Thinking About Cognitive Processes

Think about the list of cognitive processes discussed earlier (perception, attention, immediate memory, object recognition, long-term memory, memory distortion, autobiographical memory, language, decision making, and problem solving). Pick two of these processes and briefly describe how you would study each of them in the laboratory and in the real world.

▶ **The response entered here will appear in the performance dashboard and can be viewed by your instructor.**

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GESTALT PSYCHOLOGY Developed in Germany, the Gestalt perspective in psychology was very active in the first half of the last century. It emphasized the role that organizational processes play in perception and problem solving. Roughly translated, the German word gestalt means something like configuration. Psychologists who adopted the *Gestalt approach* were interested in the organizational principles that guide mental processing. So a Gestalt psychologist would be interested in investigating the way you organize visual stimuli in your environment—do you see the items in Figure 1.2 as rows or columns of X's? The Gestaltists believed that the answer to this question revealed something fundamental about visual perception.

Figure 1.2 Three Rows or Five Columns?

X X X X X
X X X X X
X X X X X

The spirit of the Gestalt approach is captured well by their oft-cited credo "The whole is different than the sum of its parts." One cannot capture the essence of conscious experience by analyzing it into its elements, as the structuralists

attempted to do. Experience is more than just a summary of elementary sensations, images, and feelings. When combined in a particular way, these elements of experience form a particular gestalt, or whole. And one cannot understand human experience and behavior by eliminating all talk of conscious experience, as the behaviorists attempted to do. Current cognitive psychology embodies the spirit of the Gestalt approach by placing the mind center stage and viewing it as an active processor of information. In addition, the Gestalt approach still has a strong influence on how we view particular cognitive processes, most notably, perception and problem solving.

Stop & Review: Psychology B.C. (Before Cognitive Psychology)

- The scientific study of thinking has its roots in philosophy, which provided the basic questions that empirical research in cognition attempts to answer. The science of physiology provided a basic method for the investigation of perceptual processes. Modern attempts to understand the mind can be traced to the psychophysicists, who studied the relationship between physical stimulation and psychological experience.
- Psychology was established in 1879, when the structuralists began to formally investigate the elements of conscious experience. Their primary method was introspection, an intensive analysis of the contents (images, feelings, and sensations) of one's own consciousness. The functionalists were concerned with specifying the functions of consciousness rather than its structure, and ultimately had a much larger impact on the field.
- Behaviorists favored the elimination of consciousness as a topic of study, given its subjective nature. Behaviorists believed a science of psychology should focus on observables like behavior. Behaviorism is sometimes referred to as S-R psychology because of its emphasis on the analysis of observable stimuli and responses and their relation to one another.
- Ebbinghaus demonstrated that rigorous experimental work on cognition was possible. His research on memory for nonsense syllables established a number of key principles of memory that are still recognized today. Bartlett investigated memory for more realistic materials and, based on his results, argued that memory involves processes of reconstruction. Gestalt psychologists were interested in the organizational tendencies of the mind and had a significant influence on views of perception and problem solving.

1.3: The Emergence of Cognitive Psychology

1.3 Identify the challenges to standard behaviorist explanations that led to the emergence of cognitive psychology

Although behaviorism had struck a chord, to many it rang hollow in failing to capture the richness and diversity of human behavior and creativity. The challenges to behaviorism came from outside and from within and were both empirical and theoretical. From within the behaviorist camp, some studies of animal behavior were producing results that were problematic for S-R accounts, results revealing that rats in some circumstances could rightfully be described as "thinking."

The momentum from these research challenges began to build in the 1930s, posing a threat to the behaviorist stronghold on scientific psychology. In addition, psychologists were growing increasingly frustrated with the narrowness of explanations offered within the behaviorist paradigm, arguing that such explanations captured virtually nothing of what human beings do on a day-to-day basis, such as using language. Another major influence on the emergence of cognitive psychology was the development of new technologies like calculators, computers, and communication systems. These developments revolutionized how humans viewed machines and their capabilities. This, in turn, revolutionized the way humans viewed themselves and their capabilities.

1.3.1: S-R Explanations, *Seriously* wRong?

As we've seen, behaviorists viewed reference to mental states or mental representations as useless, preferring to focus only on behavior, and using only the concepts of stimuli, responses, and the associations between them.

FAILURE TO ACCOUNT FOR DATA Suppose we have a rat that we place in a T-maze. The rat has to learn to run down the straightaway and choose the side with food in it. Over a series of trials, what do you suppose happens? As you might suspect, the rat starts to make the correct turn to obtain the food.

Rats may not be the brightest of animals, but they can learn that simple association. A behaviorist would explain the rat's learning of the maze with three simple concepts:

1. Stimuli
2. Responses
3. Reinforcement

Associations are formed between stimuli and responses, with reinforcement as the "glue" that holds the

associations together. When placed in a particular stimulus situation (the feel and smell of a maze), the rat engages in a particular response (running forward in the maze). If it receives reinforcement at the end of the maze, this bonds the stimulus and the response together—an S-R association.

The next time the rat is confronted with the feel and smell of the maze (the S), the response of running (the R) will be triggered. Each time the rat is placed in the maze, this association plays itself out again and becomes stronger with each reinforcement. The rat runs faster. Over time, it zips down the alley and without hesitation and makes the correct turn.

The behaviorist account of the learning process is simple and elegant and does not rely on reference to unobservable mental processes, like the rat expecting or knowing where the food is. The rat doesn't "know" anything; a chain of S-R associations that have been built up over a series of trials is at the root of the behavior. But the trouble is that there are too many scenarios in which this simple account doesn't apply.

Let's briefly preview a few of these findings:

- Learning without Responding
- Learning without Reinforcement
- Cognitive Maps
- Failure to Explain Complex Behavior
- Failure to Explain Language

Learning Without Responding According to the behaviorists, responding is absolutely essential for learning. It's the R in the S-R association link. Demonstrating that learning occurs in the absence of R would be difficult, if not impossible, to explain. A study by McNamara, Long, and Wike (1956) investigated whether learning would occur in this type of situation.

Methodology: Rats were tested in a T-maze, as described above. Some of the rats ran the maze themselves, eventually learning that they had to turn right to get to the food. Other rats were pushed by the experimenters down the alleyway in small carts. At the end of the runway, the experimenters turned the cart to the right and let the rat out to eat the food.

Which group of rats will *know* where the food is? "Isn't it obvious?" you must be thinking. They both will. They both saw the maze and saw that food was on the right. So now they *expect* the food to be on the right. But this is exactly the type of mentalistic explanation that behaviorists rejected.

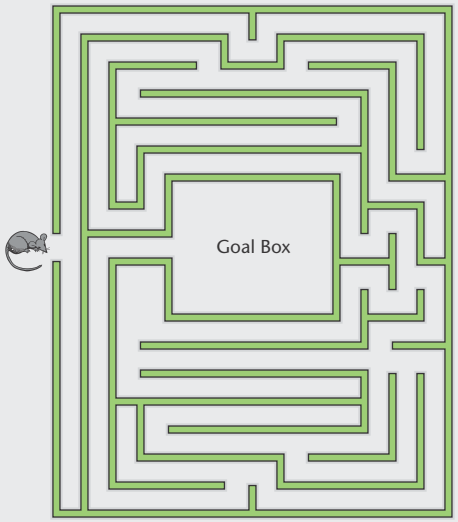
Behaviorists would say only the group of rats that ran on their own would learn the correct response. Why? Because R is required for learning.

Results: The results, however, failed to support the behaviorist prediction. When allowed to run on their own, the rats that had previously gotten a ride to the food showed a preference for the right side, just like the rats that had run there on their own from the beginning. Clearly, the hitchhiking rats learned—and without responding.

Learning Without Reinforcement Recall that, according to the behaviorist view, reinforcement is necessary for learning to occur; as described above, it's the "glue" that holds the S and the R together. Without reinforcement, the stimulus and response will not be bonded, and there will be no learning. Tolman and Honzik (1930) tested this in a classic study.

Methodology: Over the course of 2 weeks, they placed three different groups of rats in a complex maze like the one in Figure 1.3 and had them explore it.

Figure 1.3 A Complex Garden-Style Maze Used in Some Early Studies of Simple Learning



1. One group of rats was reinforced food every time they reached the goal box, starting on day 1.
2. A second group was never reinforced.
3. A third group was not reinforced during the first 10 days but began receiving a reinforcement in the goal box on the 11th day.

What would an S-R view predict?

Answer

1. The rats in group 1 should show a steady decrease in error rate. The reinforcement in the goal box strengthens the response (R) of running when placed in the stimulus (S) of the maze.
2. Group 2 rats should show no decrease in error rate; they were never reinforced, so S and R were never bonded.
3. Group 3 should look exactly like group 2 until day 11, when the rats receive food in the goal box. Then, starting on day 12, group 3 rats should show the same gradual decrease in error rate shown in group 1, as the goal box reinforcement starts to strengthen the S-R connection.

Results: The findings were surprising, at least to those operating from an S-R perspective. The rats in groups 1 and 2 behaved exactly as predicted, showing a gradual decrease in error rate