

SEVENTH EDITION



Behavior Analysis and Learning

A Biobehavioral Approach



ERIN B. RASMUSSEN, CASEY J. CLAY,
W. DAVID PIERCE, AND CARL D. CHENEY

Behavior Analysis and Learning

Using a behavioral perspective, *Behavior Analysis and Learning* provides an advanced introduction to the principles of behavior analysis and learned behaviors, covering a full range of principles from basic respondent and operant conditioning through applied behavior analysis into cultural design. The text uses Darwinian, neurophysiological, and biological theories and research to inform B. F. Skinner's philosophy of radical behaviorism.

The seventh edition expands the focus on neurophysiological mechanisms and their relation to the experimental analysis of behavior, providing updated studies and references to reflect current expansions and changes in the field of behavior analysis. By bringing together ideas from behavior analysis, neuroscience, epigenetics, and culture under a selectionist framework, the text facilitates understanding of behavior at environmental, genetic, neurophysiological, and sociocultural levels. This "grand synthesis" of behavior, neuroscience, and neurobiology roots behavior firmly in biology. The text includes special sections, "New Directions," "Focus On," "Note On," "On the Applied Side," and "Advanced Section," which enhance student learning and provide greater insight on specific topics. This edition was also updated for more inclusive language and representation of people and research across race, ethnicity, sexuality, gender identity, and neurodiversity.

Behavior Analysis and Learning is a valuable resource for advanced undergraduate and graduate students in psychology or other behavior-based disciplines, especially behavioral neuroscience. The text is supported by Support Material that features a robust set of instructor and student resources: www.routledge.com/9781032065144.

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W. David Pierce (1945–2020) was a Professor Emeritus of Sociology at the University of Alberta, Canada. He has investigated a biobehavioral model of activity anorexia, exercise-induced taste aversion, and behavioral-neurometabolic determinants of obesity. His research also focused on wheel-running reinforcement, the response deprivation hypothesis, and extensions of behavioral momentum theory.

Carl D. Cheney is Professor Emeritus of Psychology at Utah State University, USA. He taught behavior analysis and physiological psychology, and published widely in the experimental analysis of behavior—conducting basic analyses of predator–prey interactions, diet selection in domestic live-stock, as well as reinforcement-schedule alterations and transitions in humans. His current research is focused on encouraging the wider use of behavior analysis in all appropriate situations.



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Erin B. Rasmussen, Casey J. Clay, W. David Pierce,
and Carl D. Cheney

Designed cover image: © Getty Images

Seventh edition published 2023
by Routledge
605 Third Avenue, New York, NY 10158

and by Routledge
4 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

Routledge is an imprint of the Taylor & Francis Group, an informa business

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First edition published by Prentice Hall 1995
Sixth edition published by Routledge 2017

ISBN: 978-1-032-06514-4 (hbk)
ISBN: 978-1-003-20262-2 (ebk)

DOI: 10.4324/9781003202622

Typeset in Univers
by Newgen Publishing UK

Access the Support Material: www.routledge.com/9781032065144

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PREFACE

Instructors who use *Behavior Analysis and Learning: A Biobehavioral Approach* will notice a proverbial passing of the torch to the next generation of behavior analysts with the seventh edition. In 2020, the behavior science community was shocked at the unexpected death of David Pierce. He was a vibrant, creative, and productive colleague. Dave's contributions to the experimental analysis of behavior (EAB), including a cogent development of an animal model of activity-based anorexia, were impactful. Many of these research endeavors were conducted with his dear friend and collaborator W. Frank Epling (1943–1998), an original author of this text. Further editions of this book will continue to owe a great deal to both of them, as well as to Carl Cheney, who was an author since the third edition. Carl also has made a lifetime of research contributions to EAB using approximately 20 different species of animals and has taught thousands of students over the years.

The new set of authors, Erin B. Rasmussen and Casey J. Clay, were invited on the basis of their accomplishments and commitment to the science of behavior analysis. They represent both the basic experimental analysis research side and the behavioral engineering applied side. Rasmussen began her training in animal research in EAB as an undergraduate in Carl's lab at Utah State University. She completed her doctoral training in EAB at Auburn University with an emphasis in behavioral pharmacology and toxicology and has contributed numerous peer-reviewed research articles with both non-humans and humans to the field to date. Clay is a board-certified behavior analyst-doctoral level who also had humble beginnings in rat and pigeon labs at USU; however, his interests turned to human behavior, specifically individuals with developmental disabilities who engaged in severe challenging behavior. He continued his training at Northeastern University and through the New England Center for Children and earned his master's degree. He later returned to USU for doctoral training and continues to publish and engage in clinical work.

Indeed, *Behavior Analysis and Learning* has come a long way since its inception in 1995. Rasmussen fondly recalls the first edition of the text, which was published in 1995, the year she started graduate school. While instructors used the text for courses there, she used it as a supplementary resource to assist her understanding of the many complicated empirical articles that were required for conceptualizing her thesis and dissertation. The chapter on Choice in particular, effectively broke down the complexities of the generalized matching relation in a manner that made it easy to learn. No other textbook published at the time (or perhaps even now) described matching to students with such clarity. Therefore, the value of this text both inside and outside of a classroom has been historically significant to her and having the opportunity to contribute to it as an author has been a gratifying and exciting experience.

Clay recalls using this text in teaching his courses as a professor at the University of Missouri. Students were amazed at how the principles of behavior science could be applied universally and across species. He took great joy in explaining to students how an operant chamber with some modifications could be used to teach pigeons how to talk to each other. Students in his courses were also charmed when an invited guest would nonchalantly attend classes and sit in the back of the room and make comments on the lecture only to be eventually

introduced as Dr. Carl Cheney—the author of the textbook they were using for the semester. Clay is also excited by the opportunity to contribute as an author and hopes to fill the large shoes offered as he attempts to stand on the shoulders of giants.

Indeed, the seventh edition of this text is transgenerational. On one hand, this version holds strongly to the foundational principles of behavior analysis. As with any solid science grounded in empiricism, the foundations of EAB have not changed much over the years—behavior is still a function of its consequences; reinforcement still strengthens behavior; resurgence of behavior still occurs during extinction; differential reinforcement of successive approximations still shapes new responses; and the operant chamber is still a major apparatus for exploring environment–behavior interactions.

On the other hand, our expansion and understanding of behavior has grown and become more complex. Our views of verbal behavior and transfer of function by way of relational frame theory, which was built on the science of stimulus equivalence, has advanced our understanding of the rapid expansion of verbal relational classes. We have strongly extended our characterization of choice with behavioral economics, as evidenced by the explosion of research on delay discounting and the conceptualization of reinforcer pathologies. We also have expanded on the third level of selectionism—cultural behavior. At the cultural level, we have observed rapid changes worldwide in a relatively small window of time. The internet, the streaming of media, smart phones, social media apps, and gaming systems serve as strong reinforcers to everyone from young children to older adults. We offer some application and analyses, including insights from fields outside of behavior analysis, on how these environmental influences might impact behavior in our sociocultural environment. We also have observed how millennial parenting practices, such as “helicopter parenting” might affect the behavior of offspring in the long run. We also continue to discuss how eco-friendly behavior and cultural practices might affect climate change predictions. Importantly, we have also been through a global pandemic since the sixth edition of the text, and with that, swift sociocultural movement; we would be remiss to exclude these topics and their influence on behavior from the seventh edition.

In this edition of the text, we also have continued to expand the presentation of neural mechanisms as another level to consider for the experimental analysis of behavior. The contributions of neuroscience substantially improve our ultimate explanation of behavior and how it can be influenced. We also expand coverage of behavior–gene interactions, including epigenetics. We recognize the importance of *heterogeneous reductionism* (Marr, 1977; Marr & Zilio, 2013)—the explaining of phenomena on multiple levels (e.g., neural and the behavioral)—as creating a more complete science.

We also continue to examine behavior through a selectionist lens—the evolutionary, behavioral, and cultural levels—and are impressed by the growing number of evidenced-based studies that support this position. We continue to promote the broad practice of applied behavior analysis and the growing literature illustrating diverse applications of behavior science. Several professional organizations exist whose members express, either in research or application, the philosophy of radical behaviorism in the analysis of behavior. The discovery of the way behavior works upon the world is illuminated by EAB in learning and genetics laboratories, free-ranging animal environments, psychopharmacology, educational instruction methods for classrooms, training centers for explosive-sniffing dogs, language and verbal development, treatment of substance abuse disorders, care and treatment of zoo animals, early intensive behavioral intervention for children with autism and developmental disabilities, computer labs

and virtual human learning environments, applications to business and organizations, and university behavior laboratories investigating contingencies of reinforcement with a variety of organisms.

To ensure we stay current with the scientific analysis of behavior–environment relationships, we have added over 100 new references to the seventh edition, some from traditional sources like the *Journal of the Experimental Analysis of Behavior* and other citations from more general biological journals, such as *Science* and *Nature*. We also bring in impactful references from outside the field, such as clinical psychology, substance abuse, parenting, and health psychology. Refinements of technology, research design, and data analysis have vastly expanded the field of behavior analysis and therefore the topics and sources to present to students and readers. We have been driven not only by the breadth of findings from the scientific literature, but also media coverage of topics relevant to behavior analysis. We suggest instructors recommend their students access original sources to appreciate them more fully.

Chapter titles and their order have remained virtually the same as the sixth edition. The addition of more recent citations, however, has necessitated the removal of some references—in many cases older papers. Some of these removed papers gave a historical impression of how behavior analysis was conducted along with the ethical practices of the time in which they were published. Because some of these ethical practices give the reader an inaccurate impression of the field today (especially with work using aversive stimuli), we focus instead on more contemporary research and applied practices. However, we consider many early papers in the experimental analysis of behavior to remain as relevant today as ever, even when ethical practices were somewhat different. When these papers were retained in the seventh edition, we include balanced discussions about these ethical issues to assist our readers with understanding how our field has evolved over the years.

One may also notice the use of more sensitive and inclusive language and representation. We believe this practice is aligned with the values of a more diverse scientific and global community. In addition, we believe that all students need to see themselves represented in textbooks. To this end, we use gender-inclusive pronouns and language that involves all couples and sexualities. We also include greater ethnicity, race, and gender representation in photos and research throughout the text. Finally, we also describe the neurodiversity movement in a balanced manner in this edition and strive to use respectful terms for individuals with developmental disabilities. It is possible we missed some opportunities for inclusive language, and if so, we apologize and invite you to contact us so that subsequent editions can be amended.

In conclusion, the authors want to provide the information necessary for readers who may never take another course on behavior to better understand and apply evidence-based principles to manage the behavior of organisms. We are not promoting a theory or school of psychology, but rather showing through empirical evidence that environmental events influence behavior in predictable and replicable ways. We have always wanted to expand our realm of influence as behavior scientists to other fields, such as biology, wildlife, pharmacology, speech pathology, education, and health. Behavior is everywhere and making the principles by which behavior operates explicit is the purpose of this text. We hope you enjoy the seventh edition of *Behavior Analysis and Learning: A Biobehavioral Approach*.

Erin B. Rasmussen
Casey J. Clay
W. David Pierce
Carl D. Cheney

CHAPTER

1

A Science of Behavior: Perspective, History, and Assumptions

- 1 Inquire about *learning*, a science of behavior and behavior analysis.
- 2 Discover how *selection by consequences* extends to evolution and behavior.
- 3 Explore new directions in behavior analysis and behavioral neuroscience.
- 4 See how early learning is retained by *epigenetic* mechanisms.
- 5 Investigate the early beginnings of behavior analysis and learning.
- 6 Analyze feeling and thinking as complex behavior.

Learning refers to the acquisition, maintenance, and change of an organism's *behavior* as a result of lifetime experience and events. The **behavior** of an organism is everything it does, including private and covert actions like thinking and feeling (see "Science and Behavior: Some Assumptions" section of this chapter). Learning also involves **neuroplasticity**—alterations in the brain that accompany behavior change and participate in the regulation of behavior. While our focus in this book is centered on the study of behavior for its own sake, the links to the brain and neural processes are increasingly important to the field of learning and behavior analysis as we discuss throughout the book.

An important aspect of human learning concerns the experiences arranged by other people. From earliest history, people have acted to influence the behavior of other individuals. At the level of the individual, rational argument, rewards, bribes, threats, and force are used in attempts to promote learning or change the behavior of people. At the level of culture, people are required to learn socially relevant behavior of which the culture agrees and approves. As long as a person conforms, no one pays much attention. People may also praise or reward the socially appropriate behavior of the individual (e.g., "such an upstanding citizen!"). But when the conduct substantially departs from cultural norms, people may get upset and socially reject the behavior of the non-conformist or even the non-conformist themselves—ensuring that most of us will comply with society's wishes (Williams & Nida, 2011). At the societal level (e.g., community, city, state, or nation), there are codes of conduct and laws that people must learn; those who break moral codes or civil laws may face penalties ranging from minor fines to capital punishment. Human learning, then, and the regulation of human conduct, is relevant

to families, communities, cultures, and societies. Without regulation of behavior, anarchy and confusion eventually destroy the civil order of society.

Human behavior has been attributed to a great variety of causes. The causes of behavior have been located both inside a person and outside, that is, from the environment. Internal causes have ranged from metaphysical entities like the soul to hypothetical constructs (e.g., impulsivity). Internal causes also include structures of the nervous system, such as parts of the brain. Suggested external causes of behavior have included the effect of the moon and tides, the arrangement of stars, and the whims of gods. Unfortunately, some of these bizarre, prescientific attempts to explain human behavior remain popular today, despite the lack of evidence for their role on behavior.

One such example is astrology. In an interview with Ashley Lutz for *Business Insider* (2012), Susan Miller, a successful astrologer with a business degree from NYU, said, "What I do is scientific. Astrology involves careful methods learned over the years and years of training and experience." Her website has six million visitors every month and she has built an empire based on her "scarily accurate" predictions, said the *Insider*. Miller states "one unlikely group of customers ... are professional men from 25 to 45 years old. In these uncertain economic times, astrology is more important than ever!" Many people faced with the unpredictability of daily existence turn to the theory of celestial alignment (astrology) to inform and guide their actions in business, life, and personal relationships.

The trouble with astrology and other spurious accounts of human behavior is that they are not scientifically supported. These theories do not hold up to objective testing, replication, and close scrutinizing by researchers who follow the scientific method. Indeed, many astrological predictions that are made are general and **unfalsifiable**, meaning they are not capable of being proven false. Consider this astrological prediction for the new year: "Career wise, the year has many new opportunities to offer." This statement could mean many things, such as a person may find a new job, they may find something new in terms of opportunities (e.g., a task or leadership position) in their current career, or they find another way to enjoy what is not changeable in their current job (e.g., a new friendship with a colleague), or something else entirely. There is nothing specific about this prediction that can be proven false. Related to this issue is **confirmation bias**; that is, people may seek information that confirms a statement or belief and ignore other information that suggests otherwise. For example, if after this prediction, a person lost their job, but found a new one, they might say "See? I found a new career opportunity, just like my horoscope said," and ignore the issue of losing the job in the first place.

Over the last century, a science-based model of learning and behavior has developed and undergone careful and rigorous scientific testing. Behavioral theory states that all behavior is due to complex interactions between genetic influences and environmental experiences. The theory is based on observation and controlled experimentation, and it provides a natural-science account of the learning and behavior of most, if not all, organisms, including humans. This book is concerned with such an account.

SCIENCE OF BEHAVIOR

The **experimental analysis of behavior** is a natural-science approach to understanding behavior regulation. Experimental analysis is concerned with controlling and changing the

factors that affect the behavior of humans and other animals in order to observe systematic and predictable changes. For example, a behavioral researcher in a classroom or a home environment may use a computer to arrange feedback for a student's mathematical performance—for example, the visual presentation of a star when a correct answer is given. The relevant condition manipulated or changed by the experimenter may involve presenting feedback on some days and withholding it on others—this latter condition is called a **control**. In this case, the researcher would probably observe more accurate mathematical performance on days with the visual presentation of the star. This simple experiment illustrates one of the most basic principles of behavior—the principle of **reinforcement**.

The principle of reinforcement (and other behavior principles) provides a scientific account of how people and animals learn complex actions. When a researcher identifies a condition or set of conditions that govern behavior, this is called an analysis of behavior. Thus, the experimental analysis of behavior involves discovery of the basic processes and principles through experimentation that regulate the behavior of organisms. Experiments are used to test the adequacy of the analysis. The manner in which this is done will be discussed in this book

NOTE ON: EXPERIMENTAL ANALYSIS OF BEHAVIOR IN THE NATURAL WORLD

Experimental analysis can occur outside of the laboratory and in a more naturalistic setting. Consider when, for example, a researcher notices that more seagulls fly and congregate along a shoreline when people are on the beach than when the beach is deserted. After checking that changes in climate, temperature, time of day, and other conditions do not affect the behavior of the seagulls, the researcher offers the following analysis: People feed the birds and this reinforces flocking to the beach. When the beach is abandoned, the seagulls are no longer fed for congregating on the shoreline. Therefore, the reason for flocking could be food. It could also be the mere presence of people (and not food), but the former is a reasonable first guess. This guess can only be tested by an experiment. Pretend that the behavior analyst owns the beach and has complete control over it. The experiment involves changing the usual relationship between the presence of people and food across different conditions. In a beginning condition, people are allowed on the beach, but are not allowed to feed the birds. In a second condition, the opposite holds—food is placed on the beach when people are not around. Over time and repeated days of each condition, the behavior analyst notes that there are fewer and fewer seagulls on the beach when people are present, and more and more gulls when the shoreline has food, but is deserted. The behaviorist concludes that birds came to the beach because the birds were fed, or reinforced, for doing so only when people were present. This is one example of an experimental analysis of behavior.

Behavior Analysis: A Science of Behavior

Experimental analysis is the fundamental method used to establish the principles for a **science of behavior**. A science of behavior is informed by a philosophy of naturalism and is called *behavior analysis*. This term implies a more general scientific approach that includes assumptions about how to study behavior, techniques for carrying out the analysis, a systematic body of knowledge, and practical implications for society and culture.

Behavior analysis is a comprehensive, natural-science approach to the study of the behavior of organisms. Primary objectives are the discovery of principles and laws that govern

behavior, the extension of these principles across species, settings, and different levels of analysis (e.g., the level of one individual, a group, or the level of an entire culture), and the development of applied technology for the management of behavior. The discipline of behavior analysis used to be known as behavioral psychology, but was changed to behavior analysis to emphasize the focus on behavior and the analysis of conditions that change it. A good example of a principle of behavior that we will cover in greater depth later in this textbook is called **discrimination**. The principle of discrimination states that an organism will respond differently to two situations if its behavior has been reinforced in one setting but not in the other (*differential reinforcement*). For example, a deer may choose a pond from which to drink, in which the water is fresh and plentiful. Another pond nearby may have equally fresh and plentiful water, but on occasion, there is a cougar that frequents the area. The deer learns to discriminate between the two ponds and chooses the one without the predator.

The principle of discrimination may be extended to human behavior and social reinforcement. You may discuss dating with Carmen, but not Tracey, because Carmen has shown interest in such conversation while Tracey rolls her eyes at the topic and wants to instead discuss politics (*differential reinforcement*). In a classroom setting, the principle of discrimination can be used to improve teaching and learning. A child is given a series of multiplication problems from the 2-times tables such as $2 \times 4 = _?$. Correct answers result in the next question, while incorrect responses lead to corrective feedback from the teacher, and repetition of the question. In this way, most children learn their 2-times table. The use of behavior principles to solve practical problems is called **applied behavior analysis** and is discussed at some length in Chapter 13.

As you can see, behavior analysis has a strong focus on behavior–environment relations. The focus is on how organisms alter their behavior to meet the ever-changing demands of the environment. When an organism learns new ways of behaving in reaction to the changes in its environment, this is called *conditioning*. The two basic kinds of conditioning are called respondent and operant.

Two Types of Conditioning

A **reflex** involves behavior *elicited* by a biologically relevant stimulus. When a stimulus (S) automatically elicits ($\rightarrow$) a stereotypical response (R) or **respondent**, the $S \rightarrow R$ *relationship* is called a reflex. The reflex is present at birth, in the sense that those animals that quickly and reliably responded to particular stimuli were more likely than other organisms to survive and reproduce. For instance, animals that startle to a sudden noise may also be able to escape a predator, hence the startle reflex may have provided an adaptive advantage over organisms that did not startle to the noise. Thus, reflexes are selected across the evolutionary history of the species. Of course, different species of organisms exhibit different sets of reflexes.

Respondent Conditioning

Respondent conditioning occurs when a feature of the environment (generally called a **stimulus**) without a known effect on behavior is **correlated** with an **unconditioned stimulus (US)**. The US is a stimulus that naturally *elicits* a response based on an organism's biological history. For example, a puff of air (US) in the eyes elicits blinking (**unconditioned response** or

UR). You can see that this is an inherited response—it is present at birth and occurs without the organism’s learning; indeed, the term “unconditioned” means *unlearned*. If I say the word “paper,” it does not elicit eye blinking, and has no stimulus function with respect to the eye-blinking response before conditioning. Indeed “paper” is a neutral, non-functional stimulus. However, the word “paper” comes to predict the air puff (US) because we pair the two stimuli together multiple times; pretty soon the word “paper” by itself (without the US) will produce the blink response. When “paper” elicits the eye blink, it has acquired a **conditioned-stimulus (CS)** function. One method to ensure that a feature of the environment predicts the US is called pairing or *temporal contiguity*; the neutral stimulus precedes the presentation of the US close in time. For example, respondent conditioning occurs when the buzz of bees (initially neutral) is paired with painful stings, which are also startling to the individual receiving them (US). After this conditioning, a buzzing bee (CS) usually causes people to startle at the sound, which also occasions them to escape it; this startle response is the **conditioned response (CR)**.

You may have read about the Russian physiologist *Ivan Petrovich Pavlov* who made explicit this form of conditioning at the turn of the 20th century. He observed that dogs salivated when food was placed in their mouths. This relation between the food stimulus and salivation is an *unconditioned reflex*, and it occurs because of the animals’ evolutionary history. However, when Pavlov rang a bell just before feeding the dogs, the animals began to salivate at the sound of the bell. In this way, a new feature (the sound of the bell) that predicted the presentation of food came to control the CR of salivation. As shown in Figure 1.1, the CR is now elicited by the new *conditioned stimulus* (CS).

Respondent (also called classical or Pavlovian) conditioning is one way in which organisms meet the challenge of change in their environments. A grazing animal that startles in conditions to the sound of rustling grass before a predator’s attack, but not to grass blowing in the wind, gains a survival advantage. The animal is able to efficiently consume food, running away only when certain stimuli may signal a life-threatening situation. All species that have been tested, including humans, show this kind of conditioning. In terms of human behavior, many of what we call our likes and dislikes are based on “evaluative” conditioning. Evaluative conditioning of humans replicates many of the respondent-conditioning effects found in animals, although some differences have been noted (De Houwer, Thomas, & Baeyens, 2001). Generally, when good or bad things happen to us, we usually have an emotional reaction. These emotional responses can be conditioned to other people who are present when the positive or negative events occur. For example, if you were to get in a car wreck with a person you have never met,

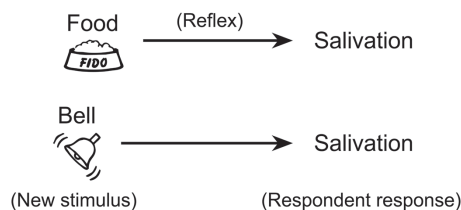


Fig. 1.1

Simple respondent conditioning: In a reflex for a dog, food in the mouth (US) produces salivation (UR) as reflexive behavior. Next, a bell rings (neutral stimulus) just before feeding the dog; after several pairings of the neutral bell and food the dog begins to salivate at the sound of the bell, even when the food is not presented. The bell has now become a conditioned stimulus (CS) that causes a CR.

you are likely to associate the person with the wreck and therefore feel ill feelings toward that person, even if that person is a decent human being. Thus, respondent conditioning plays an important role in our social relationships—determining, to a great extent, how we evaluate and come to “feel” about our friends as well as our enemies. Respondent conditioning is covered in more detail in Chapter 3.

Operant Conditioning

Operant conditioning involves the *regulation of behavior by outcomes or consequences*. B. F. Skinner called this kind of behavior regulation **operant conditioning** because, in a given situation or setting (S^D), behavior (R) *operates* on the environment to produce effects or outcomes (S^r). An **operant** is any behavior that operates on the environment to produce an effect. The effect or outcome in turn changes the likelihood that the operant will occur again in a similar situation. During operant conditioning, an organism emits operant behavior that produces an effect that increases (or decreases) the frequency of the response in a given situation. In the laboratory, a hungry rat in a chamber may receive food if it presses a lever when a light is on. If lever pressing increases in the presence of the light, then operant conditioning has occurred and food functions as *reinforcement* (S^r) for this operant response (Figure 1.2).

In this example, the light (S^D) eventually *sets the occasion* for lever pressing in the sense that *the operant is likely to occur* when the light is on and is unlikely to occur when it is off. Basically, the frequency of lever pressing increases in the presence of the light (S^D). Turning the light on, however, does not force or elicit lever pressing as with a respondent conditioned stimulus; it simply increases the probability of the lever-pressing response when the light is on. In essence, operants are voluntary, probabilistic behaviors that are **emitted** rather than elicited (as with respondent conditioning). The control of the bar press by the light stimulus is based on the past history of reinforcement for lever pressing in the presence of the light. It is also controlled by the absence of food delivery (no reinforcement) when the light is off.

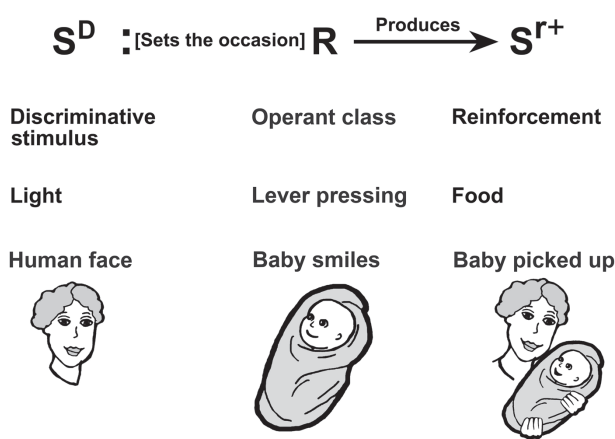


Fig. 1.2

Two examples of simple operant conditioning: In an operant chamber, lever pressing produces food for a hungry rat. The consequences of lever pressing (presentation of food) increase its frequency in that setting. In another example, a baby smiles at a human face and is picked up. The consequence of smiling (social attention) increases the frequency of this behavior in the presence of human faces.

Most of what we commonly call voluntary, willful, or purposive action is analyzed as operant behavior. *Operant conditioning* occurs, for example, when an older baby smiles at a human face and is then picked up. If smiling at faces increases in frequency because of such social attention, then smiling is an operant and the effect is a result of conditioning. The presentation of a human face (S^D) *sets the occasion for* infant smiling only after a history of operant conditioning. When a face appears, the frequency of smiling increases; also, smiling has a low frequency of occurrence when no one is around. In a more complex example using video games, the presence of targets on the screen (S^D) *sets the occasion for* pressing a sequence of buttons (operant) that results in hitting a target (S^I) and increasing the probability of the response sequence. Other examples of operant behavior include driving a car to work to get paid, talking on the phone, taking notes during class, walking to the store to buy groceries, reading a book for pleasure, writing a term paper for grades, or conducting an experiment to resolve a scientific question. In each case, we say the operant is *selected by its consequences or outcomes*.

Selection as a Causal Process

The behavioral view of psychology and behavior analysis is heavily influenced by B. F. Skinner (1938), who viewed psychology as the study of the behavior of organisms. From this point of view, psychology is a subfield of biology. The main organizing principle of contemporary biology is evolution through natural selection. Skinner generalized this concept to a broader principle of **selection by consequences**. Selection by consequences applies at three levels: (1) the selection over generations for genes related to survival and reproduction (natural or Darwinian selection); (2) the selection for behavior within the lifetime of an individual organism (selection by operant conditioning); and (3) the selection for behavior patterns (practices, traditions, or rituals) of groups of human beings that endure beyond the lifetime of a single individual (cultural selection). In all three cases, it is the outcomes or consequences arranged by the environment that select for (or against) the frequency of genetic, behavioral, and cultural forms (see Chapter 14). It is important to note that *consequences* refers to all events that affect behavior—both good and bad—not just ones we traditionally view as negative.

Selection by consequences is a form of causal explanation. In science we talk about at least two kinds of causation: immediate and remote. **Immediate causation** is the kind of mechanism studied by physics and chemistry—the “billiard ball” type of processes where we try to isolate a chain of events that directly, and close together in time, result in some effect. For example, chemical reactions are explained by describing molecular interactions. In the study of behavior, an immediate causal explanation might refer to the physiology or biochemistry of the organism. For example, the bar pressing of a rat for food or a gambler playing roulette could each involve the release of endogenous opiates and dopamine in the hypothalamus and the part of the brain responsible for reward called the nucleus accumbens (Shizgal & Arvanitogiannis, 2003). When this neurotransmitter is released, rewarding processes happen at the neural level.

In contrast, **remote causation** is typical of sciences like evolutionary biology, geology, and astronomy. In this case, we explain some phenomenon by pointing to remote events that made it likely or events that caused a chain of other events that led to the outcome. Thus, the causal explanation of a species characteristic (e.g., size, coloration, or exceptional vision) involves the working of natural selection on the gene pool of the parent population.

An evolutionary account of species coloration, for example, would involve showing how this characteristic improved the reproductive success of organisms in a given ecological environment. Thus, natural selection for coloration explains the current frequency of the characteristic in the population.

On the behavioral level, the principle of selection by consequences is a form of explanation that is more remote causation. When a rat learns to press a lever for food, we explain the rat's behavior by pointing to its past consequences (the function of behavior). Thus, the current frequency of bar pressing is explained by the **contingency** between bar pressing and food in the past. The rat's behavior has been *selected by its history of reinforcement*. Thus, the history of reinforcement is what explains why the rat presses the lever. Though, at the same time, when the rat earns a food reinforcer, there are immediate causes (dopamine release) that also strengthen the response in the moment. Therefore, there are also immediate causes happening.

Both immediate and remote causal explanations are acceptable in science. **Behavior analysts** have emphasized functional analysis and selection by consequences (remote causation), but are also interested in direct analysis of physiological and neurochemical processes (immediate causation). Ultimately, both types of causal explanation will provide a more complete account of learning and behavior.

FOCUS ON: BEHAVIOR ANALYSIS AND NEUROSCIENCE

Behavior analysis is becoming more involved with the scientific analysis of the brain and nervous system or neuroscience. Researchers who primarily study the behavior of organisms and learning are often interested in the brain processes that participate in the regulation of behavior (Schaal, 2013; see also special issue on "Relation of Behavior and Neuroscience" (2005) in *Journal of the Experimental Analysis of Behavior*, 84, pp. 305–667). The word *participate* is used because the brain shows **neuroplasticity**, or changes in the interconnections of neurons or nerve cells (Kandel, 2006) and glia or non-neuronal cells (Fields, 2009) as an organism interacts with the world in which it lives—altering gene transmission, gene expression, and neural pathways related to learning and memory (McClung & Nestler, 2008; also see "New Directions: Epigenetics and Retention of Early Learning" in this chapter). The brain is not a static structure that determines behavior, but a malleable organ constantly adjusting to the behavioral requirements of everyday life or the laboratory (Draganski et al., 2004). For example, brain mechanisms (neurons or groups of neurons) obviously participate in the regulation of behavior (bar pressing) by its consequences (food). Describing how neurons assemble, code for, and respond to stimulation and reinforcement is an important and exciting addition to behavior analysis.

Currently, neuroscientists are mapping neurons to behavior in simple organisms like the fruit fly, *Drosophila* (Vogelstein et al., 2014). Flies are genetically engineered to selectively express a light-sensitive protein in defined sets of neurons (1054 neuron lines), which researchers activate with the presentation of light (optogenetic stimulation). Larvae are placed in plastic dishes and light stimulation is applied to the genetically engineered neurons, allowing observation and control of defined behavioral sequences (e.g., "wiggle escape" or "turn-turn-turn"). One finding is that the relation between a specific line of neurons and evoked behavior is probabilistic—repeatedly activating the same neurons did not always produce the identical behavioral sequence; thus, the *topography of response* varies even though the identical brain

pathway is activated. The researchers note that optogenetic mapping of neurons to behavior would allow for an atlas of connectivity–activity maps to further investigate how neurons participate in the regulation of complex behavior.

At the practical level, knowing the reinforcement contingencies for lever pressing is sufficient by itself to allow us to predict and control the rat's behavior. We can get the rat to increase or decrease its lever pressing by providing or denying food reinforcement for this behavior—there is no need to look at neural systems. However, we gain a more complete account of how a rat's behavior increases when the action of neurons (and neural systems) is combined with the analysis of behavior. For example, in some cases it may be possible to “sensitize” or “desensitize” a rat to the behavioral contingencies by drugs that activate or block the action of specialized neurons (e.g., Bratcher, Farmer-Dougan, Dougan, Heidenreich, & Garris, 2005). Research at the neural level could, in this way, add to the practical control or regulation of behavior by its consequences.

Neural processes also may participate as immediate consequences (local contingencies) for behavior that had long-range benefits for organisms—remote contingencies, as in evolution and natural selection (Tobler, Fiorillo, & Schultz, 2005). The so-called *neural basis of reward* involves the interrelationship of the endogenous opiate and dopamine systems (as well as other neural processes) in the regulation of behavior and learning (Fiorillo, Tobler, & Schultz, 2003; Puig, Rose, Schmidt, & Freund, 2014). For example, rats that are food restricted and allowed to run in activity wheels increase running over days—up to 20,000 wheel turns. Wheel running leads to the release of neural opiates and endocannabinoids that reinforce this behavior (Pierce, 2001; Rasmussen & Hillman, 2011; Smith & Rasmussen, 2010). If wheel running is viewed as food-related travel, one function of neural reinforcement is to promote locomotion under conditions of food scarcity. The long-range or remote contingency (travel produces food: travel → food) is supported proximally by the release of endogenous opiates and endocannabinoids (physical activity → release of endogenous opiates and cannabinoids) that “keep the rat going” under conditions of food scarcity (e.g., famine or drought).

The integration of the science of behavior with neuroscience (**behavioral neuroscience**) is a growing field of inquiry. Areas of interest include the effects of drugs on behavior (behavioral pharmacology), neural imaging and complex stimulus relations, choice and neural activity, and the brain circuitry of learning, addiction, and obesity. We shall examine some of this research in subsequent chapters in sections that focus on behavior analysis and neuroscience (“Focus On” sections) or in sections that emphasize applications (“On the Applied Side” sections).

The Evolution of Learning

When organisms were faced with unpredictable and changing environments in their evolutionary past, natural selection favored those species whose behavior could be conditioned. Species that condition are more flexible, in the sense that they can learn new requirements and relationships in a dynamic environment (see section on “Behavioral Flexibility” in Chapter 14 for evidence by Mery and Kawecki (2002) on the link between learning ability and improved fitness in the fruit fly, *Drosophila melanogaster*). Such behavioral flexibility must reflect underlying structural changes of the organism. During embryonic development, genes are sequenced to form the anatomical and physiological characteristics of the individual, allowing for different

degrees of functional flexibility (Mukherjee, 2016, pp. 185–199). Thus, differences in the structure of organisms based on genetic control give rise to differences in the regulation of behavior. Processes of learning, like operant and respondent conditioning, lead to greater (or lesser) reproductive success. Those organisms that changed their behavior as a result of experiences during their lifetimes survived and had offspring (passing on the genome), while those that were less flexible did not. Simply stated, this means that *the capacity for learning is inherited*.

The evolution of learning processes had an important payoff: Behavior that was closely tied to survival and reproduction could be influenced by experience. Specific physiological processes, orchestrated by genes and proteins at the cellular level, typically regulate behavior related to survival and reproduction. However, for behaviorally flexible organisms, this control by physiology may be modified by experiences during the lifetime of the individual. The extent of such modification depends on the amount and scope of behavioral flexibility. For example, sexual behavior is closely tied to reproductive success and is regulated by distinct physiological processes. For many species, sexual behavior is rigidly controlled by genetically driven mechanisms. In humans, however, sexual behavior is also influenced by socially mediated experiences. It is these experiences, not genes, which come to dictate when sexual behavior occurs, how it is performed, and who can be a sexual partner. Powerful religious or social controls also can make people abstain from sex. This example demonstrates that even the biologically relevant behavior of humans is partly determined by life experience.

The Biological Context of Behavior

As we have emphasized, behavior analysts recognize and promote the importance of biology, genes, and evolution, but focus more on the interplay of behavior and environment. To maintain this focus, the evolutionary history and biological status of an organism are examined as part of the *context of behavior* (see Morris, 1988). This contextualist view is seen in an analysis of imprinting in a duckling. Imprinting is viewed as behavior in which a very young animal fixates its attention on the first object with which it has visual, auditory, or tactile experience, and subsequently follows the object. Generally, this object is the mother, but other objects (other animals or even inanimate objects) can be the source of imprinting.

The duckling's evolutionary history, in terms of providing the *capacity for reinforcement* by proximity to a duck-sized object, is the context for the regulation of its behavior. In other words, this capacity for reinforcement is present at birth, but to what it will "imprint on" is contextual. Of course, the anatomy and neurophysiology of the duckling allow for this capacity. The way the environment is arranged during critical periods of development (i.e., early in life), however, determines the behavior of the individual organism on a specific occasion. Laboratory experiments in behavior analysis identify the general principles that govern the behavior of organisms, the specific events that regulate the behavior of different species, and the arrangement of these events during the lifetime of an individual.

NEW DIRECTIONS: EPIGENETICS AND RETENTION OF EARLY LEARNING

Did you know that diet plays a large role in the genetic expression of queen bees versus worker bees? Both queen and worker honeybees have the same genome and as larvae are fed a rich diet of royal jelly, which is produced by nurse bees. However, bees that are weaned early from royal jelly, and have it replaced with nectar and pollen, become worker bees. Worker bees (which are

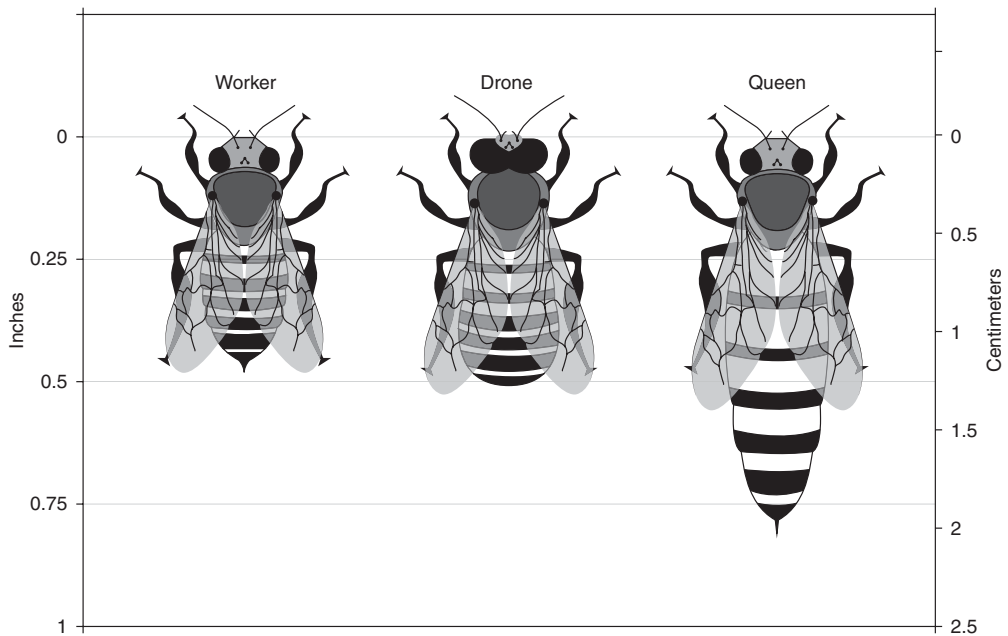


Fig. 1.3

Epigenetics at work. The image shows structural changes in worker and queen bees that occur as a result of differential exposure to royal jelly. Queen bees are much larger than worker bees, but also lay eggs.

Source: Used with permission—May, 2022. ©Arizona Board of Regents / ASU Ask A Biologist <https://askabiologist.asu.edu/bee-colony-life>

sterile) forage for food, collect pollen, maintain the hive, and fight off predators. In contrast, a larval bee that continues an extended diet of royal jelly becomes an adult queen bee (see Figure 1.3). Queens can lay up to 2,000 eggs per day, are up to five times larger than worker bees, and live up to 20 times longer (Chittka & Chittka, 2010).

This ability for environmental experiences to make structural and functional changes in genetic expression is called *epigenetics* (Roth & Sweatt, 2011) and it has rocked the scientific world in recent years. Epigenetics is a branch of biology concerned with the expression of heritable, functional changes to the genome that do not involve alterations of the gene itself (sequence of deoxyribonucleic acid, or DNA code). All cells in the body have a nucleus which includes chromatin, a combination of DNA and histone protein in a spool-like structure (see illustration at https://en.wikipedia.org/wiki/Epigenetics#/media/File:Epigenetic_mechanisms.jpg). Biochemical markings of the chromatin control accessibility to genes and gene expression, allowing cells to adapt to an ever-changing environment, beginning with cell differentiation and fetal development in utero and continuing throughout the organism's lifetime. The molecular biology of epigenetic (outside of genetic) processes is beyond the scope of this textbook (see Tammen, Friso, & Choi, 2013 for overview), but the basics can be outlined briefly. There are two primary epigenetic mechanisms called DNA methylation (adding methyl groups to DNA) and histone modification (e.g., acetylation, adding acetyl groups to histone tails), both of which determine whether “packaged” cellular DNA is available for gene transcription by messenger RNA (mRNA) and subsequent translation by mRNA into proteins. DNA methylation increases the affinity between DNA and histone (alkaline proteins

of eukaryotic cell nuclei) “spools,” limiting accessibility to the genetic code and silencing the gene transcription machinery; therefore, DNA methylation provides an epigenetic mark (signal) for *gene silencing*. Histone acetylation, in contrast, usually decreases the affinity between histone and DNA, allowing for mRNA transcription and subsequent translation into proteins; thus, histone acetylation is an epigenetic mark for *gene activation*. Thus, an active chromatin structure (“packaged” genes available for activation) allows mRNA access to the genetic material for transcription and subsequent translation into proteins, which in turn controls the cell structure and function of the organism—including the cells or neurons in its brain (Day & Sweatt, 2011).

Evidence in rats indicates that epigenetic changes underlie the effects of maternal caretaking of pups on the adult behavior of these offspring (see Roth, 2012). Rodent mothers (dams) differ in the amount of grooming and licking they provide to pups within the first 10 days after birth. Compared to low nurturing mothers, dams that provided high levels of grooming and licking produced adult offspring with lower indicators of physiological stress and less fear responses to a novel environment.

Subsequent research showed that maternal care influenced DNA transcription of the glucocorticoid receptor gene (GR) in the hippocampus (see Roth, 2012). Notably, increased GR gene transcription helps to moderate the animal’s neural and behavioral responses to stressful (aversive) situations with higher GR expression linked to less severe stress responses. Thus, adult male rats from high-caregiving dams were shown to have less DNA-methylation markers (lower silencing of GR gene) and greater histone-acetylation markers (higher transcription of GR gene) in the hippocampus than dams providing lower amounts of grooming and licking of pups after birth. Further research subsequently established causal connections among postnatal maternal caretaking, epigenetic alterations of gene expression, and differences in adult offspring responses to stressful situations.

Non-genetic factors including learning experiences (e.g., conditioning) can result in epigenetic changes by histone acetylation and DNA methylation, which in turn affect brain and behavior via mRNA transcription and mRNA translation to proteins; although still controversial (Francis, 2014), it appears that cell division passes on epigenetic markings over one’s lifetime and even from one generation to the next via noncoding mRNAs of sex cells or gametes (Dias & Ressler, 2014; Gapp et al., 2014; see Jablonka & Raz, 2009 for a complete discussion of transgenerational epigenetic inheritance). One implication is that learning sometimes can be transmitted epigenetically from one generation to the next with no change in the genes themselves. Also, in the future, it may be possible to produce lasting reversal of epigenetic changes by targeted early behavioral interventions (as in autism; see Chapter 13) or reverse epigenetic effects in later life by arranging new (re)programmed learning experiences (Tammen et al., 2013). Generally, evolution has provided animals with epigenetic mechanisms that allow for retention of learning experiences (changes in behavior due to the prevailing environmental contingencies) over an organism’s lifetime and perhaps beyond.

The Selection of Operant Behavior

Early behaviorists like John B. Watson (1913) used the terminology of stimulus–response (S–R) psychology. From this perspective, stimuli force responses much like meat in a dog’s mouth elicits (or forces) salivation. In fact, Watson based his stimulus–response theory of behavior on Pavlov’s conditioning experiments. Stimulus–response theories are mechanistic in the sense

that an organism is compelled to respond when a stimulus is presented. This is similar to a physical account of the motion of billiard balls. The impact of the cue ball (stimulus) determines the motion and trajectory (response) of the target ball. Although stimulus–response conceptions are useful for analyzing reflexive behavior and other rigid response patterns, the push–pull model is not as useful when applied to voluntary actions or *operants*. To be fair, Watson talked about “habits” in a way that sounds like operant behavior, but he lacked the experimental evidence and vocabulary to distinguish between respondent and operant conditioning.

It was B. F. Skinner (1935) who made the distinction between two types of conditioned responses, corresponding to the difference between operant and respondent behavior. In 1938, he introduced the term “operant” in his classic book, *The Behavior of Organisms*. Eventually, Skinner rejected the mechanistic (S–R) model of Watson and based operant conditioning on Darwin’s principle of selection. The basic idea is that an individual *emits behavior that produces effects or consequences*. Based on these consequences, those performances that are appropriate to the environmental requirements increase, becoming more frequent in the population or class of responses for the situation; at the same time, less appropriate forms of response decline or become extinct.

Skinner recognized that operants are selected by their consequences (behavioral selection). He also noted that operant behavior naturally varies in form and frequency. Even the simple movement of opening the door to your house is not done exactly the same way each time, an observation consistent with recent optogenetic studies of variation of neuron firing in fruit flies (Vogelstein et al., 2014). Pressure on the doorknob, strength of pull, and the hand used change from one occasion to the next. If the door sticks and becomes difficult to open, a more forceful response may eventually occur (an effect of extinction). This energetic response may succeed in opening the door and become the most likely performance for the situation. Other forms of response may occur at different frequencies depending on how often they succeed in opening the door (reinforcement). Thus, *operants are selected by their consequences*.

Similarly, it is well known that babies produce a variety of sounds called “babbling.” These natural variations in sound production are important for language learning. When sounds occur, parents usually react to them. If the infant produces a familiar sound (such as “ma”), parents often repeat it more precisely. Unfamiliar sounds are usually ignored. Eventually, the baby begins to produce sounds (we say talk) like other people in their culture or verbal community. Selection of verbal behavior by its social consequences is an important process underlying human communication and language (Skinner, 1957).

Culture and Behavior Analysis

Although much of the basic research in the experimental analysis of behavior is based on laboratory animals, contemporary behavior analysts are also concerned with human behavior. The behavior of people occurs in a social environment. Society and culture refer to aspects of the social environment, the social context, which regulates human conduct. One of the primary tasks of behavior analysis is to show how individual behavior is acquired, maintained, and changed through interaction with others. An additional task is to account for the practices of the group, community, or society that affect an individual’s behavior (Lamal, 1997).

Culture is usually defined in terms of the ideas and values of a society. However, behavior analysts define **culture** as all the conditions, events, and stimuli arranged by other people that regulate human action (Glenn, 2004; Skinner, 1953). The principles and laws of behavior analysis provide an account of how culture regulates an individual's behavior. A person in an English-speaking culture learns to speak in accord with the verbal practices of that community. People in the community provide reinforcement for a certain way of speaking. In this manner, a person comes to talk like and share the language of other members of the public and, in doing so, contributes to the perpetuation of the culture. The customs or practices of a culture are therefore maintained through the social conditioning of individual behavior.

Another objective is to account for the evolution of cultural practices. Behavior analysts suggest that the principles of variation and selection by consequences occur at the biological, behavioral and cultural levels (Wilson, Hayes, Biglan, & Embry, 2014). Thus, cultural practices increase (or decrease) based on consequences produced in the past. A cultural practice of making containers to hold water is an advantage to the group because it allows for the transportation and storage of water. This practice may include using shells or hollow leaves, or making fired-clay containers. The cultural form selected (e.g., clay jars) is the one that proves most efficient and least costly. In other words, the community values and uses those containers that last the longest, hold the most, and are easily stored. People manufacture and use clay pots, while production and use of less efficient containers declines.

Behavior analysts are interested in cultural evolution because cultural changes alter the social conditioning of individual behavior. Analysis of cultural evolution suggests how the social environment is arranged and rearranged to support specific forms of human behavior. On a more practical level, behavior analysts suggest that the solution to many social problems requires a technology of cultural design. Behavioral technology also has been used to manage environmental pollution, encourage energy and resource conservation, increase recycling, enhance green technology and use, and regulate overpopulation (e.g., Austin, Hatfield, Grindle, & Bailey, 1993; Bostow, 2011; Lehman & Geller, 2004; Parece, Grossman, & Geller, 2013; Wilson, Hayes, Biglan, & Embry, 2014). Behavioral scientists have also analyzed the important cultural contingencies that have led to and maintained systemic racism, poverty, and violence and abuse (e.g., Biglan, 1995; Biglan, 2015; Isaacs, 1982; see review Matsuda, Garcia, Catagnus, & Brandt, 2020).

FOCUS ON: BURRHUS FREDERIC SKINNER

B. F. Skinner (1904–1990) was the intellectual force behind behavior analysis. He was born and named Burrhus Frederic Skinner on March 20, 1904 in Susquehanna, Pennsylvania. When he was a boy, Skinner spent much of his time exploring the countryside with his younger brother. He had a passion for English literature and mechanical inventions. His hobbies included writing stories and designing perpetual-motion machines. He wanted to be a novelist, and went to Hamilton College in Clinton, New York, where he graduated with a degree in English. After graduation in 1926, Skinner reported that he was not a great writer because he had nothing to say. He began reading about behaviorism, a new intellectual movement at that time, and as a result went to Harvard in 1928 to learn more about a science of behavior. He earned his master's degree in 1930 and his PhD the following year.



Fig. 1.4

A photograph of B. F. Skinner.

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Skinner (Figure 1.4) began writing about the behavior of organisms in the 1930s, when the discipline was in its infancy, and he continued to publish papers until his death in 1990. During his long career, he wrote about and researched topics ranging from utopian societies to the philosophy of science, teaching machines, pigeons that controlled the direction of missiles, air cribs for infants, and techniques for improving education. Some people considered him a genius, while others were critical of his theory of behavior.

Skinner was always a controversial figure. He proposed a natural-science approach to human behavior. According to Skinner, the behavior of organisms, including humans, was determined by observable and measurable processes. Although common sense suggests that we do things because of our feelings, thoughts, and intentions, Skinner stated that behavior resulted from genes and environment. This position bothered many people who believed that humans have some degree of self-determination and free will. Even though he was constantly confronted with arguments against his position, Skinner maintained that the scientific facts required that feelings, thoughts, and intentions—though very real private events—were not *causes* of behavior. He said that these internal (private) events were not explanations of behavior; rather these events were additional behaviors that, though not observable, could still be explained by genes and environment:

The practice of looking inside the organism for an explanation of behavior has tended to obscure the variables which are immediately available for a scientific analysis. These variables lie outside the organism in its immediate environment and in its environmental history. They have a physical status to which the usual techniques of science are adapted, and they make it possible to explain behavior as other subjects are explained in science. These independent variables [causes] are of many sorts and their relations to behavior are often subtle and complex, but we cannot hope to give an adequate account of behavior without analyzing them.

(Skinner, 1953, p. 31)

One of Skinner's most important achievements was his theory of operant behavior. The implications of behavior theory were outlined in his book, *Science and Human Behavior* (Skinner, 1953). In this book, Skinner discussed basic operant principles and their application to human behavior. Topics include self-control, thinking, the self, social behavior, government, religion, and culture. Skinner advocated the principle of positive reinforcement and argued against the use of punishment. He noted how governments and other social agencies often resort to punishment for behavior control. Although punishment works in the short run, he noted that it has many negative side effects. Positive reinforcement, Skinner believed, is a more effective means of behavior change—people act well and are happy when behavior is maintained by positive reinforcement.

People have misunderstood many of the things that Skinner said and did (Catania & Harnard, 1988). One popular misconception is that he raised his children in an experimental chamber—the so-called “baby in a box.” Some critics claimed that Skinner used his daughter as an experimental subject to test his theories. A popular myth was that this experience drove his child crazy. His daughter, Julie, was confronted with this myth and recalls the following:

I took a class called “Theories of Learning” taught by a nice elderly gentleman. He started with Hull and Spence, and then reached Skinner. At that time I had read little of Skinner, and I could not judge the accuracy of what was being said about Skinner's theories. But when a student asked whether Skinner had any children, the professor thought Skinner had children. “Did he condition his children?” asked another student. “I heard that one of the children was crazy.” “What happened to his children?” The questions came thick and fast.

What was I to do? I had a friend in the class, and she looked over at me, clearly expecting action. I did not want to demolish the professor's confidence by telling who I was, but I couldn't just sit there. Finally, I raised my hand and stood up. “Dr. Skinner has two daughters and I believe they turned out relatively normal,” I said, and sat down.

(Vargas, 1990, pp. 8–9)

In truth, the “box” that Skinner designed for his children had nothing to do with an experiment. The *air crib* is an enclosed bed that allows air temperature to be controlled. Because of this feature no blankets are needed, so the baby is free to move and there is no danger of suffocating. The air crib was designed to keep the child warm, dry, and safe. Most importantly, the infant spent no more time in the air crib than other children do in ordinary beds (Skinner, 1945). It was like a climate-controlled playpen. Indeed, the air crib was something that was advertised and sold in *Ladies Home Journal* at the time.

Although Skinner did not experiment with his children, he was always interested in the application of conditioning principles to human issues. His writings on applied behavioral technology led to the field of applied behavior analysis or ABA (see Rutherford, 2009 who provides an historical account of the transition from Skinner's work in the laboratory to applications of behavior principles in everyday life). Applied behavior analysis is concerned with the extension of behavior principles to socially important problems. One area of application that Skinner wrote about extensively was teaching and learning. Although Skinner recognized the importance of behavior principles for teaching people with learning disabilities, he claimed that the same technology could be used to improve our general educational system. In his book *The Technology of Teaching*, Skinner (1968) offered a personalized system of positive reinforcement

for the academic performance of students. In this system, teaching involves arranging materials, designing the classroom, and programming lessons to shape and maintain the performance of students. Learning is defined objectively in terms of answering questions, solving problems, using grammatically correct forms of the language, and writing about the subject matter.

In the later part of his life, Skinner worked with Margaret Vaughan (Skinner & Vaughan, 1983) on positive approaches to the problems of old age. Their book *Enjoy Old Age: A Program of Self-Management* is written for the elderly reader and provides practical advice on how to deal with daily life. For example, the names of people are easy to forget, and even more so in old age. Skinner and Vaughan suggest you can improve your chances of recalling a name by reading a list of people you are likely to meet before going to an important occasion. If all else fails “you can always appeal to your age. You can please the friend whose name you have momentarily forgotten by saying that the names you forget are always the names you most want to remember” (Skinner & Vaughan, 1983, p. 52).

Skinner, who held the Edgar Pierce Chair in Psychology, officially retired from Harvard University in 1974. Following his retirement, he continued an active program of research and writing. Each day he walked two miles to William James Hall, where he lectured, supervised graduate students, and conducted experiments. Eight days before his death on August 18, 1990, B. F. Skinner received the first (and only) Citation for Outstanding Lifetime Contribution to Psychology from the American Psychological Association (Schlinger, 2011). The citation for the award, published in the *American Psychologist*, read “Few individuals have had such a dynamic and far-reaching impact on the discipline” (1990, p. 1205). In a study of renowned psychologists by Haggblom (2002), Skinner ranked as the most eminent psychologist of the 20th century. Skinner’s contributions to psychology and a science of behavior are documented in the film *B. F. Skinner: A Fresh Appraisal* (1999). Murray Sidman, a distinguished researcher in the experimental analysis of behavior, narrated the film (available from the bookstore of the Cambridge Center for Behavioral Studies, www.behavior.org).

A BRIEF HISTORY OF BEHAVIOR ANALYSIS

Contemporary behavior analysis is based on ideas and research that became prominent at the turn of the 20th century. The Russian scientist Ivan Petrovich Pavlov discovered the conditioned reflex (a reflex that only occurs under a particular set of conditions, such as the pairing of stimuli), and this was a significant step toward a scientific understanding of behavior.

Ivan Petrovich Pavlov (1849–1936)

Pavlov (Figure 1.5) was born the son of a village priest in 1849. He attended seminary school to follow his father into the priesthood. However, after studying physiology he decided on a career in the biological sciences. Although his family protested, Pavlov entered the University of St. Petersburg where he graduated in 1875 with a degree in physiology. After completing his studies in physiology, Pavlov was accepted as an advanced student of medicine. He distinguished himself and obtained a scholarship to continue his studies of physiology in Germany. In 1890, Pavlov was appointed to two prominent research positions in Russia. He was Professor of Pharmacology at the St. Petersburg Medical Academy and Director of the Physiology Department. For the next 20 years, Pavlov studied the physiology of digestion, and in 1904 he won the Nobel Prize for this work, the year that B. F. Skinner was born.

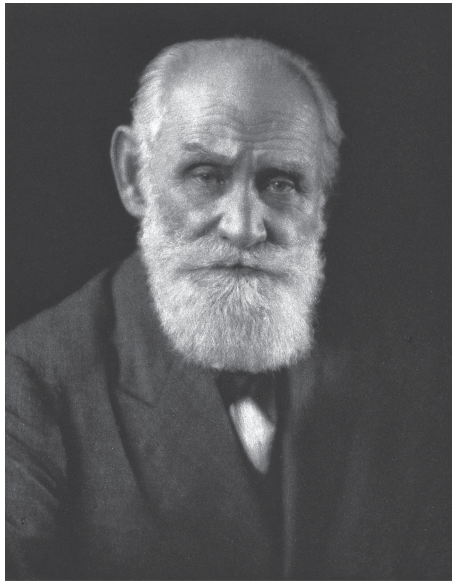


Fig. 1.5

A photograph of Ivan Petrovich Pavlov.

Source: Reprinted with permission from the Archives of the History of American Psychology, Center for the History of Psychology, The University of Akron.

Ivan Pavlov initially worked on the physiology of salivation and digestion; later he began investigations of “psychic secretions” involving the salivary reflex and its role in digestion. The animals were brought into the laboratory and put in restraining harnesses. As shown in Figure 1.6, food was then placed in the dogs’ mouths and the action of the salivary glands was observed and measured.

The analysis of the salivary reflex was based on prevailing notions of animal behavior. At this time, many people thought that animals, with the exception of humans, were complex biological machines. The idea was that a specific stimulus elicited a particular response in much the same way that turning a key starts an engine. In other words, animals reacted to the environment in a simple cause–effect manner. Humans, on the other hand, were seen as different from other animals in that their actions were purposive. Humans were said to anticipate future events. Pavlov noticed that his dogs began to salivate at the sight of an experimenter’s lab coat *before* food was placed in the animal’s mouth. This suggested that the dogs “anticipated” the delivery of food. Pavlov recognized that such a result challenged conventional wisdom.

Pavlov made an important observation in terms of the study of behavior. He reasoned that anticipatory reflexes were learned or conditioned. Further, Pavlov concluded that these conditioned reflexes were an essential part of the behavior of organisms. Although some behaviors were described as innate (present at birth) reflexes, other actions were based on conditioning that occurred during the animal’s life. These **conditioned reflexes** (termed conditional reflexes in Pavlov, 1960) were present to some degree in all animals, but were most prominent in humans.

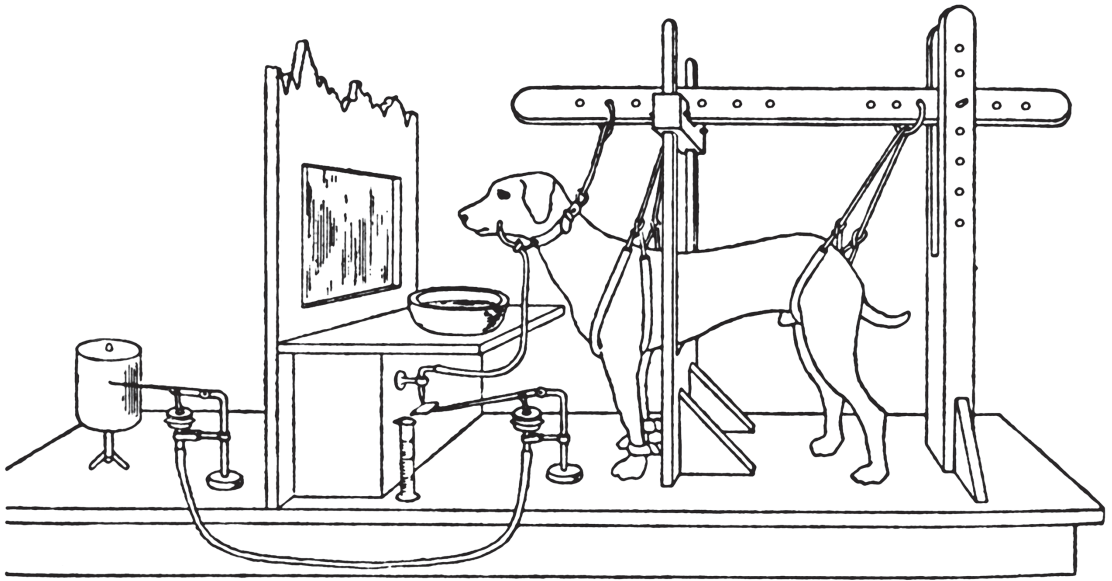


Fig. 1.6

A dog in the experimental apparatus used by Pavlov.

The question was how to study conditioned reflexes systematically. Pavlov's answer to this question represents a major advance in the experimental analysis of behavior. If dogs reliably salivate at the sight of a lab coat, Pavlov reasoned, then any arbitrary stimulus that preceded food might also be conditioned and evoke salivation. Pavlov replaced the experimenter's lab coat with a stimulus that he could systematically manipulate and reliably control. In some experiments, a metronome (a device used to keep the beat while playing the piano) was presented to a dog just before it was fed. This procedure resulted in the dog eventually salivating to the sound of the metronome. If a particular beat preceded feeding while other rhythms did not, the dog salivated most to the sound associated with food.

Although Pavlov was a physiologist and believed in mental associations and subjective experience (Specter, 2014), his research was directed at observable responses and stimuli and he foreshadowed the modern study of behavioral neuroscience, the objective and direct study of brain and behavior emphasized in this book. He discovered many principles of the conditioned reflex including spontaneous recovery, discrimination, generalization, and extinction. The later part of his career involved an experimental analysis of neurosis in animals. He continued these investigations until his death in 1936.

John Broadus Watson (1878–1958)

Pavlov's research became prominent in North America, and the conditioned reflex was incorporated into a more general theory of behavior by the famous behaviorist John B. Watson (Figure 1.7). Watson argued that there was no need to invent unobservable mental associations to account for human and animal behavior. He proposed that psychology should be a science based on observable behavior. Thoughts, feelings, and intentions had no place in a

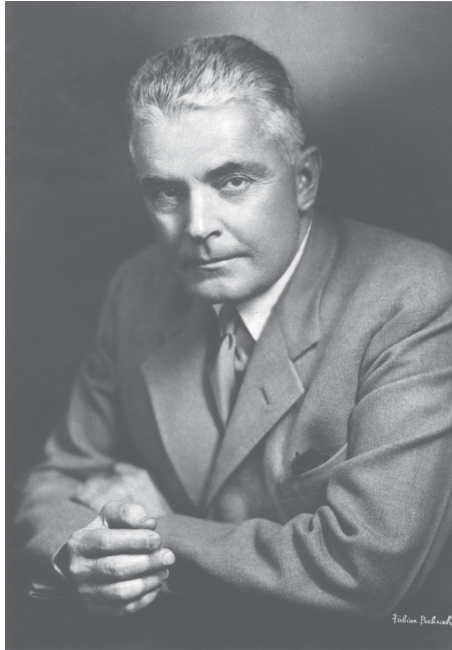


Fig. 1.7

An image of John Watson.

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scientific account, and researchers should direct their attention to muscle movements and neural activity. Although this was an extreme position, Watson succeeded in directing the attention of psychologists to behavior–environment relations, although his status as the originator or “founder” of behaviorism is doubtful (Malone, 2014).

Watson graduated from Furman University in 1899, when he was 21 years old. After spending a year as a public-school teacher, he was admitted to graduate studies at the University of Chicago. There he studied philosophy with John Dewey, the famous educator. While a graduate student at the University of Chicago, he also studied psychology with James Angell and biology and physiology with Henry Donaldson and Jacques Loeb (Pauley, 1987). In 1903, he obtained his doctorate for research with laboratory rats. The experiments concerned learning and correlated changes in the brains of these animals.

Watson published his most influential work in 1913 in the *Psychological Review*, “Psychology as the Behaviorist Views It.” This paper outlined Watson’s views on **behaviorism** as the only way to build a science of psychology, avoiding the philosophical speculation of mind–body dualism and focusing research on objective behavior (Watson, 1913; also see Malone & Garcia-Penagos, 2014 for Watson’s contributions to behaviorism).

In his 1913 paper, Watson rejected as scientific data what people said about their thoughts and feelings by pointing to the unreliability of psychological inferences about another person’s mind. He also noted that the psychology of mind (because it is not observable) had little practical value for behavior control and public affairs. Modern behavior analysts, informed

by the writings of Watson and Skinner, study what people *say* as verbal behavior regulated by the social environment (behavior of other people), not reports on the mind or mental states. Behavior analysts study thinking and remembering as private behavior often related to challenges or problems faced by the person. A person may “think about the house key” and check their coat pocket just before leaving for work, especially if they have been locked out in the past. Notice that thinking about the key is not treated as a *cause* of behavior, but as more behavior to be explained by its interaction with the environment (history of being locked out of the house). In other words, private behavior falls under the same environmental control as overt (observable) behavior.

In addition to his influence on modern behaviorism, Watson is best known for his early studies of conditioning. Perhaps Watson’s most famous experiment was one he conducted with Rosalie Rayner, a student at Johns Hopkins University, on the study of fear conditioning with Little Albert. Rayner later went on to publish studies on developmental psychology with Watson, but also independently.

Little Albert (see Figure 1.8) was a normal, healthy 9-month-old child who attended a day-care center. Watson and his assistant used classical-conditioning procedures to condition Little Albert to fear a white rat. When first exposed to the animal, the child looked at the rat and tried to touch it. The unconditioned stimulus was the sound of a hammer hitting an iron rail. This sound made Little Albert jump, cry, and fall over. After only six presentations of the rat (CS) and the noise (US) the furry animal alone also produced the fear responses. The next phase of the experiment involved a series of tests to see if the child’s fear reaction transferred or *generalized* to similar stimuli. Albert was also afraid (showed fear behaviors) when presented with a white rabbit, a dog, and a fur coat. While the conditioning of fear in infants today would likely be seen as unethical, at the time when it was conducted, views on research ethics with humans were not well developed.

At this point, Watson and his student Rayner discussed a number of techniques that could be used to eliminate the child’s fear. (If fear behavior was learned, the opposite behavior could also be learned.) Unfortunately, Little Albert was removed from the day-care center before counterconditioning could be carried out.

NOTE ON: LITTLE ALBERT AND WHAT HAPPENED TO HIM

Not surprisingly, Watson received bad press for his fear conditioning experiment with Little Albert (see Figure 1.8), and introductory psychology textbook authors and instructors have commented on the methods and ethics of the study (Kalat, 2014). A long-standing mystery has been the identity of Little Albert and what happened to him after the experiment ended. Did the child grow up with a strange phobic reaction to white, furry objects? In a 2009 article in the *American Psychologist* on “Finding Little Albert ...” Hall P. Beck and his associates claimed to have found the identity of the boy’s mother and discovered that Albert was actually Douglas Merritte (Beck, Levinson, & Irons, 2009). With further investigation by Alan J. Fridlund, Beck and colleagues reported that Douglas had hydrocephalus, a neurological impairment, and the boy was not a healthy, normal child as Watson had stated in his 1920 experiment (Fridlund, Beck, Goldie, & Irons, 2012; Watson & Rayner, 1920). These authors erroneously suggested that Watson had known about the child’s neurological condition and had intentionally misrepresented his health, a conclusion that further damaged the already soiled reputation of Watson, behaviorism, and the Little Albert experiment.



Fig. 1.8

Rosalie Rayner holds Little Albert as he plays with a white lab rat before fear conditioning. Watson, left, observes the boy.

Source: Archives of the History of American Psychology, The University of Akron. Published with permission.

In a 2014 evidence-based rebuttal published in the *American Psychologist*, however, these conclusions and charges by Beck's team were severely challenged by Russell Powell and his colleagues in their article, "Correcting the Record on Watson, Rayner and Little Albert ..." (Powell, Digdon, Harris, & Smithson, 2014). Powell's team was able to identify another child by the name of Albert Barger with characteristics that matched closely those originally described for Little Albert, involving normal health and development. Furthermore, these investigators by an extensive historical analysis established that the weight of the evidence indicated that Albert Barger was in fact the Little Albert in Watson's experiment and not Douglas Merritte as claimed by the Beck team. With regard to the claim of misrepresentation by John Watson, Powell and his colleagues concluded "there is no evidence that he [Watson] committed fraud in his scientific endeavors" (p. 23). Given the life of most textbooks, it will take time to correct the accusations directed at Watson. Many introductory psychology textbooks probably will continue to report the bogus claims of neurological impairment of Little Albert and fraudulent science by John B. Watson, thereby maintaining this myth about behaviorism and its renowned advocate.

As for whether Little Albert (Albert Barger) grew up with a conditioned phobic reaction to furry objects, Powell and colleagues were able to establish that he showed some aversion to and dislike of dogs, but there was no clear evidence that Albert showed a generalized avoidance of furry animals or other objects related to his participation in Watson's experiment. Thus, the speculation by Watson and Rayner of lasting effects of their fear conditioning is not well supported by the extensive follow-up inquiry on Albert Barger's life history.

Watson had many professional interests, and he investigated and wrote about ethology, comparative animal behavior, neural function, physiology, and philosophy of science. Based on his provocative views and charisma, he was elected president of the American Psychological Association in 1915 when he was only 37 years old. After leaving Johns Hopkins University in

1920, he became successful in industry by applying conditioning principles to advertising and public relations (Buckley, 1989). Watson implemented the use of “subliminal” suggestion and the pairing of hidden symbols in advertising—techniques that are still used today.

Edward Lee Thorndike (1874–1949)

Watson’s behaviorism emphasized the conditioned reflex. His analysis focuses on the events that precede action and is usually called a stimulus–response approach. Another American psychologist, Edward Lee Thorndike (Figure 1.9), was more concerned with how success and failure affect the behavior of organisms. His research emphasized the events that followed behavior. In other words, Thorndike was the first scientist to systematically study operant behavior, although he called the changes that occurred **trial-and-error learning** (Thorndike, 1898).

Thorndike was always intrigued by animal behavior. While he was at Harvard, his landlady became upset because he was raising chickens in his bedroom. By this time, William James, his mentor at Harvard, and Thorndike were good friends, and Thorndike moved his experiments to the basement of James’s house when he could not get laboratory space at Harvard. (This is not something you could do today, as all laboratory animal research with protected species must be approved and conducted in regulated facilities.) He continued his research and supported himself by tutoring students for two years at Harvard. Then Thorndike moved to Columbia University, where he studied with James McKeen Cattell, the famous expert on intelligence testing. Thorndike took two of his “smartest” chickens with him to Columbia, but soon switched to investigating the behavior of cats.

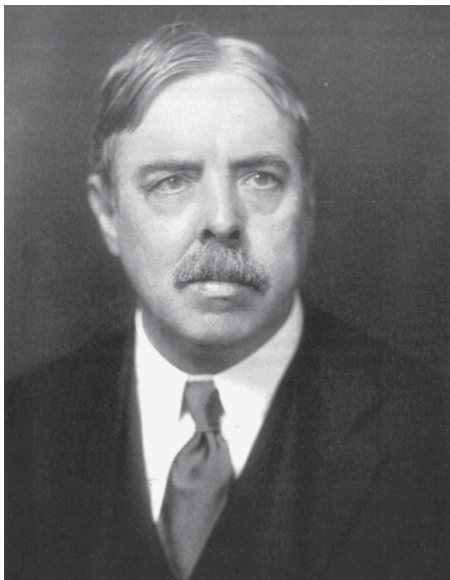


Fig. 1.9

An image of Edward Thorndike.

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At Columbia University, Thorndike began his famous experiments on trial-and-error learning in cats. Animals were placed in what Thorndike called a “puzzle box” and food was placed outside the box (Chance, 1999). A cat that struggled to get out of the box would accidentally step on a treadle, pull a string, and lift a latch. These responses resulted in opening the puzzle-box door. Thorndike found that most cats took less and less time to solve the problem after they were repeatedly returned to the box (i.e., repeated trials). From these and additional observations, Thorndike developed the first formulation of the **law of effect**, which in essence states that behaviors that result in a satisfaction or pleasure get “stamped in” and those that result in discontent and are not successful, get “stamped out.” We can see some problems with the law of effect, of course. Not everything that results in satisfaction or success gets repeated. For example, a college student may find candy satisfying, but is it a strong enough stimulus to alone increase the behavior of studying for a big exam? It might be the exam that does this, which is not all that pleasant. Indeed, there are also situations in which we have to repeatedly do things that we do not enjoy. Many of us, for example, have experienced going to places of employment that are labor-intensive or have toxic working environments, yet we show up and do the work. Therefore, the law of effect has many exceptions, rendering it not a law at all.

Today, Thorndike’s law of effect is restated more carefully and scientifically as the principle of reinforcement. This principle states that all operants may be followed by outcomes that increase or decrease the probability of response in the same situation. The focus is not on the aspects of the stimulus, but rather how the *stimulus impacts the probability of response*. Notice that references to “stamping in” and “pleasure” are not necessary for this definition and that nothing is lost by this more accurate restatement of the law of effect.

B. F. Skinner and the Rise of Behavior Analysis

The works of Pavlov, Watson, Thorndike, and many others have influenced contemporary behavior analysis. Although the ideas of many scientists and philosophers have had an impact, B. F. Skinner (1904–1990) is largely responsible for the development of modern behavior analysis. In the “Focus On: Burrhus Frederic Skinner” section, we described some details of his life and some of his accomplishments. An excellent biography is available (Bjork, 1993), and Skinner himself wrote a three-volume autobiography (Skinner, 1976; Skinner, 1979; Skinner, 1983).

Behavior analysis has continued to grow and thrive since the early days. In 1964, the number of behavior analysts had grown so much that the American Psychological Association established Division 25 called The Experimental Analysis of Behavior, which has several thousand members. Subsequently, the Association for Behavior Analysis (ABA) (now called Association for Behavior Analysis International—ABAI) was founded in the late 1970s, and is still growing today with thousands of members worldwide. This association holds an annual international convention in the USA, a convention every other year in a non-US country, an annual conference on autism, and special conferences on particular topics, such as culture or substance abuse. It also has nearly 100 affiliated regional chapters (over 30,000 members) all over the world, many with their own regional conferences. ABAI publishes six journals with their most impactful journal being *Perspectives on Behavior Science* (formerly *The Behavior Analyst*).

A continuing issue in the field of behavior analysis is the continuum of applied behavior analysis and basic research. During the 1950s and 1960s, no clear distinction existed between applied and basic investigations (see Rutherford, 2009 for more on the transition from the operant laboratory to applications of behavior principles in everyday life). This was because applied behavior analysts were trained as basic researchers. The first applications of behavior principles therefore came from the same people who were conducting laboratory experiments. The applications of behavior principles were highly successful, and this led to a greater demand for people trained in applied behavior analysis. Soon applied researchers were no longer working in the laboratory or reading the basic journals. Today, Masters programs that focus on the training of applied behavior analysts far outnumber those that train basic scientists in behavior analysis (e.g., PhDs in the experimental analysis of behavior). The demand for effective treatments of applied behavioral problems has been met with extensive training of those that can help. The difference in these applied programs as opposed to the basic, though, is that many of these programs do not contain the basic laboratory experience including animals (e.g., pigeons, rats). However, applied behavior analysts are naturally more concerned with procedures to improve or help those with severe disorders, and are less connected to exploring basic phenomena directly with traditional animal laboratory models.

The large influx of applied behavior analysts has been observed greatly in areas such as the treatment of autism and developmental disabilities, behavioral safety, and behavioral medicine. Many of the college degree programs for applied behavior analysts offer the credential of Board Certified Behavior Analyst, which means that specific standards of training and ethics have been met. These training requirements involve extensive fieldwork experience and supervision while working in applied settings (e.g., autism services). This certification is also frequently required for legal licensure to practice in several states in the US.

More recent trends in behavior analysis also show the integration of the basic science in behavior analysis with other areas. For instance, there has been a trend towards infusing behavioral economics, behavioral neuroscience, and behavior analysis in examining problems such as substance abuse. The reinforcer pathology model (Bickel et al., 2011), for example, focuses on variations in behavior sensitivity to delays and effort to stimuli that contribute to the overconsumption of drugs and food (e.g., DeHart et al., 2020). Neural structures, such as reward areas and the prefrontal cortex, that play a role in these reinforcer pathologies, have been identified as important neural mechanisms. Another area is in obesity. The role of the D2 dopamine receptor subtype is altered with chronic exposure to high-fat, high-sugar diets. These types of diets also alter reward processes, contributing to food functioning more highly as a reinforcer (see Johnson & Kenny, 2010; Robertson & Rasmussen, 2017).

The principles of behavior analysis are also foundational to many empirically supported treatments in clinical psychology. The earlier days of behavior therapy, in which environmentally based treatments were used to reduce a variety of problems and disorders, such as enuresis (bed wetting), bruxism (teeth grinding), anxiety-related disorders (including post-traumatic stress disorder), and depression were effective and successful, and many are still used today. More recently, the third-wave behavioral therapy Acceptance and Commitment Therapy (ACT) (see Hayes et al., 2009), which is based on changing the relations of emotions and contexts with the words we tell ourselves through conditioning, is one of the most successful clinical therapies of modern times. It is important to mention that the foundations for all of these

therapies were derived from studies from the laboratory. One area in particular—relational frame theory—contributes to ACT (see Hayes, 2004).

Other changes in the field relate to inclusion and diversity. Before the late 1800s and early 1900s, our understanding of medicine was superstitious and often flat-out inaccurate. The main belief in disease was that illnesses and mental health problems were caused from an imbalance of blood. This is why leeches and blood-letting was a common practice for treating a variety of conditions at the time. Then, the scientific method became the foundation of medicine and fundamentally changed our understanding of medicine (see *The Great Flu Pandemic* for this historical account). Other areas, including psychology, also began systematically using the foundation of the scientific method for determining causes. During this era when we read the history books of various sciences, we see that it was mostly white men who were participating as scientists during this time. This was true even in psychology with a few notable exceptions, such as Rosalie Rayner and Mary Cover Jones. Today, women are participating much more as both scientists and practitioners and there is much more demographic variation in terms of who our scientists and practitioners are from the perspectives of ethnicity, race, sexual orientation, gender identity, ablebodiedness, and the like. Indeed, the Black Applied Behavior Analyst, Inc. association, which was organized in 2019 as one of the ABAI affiliate chapters, has the primary aim to reduce barriers in the field related to race and to promote diversity and inclusion; the group has over 1,000 members to date.

The early years of behavior analysis are sometimes difficult to understand through our modern lens. Back in the early days of behavior analysis (1940s–1960s), family members sought behavior analysts to help loved ones with challenging behaviors, including aggression and self-injurious behavior. The goal was to increase safety and reduce harm, but sometimes the goal was to help behavior conform to what was viewed at the time as “normal.” One especially controversial study was published in 1974 by Rekers and Lovaas. In this study, a male child was showing what was regarded at the time as gender-non-conforming behavior, such as preferences for cross-gender clothing and cosmetics and behavioral mannerisms that were described as feminine. At the time, this type of behavior for a young boy was viewed as abnormal by the American Psychiatric Association (see Kawa & Giordano, 2012 for a history of the *Diagnostic and Statistical Manual*). Because parents wanted their children to fit in, they sought help for changing this behavior. The applied behavior analysts used social reinforcement to increase more masculine behavior and punishment to reduce feminine behavior.

Today, because of an extensive body of research, we know a great deal more about behavior related to gender identity and sexual orientation and what we accept and affirm for every individual includes a much broader range of behavior. The Association for Behavior Analysis International, the American Psychological Association, and the American Psychiatric Association have taken strong positions on treatments that aim to change behavior related to gender orientation or sexual orientation, such as conversion therapy. Not only are these therapies often ineffective in the long run, they can also be harmful to the individual. In short, these types of therapies are viewed as unethical and their practice is condemned. Presently, there is also discussion on the neurodiversity movement, in which more variation in behavior in individuals who are diverse from a neurological standpoint (e.g., autistic individuals) is accepted. These types of cultural changes affect treatment goals for behavioral change.

Science is self-correcting. When we discover new information, it is up to us to look at our current views and determine if they reflect what the new data offer. We do not hold tightly to

old, outdated views, no matter how much we may feel they are right. Being a scientist means looking at perspectives with as much objectivity and humanity as possible, to consider alternate perspectives, and to do that with humility—we recognize that we do not know all of the answers. Openness is key, especially if there are views that can be potentially harmful or unfair to others that are in less dominant positions. When we practice openness and humility, we help society progress.

Our goal in this textbook also is to further the integration of applied and basic areas of behavior analysis and to encourage closer ties to other biological sciences. We have written this book assuming that an acquaintance with basic research is important, even for those who are primarily concerned with behavioral applications and translational studies. We also assume that those who have an interest in laboratory science should also appreciate the manner and complexities of the issues that surround the application of behavioral principles to socially and culturally relevant problems. Students can study this text for a basic grounding in behavior science, or for a solid foundation in human behavior and application.

SCIENCE AND BEHAVIOR: SOME ASSUMPTIONS

All scientists make assumptions about their subject matter. These assumptions are based on prevailing views in the discipline and guide scientific research. In terms of behavior analysis, researchers assume that the behavior of organisms is lawful and deterministic. This means that it is possible to study the interactions between an organism and its environment in an objective manner. To carry out the analysis, it is necessary to *isolate* behavior–environment relations. The scientist must identify events that reliably precede the onset of some action and the specific effects or consequences that follow behavior. If behavior systematically changes with variation in the environmental conditions, then behavior analysts assume that they have explained the action of the organism. There are other assumptions that behavior analysts make about their science.

The Private World

Contemporary behavior analysts include internal, *private events* as part of an organism's environment. Part of each person's experiences is private with stimulation only available to that person. Consider physiological sensations that relate to internal functioning, like an upset stomach, full bladder, or low blood sugar. Consider also the emotions of feeling sad or worried (e.g., muscle tension or “knots” in your stomach). These private events have the same status as external, public stimuli such as light, noise, odor, and heat; they are very real to the observer. Both public and private events regulate behavior. Although this is so, behavior analysts usually emphasize the external, public environment. This is because public events are the only stimuli available for behavior change, a major goal of behavior analysis. It is difficult (if not impossible) for two more people to observe objectively what someone is privately experiencing. We have to rely on a response (often a verbal report) of these types of phenomena, which are then also subjective to consequences from the environment, such as social disapproval.

It is important to note that, just like public events, private events also are regulated by the environment. The objective procedures of psychological experiments or clinical treatments often are giving instructions and observing how the person acts. From a behavioral view, the instructions are external, public stimuli that regulate both verbal and nonverbal behavior. Even

when a drug is administered to a human participant, the chemical alters the person's biochemistry, which can sometimes be felt (private event), but the *direct injection* of the drug or swallowing of the pill is an external, public event that subsequently regulates behavior. To make this clear, without the drug administration neither the biochemistry nor the behavior of the person would change.

Many psychological studies involve giving information or a condition to a person to change or activate cognitive processes, which in turn activates behavior. In the cognitive view, thoughts are used to *explain* behavior. The problem is that the existence of thoughts (or feelings) is often *inferred* from the behavior to be explained, leading to circular reasoning. For example, a child who peers out of the window at around the time her mother usually comes home from work is said to do this because of an "expectation." The expectation of the child is said to explain why the child peers out of the window. This is an explanatory fiction because the cognition (expectation) is inferred from the behavior it is said to explain, when actually, the explanation is observable and testable and can be found in the environment: The boy looks out the window because around this same time every day, his mother comes home. You can test this by having his mother come home at a different time; his window peering would likely change. Cognitions could explain behavior if the existence of thought processes were based on some evidence other than behavior. In most cases, however, there is no independent evidence that cognitions caused behavior, and the explanation is not scientifically valid. One way out of this problem of logic is not to use thinking and feeling as causes of behavior. Thinking and feeling are treated *as* behavior to be explained and the explanations come from the environment—just like observable behavior.

Feelings and Behavior

Many people assume that their feelings and thoughts explain why they act as they do. Contemporary behavior analysts agree that people feel and think, but they do not consider these events as *causes* of behavior. They note that these terms are more correctly used as verbs rather than nouns. Instead of talking about thoughts, behavior analysts point to the action word "thinking." And instead of analyzing feelings as things we possess, the behavioral scientist focuses on the *action* of feeling or sensing. In other words, thinking and feeling are activities of the organism that require explanation.

Feelings: Real, But Not Causes

Because feelings often occur at the same time as we act, they are often mistaken as causes of behavior. Although feelings and behavior necessarily go together, it is the environment that determines how we act, and at the same time, how we feel. Feelings are real private activities, but they are the result of the environmental events that regulate behavior. Thus, a behavioral approach requires that the researcher trace feelings back to the interaction between behavior and environment.

Pretend that you are in an elevator between the 15th and 16th floors when the elevator suddenly stops, and the lights go out. You hear a sound that appears to be the snapping of elevator cables. Suddenly, the elevator lurches and then drops 2 feet. You call out, but nobody comes to your rescue. After about an hour, the elevator starts up again, and you get off on the 16th floor. Six months later, a good friend invites you to dinner. You meet downtown, and you discover that your friend has made reservations at a restaurant called The Room at the Top, which is located on the 20th floor of a skyscraper. Standing in front of the elevator, a sudden

feeling of panic overwhelms you. You make a socially appropriate excuse like, “I don’t feel well,” and you leave. What is the reason for your behavior and the accompanying feeling?

There is no question that you feel anxious, but this feeling is not why you decide to go home. Both the feelings of anxiety and your decision to leave are easily traced to the negative experience in the elevator that occurred six months ago. It is this prior conditioning that behavior analysts emphasize. Notice that the behavioral position does not deny your feelings. These are real events. However, it is your previous interaction with the broken elevator that changed both how you feel and how you act.

Reports of Feelings

You may still wonder why behavior analysts study overt behavior instead of feelings—given that both are changed by experience. The answer concerns the accessibility of feelings and overt behavior. Much of the behavior of organisms is directly accessible to the observer or scientist. This public behavior provides a relatively straightforward subject matter for scientific analysis. In contrast, feelings are largely inaccessible to the scientific community. Of course, the person who feels anxiety has access to this private stimulation, but the problem is that reports of feelings are highly unreliable.

This unreliability occurs because we learn to talk about our feelings (and other internal, private events) as others have trained us to do. During socialization, people teach us how to describe ourselves, but when they do this, they have no way of accurately knowing what is going on inside us. Parents and teachers rely on public cues to train self-descriptions. They do this by commenting on and correcting verbal reports when behavior or events suggest a feeling. A preschooler is taught to say “I feel happy” when the parents guess that the child is happy. The parents may base their judgment on smiling, excitement, and affectionate responses from the child. Another way in which this training occurs is that the child may be asked “Are you happy?” in a circumstance where the parents expect the child to feel this way (e.g., on their birthday). When the child appears to be sad, or circumstances suggest this should be so, saying “I am happy” is not reinforced by the parents. Eventually, the child says “I am happy” in some situations and not in others.

Perhaps you have already noticed why reports of feelings are not good scientific evidence. Reports are only as good as the training of *correspondence* between public conditions and private events. In addition to inadequate training, there are other problems with accurate descriptions of feelings. Many of our internal functions are poorly correlated (or uncorrelated) with public conditions, and this means that we cannot be taught to describe such events accurately. Although a doctor may ask for the general location of a pain (e.g., the abdomen), they are unlikely to ask whether the hurt is in the liver or the spleen. This report is simply inaccessible to the patient because there is no way to teach the correspondence between exact location of damage and public conditions. Generally, we are able to report in a limited way on private events, but the unreliability of such reports makes them questionable as scientific observations. Based on this realization, behavior analysts focus on the study of behavior rather than feelings.

Thinking as Behavior

Behavior analysts have also considered “thinking” and its role in a science of behavior. In contrast to views that claim a special inner world of thought, behavior analysts suggest that human thought may be analyzed as human behavior.



Fig. 1.10

An image of Darrian Robinson moving a piece on a chessboard. Ms. Robinson, who learned to play chess when she was 9 years old, became one of the highest-ranking chess players in the United States Chess Federation by the time she was 19. Ms. Robinson illustrates that thinking is operant behavior.

Source: *Chicago Tribune*, July 20, 2014.

A number of behavioral processes, such as generalization, discrimination, matching to sample, and stimulus equivalence (see later chapters), give rise to behavior that, in a particular situation, may be attributed to higher mental functions. From this perspective, thinking is treated as **private behavior** (see Moore, 2003, and Tourinho, 2006 on private events); that is, behavior only accessible to the person doing it.

One of the more interesting examples of thinking, which involves private behavior, might be observed in a game of chess (Figure 1.10). We may ask another person, “What is the player thinking about?” A response like “She is probably thinking of moving the castle” refers to thinking that precedes the move itself. Sometimes this prior behavior is observable—the player may place a hand on the castle in anticipation of the move, showing a high probability of moving the castle given the layout of the chessboard. At other times, such behavior is private and cannot be observed by others. An experienced chess player may think about the game, evaluating the consequences of moving the castle to different locations. Of course, evaluating the consequences of chess moves itself depends on the actual consequences of such moves in the past (*history of reinforcement*). How often did the move result in a capture or checkmate?

Presumably, the private behavior of playing chess is overt when a person learns to play the game. For example, first the basic rules of the game are explained and a novice player is shown how the pieces move and capture. In moving the pieces from place to place, the player is asked to describe the relations between the opposing chess pieces. This establishes the behavior of viewing and describing the layout of the board and possible moves. As the player receives additional corrective feedback and reinforcement, viewing the layout becomes more skillful. The novice begins to see relations and moves that were not previously apparent. During the first few games, new players are often given instructions like “Don’t move your knight there, or you’ll lose it.” Additionally, the player may be told, “A better move would have been ...,” and a demonstration of the superior move is usually given. After playing a number of

games, the student is asked to explain why a particular move was made, and the explanation is discussed and evaluated. Eventually, the teacher stops prompting the player and encourages the person to play chess in silence. At this point, viewing the layout of the board (e.g., white controls the center of the board) and describing the possible consequences of moves (e.g., moving the knight to this square will split the two rooks) becomes covert and private.

As skill at chess further improves, the player no longer relies on viewing the board and its layout, but increasingly relies on thinking about the game. Blindfolded chess masters report that their thinking does not use mental images as surrogates for viewing the board, but rather *abstractions with minimal or no physical features*. Mechner (2010) suggests that “visualizing the board” involves private verbalizing rather than mental imaging—something like verbal chess notation. In chess notation, a letter and the coordinate of the destination square indicate each move of a piece. For example, a sequence of moves might be as follows: move a bishop to position e5 (Be5), move a knight to f3 (Nf3), and move a pawn to c5 (c5 with no initial).

FOCUS ON: THINKING ALOUD ABOUT CHESS MOVES

The current layout of the chessboard provides players with the opportunity to think about moving pieces to gain either a momentary or long-run advantage in the game. One way to study “thinking about chess moves” is to have tournament and expert players think aloud (saying what they are thinking about) when presented with chessboard problems with known best solutions (Moxley, Ericsson, Charness, & Krampe, 2012). Although the “think aloud” technique is related to the study of information processing and cognition, thinking aloud also is useful in behavior analysis. From a behavioral viewpoint, “thinking aloud” is considered a verbal measure of private behavior (thinking about X) that precedes public actions (making a choice), allowing for an analysis of the correspondence between saying (what I am thinking) and doing (making the choice), and its behavioral consequences (see Austin & Delaney, 1998). Moxley et al. (2012) used a chess computer program to assign “move strength scores” to the first move mentioned and to the final move actually made after further deliberation (more thinking aloud time), regarding chessboard problems (positions of pieces) that varied in degree of difficulty (easy and hard).

Figure 1.11 shows the estimated move strength scores for first move mentioned and final move chosen after further deliberation for experts and tournament players on easy and hard chessboard problems. For easy problems (top panel), experts do much better (higher move strength) on first moves mentioned than tournament players (two black bars), an effect called intuitive thinking; both types of players (tournament and expert) show improved move strength after further deliberation (move chosen), but improvement is greater for tournament players. Thus, thinking more (deliberating) about easy chess problems generally benefits all chess players (experts and tournament) by gaining a subsequent advantage (move strength) in the game, but tournament players gain the most from continuing to think about the problem.

As for the hard chessboard problems (bottom panel), experts again do better in move strength than tournament players (two black bars), indicating a difference in intuitive thinking favoring experts; tournament players show a small, but statistically unreliable, increase in move strength on the move chosen after deliberation, which suggests that further thinking about difficult chess problems did not gain an advantage for tournament players. In contrast, experts confronted with difficult problems showed a reliable improvement in move strength after

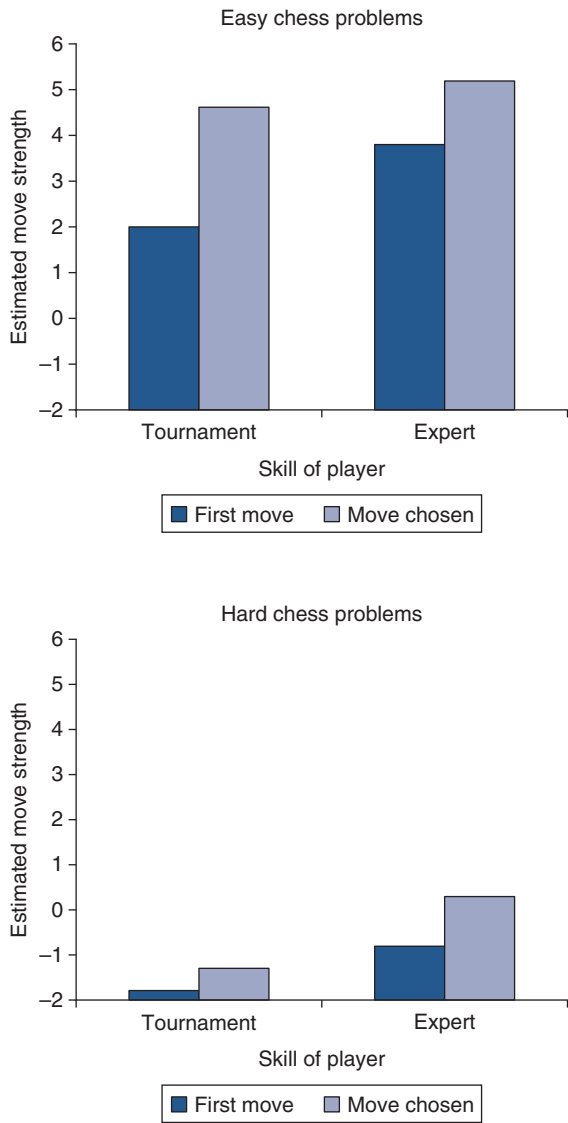


Fig. 1.11

The top panel of this figure shows a graph that depicts the estimated move strength in chess as a function of the skill of the chess player—tournament level or expert level for each chess problem. This is for easy chess problems. The strength of the first mentioned move (black) and the move chosen after deliberation (gray) is shown on the y-axis. For easy chess problems, the strength of the first move is higher for the expert player than the tournament player, but the deliberated move for both types of players is quite similar. The bottom panel shows data for hard chess problems. The move strength is very low for both types of chess players for both types of moves compared with easy chess problems. But the expert has higher move strength in the deliberated moves compared to the tournament chess player. See text for discussion of these findings.

Source: Based on a graph from J. H. Moxley, K. A. Ericsson, N. Charness, & R. T. Krampe (2012). The role of intuition and deliberative thinking in experts' superior tactical decision-making. *Cognition*, 124, pp. 72–78, 75, but omitting the results for medium difficulty chess problems. Published with permission of Elsevier B. V. all rights reserved.

deliberation (move chosen). Thus, thinking longer, and presumably in different ways, about difficult chessboard problems results in better moves (move strength) for expert players, but not for tournament players. The next step, from a behavioral view, is to use the “thinking aloud” method to analyze the verbal behavior of experts to extract rules and strategies that could be taught to tournament players, showing that once these “ways of thinking” are learned, move scores improve, as does general expertise in chess.

Verbal concepts drawn from a player’s pre-existing behavior repertoire are used for conceptualizing moves (a form of personal notation), not mental representations of the external world as suggested by cognitive psychology. To illustrate this, verbal concepts linked to vision might include the vocabulary of color (black or white), movement in space (coordinates), and distance to and between objects (knight to bishop on e5). Chess masters appear to use their full range of verbal concepts to “conceptualize certain of [the chess position] relational and dynamic attributes” (Mechner, 2010, p. 376). The term “conceptualize” is used by Mechner to refer to verbal “discrimination between [stimulus] classes and generalization within classes,” not some inferred mental entity.

The function of thinking as *private behavior* is to increase the effectiveness of practical action. People conceptualize the game privately without committing themselves publicly. An advantage is that thinking about a sequence of moves (high probability response) is not revealed to your opponent; also thinking may be revoked if the judged consequences are not reinforcing based on your recent *history of reinforcement*. Once a conceptualization is implemented, the player faces the objective consequences. If conceptualizing guides actions resulting in checkmate, then this kind of thinking is strengthened. On the other hand, conceptualizing moves that result in loss of the game weakens this sort of thinking in the future. Overall, thinking is complex operant behavior (mostly verbal) controlled by its consequences. Thinking about a move that guides effective action is likely to occur again, while thinking that prompts ineffective performance declines.

In this section, we have discussed thinking as private behavior. There are many other ways in which the term “thinking” is used. When a person remembers, we sometimes talk about thinking in the sense of searching and recalling. Solving problems often involves private behavior that furthers a solution. In making a decision, people are said to think about the alternatives before a choice is made. The creative artist is said to think of novel ideas. In each of these instances, it is possible to analyze thinking as private behavior regulated by specific features of the environment. The remainder of this book discusses the behavioral processes that underlie all behavior, including thinking.

CHAPTER SUMMARY

This chapter has introduced the idea that many behaviors are acquired during one’s lifetime as a result of experience. At birth we emit behavior with very little organized activity. However, as our behaviors cause consequences, some responses are strengthened while others are weakened. The consequences or outcomes of behavior function to select and establish a behavior repertoire. Several prominent persons were introduced to illustrate the history of the science of behavior analysis. In particular, B. F. Skinner was described as a major force behind the experimental and applied analyses of behavior, which is the topic of this book. This approach is related to biology in that behavior is considered to be

a product of genes interacting with the organism's environment over a lifetime. In this regard, we saw that responses to environmental contingencies alter gene expression (epigenetic effects), neural pathways (neuroplasticity), and retention of learning. Behavior analysis currently is extended to the understanding of feelings and to complex behavior involving problem solving and thinking.

Key Words

Applied behavior analysis	Learning
Behavior	Neuroplasticity
Behavior analysis	Operant
Behavior analysts	Operant conditioning
Behavioral neuroscience	Private behavior
Behaviorism	Reflex
Conditioned reflexes	Reinforcement
Confirmation bias	Remote causation
Contingency	Respondent
Correlation	Respondent conditioning
Culture	Science of behavior
Discrimination	Selection by consequences
Experimental analysis of behavior	Trial-and-error learning
Immediate causation	Unconditioned response
Law of effect	Unconditioned stimulus

On the Web

www.bfskinner.org As you learned in this chapter, B. F. Skinner established the natural science of behavior used in this textbook. The B. F. Skinner Foundation was established in 1987 to educate the public about Skinner's work and accomplishments, and to promote an understanding of contingencies of reinforcement in regulation of human behavior.

www.behavior.org The website for the Cambridge Center for Behavioral Studies is useful to learn more about behavior analysis, behaviorism, and applied behavior analysis. The Center publishes several journals, is host to the Virtual Behavioral Community, and offers recent publications through an online bookstore.

http://web.utk.edu/~wverplan William S. Verplanck, a major contributor to the experimental analysis of behavior and behaviorism, died in September 2002. This award-winning website provides information on his past activities, publications, and addresses, plus interesting issues in psychology and the study of behavior.

www.abainternational.org Go to the webpage for the Association of Behavior Analysis International to find out about the annual convention, the official journals (*Perspectives on Behavior Science* and *Verbal Behavior*), and membership in the Association.

http://psych.athabasca.ca/html/aupr/ba.shtml Find the resource website for the behavior analysis and learning program at Athabasca University in Canada. Many useful links are given for students who want to explore a range of issues in the field. Many of these sites can be accessed to supplement your learning from each chapter in the textbook.

www.simplypsychology.org/classical-conditioning.html This webpage tells you about John Watson and includes a video presentation of his fear conditioning experiment with the infant known as Little Albert.

www.youtube.com/watch?v=JTBg6hqeUTg This brief TEDx talk by geneticist Dr. Courtney Griffins introduces the science of epigenetics and how the environment during an organism's lifetime controls which genes are active or inactive (gene transcription). Once you watch the presentation, return to the section on "Epigenetics and Retention of Early Learning" in this chapter and read the material again.

www.nature.com/scitable/topicpage/translation-dna-to-mrna-to-protein-393 Students that need a quick reference to DNA transcription by mRNA and translation of mRNA into proteins would benefit from this website by Nature Education.

Brief Quiz

- 1 _____ is the alteration (or maintenance) of an organism's behavior due to _____.
 - a behavior; causes
 - b learning; lifetime events
 - c culture; social norms
 - d evolution; genes
- 2 The experimental analysis of behavior is:
 - a a natural-science approach to understanding behavior regulation
 - b concerned with controlling and changing factors that affect behavior
 - c concerned with the principle of reinforcement
 - d all of the above
- 3 A _____ is behavior that is elicited by a biologically relevant stimulus, while a _____ is behavior that is controlled by its consequences.
 - a reflex; respondent
 - b respondent; voluntary
 - c reflex; operant
 - d operant; respondent
- 4 Selection by consequences occurs at three levels. What are these?
 - a natural selection, behavior selection, and cultural selection
 - b artificial selection, culture, and linguistic selection
 - c natural selection, artificial selection, and cultural selection
 - d artificial selection, natural selection, and linguistic selection
- 5 Skinner emphasized that behavior (including human behavior) resulted from _____.
 - a genes
 - b environment
 - c self-determination
 - d both (a) and (b)
- 6 Which of the following statements is true of Pavlov and his contributions?
 - a he won the Nobel Prize
 - b he investigated the salivary reflex
 - c he discovered the conditioned (or conditional) reflex
 - d all of the above

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- 7** How are thinking and feeling treated from a behavioral perspective?
- a as more private behavior to be explained
 - b as the causes of overt behavior
 - c the relation between the mental and the physical
 - d the mind and its regulation of behavior

Answers to Brief Quiz: 1, b (p. 1); 2, d (p. 2); 3, c (p. 4); 4, a (p. 7); 5, b (p. 15); 6, d (p. 18); 7, a (p. 28).

CHAPTER 2

The Experimental Analysis of Behavior

- 1 Learn about a *functional* analysis of behavior.
- 2 Inquire about the method of experimental analysis of behavior.
- 3 Focus on drugs and behavioral baselines.
- 4 Learn how to design and assess behavioral experiments.
- 5 Conduct a behavior analysis of perception.

The experimental analysis of behavior (EAB) refers to a field of study that analyzes behavior–environment relations. This method is called functional analysis. **Functional analysis** involves *classifying behavior* according to its response functions and analyzing the *environment* in terms of stimulus functions. The term *function* refers to the *characteristic effect produced* by either a behavioral or an environmental event. Once a reliable classification has been established, the researcher uses experimental methods to show a causal relation between the environmental event and a specified response. Because of this objective method, behavior analysts need not restrict their findings to one or a few species. The principles of behavior–environment relations hold for all animals. Based on this assumption, and for convenience, researchers often use nonhuman subjects (e.g., rats and pigeons) as their “tools” for discovering principles of behavior, in the same way that geneticists use the fruit fly (*Drosophila melanogaster*) to establish laws of genetics.

FUNCTIONAL ANALYSIS OF BEHAVIOR

There are two ways to classify the behavior of organisms: structurally and functionally. In the **structural approach**, behavior is categorized by age to infer stages of development. For example, many developmental psychologists are interested in the intellectual growth of children. These researchers often use what a person does at a given point in the life cycle to test theories of intellectual development. Children may be said to show “object permanence” when they look for a familiar object that has just been hidden. The structure of the response or what the child does (e.g., looking for and finding the hidden object) is used to make an *inference* about cognitive development. The form or structure of behavior is emphasized because it is said to reveal the underlying “stage” of intellectual growth—knowing that objects exist

even when they are out of sight. The *structural approach* draws inferences from behavior about *hypothetical* cognitive abilities such as object permanence. These cognitive abilities in turn are used to explain the child's behavior in finding hidden objects. The child is said to find hidden objects *because she has developed the concept of object permanence*. You may remember from the previous chapter that one problem with using structure to explain behavior is circular reasoning—the behavior of finding the hidden object is used to infer cognitive abilities (object permanence), and these presumed abilities are then used to explain the behavior. Notice that nothing about the child's behavior is actually explained from a causal standpoint with the structural, developmental approach.

In the previous chapter, we noted that behavior analysts study behavior *for its own sake* and at its own level. To keep attention focused on behavior, structure and function are interrelated. A particular form of response by a child, such as opening and looking inside a handbag for a hidden object, is traced to its characteristic effects or consequences (Figure 2.1). The form, structure, or **topography**, of response occurs because that way of doing it has been highly efficient, relative to other ways of opening the bag. Thus, the current topography (structure) of a response is determined by the function (effects or consequences) of this behavior.

In the example of a child who finds a hidden object, a *functional analysis* suggests that this behavior has resulted in specific consequences—the child usually has discovered the hidden toy or object. Rather than infer the existence of some intellectual stage of development or cognitive ability (object permanence), the behavior analyst suggests that a particular **history of**



Fig. 2.1

Picture shows a toddler finding an object hidden in a purse. The conditioning of finding hidden objects (object permanence) may begin early in life when a child pulls at their mother's clothing to uncover the breast for feeding, and is further refined by finding things under blankets and is directly trained as gift-opening on birthdays or holidays and finding chocolate eggs on Easter.

Source: Shutterstock.

reinforcement is responsible for the child's capability. Presumably, from a behavioral perspective, a child who demonstrates object permanence (searching for objects when they are not in sight) has had numerous opportunities to search for and find missing or hidden objects. One advantage of this functional account is that it is testable.

A mother who breastfeeds her newborn often removes some of their clothing just before feeding the baby. After some experience, the baby may tug at the mother's blouse when they are hungry. This is one potential instance of the early conditioning of searching for hidden objects. A few months later, the infant may inadvertently cover up a favorite rattle. In this situation, getting the toy reinforces pulling back the cover when things are hidden. As children get older, they are directly taught to find hidden objects. This occurs when children are given presents to open at birthdays and when they hunt for eggs at springtime holidays, such as Easter. A functional analysis of object permanence accounts for the behavior by pointing to its usual effects or consequences. Object permanence occurs because searching for out-of-sight objects has usually resulted in finding them. Also, children who do not have these or similar experiences (playing peek-a-boo) will perform poorly on a test of object permanence, but should be able to learn this behavior by systematic instruction of the component skills (Bruce & Muhammad, 2009).

Response Functions

Behavior is often considered as *performance* that follows a specific stimulus and at some point, results in a particular consequence. (One three-term notation system used to denote this arrangement is $A: B \rightarrow C$, which stands for antecedent stimulus (A), behavior (B), and consequence (C).) Although we shall use the term *response* throughout this book, this term does not always refer to a discrete movement like a muscle twitch or a lever press. *A response is an integrated set of movements, or a behavioral performance*, which is functionally related to environmental events or happenings in the world. For example, the performance of taking notes during a lecture requires a rather complex set of behaviors in which an individual uses a writing utensil (or a computer) to write or type a series of words that characterize what the professor just stated. It involves listening and perhaps reading what is listed on a PowerPoint presentation, thinking quickly about what to write, and then writing it. This is all occasioned by something the professor says (the stimulus).

Functionally, we speak of two basic types or classes of behavior: respondent and operant (Figure 2.2). These behavioral classes were briefly discussed in Chapter 1 and are discussed further throughout the book, but here we emphasize the functional classification of behavior. The term **reflex** is used to refer to behavior that is invariantly caused by the presentation of a stimulus (or event) that *precedes* the response. We say that the *presence of the stimulus induces or elicits the response*; that is the stimulus reliably and often involuntarily activates the response. The notation used with elicited behavior is $S \rightarrow R$. The stimulus S causes (arrow) the response R. An example of a reflex is the pupillary response to light. The constriction (and dilation) of the eye pupil is reflexive behavior. It occurs when a bright light is directed into (or away from) the eye. Salivation to food is another reflex; food elicits salivation in the mouth. The stimulus S (food) elicits the response R (salivation). For the moment you may consider reflexes to be the activity of smooth muscles or glands (i.e., eye blinks and salivation), and many of them indeed are. But, as we show in Chapters 3 and 7, the modern view of behavior theory substantially expands the organism's reflexive repertoire.

Functional response classes		
Response class	Function	Controlling event
Respondent	Elicited	Stimulus preceding the response
Operant	Emitted	Stimulus following the response

Fig. 2.2

The figure summarizes the concepts used for a functional classification of behavior. The response classes are either reflexive or operant. Reflexive behavior is elicited by a stimulus preceding the response; operant behavior is emitted and increased (or decreased) by a stimulus that has followed the response in the past.

There is another large class of behavior that does not depend on an eliciting stimulus. This behavior is **emitted** at some frequency based on an organism’s genetic endowment. For example, human infants randomly emit vocal sounds usually referred to as “babbling.” These sounds contain the basic elements of all human languages. English-speaking parents attend to, repeat back, and reinforce babbling that “sounds like” English and the baby soon begins to emit more English sounds, especially when the parents are present. The same happens for those who speak other languages: Arabic-speaking parents, for example, attend to and reinforce sounds that sound Arabic. When emitted, behavior is strengthened or weakened by the events that follow the response, it is called **operant** behavior. Thus, operants are emitted responses that occur more or less often depending on the prior consequences produced in a given situation. To make clear the subtle distinction between emitted behavior and operants, consider the action word *walking* versus the phrase *walking to the store*. Walking is emitted behavior, but it has no specified function. In contrast, walking to the store is an operant defined by getting items from the store. Pecking a disk or response key is emitted behavior by a pigeon, but it is an operant when pecking the key has resulted in food. Generally, operants are emitted responses occurring without an eliciting stimulus; effects or consequences of behavior control these responses. We should note that the distinction between elicited and emitted behavior currently is disputed because often there is blending of them in behavior, but most behavior analysts support understanding the differences and we maintain the distinction throughout this version of our textbook (see Domjan, 2016 for details about this dispute).

Operant and reflexive behaviors often occur at the same time when dealing with a single organism. When you step out of a movie theater in the middle of a bright afternoon you may show both types of responses. The change from dark to bright light will elicit pupil contraction, a type of reflex. At the same time, you may shade your eyes with a hand or put on a pair of sunglasses. This latter behavior is *operant* because it is strengthened by the removal of the brightness—the aversive stimulus. In another example, you find that you have failed an important exam. The bad news may elicit a number of emotional responses (conditioned reflexes called **respondents**, which will be discussed later), such as heart palpitations, changes in blood pressure, and perspiration. You probably interpret these physiological responses as dread or anxiety. The person standing next to you as you read the results of the exam asks, “How did you do on the test?” You say, “Oh, not too bad” and walk down the hall with your head down. Your reply and posture is *operant* behavior that avoids the embarrassment of

discussing your poor performance. Although operant and reflexive (or respondent) behaviors often occur at the same moment, we will usually analyze them separately to simplify and clarify the environmental conditions that regulate such behavior.

Response Classes

When a person emits a relatively simple operant such as putting on a coat, the performance changes from one occasion to the next. The coat may be put on using either the left or right hand; it may be grasped at the collar or held up by a sleeve. Sometimes one arm is inserted first, while in other circumstances both arms may be used. Careful observation of this everyday action will reveal an almost infinite variety of responses. The important point is that each variation of the putting-on-a-coat response has the common effect of staying warm. To simplify the analysis, it is useful to introduce the concept of a class of responses. A **response class** refers to all the topographic forms (or variations) of the performance that have a similar function (e.g., to keep warm). In some cases, the responses in a class have close physical resemblance, but this is not always the case. A response class for “convincing an opponent” may include dramatic gestures, giving sound reasons, and paying attention to points of agreement. To get service from a restaurant server, you may call out as they pass, wave your hand in the air, or ask the bus-person to send the server to your table; these are all responses within a response class.

Responses within the response class tend to be emitted in a particular order (Baer, 1982a), becoming arranged as a **response hierarchy** based on likelihood of occurrence. Often response–response relations (i.e., relative degree of effort) influence the ordering of responses in the class. In a study of effort and ordering of responses, Shabani, Carr, and Petursdottir (2009; Study 1) trained children to separately press each of three buttons (low, medium, and high effort) for identical rates of reinforcement (each press resulted in reinforcement). Next, when all three buttons were available at the same time, children mainly pressed the low-effort button for reinforcement. When pressing the low-effort button no longer resulted in reinforcement (extinction), children primarily pressed the medium-effort button; reinstatement of continuous reinforcement on the low-effort alternative resulted in the children selecting and again pressing this button while reducing responses to the higher effort alternatives. In Study 2, when both low- and medium-effort responses were not functional, children pressed the high-effort button. Generally, the results suggested that the three button-press responses were part of a response class and were arranged in hierarchical order in terms of degree of effort (see also Mendres and Borrero, 2010 for modification of a response class by positive and negative reinforcement; see Beavers, Iwata, & Gregory, 2014 for influence of response–reinforcement relations—reinforcement rate, quality, delay and magnitude—on emergence of response-class hierarchies).

FUNCTIONAL ANALYSIS OF THE ENVIRONMENT

In Chapter 1, we noted that behavior analysts use the term **environment** to refer to events and stimuli that change behavior. These events may be external to the organism or may arise from internal physiology. The sound of a jet aircraft passing close overhead or an upset stomach may