An Introduction to Behavior Analysis

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What Is Behavior?

The primary subject matter of this book is *behavior*. Thus, it is important to begin by defining that term. In this book, **behavior** is defined as *an individual living organism's activity, public or private, which may be influenced by external or internal stimulation*.

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A fish watches the current, looking for edible materials. When something tasty floats by, the fish strikes. This strike is a **response** – *a single instance of behavior*.

You think about your future and consider what kind of job will make you happy, while simultaneously allowing you to pay the rent on time. Having a thought is also a response – a single instance of a different kind of behavior.

Let's dissect the definition of behavior provided in italics above. The first word indicates behavior is something *individuals* do – the fish that strikes a bug does so as an *individual*. Likewise, when you think about your job prospects, you think your own thoughts, as an individual. Behavior is something *individuals* do.

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Focusing on individual behavior is consistent with the goals of those who seek the expertise of a psychologist, counselor, or behavior analyst. The individual experiencing depression, the parent of a child diagnosed

An Introduction to Behavior Analysis, First Edition. Gregory J. Madden, Derek D. Reed, and Florence D. DiGennaro Reed.

with autism, the manager of an underperforming employee, they all want the behavior of an individual – self, child, and employee, respectively – to change in an adaptive direction, that is, a reduction in depression, an increase in social interactions, and an increase in productivity. If you were depressed, you would not be satisfied with the services of your therapist if they said, "Sorry you aren't doing any better, but 4 of my other 10 patients are getting better." While that is great for them, this helps you in no way. Your depression is experienced as an *individual*, and an effective therapist who treats individuals will seek to understand *your* behavior and the factors that can effectively reduce *your* depression. This requires a focus on the behavior of the *individual* – you.

The second component of our definition of behavior is that it is something that individual *living organisms* do. Applying an electric current to a dead fish will produce reflexive movement, but it will not produce a fish that strikes when its next meal floats downstream. Likewise, if you were dead, no amount of electrical stimulation to precise brain regions would revitalize your ability to contemplate a future career path. Moreover, while we acknowledge that advancements in the field of artificial intelligence and robotics have created robots that learn and behave in ways remarkably similar to animals, we will restrict our definition of behavior to the actions of biological organisms.

The next part of the definition – *public or private* – simply means that some behavior is *public* (everyone can observe it happening) and some behavior is *private* (you are the only person who can observe it). The bug-striking behavior of our fish is *public* – it can be observed by the fish, other nearby fish, and by anyone who takes the time to set up an underwater camera to watch the fish strike its prey.

By contrast, thinking about your career is a *private* behavior. Only you can observe the entirety of your thoughts as you think them. If you did your career contemplation while lying in a functional magnetic resonance imaging device, we could observe the areas of your brain that are active as you are thinking, but it gives us no access to the content of your thinking. Hence, this behavior remains *private*.

Source: Hero Images/Getty Images

The final component of the definition – *which may be influenced by external or internal stimulation* – means behavior can be affected (changed) by **stimulus events** (*things you see, hear, smell, taste, or feel*) and these stimulus events can occur outside or inside your body. For example, the bug floating toward the fish is an *external* visual stimulus – the bug is outside the fish's body and when the fish sees it the visual stimulus increases the probability of a striking action. Without the visual stimulus, the probability of striking is very low. Likewise, the *internal stimulation* of hunger increases the probability of searching for food and striking a bug when one is encountered.

Just like the fish, your own private behavior – contemplating career choices – is influenced by *external and internal stimulation*. If your biology instructor is charismatic and speaks convincingly of the joys of being a professor (external stimuli), the probability of contemplating this career path is increased. Simultaneously, a number of internal stimuli can increase (e.g., caffeine's stimulating effects) or decrease (e.g., a headache) the probability of a career contemplation session.

What Is Behavior Analysis?

Behavior analysis may be defined by its goals, its assumptions, and its major activities. We discuss each of these in the sections that follow. But before you read on, you should read the "How to Use the Features of This Book" section of this book's Preface. There you will find important advice about how to read this book and how to study so that you can maximize your learning, enhance your ability to use what you learn to improve your life (and the lives of those around you), *and* to earn a better grade in this class. The advice comes from scientific studies identifying effective ways to study. Interestingly, these studies find very few students use these techniques, opting instead for study methods that are much less effective (e.g., highlighting your textbook and rereading it the night before the exam). You will find the advice provided in the Preface useful not only for this class, but for all of your classes. So, take a few moments to read the "How to Study" section now.

The Goals of Behavior Analysis

The broad goal of any science is to understand the phenomena being studied. Entomologists want to understand insects. Astronomers want to understand the universe. Similarly, behavior analysts seek to understand the behavior of individuals. Whether it's you, me, your pet, or a mountain lion, behavior analysts are interested in the behavior of individual organisms.

There are many different approaches to understanding. Behavior analysts take a pragmatic approach. They want to improve the human condition (and that of the nonhuman animals with whom we share the planet) and this is reflected in the two goals of behavior analysis.

THE FIRST GOAL OF BEHAVIOR ANALYSIS

The first goal of behavior analysis *is to accurately predict behavior*. To understand why behavior analysts want to predict behavior, ask yourself, which would you prefer: a bus that arrives at a *predictable* time or a bus that arrives at an *unpredictable* time? The predictable bus arrives at the hour and the half-hour; it is never late. The unpredictable bus arrives at no particular time, but it arrives at the bus stop twice per hour. So, which bus would you prefer? The answer is obvious. We would all prefer the predictable bus.

Let's make obvious why we prefer the predictable bus. If the bus always arrives on time, then we can plan for its arrival. We can enjoy our conversation with friends a little longer, study a little longer, or finish a meal at a casual pace before we leave to catch the bus. By contrast, if the bus is unpredictable then our behavior will be less efficient as we must spend more time doing what we don't want to do (sitting at the bus stop) and less time doing what we want to do (eating and talking with friends). We prefer the predictable bus because *predictability allows adaptive behavior*.

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It's not just buses. We also like to predict the weather and we check our weather apps regularly. Why – because *predictability allows adaptive behavior*. If we know it's going to

rain, we can wear a raincoat or grab an umbrella. If we know it's going to be sunny, we can leave both of these at home and save the hassle of carrying them.

Of course, behavior analysts are interested in predicting the behavior of individuals, not of buses or the weather. **What is the utility in predicting the behavior of individuals?** To answer this question, consider your roommate who predictably joins you for breakfast at 8:30 each weekday morning. The utility in accurately predicting when your roommate will arrive, is that *it allows adaptive behavior* – you can make extra coffee, clear a spot at the table, and leave out the box of cereal. Your roommate appreciates this, and these actions increase the probability that your roommate will be nice to you at a later time.

If your roommate's behavior suddenly became unpredictable, sometimes getting up at 3 am, other times at 11 am; your acts of kindness would no longer be *adaptive* – the coffee would go to waste, the spot cleared would not be used, and the cereal box would go unopened.

Predicting behavior is important to all of us because *it allows adaptive behavior*. Have you ever noticed that when you meet someone new (e.g., a new coworker) you ask a lot of questions: What is your name? Where are you from? Are you in school? Which school? What's your major? Do you work? How many brothers and sisters do you have?

We all do this. Why? Because *it allows adaptive behavior*. If you learn, for example, that your new coworker likes street tacos, then you can behave adaptively at lunch time by saying "Hey, want to go to the taco truck for lunch?" There is no guarantee that the answer will be "yes," but the probability is higher than if you had said "Hey, want to go to the vegan restaurant for lunch?"

All of us try to accurately predict long-term patterns of behavior in those around us. We refer to this as a "reputation". If Chauncey has a reputation as a liar, we will not believe it when he tells us that his start-up company is a great investment. If Winter has a reputation for generosity, we will ask her for a ride to work when our car will not start. We keep track of the behavior of others and we use this information adaptively. If we did not track the reputations of others, we would invest in worthless ventures, walk to work, and would, ourselves, get a reputation for being naïve.

Although it is useful to accurately predict behavior, some have argued that it is either impossible or ill-advised to do so. For example, the famous Russian author Fyodor Dostoyevsky commented on the unpredictability of behavior in this way,

> *If you say one can also calculate all this according to a table, this chaos and darkness, these curses, so that the mere possibility of calculating it all in advance would stop everything and that reason alone would prevail – in that case man would go insane deliberately in order not to have reason, but to have his own way!*[1]

Fyodor Dostoyevsky (1821-1881)

Source: Fine Art Images/ AGE Fotostock

The ironic thing, of course, is that in arguing against a behavioral science, he made a *prediction* about behavior – the individual would deliberately go insane.

The extent to which we can accurately predict human behavior is a topic that we will return to throughout this textbook. For now, it is enough to remind you that the first goal of behavior analysis is to predict behavior and the reason that predicting behavior is important is that *it allows adaptive behavior*. Table 1.1 shows some predictions about behavior, adaptive behaviors that can occur if the prediction is correct, and the beneficial outcome of this adaptive behavior.

Table 1.1 Predicting behavior is useful.

Prediction about behavior	Adaptive behavior	Beneficial outcome
I will snooze my alarm clock three times tomorrow morning	Set the alarm to go off 45 minutes before I need to get out of bed	Arrive at my appointment on time
Within the next 6 months, I will drop my phone and crack the screen	Buy insurance	Save money when I need a new screen
My roommate will eat my favorite leftovers	Hide the leftovers behind something my roommate dislikes	Leftovers are there when I want them
My boss will be grumpy during the dinner rush	Avoid talking to my boss during the dinner rush	Avoid getting yelled at

* This table shows some predictions about behavior, the adaptive behavior that the prediction allows, and then the beneficial outcome expected because the adaptive behavior occurred.

THE SECOND GOAL OF BEHAVIOR ANALYSIS

The ability to accurately predict behavior is great, and in some sciences, prediction is all you can do. For example, astrophysicists can precisely predict where Mars will be two years from now, but they cannot practically influence the trajectory of the planet. Within a science of behavior, we seek to do more than just predict behavior; we want to influence it. Stated more formally, **the second goal of behavior analysis** *is to discover functional variables that may be used to positively influence behavior*. A **functional variable** is *a variable that, when changed, reliably and systematically influences behavior*.

Throughout this book we will discuss how behavior analysts have discovered functional variables. For now, let's focus on what we mean when we say our goal is to *positively influence behavior*. We mean that the behavior analyst is able to change behavior. Where we predict that a maladaptive behavior will occur (e.g., drunk driving), the behavior analyst can use existing knowledge of functional variables to do something that decreases the probability of this behavior and increases the likelihood that the individual will choose to do something else – something more adaptive (e.g., call an Uber™ when intoxicated).

There are many ways to positively influence the behavior of individuals, and this textbook provides an introduction to these techniques. By carefully studying these techniques, you will acquire insights into how you can improve lives by positively influencing behavior.

DEMAND MORE OF YOUR SCIENCE

We encourage readers to embrace the twin goals of behavior analysis and apply them to all sciences. These goals are practical, useful, and, if realized, will improve our own lives and those of others (Baer et al., 1968). As you evaluate the progress of any science, it is worth asking, does this science make accurate predictions? If not, that is a problem. If astrophysicists cannot predict exactly where Jupiter will be on a specific date four years from today, then they cannot send a probe to the planet to study its atmosphere. That is a problem.

Likewise, it is worth asking if the social and behavioral sciences have identified functional variables that may be used to positively influence behavior. The more functional variables the science has identified, the more it allows us to improve the human condition. Again, by changing those variables (something that behavioral scientists call "therapy" or an "intervention") we change people's behavior and improve their lives. So, whatever social/behavioral science you study, it is worth asking: Can this science accurately predict and positively influence behavior and, in so doing, prove beneficial to society at large?

Reading Quiz 1

Each chapter in this book will include a few reading quizzes embedded within the text. If you can answer all of these questions correctly, then you will know that you are understanding this book. The answers to these quiz questions are provided at the end of the chapter.

1. Behavior is something that _____ living organisms do.
2. _____ is defined as an individual living organism's activity, public or _____, which may be influenced by external or _____ stimulation.
3. A _____ is something you see, hear, smell, taste, or feel. These events can occur outside or inside your body.
4. Stimuli is the plural of _____.
5. One stimulus, two _____.
6. Buying a car is an instance of _____ (public/private) behavior.
7. Changing your clothes is an instance of _____ (public/private) behavior.
8. Thinking that you should not have bought that car because now you don't have enough money for new clothes is an instance of _____(public/private) behavior.
9. The first goal of behavior analysis is to _____ _____ behavior.
10. The second goal of behavior analysis is to discover _____ variables that may be used to _____ _____ behavior.
11. Accurately predicting behavior is important because it allows _____ behavior.

The Assumptions of Behavior Analysis

Recalling from above that behavior analysis may be defined by its goals, its assumptions, and its major activities, we now turn to two assumptions that guide behavior analysis.

Assumption #1: Behavior is determined

Behavior analysts assume that behavior is determined.[2] **What does it mean to say, "behavior is determined?"** It means that *behavior has a cause, or multiple causes*. This is an appropriate assumption for scientists who study behavior. If they assume that behavior is caused by knowable variables, then behavioral scientists will set out to discover those functional variables. If one assumes that behavior is not determined (i.e., behavior occurs without a cause), then one would not bother trying to discover functional variables that are assumed not to exist.

Here is a quick note about the distinction between *functional variables* and *causes*. Behavioral scientists are reluctant to discuss "causes" because it implies that we know everything there is to know about behavior, and that clearly is not the case. In recognition of this incomplete knowledge, we talk about "functional variables." When a functional variable is changed, we can be confident that it will influence behavior. However, to suggest that the functional variable "caused" the behavior change is more than the evidence supports. Perhaps, for example, the functional variable plays no causal role, but is merely correlated with behavior change. We will have more to say about correlations, functional variables, and behavior change in Chapters 2 and 3. For now, we return to the assumption that behavior is determined.

For most members of Western cultures, this assumption of determinism is difficult to accept because we have been taught that some, if not all, of our behavior is self-determined and free from external causal variables. For example, most westerners embrace the concept of *free will*. However, a careful consideration of this issue leads us to reject the idea that behavior is self-determined.

Source: rudall30/Getty Images

Consider your behavior right now. If we accept the concept of free will, then your current behavior (reading this book) is not influenced by any causal variables. If that were true, then it would not be influenced by biological variables; for example, that you have a brain capable of decoding the symbols on this page into meaningful sentences. It would not be influenced by experiences from long ago, such as learning to speak your native language or learning to read through systematic instruction provided by teachers and parents. It would not be influenced by experiences a few months ago; for example, a friend that you trust recommended that you take this class. And your behavior would not be influenced by recent experiences; for example, the instructor assigned this chapter and said that some materials from the book will appear in upcoming exams. Behavior analysis holds that this complex of causal biological and experiential variables combines to determine your behavior.

MENTALISTIC EXPLANATIONS OF BEHAVIOR

When we learn how biological and environmental events combine to influence behavior (like your reading this textbook right now), it makes sense to us. More importantly, understanding how biological and environmental events can change behavior enhances our ability to accurately predict and positively influence behavior. But this scientific way of thinking stands in contrast to how most of us explain why we, or those around us, do the things we do. Consider these examples of everyday explanations of behavior:

- "I ate a sweet potato because I decided I needed more potassium."
- "I went to a movie because I felt like laughing."
- "I hit him because I was angry."

In these sentences, the words before "because" identify the behavior that needs to be explained. The words after "because" provide the sorts of explanations that we all hear

and give every day. In the first example, eating a sweet potato (behavior) is said to be caused by "I decided that I needed more potassium." If your brother or sister said this while eating a baked sweet potato you would accept the explanation without a second thought. However, this explanation has a fundamental problem – it explains the first behavior by appealing to a second behavior:

- I ate because I decided
- I went because I felt
- I hit because I was angry

So, now instead of having one behavior to explain (I ate), we have two behaviors to explain (I ate *and* I decided). These everyday explanations of behavior violate Occam's *law of parsimony*, which, when applied to behavior, holds that, all else being equal, the best explanations of behavior are the simplest explanations. Explaining one behavior by appealing to a second behavior lacks parsimony – what was once a simple task (explaining one behavior) is now more complex (explaining two behaviors).

To make matters worse, when we explain one behavior by appealing to a second, the second behavior usually occurs *privately* (mentally) where others cannot observe it. "I decided…" appeals to private decision-making. "I felt…" and "I was angry…" appeal to private sensations. Behavior analysts refer to these as mentalistic explanations of behavior. Behavior analysts reject mentalistic explanations of behavior.[3]

To get a better understanding of the problems with mentalistic explanations, imagine you are a behavior therapist and your patient (a college student identifying as a female) complains that she has no self-control. Her diet is atrocious, she is constantly skipping classes, and when she attends she mostly looks at her social media feed and posts selfies for her friends. In addition, she has occasional anger outbursts, particularly with her partner. Your job, as the therapist, is to help your patient change her behavior.

If you believe one behavior (making the wrong food choice) is caused by a second behavior (I mentally decided to eat…), then the way to change the first behavior is to change the second behavior. Sounds like we have a plan – to change her food choices we need to change a *private behavior* – her mental decision-making. How do we do that? If we follow the logic of our explanation of bad food choices (Behavior 1), that these choices are caused by mental decision-making (Behavior 2), then we would look for a Behavior 3 that caused Behavior 2. Of course, if you found Behavior 3, you would be no closer to improving your client's food choices because to change Behavior 3 you would have to find its cause – Behavior 4. Obviously, this search for mental causes is never ending, and it will not help your patient improve her diet.

To change dietary behavior, we must identify functional variables that can positively influence this behavior. Invariably, these functional variables will be biological and environmental events. A nice thing about this approach is that we can often change biological and environmental events and, when we do, we can evaluate if they change behavior. If they do, then we have found a functional variable that can be used by other behavior therapists to positively influence behavior. For this reason, behavior analysts focus their attention on biological and environmental events that influence behavior. As you will learn throughout this book, this approach has proven effective.

I'M NOT BUYING IT. I DETERMINE MY OWN BEHAVIOR

For many people, the idea that behavior is determined by biological and environmental variables is not easily accepted. Instead, most of us feel that we *will* our own behavior; that is, we

feel that we mentally direct our own actions. The main evidence for this feeling is that, occasionally, just before we engage in a behavior we have an internal (private) dialogue in which we actively decide what to do next. For example, when deciding where to eat lunch, we might mentally consider how hungry we are, how we love hamburgers, how much money we have, how far we are from home, and if there is any food at home. All of this private decision-making gives us the feeling that we will our decision – to go home and make a sandwich.

This is an alluring idea because we can hear the internal dialogue that constitutes this mental decision-making process and this dialogue immediately precedes some of our deliberative actions:

> *Man am I hungry. I sure could go for a hamburger. But I don't have enough money for a hamburger. I guess I could go home and eat. Yeah, I've got that bread that's going to go stale if I don't eat it soon. I think I'll go home and make a sandwich.*

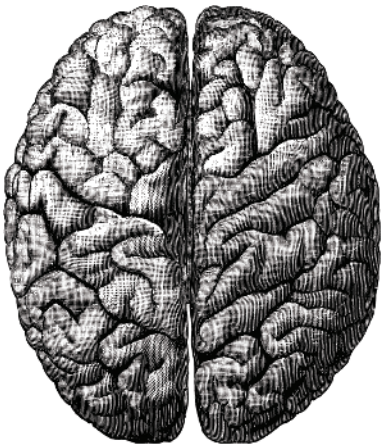
Source: AA Film Archive / Alamy Stock Photo

Because we hear this internal dialogue many of us picture this process as a tiny person, or several tiny people inside our head, much like the characters in the Pixar movie, *Inside Out*.

Although *Inside Out* was a great movie, there are at least **three problems** with the theory that a mental decision-maker wills behavior into motion:

1. ***Choice is behavior.*** Engaging in a mental decision-making process (choice) is an activity that meets the definition of behavior – it is an individual living organism's private activity, which may be influenced by external or internal stimulation. As noted earlier, suggesting that one behavior (choice) causes another behavior (making a sandwich) is unsatisfying because it leaves unanswered the question, what causes the choice? Another choice? If so, what causes that choice? You can see the parsimony problem here.
2. ***Choice is determined.*** When one makes a choice, what factors are considered before the choice is made? In the sandwich example, public events (the lack of money, bread at home) combined to influence the decision to eat a sandwich. If any of these factors were different, it would influence the choice *and* what was eaten for lunch. For example, if bread was unavailable at home, the probability of choosing to eat a sandwich would be greatly reduced. If money was more abundant, we would have eaten hamburgers. These *functional variables* influence the choices we make.
3. ***Spurious reason-making.*** One reason we all *feel* like we will our own behavior is because we are good at providing mentalistic reasons for our actions (I'm eating sweet potatoes because I decided…). The problem with this evidence is that Nobel Prize winning research shows that these reasons are spurious (false, fake) – we make these spurious reasons up when asked to do so, even though those "reasons" have nothing to do with our behavior. This was made clear in the 1960s by Roger Sperry and Michael Gazzaniga. They worked with epilepsy patients whose left and right brain hemispheres were surgically disconnected to reduce seizures. After the surgery, the two sides of the brain had no way to communicate. So, when the left ear was told to "get up and go for a walk," only the right part of the brain heard it

(everything on the left side of your body is controlled by your right brain-hemisphere, and vice versa). Spoken language is controlled by the left hemisphere, so when the right hemisphere alone was told to take a walk, the left hemisphere could not explain why the patient was walking. As the patient walked out of the room, the experimenter asked him where he was going. The truthful answer would have been "I have no idea" but the left hemisphere made up a spurious reason on the spot: "I'm going to get a Coke." Perhaps most interesting of all, the patient *believed* the reason he gave was true. That is, he believed he *chose* to get up for a Coke; when in fact, he did not choose this at all.



Source: nicoolay/E+/Getty Images

Applied to our own everyday explanations of behavior, we make up spurious explanations for our behavior all the time and, importantly, *we believe them*. This gives us a sincere *feeling* that an internal decision-maker wills our behavior into action. Science disagrees.

If you, the reader, choose to reject these three pieces of evidence (and we expect most of you will), you should be aware of two important implications of your choice. First, if an undetermined will determines behavior, then the first goal of behavior analysis cannot be achieved – accurately predicting behavior. An advanced science will make predictions by considering the biological and environmental variables that influence behavior. If these variables play no role in human behavior, then accurate predictions are impossible. Recalling that the utility in predicting behavior is that it allows us to live more adaptively, we might hope the behavior analysts are right – behavior is determined – as this assumption has the potential to improve our quality of life.

Second, if an undetermined will determines behavior, the second goal of behavior analysis also cannot be achieved – discovering the functional variables that will allow us to positively influence behavior. If will determines what behavior comes next, then the only way to positively influence behavior is to influence will. But if will is not caused by anything, then there is no way to influence will and, therefore, there is no way to influence behavior. This is bad news for all those individuals who hope that an advanced behavioral science can positively influence their behavior, or the behavior of a loved one. Because this leaves us in a hopeless situation, behavior analysts assume that behavior is determined. Thus far, this assumption has proven useful.

Assumption #2: The scientific method is a valid way to reveal the determinants of behavior

A scientific approach to learning about the workings of the natural world originated in the seventeenth century with the work of great scientists like Copernicus, Galileo, and Sir Isaac Newton. Prior to the development of the scientific method humans made very little

progress in understanding the workings of the natural world. This is because prescientific explanations were not challenged. For example, during the medieval period physicians explained behavior by referring to the balance of four liquids, called humors, in the human body – black bile, yellow bile, phlegm, and blood. If the physician's patient was depressed it was "explained" by saying the patient possessed a surplus of black bile. The cure? Bloodletting, leaches, and mercury-containing medicines that induced vomiting and diarrhea.

Source: Chronicle / Alamy Stock Photo

If the medieval physician had been versed in the scientific method, he (they were almost all men) would test his prediction by taking a sample of bodily humors and objectively evaluating the amount of black bile in the sample. If he found high levels of black bile, then an appropriate amount of blood would be extracted, and if the patient's mood improved the physician's prediction would prove correct. Unfortunately, medieval physicians did not do this. They did not empirically test the predictions of the humoral model. Instead, physicians accepted it without questioning the authority of their teachers and elders.

Because the theory of humors was not subjected to empirical tests, the ineffective medical practices informed by it continued for centuries. When the scientific method was eventually applied to medicine, the theory of humors was abandoned.

The widespread use of the scientific method is responsible for discoveries that have improved human lives (life-saving medications, modern forms of transportation, and the cell phone in your pocket; Pinker, 2018). Because the scientific method has proven so useful in revealing the workings of the world, behavior analysts assume that it is a valid method for discovering the determinants of behavior.

Reading Quiz 2

Remember, the answers to these questions are provided at the end of the chapter.

1. The first assumption of behavior analysis is that behavior is _____.
2. When we say, "behavior is determined," we simply mean that behavior has a _____, or multiple _____.
3. In our daily lives, we often explain behavior (I went to the movies) by pointing to private behaviors (I thought going to the movies was a good idea). Behavior analysts refer to these as _____ explanations of behavior.
4. The second assumption of behavior analysis is that the _____ _____ is a valid way to discover the determinants of behavior.

Scientific Method

There is no pure, disinterested, theory-free observation.

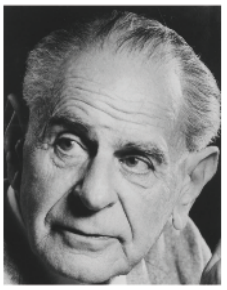
~Karl Popper, philosopher of science

The first principle [of science] is that you must not fool yourself – and you are the easiest person to fool.

~Richard Feynman, physicist

The *scientific method* describes the behavior of all scientists as they go about discovering how the natural world works. Here we briefly summarize the characteristics of the scientific method that are of most relevance to behavior analysis. The scientific methods used by behavior analysts will be discussed in Chapters 2 and 3.

Objective: Behavior analysis is an objective, unbiased, scientific approach to discovering how behavior works. Of course, humans are subject to many known biases (Kahneman & Tversky, 2013), so any *individual* behavior analyst cannot be entirely objective. Recognizing that biases can influence the outcome of their work, behavior analysts, like all good scientists, take steps to minimize this possibility. For example, data are recorded by computers or by people who are blinded to the purpose of the study. Where we fail in our objectivity, other behavioral scientists will point out our failings. Indeed, they advance their careers by doing so. Therefore, while individual scientists are fallible and subject to bias, the *scientific enterprise* is self-correcting.



Karl Popper
(1902-1994)

As noted by the great twentieth-century philosopher, Karl Popper, a second meaning of "objective" is that scientists regard no theory as a dogmatic truth. That is, our current understanding of behavior is not finalized. Behavior analysts recognize that we have much still to learn about behavior, and a goal of this textbook is to inspire a next generation of behavior analysts to make clear where we currently have it wrong. This objectivity directed toward the state of current knowledge was embraced by the influential behavior analyst, B. F. Skinner (1979) when he wrote, "Accept no eternal verity. Experiment" (p. 346).

Quantitative: Behavior analysts specify the behavior of interest with enough precision that its occurrence can be *counted*. That is, the person(s) measuring behavior has defined that behavior with enough precision that instances and non-instances of the behavior may be discriminated from each other. This discriminability allows behavior analysts to more objectively measure behavior before, during, and after conducting an intervention designed to influence behavior.

Systematic: When behavior analysts conduct an intervention designed to influence behavior, they make sure that it is *implemented exactly as it is supposed to be*. Failure to properly implement the intervention will make it impossible to evaluate if the intervention is effective. If a study is conducted to evaluate an intervention and it proves not to change behavior, a fan of the intervention could say, "Oh, well they didn't implement the intervention correctly." This fan boy might be right, so it is important that behavior analysts document that they implemented the intervention exactly as they were supposed to. If they document this and the intervention does not work, the fan boy has no basis for saying that the intervention is effective.

Empirical: Behavior analysts require empirical evidence to support any claim about behavior. By "empirical" we mean that the *evidence must be observable*. We can do this observing with the naked eye or with the aid of an unbiased measurement device.

Nonempirical evidence, such as appeals to "common sense," to authority figures ("the President of the United States says…"), or to divine revelations ("according to the Bible…") holds no sway among scientists; empirical evidence is what counts.

Falsifiable Predictions: As discussed previously, the first goal of behavior analysis is to accurately predict behavior. Predictions are usually derived from theories (conceptual models of how the world works). Good theories make accurate predictions and incorrect (or incomplete) theories make inaccurate predictions.

Karl Popper went beyond this. He held that good theories make specific predictions about what happens *next*. Popper lived at the same time as Sigmund Freud, and he noticed that Freud's predictions about human behavior were pointing to what happened *before*, not what happens *next*. For example, if Freud's patient was suffering from anxiety, he speculated about past events that caused the anxiety. For example, the patient had a rough time of toilet training; no, really, that was one of his theories. These theories are hard to disprove. If the patient could not remember traumatic toilet training, Freud held that these memories were repressed into the inaccessible subconscious.

Popper thought these kinds of theories were rubbish because they were *unfalsifiable*; there was no way to prove them wrong. Popper said scientists should conduct experiments to prove theories wrong – to falsify them. This practice makes science a destructive force, but so be it. Humans have no shortage of whacky ideas about the world, and especially about human behavior. So, owning a tool like a wrecking ball that can falsify crackpot theories is a good thing. The scientific method is that tool.

Imagine that you came up with one of these half-baked theories and everyone around you loves it. They encourage you to give lectures on your theory and lots of people pay you lots of money to talk about your theory and how it will change the lives of those in the audience. After a few months, you are convinced that your theory is not so whacky after all. It has to be true!

Now, how would you feel about taking out that wrecking ball called the scientific method and trying to disprove your theory? You're probably not going to be a big fan of that idea. After all, you have a lot to lose if your theory is falsified. So, being a good scientist means being brave – you've got to be willing to take out the wrecking ball and apply it to your own theories (even though you love them).

Sciences that make unfalsifiable predictions are, according to Popper, *pseudo-sciences*. Pseudo-sciences contribute nothing to our goals of prediction and influence. By contrast, *natural sciences* make falsifiable predictions about things that happen next. Behavior analysis is one of these natural sciences. As we will see in later chapters, behavior analysts make specific, often quantitatively specific, predictions about behavior. When these predictions are confirmed, they strengthen our confidence in the theories upon which they are based. When the predictions are falsified, the theory is abandoned.

Experimentation: The most powerful scientific method is the experiment and this method is extensively used in behavior analysis. In an experiment, the behavior of an individual is objectively measured long enough that we are confident that if nothing changes the behavior will not change. Next, something is changed. This change is called the **independent variable** – *a publicly observable change, controlled by the experimenter, which is anticipated to influence behavior in a specific way*. In therapeutic settings, the independent variable is the intervention, or the treatment. Everything else that might influence behavior is held constant in an experiment and, therefore, if behavior changes we will conclude that the independent variable is functional; it influenced behavior. If not, the prediction will be falsified.

Peer-Review: When a group of behavioral scientists have discovered something they think is important, they will prepare a written description of the study that led to the discovery. The document will outline how behavior was objectively and quantitatively recorded, how the independent variable was manipulated, and how all other variables that might affect behavior were held constant. If a theory is being tested, a falsifiable prediction will be provided, and the empirical outcomes will be presented.

Before this document can be published in a scientific journal, it will be evaluated by a handful of scientific experts. These reviewers will approach the paper skeptically, looking for problems with the study that might diminish confidence in the discovery. If the paper does not pass this peer-review process, the paper is not published. This peer-review process is designed to ensure that papers published in scientific journals can be trusted. That is, if you were to replicate the methods described in the published paper, you would get the same outcome. Of course, the only way to know for certain that you will get the same outcome is to give it a try. Which takes us to our next topic.

Replication: The most important way to evaluate if scientific discoveries are true is through replication, that is, *repeating the experiment and obtaining the same outcome*.

> "*…replication is the essence of believability.*" (Baer et al., 1968, p. 95)

Being able to replicate the results of an experiment is important in any science, but it is particularly important in behavior analysis because many behavior analysts work with individuals with challenging or problem behavior. A behavior analyst who works with a child diagnosed with autism needs to know that the therapeutic methods being used will work. Just like an engineer knows that the laws of physics can be relied upon when designing a building or a bridge, the behavior analyst needs therapeutic methods that produce replicable outcomes.

In 2015, a group of scientists known as the "Open Science Collaboration" published a paper in the prestigious journal, *Science*. The paper described the group's attempts to replicate 100 prominent findings reported in top psychology journals. For example, in one of these studies, college students were randomly assigned to either read about determinism (that behavior is caused by biological and environmental factors) or a neutral topic. The original investigators (Vohs & Schooler, 2008) hypothesized that belief in free will was important in moral action, so they anticipated that reading about determinism would undermine participants' morality. That's what they reported; participants who had just read about determinism were more likely to cheat during the study. This study was widely cited because it made "common sense." But when the Open Science Collaboration group tried, they could not replicate this finding, despite conducting the experiment exactly as described by Vohs and Schooler (2008). Indeed, the Open Science Collaboration (2015) report revealed that more than 60% of the findings published in top psychology journals could not be replicated. This finding has since been replicated (e.g., Klein et al., 2018). Psychologists were stunned by this outcome and some point to the research methods of behavior analysts (those discussed in Chapters 2 and 3) as a pathway out of this "replication crisis."

Replication has been a hallmark of behavior analysis from the beginning. By replicating behavioral outcomes over many sessions, the researcher or behavior therapist becomes increasingly confident in their findings. By replicating behavioral outcomes in several individuals, in several different studies, and in several different labs or settings, confidence is more robustly established. Rest assured that the principles of behavior analysis covered in this book have been replicated many times in many different labs and with many different species; they are believable. Where the evidence has not been replicated, we will point that out, so you may be skeptical.

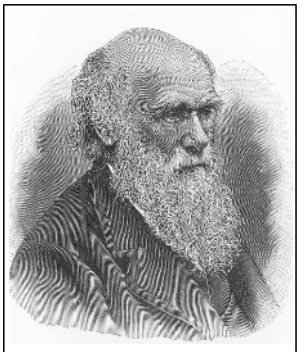
Reading Quiz 3

1. Within science, there are two meanings of the word _____. The first recognizes that humans are susceptible to biases that cloud how we evaluate evidence that supports and refutes our favorite theories.
2. The second meaning of the word _____ recognizes that our current understanding of behavior is tentative and will be changed in the future as new findings support an alternative viewpoint that better allows us to predict and positively influence behavior.
3. _____ evidence for a scientific finding is either directly observable or observable with the aid of an unbiased measurement device.
4. When a scientist makes a prediction about behavior, the prediction is precise enough that it could be shown to be incorrect. These are referred to as _____ predictions.
5. When scientists discover something, it is important that their research be repeated to see if the finding can be obtained again. This repetition of experiments to evaluate if they produced reliable results is called _____.

What Are the Determinants of Behavior?

Scientists have for the last century or so studied the determinants of behavior and the rest of this book will outline the discoveries that are most important to behavior analysts. Broadly speaking, the determinants of behavior can be organized into two categories: *nature* and *nurture*. Early in the history of behavioral science, researchers asked if behavior was determined by nature (i.e., our genetic inheritance) or nurture (events experienced during one's lifetime). Today we recognize that behavior is determined by a combination of nature *and* nurture.

Nature


Charles Darwin (1809-1882)

The behavioral determinants collectively referred to as "nature" include biological variables such as the evolutionary past of the species and the unique genome of the individual. Innate behaviors are the product of the evolutionary past of the species. Consider two of the innate behaviors of modern human infants – rooting and suckling. When an infant roots, it moves its mouth toward an object that is touching its cheek or lips. Once that object enters the mouth, the infant sucks on it (suckling). In the evolutionary past of the human species, infants who found and sucked on the mother's nipple survived; those who did not died. This survival advantage is the means by which innate behaviors are naturally selected – surviving means you live long enough to get your genes into the next generation. Genetic transmission through mating ensures your children will root and suckle too. The evolutionary past of the species is one determinant of behavior.

Another "nature" determinant of behavior is the unique genome of the individual. In sexually reproducing species (like humans), two parent genomes combine to produce a unique

genome in the child. Mutations in this genome can produce dramatic effects on the behavior of the child. For example, children born with three copies of chromosome 21 (instead of the usual two) will have Down's syndrome, which profoundly impairs learning.

The genome need not be impacted by mutations to influence behavior. Behavioral tendencies in the parent(s) can be passed genetically to offspring. Consider the tendency to consume alcohol. Extensive studies of human twins (Verhulst et al., 2015), selectively bred nonhuman animals (Murphy et al., 2002), and genetically modified organisms (Roberts et al., 2001) have demonstrated that genes passed from parents to offspring can increase consumption of alcohol.

Nurture

The behavioral determinants collectively referred to as "nurture" include all of the events experienced during an individual's life. Although behavior analysts recognize that nature plays an important role in behavior, most of their efforts are focused on studying how **environmental events** influence behavior. By "environmental" we mean *all of the things you experience through your senses*. For example, you may see a sign that says that your favorite food is available at half-price today. Seeing the sign increases the probability of a specific behavior – going to the store and buying that food. On another day, you might overhear someone say something terrible about you. This environmental event will influence how you behave around that person in the future.

The ways in which individual behavior can be influenced by environmental events is the subject matter of this book. When an individual learns by interacting with its environment, the individual's behavior is changed, often in profound ways. Consider the acquisition of a new skill, like reading. When you learned to read you were embedded in an environment in which reading instruction, reading behavior, and immediate feedback were prominent. After you learned to read, your behavior changed in profoundly adaptive ways. You were no longer dependent on your parents to read your favorite books to you. You could read advice on an online troubleshooting forum when your PlayStation3® stopped working. You could use your reading skills to acquire new behaviors at school (math, science, etc.).

Our interactions with environmental events also influence the frequency of our behavior. If you got your finger caught in the car door, leaving your fingers in harm's way decreased in frequency. If saying, "please, please, please, please, please" was an effective way to get what you wanted, that behavior increased in frequency.

Experiences also influence where and when we behave. If being noisy in the classroom leads to negative consequences but being noisy on the playground leads to positive consequences, then these outcomes will influence where your noisy behaviors are emitted. Likewise, if you attend class on the wrong day or at the wrong time, you will arrive in an empty classroom (or in a different class). This mistake will likely influence when you choose to walk to class. Clearly, environmental events influence our everyday behavior.

Behavioral Epigenetics

Behavioral epigenetics examines how nurture shapes nature. When an environmental event influences gene regulation (specific genes are turned on or off) it influences the growth of brain neurons, the activity of these neurons, and the behavior of the individual. These

changes in gene regulation do not change the individual's DNA, but they can be passed on to the offspring.

One of the earliest discoveries in behavioral epigenetics was that a rat's behavior in a stressful environment was influenced by the care provided to the rat when it was a pup. Mother rats that appropriately lick their pups produce pups that grow up to handle stress in adaptive ways. When mother rats lick their pups, it activates a gene that influences a receptor in the rat's brain (the glucocorticoid receptor); maternally neglected pups are left with an inactive gene and they behave less adaptively in stressful situations. When these rats grew up and had pups of their own, the females that had been licked appropriately provided maternal care to their offspring; those that had not tended to neglect their pups (Masterpasqua, 2009). Behavioral epigenetics provides a nice illustration that nature *and* nurture influence individual behavior.

Source: ibreakstock/Getty Images

The Activities of Behavior Analysts

Early in this chapter we said that behavior analysis is defined by its goals, its assumptions, and its major activities. We have discussed the goals of behavior analysis (to predict and influence behavior) and the assumptions of behavior analysis (determinism and the scientific method). Chapter 2 discusses the specific scientific methods behavior analysts use to predict and influence behavior. In what remains of this chapter, we examine the activities of behavior analysts.

Before going into specifics, it is important to note that there is strong demand for individuals who provide behavior analytic services. For example, from 2010 to 2017, demand for individuals trained in behavior analysis grew by approximately 800%! So, learning the principles discussed in this book may not only get you a good grade, it may get you a good job.

The Experimental Analysis of Behavior

Although a good deal is known about the determinants of individual behavior, it would be naïve to suggest that our understanding is complete. Thus, many behavior analysts work to expand our ability to predict and influence behavior by conducting research in controlled laboratory settings. Such research is referred to as the "experimental analysis of behavior."

Research conducted in the experimental analysis of behavior is not designed to therapeutically improve behavior or to address socially relevant behavior problems. Pioneers in the experimental analysis of behavior include John B. Watson, Ivan Pavlov, Edward L. Thorndike, and B. F. Skinner. We will study the contributions of each of these scientists in later chapters. The thing that unites these laboratory researchers was their passion for using the scientific method to make important discoveries about environmental events that influence behavior. Contemporary researchers in the experimental analysis of behavior continue to make important discoveries, and these are published in peer-reviewed scientific journals.

Much like Watson and Skinner, most contemporary scientists in the experimental analysis of behavior are employed as university professors. If you are thinking about pursuing such a career, you will need to attend graduate school after earning your bachelor's degree. In graduate school, you will take additional coursework and complete intensive research experiences for four to six years before earning your doctoral degree.

Applied Behavior Analysis

A second category of research in behavior analysis is applied behavior analysis. Applied behavior analysts also conduct rigorous scientific research; however, they focus on socially significant behavior in non-laboratory settings. For example, applied behavior analysts may conduct experiments exploring effective ways to teach reading skills (Daly & Kupzyk, 2013) or to reduce problem behavior in children diagnosed with autism (Hagopian et al., 2013).

Applied behavior analysts are expected to demonstrate a level of effectiveness that is readily apparent to consumers. If the applied behavior analyst is trying to decrease an individual's drug use, the intervention would be deemed effective only if the drug user and their spouse (and perhaps the judge who ordered the user into therapy) agreed that there was a noticeable decrease in drug use. In addition, the intervention must be acceptable to the client and others affected by it. In sum, applied behavior analysis aims to develop practical interventions that produce meaningful improvements in socially significant behavior.

Like those working in the experimental analysis of behavior, applied behavior analysts earn a doctoral degree and are most often employed as university professors. In addition, applied behavior analysts must pass a national certification exam administered by the Behavior Analyst Certification Board (BACB.com).

Behavioral Service Delivery

Those behavior analysts who use the discoveries of laboratory and applied behavior analysts to address the needs of patients are employed in *behavioral service delivery*. Many of these professionals work with children and adults diagnosed with a range of behavioral and intellectual disorders. Others work with individuals in traditional talk therapy settings, addressing issues of anxiety, phobias, depression, obsessive-compulsive disorders, and so on (Madden et al., 2016).

The increase in the prevalence of autism over the last 20 years, combined with the rigorous scientific evidence supporting behavior-analytic therapy in the treatment of autism (National Autism Center, 2015; Reichow, 2012; United States Surgeon General, 1998; Wong et al., 2015), has led to a dramatic increase in the number of professionals employed in behavioral service delivery. At present, more than 30 US states license behavior analysts to provide services. These licensed professionals are certified through the Behavior Analysis Certification Board after classroom training, supervised internships, and upon passing their

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EXTRA BOX 1: DIMENSIONS OF APPLIED BEHAVIOR ANALYSIS

In a seminal article published in the first issue of the *Journal of Applied Behavior Analysis*, Donald Baer, Montrose Wolf, and Todd Risley defined the seven core dimensions of applied behavior analysis (Baer et al., 1968). Researchers working in the field today aspire to these dimensions, though many important, socially significant applied research domains will not adhere to all seven dimensions (Critchfield & Reed, 2017).

1. ***Applied:*** The individual, behavior, and/or situation in which the individual behaves is socially important. If the applied behavior analyst can positively influence this behavior, it will improve the life of the individual and other members of society affected by the same behavioral malady (e.g., heroin abuse, pathological gambling, compulsive eating).
2. ***Behavioral:*** Because applied research is important, it is critical to objectively and accurately measure behavior. Asking people to tell you what they did is an inadequate foundation upon which to base a behavioral science, when the validity of those reports has not been established (e.g., Chermack et al., 2000; Mertz et al., 1991).
3. ***Analytic:*** An experimental design is employed and adequate replications conducted, thereby allowing the applied behavior analyst to identify which component(s) of the intervention is/are responsible for the behavior change.
4. ***Technological:*** Scientific reports on intervention efficacy will provide enough technical details that others can replicate the methods and evaluate the intervention's efficacy. The "replication crisis" in psychology underscores the important of this technological requirement.
5. ***Conceptual:*** The scientific theories and empirically supported principles of behavior that underlie intervention components are identified. Interventions are not pulled out of the air, nor are they a mere "bag of tricks"; they are derived from and contribute to an existing empirical science (Baer et al., 1968, p. 96).
6. ***Effective:*** Socially (and clinically) significant behavior changes are those that are obvious and meaningful to the stakeholders (client, parents, teacher, etc.). If stakeholders indicate that the behavior change has made no *practical difference*, then the applied intervention lacks efficacy.
7. ***Generality:*** Applied interventions have generality if they produce a durable (long-lasting) change in behavior that may be observed in a variety of settings where the behavior is adaptive.

certification examination. Demand for licensed and/or board-certified behavior analysts has grown continuously for decades. One level of certification, the BCaBA (Board Certified Assistant Behavior Analyst ®), is available to students after they earn their bachelor's degree and have completed supervised training in service provision. So, if you enjoy this class and want to work in the field without going to graduate school, this is the level of certification for you. More information may be found on the website of the Behavior Analyst Certification Board (BACB.com).

Organizational Behavior Management

The application of behavior analysis to business settings is called "Organizational Behavior Management." The focus of behavior analysis on objective measurement of individual behavior has proven highly compatible with a business focus on employee performance. Identifying environmental events that can be practically changed and that will produce measurable performance improvements translates in corporate settings to improved customer satisfaction, employee satisfaction, and profitability. There are several consulting companies that specialize in Organizational Behavior Management. The minimum educational requirement for employees in these companies is a master's degree in behavior analysis.

Summary

Behavior analysis has been defined by its goals, assumptions, and activities. Like a species, behavior analysis has evolved over time as scientists working in the experimental analysis of behavior, as applied behavior analysts, or as scientists in allied disciplines such as psychology have made new discoveries requiring that the field update its understanding of the determinants of behavior. Each update expands our understanding of behavior and increases the ability of those working in behavioral service delivery to provide an intervention that positively influences behavior and improves human lives. There is little doubt that the evolution of behavior analysis will continue in the decades to come. Perhaps you will be one of the behavior analysts who help to evolve the field and who will make a difference in the well-being of humanity.

Reading Quiz 4

1. Over 100 years of research has demonstrated that individual behavior is influenced by _____ *and* _____.
2. Those working in the _____ analysis of behavior, most often conduct their research in laboratory settings, where nuisance variables will not get in the way of identifying determinants of behavior.
3. Behavior analysts who conduct scientific research in clinical settings are called _____ behavior analysts.
4. Individuals who deliver behavioral services that are based on the research of laboratory and applied behavior analysts are employed in the field of behavioral _____ _____.

Answers to Reading Quiz Questions

Reading Quiz 1

1. individual
2. behavior; private; internal
3. stimulus

4. stimulus
5. stimuli
6. public
7. public – this one can be tricky. Although we often change clothes in private, changing clothes is a public behavior. It can be observed by anyone who looks in on us. Thinking about changing clothes, however, is a private behavior.
8. private
9. accurately predict
10. functional; positively influence
11. adaptive

Reading Quiz 2

1. determined
2. cause; causes
3. mentalistic
4. scientific method

Reading Quiz 3

1. objective
2. objective
3. empirical
4. falsifiable
5. replication

Reading Quiz 4

1. nature; nurture (the order of these answers does not matter)
2. experimental
3. applied
4. service delivery

Notes

1. Dostoyevsky (1864) *Notes from Underground*.
2. Behavioral scientists recognize the role of randomness (e.g., quantum mechanics) in the causal system that determines behavior. Thus, the state of the universe over time is not lockstep determined and, likewise, random events play a role in human behavior (e.g., random genetic mutations).
3. It is important to note that when behavior analysts reject mentalistic explanations, they are not rejecting the idea that brains (and other parts of the individual) play an important role in behavior. A complete scientific explanation of behavior will include environment and biology (brains, hormones, etc.). Mentalistic explanations do not refer to biology or environment in any meaningful way. Therefore, they are rejected as explanations of behavior.

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