2 TRANSLATIONAL FOUNDATIONS

LEARNING OBJECTIVES

After reading this chapter, you will be able to

2.1 Discuss the three key disciplines that are the historical antecedents to the single-case design research method.

2.2 Trace the emergence and development of the field of behavior analysis.

2.3 Explain how behavioral analysis and educational research have become interconnected fields of study.

> *"The analysis of individual behavior is a problem in scientific demonstration, reasonably well understood (Skinner, 1953, Sec. 1), comprehensively described (Sidman, 1960), and quite thoroughly practiced (*Journal of the Experimental Analysis of Behavior*, 1958–). That analysis has been pursued in many settings over many years. Despite variable precision, elegance, and power, it has resulted in general descriptive statements of mechanisms that can produce many of the forms that individual behavior may take"* (Baer et al., 1968, p. 91).

Donald M. Baer and his colleagues (1968) wrote that statement nearly 60 years ago regarding the status of the field of behavior analysis, from which single-case designs are derived. Most readers of this book were not yet born when this summary about the health and prosperity of behavior analysis was written. Since that time, research using single-case designs has provided tremendous insights into processes that improve educational practices and outcomes for a wide variety of students. For decades this approach to experimental design has yielded easier-to-implement and more effective interventions, a deeper understanding of *behavioral mechanisms*, more accurate and usable measurement systems, and greater benefits for students, families, and schools.

Single-case designs are used to demonstrate experimental control within a single participant. That, in a nutshell, is the definition of single-case designs. However, we need to unpack that deceptively simple definition to better understand what constitutes these designs. Single-case designs demonstrate experimental control using *one person as both the control and experimental participant*. For this reason, these designs are also referred to as $N = 1$ designs. Other names for this approach include single-case experimental designs, single-subject designs, and intrasubject replication designs. Unlike case histories, single-case designs demonstrate *a rigorous degree of experimental control*. Case histories are based on correlations among events, but single-case designs specifically hold all conditions constant except for the independent variable, which is systematically introduced and withdrawn to study its effects on behavior (see Chapter 3). In addition, single-case designs are not a single type of experimental design, but *an overarching approach to experimentation that has multiple variations*, all of which meet the defining characteristics of this approach to research (see Part IV).

Along with the characteristics just mentioned, there are some underlying assumptions in the use of single-case designs that should be explicitly noted. These assumptions constitute what is referred to as the *epistemological* basis of single-case designs, which is largely based on the field of behavior analysis (see Chiesa, 1994; Moore, 2008). First, this approach to research is *idiographic*. This type of research is used to approach subject matter by understanding how individuals behave, not by describing mathematical averages of groups (Molenaar & Campbell, 2009; Sidman, 1952). Stated differently, these designs are used to discover why a person does what they do and then test whether other people behave the same way under similar conditions. Proof is developed one participant at a time, under high degrees of experimental rigor. This can be contrasted with group-comparison research, which looks for general tendencies among large numbers of participants and differences among group averages (see Underwood [1957] and Box 2.1).

BOX 2.1: IDIOGRAPHIC VERSUS NOMOTHETIC APPROACHES TO EXPERIMENTATION

It has been observed that there are two "schools" of experimental design in applied psychology, and both emerged during the early 20th century from experimental psychology (Kazdin, 1978; Molenaar & Campbell, 2009). One approach is group-comparison designs, also referred to as experimental and quasi-experimental designs (Shadish et al., 2002). The second is single-case designs or $N = 1$ designs. These two approaches are not simply different ways of asking the same experimental question, but deeply distinct ways of framing experimental questions (Johnston et al., 2020). Group-comparison designs are based on *nomothetic* conceptualizations of experimentation derived from a *vaganotic* theory of measurement. Such efforts focus on sampling from a population in an effort to extrapolate experimental findings from the sample to the population as a whole. The goal is to describe populations of individuals and compare similarities and differences among them. In contrast, single-case designs are based on *idiographic* conceptualizations of experimentation derived from an *idemnotic* theory of measurement. The goal is to experimentally analyze individual cases in search of the mechanism of change. The goal is to experimentally describe processes acting at the individual level and build up evidence from subsequent replications. These are fundamentally distinct ways of framing an experimental question. An example might help illustrate this point. A nomothetic approach to test-taking performance would likely yield the finding that students who are fastest at taking tests produce higher scores when measured as a group. However, an idiographic approach would likely yield the finding that as an individual student increases their test-taking time, that person increases their error rate, and that effect occurs over and over again across students.[1] Neither approach is correct or incorrect. They are simply different ways of conceptualizing and conducting experiments.

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[1]I would like to thank my colleague, Dr. Eric Loken at the University of Connecticut, for providing me with this example.

Another assumption has to do with the nature of the variables being studied. The only requirement that single-case designs impose on the variables used to study behavior is that they be physical events. This means that the events must have material existence. Another way of saying this is that everything measured as an effect or done as an intervention must be *operationalized*. To operationalize a variable, it needs to be described in objective terms that can be agreed upon as occurring, or not occurring, by anyone who understands the operational definition (see Chapters 7 and 8). This assumption means that some terms we use in everyday discourse are not amenable to being operationalized, even though we use them as if they have causal status. Examples of these *hypothetical constructs* include inferences about intentions ("I think they meant to do that"), mental states ("The student may have had a lapse in memory"), or emotions ("They acted that way because they were angry").

However, the need to operationalize experimental variables does not preclude the study of brain–behavior interactions. As long as internal events—also referred to as *private events*—can be operationalized and directly measured (i.e., they can be shown to exist), then they are permissible elements in single-case designs (Moore, 1984; see Box 2.2). Again, it is not the location of a variable but the ability to measure it, rather than infer it, that is at issue (see MacCorquodale & Meehl, 1948; Meehl, 2016).

BOX 2.2: CAN THE BRAIN BE PART OF THE ANALYSIS OF BEHAVIOR?

The answer to this question is an emphatic *yes*. However, if this question was posed 30 years ago, the answer would have been an equally emphatic *no*. A great deal has changed in neuroscience in recent years that allows direct measurement of events occurring in the brain. Examples of such data include events such as oxygen metabolism (measured via functional magnetic resonance imaging [fMRI]), binding of neurotransmitters to certain brain nuclei (measured via computed tomography [CT] scans), and neuronal firing patterns (measured via electrophysiological recording of event-related potentials [ERPs]). Because these are measurable events, not inferences or assumptions, they are variables that can be, and are being, used to analyze behavior. As neuroscience is advancing, increasing opportunities are occurring to expand the variables studied in single-case designs (Kennedy et al., 2001).

A third assumption is that an *inductive* approach to understanding human behavior is the most productive strategy. The overarching goal of conducting research is to explain something. Researchers who use single-case designs approach their subject matter with a great deal of respect for its complexity. Rather than developing a priori theories of why people learn and then conducting experiments to test the accuracy of the theory, single-case designs are typically used to explore the nature of mechanisms or causes from the data that are collected. This former approach is widely used in traditional psychological research and is referred to as "theory-driven research," "top-down theorizing," or "deductive research." This can be contrasted with a behavior-analytic approach that is often referred to as "grounded theory," "bottom-up theorizing," or "inductive research."

The general approach that single-case designs are used for is to directly study how human behavior functions and use that information to develop more robust explanations and interventions derived from these mechanisms. An example of this difference can be illustrated with research on choice making. In economics, *rational choice theory* has been used to explain consumer spending (Scott, 2000; von Neumann & Morgenstern, 1947). Rational choice theory states that consumers optimize their spending among available options (i.e., they spend rationally based on their expectations of value). This theory was developed independent of research data, and its adequacy was initially based on logical arguments (Thaler, 2016). When research was conducted, it was conducted to test the accuracy of the theory, not to ask open-ended questions about how consumers actually spend their money. This is an example of top-down theorizing.

A bottom-up approach can be illustrated by the work on concurrent operant schedules of reinforcement. Concurrent operants compare response allocation in situations where two different options are available for reinforcement. Or, put another way, this research focuses on experimentally analyzing *choice*. In concurrent reinforcement schedules, one experimental variable is altered at a time (e.g., delay or magnitude of reinforcement), its effect on choice is noted, and then another variable is analyzed, and so on. After many experiments were conducted, a general set of patterns became clear that described how choice making occurs. In this case, a quantitative formula was proposed, referred to as the *matching law*, that explained how organisms as simple as birds or organizations as complex as corporations make choices (Davison & McCarthy, 1987). For better or worse, we do not make choices rationally, but instead our behavior tends to be biased toward options with faster rather than larger payoffs. In this instance, the bottom-up approach produced a far more adequate explanation for this type of complex behavior (Herrnstein, 1990; Thaler & Ganser, 2015).

Using single-case designs, knowledge is developed incrementally, experiment by experiment. This is a very conservative approach to arriving at explanations but in the long term has proven to be the most productive strategy because of the high degree of direct contact researchers maintain with their subject matter (E. F. Keller, 2002). As the astronomer Sidney van den Bergh (1995) noted about the relation between theory and experimentation, *"Our job is to listen to what nature is telling us and not impose our own esthetics."* It is a naïve researcher who thinks they are more clever than nature.

All of these characteristics and assumptions associated with single-case designs are directly linkable to the historical antecedents of this approach. There are three historical precursors to what we refer to as single-case designs. They include *biology, medicine*, and *psychology*. Each of these disciplines—which are linked by the common theme of trying to understand animate life—developed research strategies that focused on idiographic, objective, and inductive approaches to arriving at explanations.

HISTORICAL ANTECEDENTS TO SINGLE-CASE DESIGNS

The concept of a new field, separate from physics or chemistry, focusing on understanding how living organisms develop and mature was not proposed until the early 19th century. The first proposal for a discipline that we now call *biology* came from Jean-Baptiste Lamarck's *Philosophical Zoology* (1809/2011). In this treatise, Lamarck called for a new scientific field to study how plants and animals come into existence, reproduce, and evolve. At this point in time, the term *philosophical* had a very different meaning from what we mean by the word in the 21st century. Emerging from the Age of Enlightenment (Brittan, 2015), philosophers were individuals who intensively studied a problem using systematic techniques that eventually evolved into what we call the *scientific method* (see Bacon, 1620/2000). Hallmarks of this new approach to acquiring knowledge were objective observation, manipulating one variable at a time, holding other variables constant, carefully recording findings, and replicating results. Today, this approach to gaining knowledge about the world is referred to as *empiricism* (Brittan, 2015).

The best-known scholar in biology during the mid-19th century was Charles Darwin. Both Darwin (1859) and Alfred R. Wallace (1875) developed the concept that individual organisms within a species vary slightly from one another and generation to generation and that environmental conditions can select some individuals to be more likely to reproduce, making the variations they exhibit more likely to occur in future generations. We now refer to these concepts as *evolutionary biology* (see Gould, 2002). Darwin and Wallace arrived at their conclusions simultaneously and by using similar research methods. That is, they studied individual cases (e.g., a particular bird species), looked for variations in individuals within the same species and across species, recorded their observations, noted the environmental conditions under which they lived, and used these data to draw conclusions about how nature is structured and functions.

The research of individuals such as Darwin and Wallace was largely *descriptive* in that they could not directly manipulate evolutionary processes, only describe patterns in these processes. During the last half of the 19th century, a more *experimental* approach was adopted, particularly in embryology (now referred to more generally as developmental biology). The goal of this area was to understand how organisms develop from a fertilized egg to a mature organism (E. F. Keller, 2002). Importantly, developmental biologists were eventually able to directly manipulate a variable of interest (e.g., a particular gene sequence) and observe its effects on the developing embryo. This allowed biologists to gather direct experimental evidence about how discrete events influence biological development and paved the way for the field of *genomics* that emerged a century later (Collins et al., 2003).

In a related and contemporaneous field of study, medicine also developed approaches for conducting experiments in the 19th century. Medicine has a long history of using *case histories* to inform physicians about new innovations in treating patients. For example, Ephraim McDowell was a surgeon practicing medicine in the early 19th century. At this time, internal surgery was largely an abstract concept, yet to be proactively practiced. If you had a tumor in your gut, for example, you would die a slow and painful death as the tumor grew and suppressed the functioning of various organs. McDowell (1817) developed a surgical technique for successfully removing ovarian cysts (a common, but deadly, type of tumor), which he replicated with other patients and then published so that other surgeons could use his technique with their patients. This was one of the first published case histories of a replicable technique for conducting successful internal surgery.

A significant limitation of case histories, as previously noted, is that they are based on an unfolding sequence of events that are not experimentally controlled, only systematically described. In addition, case histories rely on naturally occurring events, which limits what can be studied, as well as when. For example, a physician might be treating a patient, and along with the treatment they prescribed, the patient might also start a series of "self-prescribed" treatments without telling the doctor.

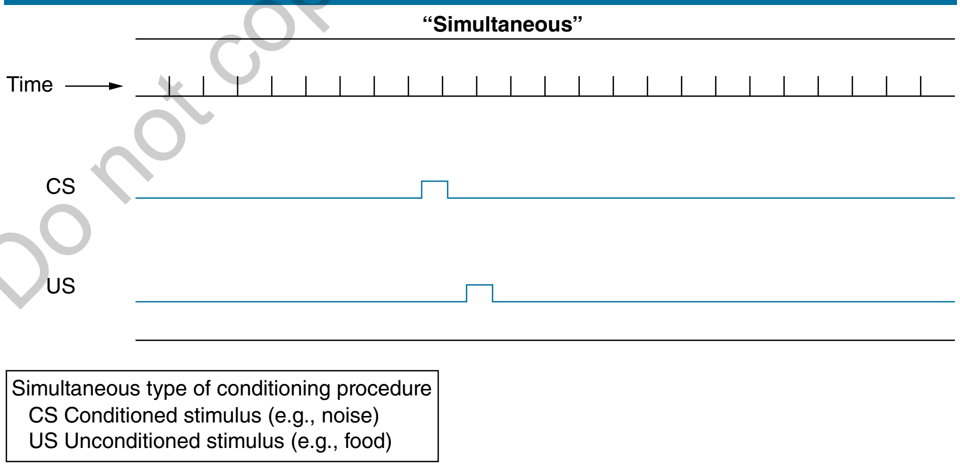
Combining the need for an experimental approach to medical issues and developments in experimental biology, Claude Bernard (1865/1927) introduced the idea of *experimental medicine*. A key component of Bernard's experimental medicine was the use of *model systems* to study questions relating to human physiology (Thompson, 1984). Model systems are experiments that use an analogous situation in a nonhuman species to analyze the effects and mechanisms influencing the phenomenon of interest in humans. For example, Bernard studied phenomena such as diabetes and blood oxygenation in animals to reveal how the pancreas and hemoglobin functioned in relation to disease processes seen in humans, respectively. This type of direct experimental approach using model systems has been the foundation for many of the medical innovations seen during the last 150 years (Cooter & Pickston, 2000). Again, this type of experimentation was based on idiographic, objective, and inductive research procedures. These were experimental precursors to single-case designs. (As an aside, the reader is also referred to the work of Charles S. Sherrington [1906/1989] for the use of model systems directly relating to neuroscience and behavior [Sherrington, 1975]).

A final area that has influenced single-case designs, and the one most familiar to readers of this book, is *experimental psychology*. Not surprisingly, the first researchers in experimental psychology at the beginning of the 20th century often emerged from medicine and biology. Two of the most prominent early researchers studying psychological topics were Ivan M. Sechenov and Ivan P. Pavlov. Sechenov (1965), often referred to as the "father of Russian physiology," was an international pioneer in neurophysiology. He had been trained in Europe in biology and medicine, and used these techniques to study human behavior via neural processes. His work was largely driven by the idea that all human action was a series of reflexes mediated by the nervous system. The experimental methods he used were based on his biological and medical training and reflected many of the characteristics previously discussed, including the use of model systems, idiographic techniques, and the inductive accumulation of experimental evidence. Like Pavlov, whom we will discuss next, Sechenov's focus was not on creating new experimental designs; instead, he applied what he had learned in biology and medicine to a new topic—psychology.

Pavlov (1897/1960) discovered the learning processes we now refer to as *respondent conditioning*. Pavlov was a physiologist studying digestive processes in mammals. Indeed, he won the Nobel Prize in Physiology or Medicine in 1904 for this work. However, his discovery of classical (respondent) conditioning was serendipitous. While studying salivary duct secretion in dogs using a model system, Pavlov and his colleagues noticed that saliva would begin flowing prior to the introduction of food to the dog's mouth. Typically, salivation is a reflexive event elicited by the presence of food in the mouth. However, Pavlov's subjects had learned to associate certain noises with the food and began salivating when they heard familiar noises (e.g., the footsteps of a laboratory technician). This meant that a physiological reflex could be conditioned to be psychologically associated with an arbitrary stimulus. This process—classical conditioning—is also referred to as *stimulus-response (S-R) psychology* (see Figure 2.1).

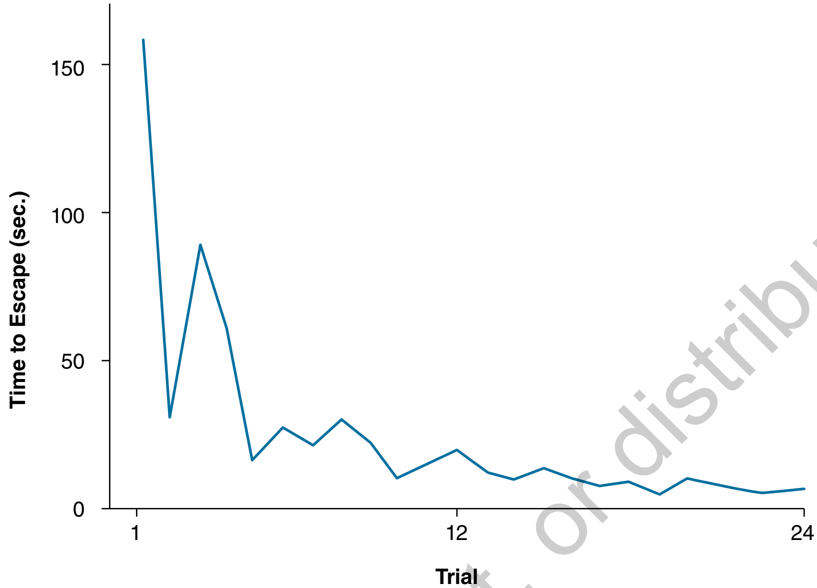
At the same time that Pavlov was conducting his work on classical conditioning, an American named Edward L. Thorndike (1898) was conducting his dissertation on another type of learning, which Thorndike labeled the "law of effect." Thorndike used a model system, much like a biologist, to analyze how learning occurred. His primary apparatus was a box that required some arbitrary response (e.g., pushing a lever) for the animal to escape and gain access to food. Access to the food was the driving force for the animal to learn a novel behavior. An example of the *learning curves* he obtained using this method is presented in Figure 2.2. The graph shows that over successive trials, the novel behavior was emitted faster and faster. This was the first time that the process of learning had been measured and analyzed using biologically derived methods. Thorndike used a variety of responses, including chaining behaviors into a sequence, and replicated his procedures from one animal to the next, even using different species to establish the generality of his learning curves. Interestingly, Thorndike, while a professor at Columbia University in the early 20th century, established one of the first programs in *educational psychology*, providing a bridge between experimental psychology and education (Joncich, 1968; Thorndike, 2011).

FIGURE 2.1 ■ A Schematic of Respondent Conditioning First Developed By Ivan P. Pavlov.



Note: By pairing the US with the CS, the CS comes to elicit the response previously occasioned by the US. (Figure 3, p. 22, from: Keller, F. S., & Schoenfeld, W. N. (1950). *Principles of psychology.* Copyright 1995 by the B. F. Skinner Foundation. Reproduced by permission.)

FIGURE 2.2 ■ A Learning Curve Demonstrating Edward L. Thorndike's Law of Effect.



Note: The number of seconds required to escape from the puzzle box and obtain food is listed along the *y*-axis. The number of successive trials is presented along the *x*-axis. (From: Thorndike, E. L. (1898). Animal intelligence: An experimental study of the associative processes in animals. *Psychological Review Monograph Supplement 2*(4, Whole No. 8). Macmillan. In the public domain.)

Another influential figure in bringing a biologically based perspective to psychology was John B. Watson (1924). Watson is not so much known for his research as for his advocacy of an approach to psychology that was radically different from other psychologists of his time. Early in the 20th century, most psychologists focused on people's subjective experiences of events (e.g., describing the sensations experienced when seeing a particular color), often using group-comparison designs to contrast different experimental conditions (Boring, 1950). Watson's perspective was that only events that were observable by others (i.e., that could be objectively defined and observed) should be the subject matter of experimental psychology. This approach was quickly referred to as *behaviorism*. The focus of behaviorism was to make psychology as objective and precise as biology and other natural sciences. This perspective influenced an entire generation of young scholars who were looking to make psychology more scientific (Todd & Morris, 1994). (See Table 2.1 for a timeline of events relating to single-case designs and educational research from the 1800s to the early 1970s.)

Most notable among this next generation of behaviorists was B. F. Skinner. Skinner completed his doctorate at Harvard University approximately 35 years after Thorndike studied there. While conducting his dissertation, which would eventually be published as the *Behavior of Organisms* (1938), Skinner developed an approach to psychology that was heavily influenced by experimental biology (Boakes, 1984; Todd & Morris, 1995).

TABLE 2.1 ■ A Timeline of Critical Figures and Events in the History of Single-Case Designs[a]

1800s	1900–1940s	1950s	1960s	1960–1970s
Precursors	**Psychology**	**Experimental Analysis**	**Applied Behavior Analysis**	**Education**
Biology Lamarck (1809/2011) Darwin (1859) Wallace (1875)	Thorndike (1898) Sherrington (1906/1989) Watson (1924) Skinner (1938)	Fuller (1949) Lindsley (1956) Ferster & Skinner (1957) *Journal of the Experimental Analysis of Behavior* (1958–present) Ayllon & Michael (1959)	Ferster & DeMyer (1961) Baer (1962) Bijou (1963) Lovaas et al. (1965) *Journal of Applied Behavior Analysis* (1968–present)	Hall et al. (1968) Walker & Buckley (1968) Lovitt & Curtis (1969) Alper & White (1971) Haring & Phillips (1972)
Medicine Bernard (1865/1927) Pavlov (1897/1960)				

[a] See text for additional details.

In keeping with experimental biology, Skinner used less "complex" animals to model the behavior of people. This approach was based on the *continuity assumption*, derived from evolutionary biology, that is based on physiological, anatomical, and behavioral characteristics being genetically conserved across species, with subsequent species elaborating (and incorporating) features from which they had evolved. Hence, behavioral processes that are present in rodents or pigeons are likely to be conserved in primates, such as human beings. He also used highly simplified environments. The goal was to hold constant all possible environmental variables, except the variable of experimental interest (e.g., food presentation). By doing this, environmental processes influencing behavior can be individually identified, and the *functional relations* they enter into with behavior can be analyzed (see Chapter 3).

Along with these features, Skinner's approach also used biological practices in that it was idiographic, operational, and inductive. Skinner's experimental approach was to use a rodent or pigeon as the organism, select an arbitrary response that could be quickly emitted and repeated (i.e., a lever press), choose a biologically powerful stimulus (i.e., food), and study how reinforcement contingencies influence response patterns. This arrangement allowed for a single response to be measured continuously in time to study the effects of reinforcement on patterns of behavior. One such pattern is presented in Figure 2.3. This graph presents a *cumulative record* of behavior. Along the *x*-axis (horizontal line) is time. Along the *y*-axis (vertical line) each occurrence of behavior is recorded by a slight rise in the line. In this way, the *rate of responding* in real time can be recorded and visually analyzed (see Chapter 7). This general approach to studying behavior has become known as the *experimental analysis of behavior*, and a journal devoted to this approach to research was established in 1958 (*Journal of the Experimental Analysis of Behavior* [*JEAB*], 1958–present).

THE EMERGENCE OF BEHAVIOR ANALYSIS

Skinner's primary findings were that the *contingency* between a response and a reinforcing stimulus determines the probability of that response, and that intermittent *schedules of reinforcement* produce very distinct patterns of behavior (Ferster & Skinner, 1957; Skinner, 1938). For example, the contingent delivery of a reinforcer for a lever press on a fixed-interval schedule (i.e., reinforcement is only available for a response after a fixed amount of time has passed) produces a scalloped pattern of behavior increasing in probability as the end of the time interval nears (see Figure 2.3). This approach is referred to as *operant conditioning* or *response-stimulus (R-S)* psychology.

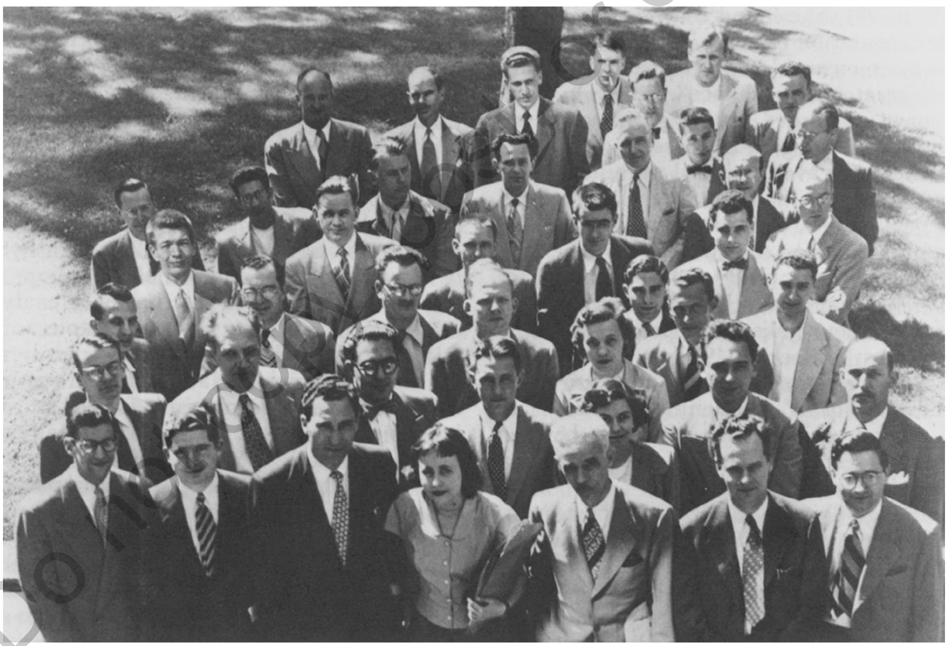
Skinner also conducted early experiments on topics such as behavioral pharmacology, superstition, anxiety, language use, and systematic instruction (see Skinner, 1983). However, there are two other reasons that Skinner is considered the most famous psychologist in history (Bjork, 1993). First, he extrapolated his laboratory findings from model systems to the everyday lives of people (Skinner, 1953). This allowed him tremendous insight into the causes of human behavior and created a great deal of resistance from laypersons and experts alike (reminiscent of the stormy reception that evolutionary biology received a century earlier).

FIGURE 2.3 ■ Performance on A Fixed-interval (fi) Reinforcement Schedule.

Note: The cumulative record shows successive responses (R) as upward movement of the line along the *y*-axis or ordinate. Time is represented along the *x*-axis or abscissa. (Figure 156, p. 162, from: Ferster, C. B., & Skinner, B. F. (1957). *Schedules of reinforcement*. Copyright 1995 by the B. F. Skinner Foundation. Reproduced by permission.)

Second, he produced an entire generation of new researchers who went on to prominent scientific careers and who produced, themselves, subsequent generations of *behavior analysts*. Most of these individuals were trained by Skinner or his associates in the 1940s and 1950s at Harvard, Columbia, or Indiana University (Dinsmoor, 1990). A too brief mention of the most noteworthy of these individuals is given here. William K. Estes studied anxiety and learning (Healy et al., 1992a, 1992b). Peter B. Dews developed what became known as behavioral pharmacology (Dews, 1987). Joseph V. Brady co-developed behavioral pharmacology and integrated biomedical and behavior-analytic research (Hodos & Ator, 1994). Charles B. Ferster conducted the initial experiments on schedules of reinforcement and time out (Skinner, 1981). Murray Sidman worked on avoidance responding (Sidman, 1989). Richard J. Herrnstein developed the first analyses of choice making and the quantitative analysis of behavior (Baum, 2002). Many of these individuals are pictured in Figure 2.4, which was taken during the third conference on the experimental analysis of behavior in 1949.

FIGURE 2.4 ■ Group Photograph of People Attending the Third Conference on The Experimental Analysis of Behavior (1949).



Note: Taken from the second floor of Schermerhorn Extension at Columbia University. Left to right, first row: Mike Kaplan, Donald Perlman, Nat Schoenfeld, Ruth (Morris) Bolman, Fred Keller, Fred Skinner, Phil Bersh. Second row: Harold Coppock, Ralph Hefferline, Helmut Adler, Fred Frick, Elaine (Hammer) Graham, Joe Notterman, Bill Jenkins. Third row: Ben Wyckofk, Joel Greenspoon, Bill Daniels, Van Lloyd, Dorothy Yates, unknown, Norm Guttman. Fourth row: Lloyd Homme, Joe Antonitis, Sam Cambell, Jim Dinsmoor, Charlie Ferster, George Collier. Fifth row: unknown, Burt Wolin, Doug Ellson, Fred Lit, Clancy Graham, Bill Verplanck, Bill Estes. Sixth row: Mac Parsons, Dave Anderson, Don Page, Murray Sidman, Phil Ratoosh, George Roth. Seventh row: Don Cook, Rod Funston. (Figure 5, p. 145, from: Dinsmoor, J. A. (1990). Academic roots: Columbia University, 1943–1951. *Journal of the Experimental Analysis of Behavior*, *54*, 129–150. Copyright 1990 by the Society for the Experimental Analysis of Behavior. Reproduced by permission.)

The previously mentioned research was all conducted with model systems in the laboratory to establish the existence of *basic behavioral mechanisms*, such as positive reinforcement, negative reinforcement, concurrent operants, behavioral contrast, and behavioral momentum, among others (see Catania, 2013). A new generation of research, initiated in the late 1950s and continuing through the 1960s, emerged from this work and translated basic behavioral mechanisms to the behavior of humans. Not surprisingly, these early studies on *human operant behavior* were conducted in laboratory settings, just like the previous research using model systems (see Box 2.3).

BOX 2.3: TRANSLATIONAL RESEARCH AND BEHAVIORAL MECHANISMS

"Translational research" emerged in the 1990s from policy initiatives put forward by the National Institutes of Health (Leschner et al., 2013; Nathan & Varmus, 2000). The initiatives focused on facilitating the translation of preclinical (basic) research into clinical (applied) interventions. Since then, translational research has become a common theme for many research teams working to exploit mechanisms of action discovered in the laboratory into effective treatments for people. Most of these efforts have emerged from the life sciences with an emphasis on basic biochemical findings (e.g., the identification and manipulation of targeted genes for disease processes). However, researchers using single-case designs in the experimental analysis of behavior have been translating model system findings into application since the late 1950s. These mechanisms of action are *behavioral*, rather than biological, and involve processes like positive reinforcement, negative punishment, and behavioral momentum, just as examples. Interventions such as the "good behavior game," "token economies," and "response cost" are directly translated from basic operant mechanisms. What is interesting is that basic behavioral mechanisms discovered using rodent and avian model systems have proven uniquely translatable into behavioral interventions for human beings. The translatability of behavioral mechanisms from laboratories to classrooms and clinics is an exemplar of translational research. It may also suggest that the emphasis on internal validity (experimental control) in single-case design research has aided in the identification of behavioral processes that are robust and readily translated across contexts (see also Chapters 1 and 4).

The first human operant study was conducted by Paul R. Fuller (1949) who studied reinforcement processes in a person with profound intellectual disabilities. His findings demonstrated that basic behavioral mechanisms could be translated to humans and showed that even people with the most profound disabilities could learn if taught in a systematic manner. Another early extension to human behavior was the dissertation research of Ogden R. Lindsley. Lindsley studied the effects of reinforcement schedules on the behavior of people with schizophrenia, finding similar effects to nonhuman research, and initiating the idea of "behavior therapy" (Lindsley, 1956).

Unlike the previous studies, Sidney W. Bijou in the late 1950s sought to study typical development from a behavior-analytic perspective. Bijou experimentally analyzed the behavior of young children in order to develop a behavioral theory of child development (Bijou, 1995). He also developed the first behavior-analytic conceptualization of intellectual disabilities (Bijou, 1963). Bijou's work laid the foundation for subsequent generations of psychologists and educators to study human development from a naturalistic, experimental perspective (Baer & LeBlanc, 1977).

In 1959, the first application of behavioral mechanisms from the laboratory occurred (Ayllon & Michael, 1959). The Ayllon and Michael (1959) study differed from previous experiments on human operant behavior in that it did not focus on establishing the generality of behavioral mechanisms from nonhumans to humans, but, instead, focused on using those behavioral mechanisms to solve a social problem. What Ayllon and Michael did was to use the concept of reinforcement contingencies to improve the living conditions of people with schizophrenia in an institutional setting. By arranging various contingencies for the delivery of salient events, Ayllon and Michael were able to improve the behavior not only of patients, but also of staff (whom the patients were dependent upon). In many respects, this was the first study in *applied behavior analysis* to be conducted, although it would be another decade before that term was introduced.

Charles B. Ferster was the first individual to take laboratory findings from behavior analysis and use them to improve the behavior of children with autism. Ferster and DeMyer (1961) conducted a series of experiments on how to shape and maintain behavior in children with autism. By using reinforcement contingencies, they were able to establish complex behaviors in children who were thought incapable of such performances. Their findings showed that even children with very complex disabilities could be taught through the use of systematic instruction.

A few years later, Wolf et al. (1964) published a study that showed how to alter the behavior of a child with autism in a therapeutic manner. Wolf et al. worked with a child with autism who engaged in self-injury and refused to wear eyeglasses. These authors worked with his staff and parents to implement a differential reinforcement program that included time out from positive reinforcement. The result was a dramatic decrease in self-injury and increased wearing of eyeglasses. In addition, there were generalized improvements in this boy's behavior across settings and tasks.

This work in autism was replicated and extended by Ivar O. Lovaas and his students. Lovaas, although he was not the first individual to work with children with autism, was the first to initiate a prolonged program of therapeutic research with this population. Lovaas was able to identify environmental causes for self-injury (Lovaas et al., 1965) and restrictions in the ability of children with autism to attend to complex stimuli (Lovaas et al., 1971), among other findings. In addition, many of the leaders in the field of autism collaborated with Lovaas in the 1960s and 1970s, including Edward G. Carr, Marjorie Charlop, Robert L. Koegel, Laura Schreibman, and Tristram Smith.

The advances of the early '60s in applying the experimental analysis of behavior to social problems rapidly spread to a range of topic areas. Donald M. Baer (1962) studied behavioral processes relating to typical and atypical child development and creativity. James A. Sherman

TABLE 2.2 ■ The Founding Editorial Board for the *Journal of Applied Behavior Analysis*

Role	Personnel
Editor	Montrose M. Wolf, University of Kansas
Associate Editor	Donald M. Baer, University of Kansas
Executive Editor	Victor G. Laties, University of Rochester
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(1965) used reinforcement techniques to establish imitation and spoken language in adults with schizophrenia who were thought to be mute. Israel Goldiamond (1965) initiated the first studies of operant conditioning to reduce stuttering and increase fluent speech and coined the term *functional analysis*. Harlan Lane (1963) studied the development of language in people who were deaf. Murray Sidman began to study the receptive and expressive language of people with aphasia (Leicester et al., 1971). Arthur W. Staats studied the development of reading abilities (Staats et al., 1962).

At this time, behavior analysts were beginning their first forays into educational settings. Two early efforts are particularly noteworthy. B. F. Skinner (1961) developed the teaching machine. Skinner devised an electromechanical device that would present written questions to children, allow them to respond, and provide them feedback about the accuracy of their answers. This work was a forerunner of computer and web-based teaching strategies. In addition, Fred S. Keller (1968) developed the personalized system of instruction (PSI). Using PSI, students are taught curriculum content through a self-paced program that uses shaping of more and more complex question–answer pairings until the student meets a proficiency criterion. This approach has been widely adopted, particularly for adult learners at community colleges.

With all of this work occurring in the application of behavioral principles, the Society for the Experimental Analysis of Behavior (SEAB), publisher of *JEAB*, elected to create a new journal, the *Journal of Applied Behavior Analysis* (*JABA*, 1968–present). SEAB's goal was to establish a journal to publish applications of the experimental analysis of behavior to issues of social concern. Montrose M. Wolf was selected as the first editor of *JABA*, and the initial board of editors was comprised of many of the researchers previously mentioned (see Table 2.2).

A particularly influential paper by Baer et al. (1968) was published in the first volume of *JABA* that helped codify the dimensions of the new field of applied behavior analysis. Baer et al. outlined seven dimensions that characterized applied behavior analysis:

- The focus of this area is the *application* of behavioral principles to areas that are judged to be in need of improvement.
- The focus of change is on a person's *behavior* and requires objective and precise measurement.
- In order to demonstrate change in a person's behavior, single-case designs need to be used to *analytically* evaluate the effects of an intervention.
- The interventions that are used are specified in operational terms to clearly specify what is being done, so a replicable *technology* of behavior change can be created.
- The effects of interventions on behavior need to be understood in regard to known behavioral mechanisms to link these effects to a coherent *conceptual system.*
- The focus of analyses is on producing *effective* outcomes that show clear benefits to the recipients of the interventions.
- Interventions need to have *generalized* effects across relevant settings and behaviors.

Many of these dimensions are explicitly derived from the antecedents of applied behavior analysis in terms of scientific practices, such as being objective, analytical, and conceptual. The others are clearly tied to the applied nature of this endeavor. With a new journal and a clear view of what applied behavior analysis was, researchers from a range of disciplines began gravitating toward this new approach to solving social problems.

LINKING EDUCATIONAL RESEARCH AND BEHAVIOR ANALYSIS

One area that quickly adopted applied behavior analysis was educational research, particularly for students who were the most challenging to teach. Beginning in the 1950s and hitting a peak in the 1960s, universities throughout the United States started opening departments of special education to prepare teachers to effectively educate children and youth who were not adequately being served in the existing educational systems (Trent, 1994; Winzer, 2009). As a new approach to education, special education was being developed from scratch. The primary criterion for adopting a particular practice was not whether traditional educators thought it was the appropriate approach to use or consistent with existing theory, but whether the approach worked (Lagemann, 2002; see Chapter 6).

One of the first special educators to adopt applied behavior analysis was Norris G. Haring (Wolery, 2005). Haring's general approach was relatively straightforward: Special educators will be more effective teachers if they adopt a systematic approach to instruction based in the science of behavior (Haring, 2016; Haring & Phillips, 1972). This was a strategic decision that required a belief that the evidence supporting behavioral mechanisms at that time suggested that it could be applied to educational issues, such as special education.

In regard to the establishment of special education departments at universities, four departments stand out for having quickly adopted applied behavior analysis as an approach to educational issues. These departments were located at the University of Washington, the University of Kansas, the University of Oregon, and Peabody College (now part of Vanderbilt University). Interestingly, Haring was the founding chair of the first two departments. These departments, and others, quickly began producing new researchers who were linking behavior analysis and education to develop *new and effective classroom practices.*

In fact, the first paper to appear in the initial issue of *JABA* was by R. Vance Hall who studied the effects *contingent teacher attention* had on the academic engagement of students in general education classrooms (Hall et al., 1968). At the same time, Hill M. Walker demonstrated a very similar effect for students with behavioral disorders (Walker & Buckley, 1968). These were the first demonstrations that classroom teachers could be more effective if they provided their attention to students behaving appropriately, rather than waiting until they misbehaved.

At the same time, Thomas C. Lovitt began developing systematic instruction techniques for improving the performance of students with learning disabilities (Lovitt & Curtis, 1969). This research combined systematic prompting and feedback to improve the academic performances of students. Working on similar issues, but with people with severe intellectual disabilities, Joseph E. Spradlin was simultaneously conducting applied and basic research on learning processes (Spradlin et al., 1973). This work led to an improved understanding of the emergence of symbolic behavior and how to more effectively teach students who, at the time, were considered unteachable.

Ogden R. Lindsley continued to extend basic operant findings to ever more applied issues (Lindsley, 1991). Working separately, Lindsley and Owen R. White (Alper & White, 1971) developed techniques for teachers to base their instructional decision making on objective data (i.e., graphs) regarding student performance, rather than the teacher's intuition. Just like researchers in a laboratory, if teachers used objective information rather than their personal perceptions, it was demonstrated that they could be more effective at accomplishing their jobs. From this work, data-based decision making has become a hallmark of effective teaching practices throughout education (Kirschner et al., 2006).

Beth Sulzer-Azaroff and G. Roy Mayer produced a series of studies, together and separately, that demonstrated effective approaches for managing student behavior at a school-wide level (Sulzer & Mayer, 1972). Their work focused on the careful application of behavioral mechanisms derived from laboratory research. These researchers had a strong influence on how school psychologists and educational administrators approach school discipline issues, which served as a precursor to positive behavior interventions and supports.

During this early period of applying behavioral mechanisms to educational topics, Doug Guess, Wayne Sailor, Gorin Rutherford, and Donald M. Baer studied language development in people with severe intellectual disabilities (Guess et al., 1968). This work demonstrated that complex language forms could be taught to students who were typically characterized by the lack of language use. The success of this work was instrumental in focusing attention on providing meaningful educational opportunities for students with severe intellectual disabilities.

Phillip S. Strain and Richard E. Shores initiated the idea of teaching social skills to students with disabilities (Strain et al., 1976; Strain & Timm, 1974). These researchers used prompting and reinforcement techniques, much like those noted previously, to establish new socially competent behaviors. Their demonstrations were the first studies showing that appropriate social behaviors could be directly taught and used to gain entrée into a new set of social contexts that children might not otherwise contact.

All of the individuals mentioned in this chapter had highly productive careers as both behavior analysts and educators. Each person produced several generations of students too numerous to mention in such an abbreviated history. As a result, most colleges of education in the United States have several generations of behavior analysts among their faculty.

CONCLUSION

The foundations for single-case designs emerged in fields that many educators are not familiar with, such as biology, medicine, and psychology. These are the disciplines that took on the challenge of studying animate life in the 1800s. Researchers in these fields learned through a century of experience that the most productive means of studying their subject matter was to use techniques that focused on intensive analyses of individual cases, moving from there to establish their generality among larger populations. As noted previously, this is a conservative approach to knowledge production. However, if the alternative is false leads and misguided theorizing, research strategies such as single-case designs should not be viewed as conservative in the long term (Kennedy, 1995). Rather, these approaches have been repeatedly demonstrated to be productive strategies for learning about how human behavior works.

In translating these behavioral mechanisms to educational issues, researchers have made a great deal of progress in a relatively short period of time. Much has been learned about behavioral mechanisms, such as reinforcement, that underlie how we learn. Not only has this information yielded consistent and reliable results in the laboratory, but the application of these behavioral mechanisms has been repeatedly shown to change behaviors of relevance to educators. These techniques are effective enough that they have become standard practices in the training of most educators, even if some people might not be aware of their origins.

REFLECTION QUESTIONS

1. Describe differences between idiographic and nomothetic approaches to conducting experiments.
2. How do basic assumptions that underlie the research process shape the way investigators conduct and interpret research studies?
3. What were some of the very early research methods that led to the development of behavioral approaches to conducting experiments?
4. Using the idea of "translational research," provide some examples of behavioral mechanisms that are used in educational interventions.
5. Can you describe two or three researchers whose work was particularly influential in shaping the field of behavior analysis?