Preface

This book started as a brief outline tentatively entitled *A Primer of Behavior Analysis*. One of its antecedents was George Reynolds' *Primer of Operant Conditioning*, published by Scott, Foresman in 1968. That book ran to 130 text pages plus supporting material and brought together the basic concepts of the field later to be known as behavior analysis. In those days primer was pronounced to rhyme with trimmer, befitting a book that's supposed to be short; nowadays it's sometimes pronounced like rhymer.

My earlier book, *Learning*, had grown longer over successive editions and had become more a graduate than an undergraduate text. I'd often thought about a brief version that could function as George Reynolds' book once did. But we know much more now than we did then, so I'm happy to have ended up with a bit more than 300 text pages plus supporting material. Of course it could have been much shorter, but that would have made it impersonal and far more abstract. I hope readers will find I've struck a reasonable balance among concise presentations of basic concepts, discussions of relevance, concrete examples and illustrations of applications.

I can't date when I first drafted the outline, but I stopped worrying about pronunciation when length made it obvious the Primer title was inappropriate. The main title, *The ABCs of Behavior Analysis*, captures the basics while also highlighting the three-term contingency: Antecedents–Behavior–Consequences. The subtitle, *An Introduction to Behavior and Learning*, provides a reminder of the linkage between behavior and learning. The essence of learning is creating new behavior, and that encompasses much of what we behavior analysts do.

Three features seemed especially important as the manuscript evolved. First, it had to represent behavior analysis as a discipline in its own right rather than as a component of psychology: psychology has become an umbrella designation for a variety of approaches only some of which are compatible with behavior analysis, and behavior analysis encompasses many topics treated by psychology as separate domains. Second, selection by consequences had to be its organizing principle: in both its methods and underlying assumptions, behavior analysis has more in common with biology than with most varieties of psychology and cognitive science.

Third, it could not be limited to the basic nonverbal processes: it would assume no one unfamiliar with at least the rudiments of the science of verbal behavior could truly be counted as a behavior analyst.

These three prerequisites made the new work inevitably parallel in many ways the organization of my earlier *Learning*. Anyone comparing the respective tables of contents should expect similarities. But old material has been rewritten, new material has been added, peripheral treatments have been deleted and some topics have been differently juxtaposed. If behavior analysis is a field in its own right, it must be able to stand alone, so this book doesn't rely on other disciplines to lay out its principles or prerequisites.

Ours is a cumulative science, so many chapters necessarily depend on those that came before. But where it seemed feasible I've tried to design them so they can be read separately and in different orders, with help from the basic terminology provided in the glossary. I've included some introductory treatments of topics fundamental to behavior analysis but traditionally covered in other courses. For example, the three-term contingency accommodates stimuli as both antecedents and consequences and responses as behavior, so chapters on motor and sensory processes and on motivation are included. Some sections treat material often covered in developmental or social or other psychology courses, but from a perspective specific to behavior analysis. There is no good reason to let other approaches preempt what so naturally fits into behavior analysis as the modern science of behavior. Behavior analysis delivers a way of thinking about socially significant issues like discrimination and prejudice not provided by other approaches. And because a science may be judged by whether it spins off a technology, a sampling of applied behavior analysis illustrates the breadth of what we behavior analysts can do.

For those who like to think in terms of scientific paradigms and paradigm shifts, this text illustrates a behavioral paradigm that emerged during the first half of the twentieth century, consolidated itself during the second half, and in this century exploded with applications some of which were foreshadowed from the very beginning. With selection at its core, it's a modern synthesis of basic concepts and their extensions to the sources of novel behavior. These in turn are prerequisites for applications that, in their fundamentals, are about teaching effective behavior that didn't get shaped by natural contingencies.

In the tradition of Fred Keller and Nat Schoenfeld, I've emphasized research findings rather than theories. The approach is theoretical mainly in adhering to a consistent behavioral language and attempting a systematic organization that accommodates a broad range of phenomena. Whenever I encountered interesting findings in the research literature, whether or not behavior analysis was their source, I found the most crucial question to resolve was where I should put it if I were to include it somewhere in a book like this one. Whether there was a place for it at all was a test of the adequacy of the book's organization.

Resources

In lieu of study guides and other supplementary materials, some organizational material has been brought together in the glossary and appendices. A preface for students provides a rationale for the use of those resources.

Earlier treatments of behavior analysis and learning were supplemented by a set of computer programs called Behavior on a Disk, which ran on the MS-DOS operating system. They included shaping simulations, demonstrations of cumulative records and exercises on reinforcement schedules, among others. With the repeated upgrading of Windows and Apple platforms those programs became obsolete, but MS-DOS emulators are now available that run on both Macintosh and Windows platforms, so some have again become usable. Check the Sloan Publishing website; as those programs become available they will be posted there for downloading.

ANTECEDENTS AND APPRECIATIONS

There are so many to thank. I must particularly single out Philip N. Hineline, Peter Killeen, Allen Neuringer, and John A. Nevin, and one outside of behavior analysis but with a keen appreciation for this approach, Norbert Hirschhorn. Lanny Fields, Freeman Hrabowski, Hank Pennypacker, Howie Rachlin and Dave Stahlman have all made important contributions, some more directly than others; I invite them to check with me if they can't figure out what those contributions were.

I no longer teach formal courses, but I remain indebted to my students and colleagues at the University College of Arts and Science of New York University and at UMBC, the University of Maryland, Baltimore County. I've collaborated in research and writing and teaching with many colleagues whose work has so informed and enriched my own that they must be acknowledged as my tacit coauthors of this book, though they bear no responsibility for any of my errors or omissions. I will list only a few: Deisy de Souza, Pauline Horne, Vic Laties, Fergus Lowe, Bud Matthews, Koichi Ono, George Reynolds, Terje Sagvolden, and Eliot Shimoff. To these I must add a few of those from whom I've directly or indirectly learned: Nate Azrin, Joe Brady, Peter Dews, Lew Gollub, Eliot Hearst, Herb Jenkins, Bill Morse, Marc Richelle, Masaya Sato, Murray Sidman, and of course Fred Skinner. Fortunately, contributions by many more I haven't named here are recognized by their inclusion among the references.

I must once again acknowledge Bill Webber, the kind of publisher about whom all authors dream. He has consistently exceeded expectations. I could not have brought this project to fruition without his unflagging and enthusiastic support.

One more appreciation remains. I owe more than I can say to Nat Schoenfeld and Fred Keller. I became irrevocably committed to behavior analysis through their courses and their *Principles of Psychology*. I hope this book is true to their teaching.

—A. Charles Catania
Columbia, Maryland

Student Preface

You may find our approach here unconventional. For example, are you ready for the argument that it's misleading to say emotions cause behavior? We learn names for emotions from those around us. First we see people acting angrily or happily or sadly; later we see others acting like that and we're inclined to say they did it because they were angry or happy or sad. This is circular reasoning, not explanation. Learn to identify a few examples and you'll discover how common they are. Some topics in this book may disturb you. How will you react to a discussion of punishment by electric shock? Understanding something shouldn't depend on whether you like it or not, but often it does. Even if you don't like the idea of punishment you should know when and how it works.

Learners learn what they do, so what you learn depends far more on what you do than on what your instructor does. Along with reading you'll probably be writing, memorizing, judging what needs more study, figuring out why you could answer some questions but not others, and worrying when you discover something so much more appealing that you start to procrastinate. Any time you think about asking your instructor to do something for you, like preparing more detailed outlines, consider the possibility that you'll learn more by doing it yourself. Your instructor can't pour knowledge into you; your instructor is there to get you to engage with this material. The more you do, the more you learn.

For that reason, I've deliberately omitted some common textbook aids. It should be easy enough to develop your own lists of key words for a chapter by cross-checking chapter contents against the glossary and the index. The Table of Contents shows basic structure, but the detailed outlines are presented in an appendix instead of juxtaposed with parts or chapters. I urge you to generate your own outlines and then see how they compare with what you find there. Treat the glossary and appendices and other resources as tools to be worked with, not as abbreviated substitutes for the text.

Spend your time productively. Some things you do might make minimal or even negative contributions. Here's an example: do you highlight? If so, what does it do besides saving you time later when you skip what isn't highlighted? Probably not much. And wasn't highlighting the first time through the worst time to tell what's important? Probably. If later you skip all but what you highlighted,

you might skip what you most need to review. If you feel compelled to highlight, therefore, don't do it the first time around and do it reversibly: use pencil in the margins instead of permanent markers.

Try to apply what you learn here to your own study behavior. A course about behavior and learning ought to offer a lot about studying and mastery and taking notes, but you needn't wait to get to it. Browse the index for terms like education, teaching and study habits. You may be surprised where some entries take you.

—A. Charles Catania
Columbia, Maryland

Part I: INTRODUCTION

Chapter 1
Learning and Behavior

A little learning is a dang'rous thing;
Drink deep, or taste not.
— Alexander Pope

Maybe you want me to start with a definition of learning but I'm not going to. We pretty much know it when we see it. Spelling out how we know isn't easy, though. What is learning? Here are some things we say we learn: where things are, what's happened in the news, how to get along with people, definitions, how to play a game or ride a bicycle. Any good definition must include all these and more. But how is learning what to say related to learning what to do and how to do it? How is learning how something works related to learning how to use it? Do these examples have anything in common? We can say one thing: whatever else goes on, you're not the same after you've learned something. Something about you is new and different.

It's usually easy to see what's new. We can say some things we couldn't say before or do some things we couldn't do before. But how did it happen? Where did our new behavior come from? This book deals with some answers to these kinds of questions. Before we can get down to the details, we must cover some preliminaries. We have to look at what's already there before learning begins. Before we do that, we have to consider what behavior is—not just ours but also the behavior of the other organisms with which we share our planet. Throughout all this, behavior will come first. We are who we are because of what we can do; everything about us evolved in the service of behavior.

We'll start by seeing what behavior is like without learning. We'll examine its origins and its evolution and its development. With that foundation, we'll consider learning in the absence of words. We humans are special because we talk. We talk so much we find it hard to look at the behavior of the nonverbal creatures with which we share our world without projecting our words onto them. In many ways they're as alien to us as extraterrestrials. We have to approach them without assuming they think like us. To make sense of their behavior we mustn't assume that first they talk to themselves about what they're going to do and then they do it.

We won't be able to appreciate the learning made possible by words until we've seen how nonverbal learning works. Nonverbal learning underpins verbal learning: we can't do anything with words unless they're built on what was there before words existed. Once we get that far, we'll be ready to talk more clearly about topics dear to us, like human language and memory.

But back to learning. Suppose I'm unfamiliar with the word *phenomenon* and then I see it in a sentence. I might guess from the context it means something like an event worth noticing. I look it up and find it defined as an event that can be observed and as a remarkable or unusual person or thing. The definition might show the word as a singular noun with *phenomena* as its plural, and this form of plural, so different from the usual final *-s*, suggests to me that it's a pretty old word probably with Latin origins. What I've learned by checking the definition could be use-

ful next time I come across the word even if I hardly ever use it myself.

So, what is this phenomenon called *learning*? It doesn't give us trouble in everyday talk, but a dictionary definition telling us that it means getting to know something or gaining knowledge or acquiring a skill isn't very helpful. The word is more familiar than *phenomenon* and yet harder to define. Sure, we can usually say whether we've learned something and we can usually agree on what counts as learning. Even so, we run into problems when we try to frame a definition. For example, a textbook might define learning as a relatively permanent change in behavior resulting from an organism's interaction with its environment. But what is meant by *behavior* and by *environment*, and how permanent is *relatively permanent*? What happens when we get better at swimming or running or lifting weights? Should we distinguish between some parts called learning and others called muscle development through exercise? Or take a more extreme example: staring at an eclipse of the sun is an interaction with the environment and if it damages your eyes your behavior will certainly change. Yet I hope you'd disagree if I told you the damage should count as learning.

THE LANGUAGE OF LEARNING AND BEHAVIOR

There are no satisfactory definitions of learning, but that won't stop us. We can look at how organisms come to behave in new ways. In our study of learning, we'll ask two different types of questions: (i) What kinds of changes are those we call learning? and (ii) What's the best way to talk about them? How does learning work; under what conditions do organisms learn and what happens as they do so? This will give us plenty to do, so we'll only occasionally consider theories of learning or explanations based on changes in the brain or other physiological events. Those are interesting topics but we already have plenty to keep us busy.

I wanted to start out with an anecdote or two, but learning means different things at different times to different people, so I couldn't settle on any representative examples. A pigeon discovers food in its travels and returns to the same place later when hungry. A child becomes able to read a story or to spell simple words. A dog is taught to sit or lie down on command. A patient who once had a bad experience in a dentist's office feels uneasy in the waiting room. A young cat, after its early hunting expeditions, now avoids skunks and porcupines. A shopper sees an announcement for a sale that hasn't begun yet and several days later returns to the store to take advantage of bargain prices. An author who encounters an unfamiliar word later uses it in a story. You read a section in a math text and find a way to solve a problem that had baffled you. I need to check a point somewhere in this book and find a relevant paper through an internet search. What do these examples have in common? They involve dogs and cats, children and adults, and yet we'd probably agree that they are all instances of learning. But is it reasonable to group a pigeon who learns a route to food with a human who discovers a solution to a math problem? Chipmunks and spiders and clams are distantly related in the realm of animal life, so are these examples somehow also distantly related in the realm of behavior?

Can we resolve our problem by adding that learning must come about through some change in the brain? We might think so, but do we look at brains to decide whether learning has occurred? Even if we could watch a brain doing something, how would we know what it was doing was learning? Sure, the brain does a lot, but except with the aid of sophisticated instruments we mostly don't see what it's doing; usually all we see is behavior. Besides, we'd have trouble figuring out what to look for in the nervous system if we didn't know much about learning. In fact, we can't have a neuroscience of learning if we don't understand its properties. Those properties determine what neuroscientists should look for in the nervous system if they want to know what happens during learning. That's why our main

concern will be with the properties of learning as behavior rather than with its physiological basis.

Of course brains change when organisms interact with their environments. For example, when a stroke partially paralyzes someone's arm, one therapy is to restrain the other arm so that use of the impaired arm will help it to regain full function. This is said to change the brain, but the recovery of the arm, not the change in the brain, is the goal of the therapy. Changes in the brain matter, but if the therapy is successful the behavior of the arm is what drove those changes. That's why, though we must give the nervous system its due, behavior will always be our starting point. For us, **behavior will always come first**.

Notice that we're not worrying yet about the facts of learning; we're still on how we talk about it. Languages reflect what's important to their speakers, and the language that evolved in our everyday interactions with others isn't necessarily well suited to be a language of learning. That's in part because we're usually more interested in what other people know and in what they're likely to do than in how they came to be that way. For example, a parent might worry if a child fights with other children and rarely plays cooperatively. If the child begins to play cooperatively, the parent might not care whether this happened because of the natural rewards of cooperative play or because cooperative play was explicitly taught or because fighting was punished. The child's play might look the same in each case. But it might make a difference how the child got there. It's good to know what to expect of others, and that's probably why we describe people by saying how they're likely to behave. We speak of each other as *outgoing* or *reserved*, *easygoing* or *compulsive*, *trustworthy* or *unreliable*. Describing people with words like *artistic*, *athletic*, *social*, *intellectual* or *musical* specifies their preferred activities. Yet these labels don't tell how someone's interests or traits arose or changed.

Similar problems exist elsewhere. When physicists look at the world, they don't find the everyday vocabulary adequate. Sometimes it even gets in the way. So they coin new terms or take over existing ones. The latter tactic can create trouble. Words like *work*, *force* and *energy*, for example, mean different things to physicists in their technical talk than to most people in casual conversation. Fortunately for physicists, much of what they study is remote enough from our daily experience that we don't confuse their technical language with our everyday talk.

This isn't so for behavior. We can't help being involved with it. We talk about how people grow and change and speculate about why they do things. If we want new ways to talk about these events, we mustn't confuse our new ways of talking with the old ones. We've all spent most of our lives talking about what we do, but those familiar ways may interfere with our new talk, so we must beware of language traps. This book introduces a language of behavior that isn't a mere paraphrase of everyday usages. **It is fundamentally different**. It demands new ways of looking at familiar phenomena.

Function and Structure

An organism is more than what shows in its behavior. Two students may sit silently through my class. They aren't behaving differently right now in any way I can see and yet based on their past work I may know one can answer questions the other can't. The difference is in what each can do; it's simpler to say one student knows more than the other. Debates between those who call themselves behaviorists and those who call themselves cognitivists or mentalists have been long-standing. Basically, they've been about how we talk. Difficulties arise because behaviorists and cognitivists are often interested in very different types of questions. Behaviorists tend to deal with questions of function and cognitivists with questions of structure or form.

Suppose I'd like to teach a child to read. Where do I start? On the one hand, I could worry about how to involve the child in reading. What will keep the child alert, what will help the child to attend to the words presented, what will help the child remember what the various words are? Will I be more successful rewarding the child's right answers or penalizing wrong ones? When

I arrange different consequences for the child's different answers, I determine the functions of these answers. On the other hand, no amount of worry about the effects of reward and punishment on the child's reading will tell me the most efficient way to present reading materials to the child. What's the best way to order them? Should I start with single letters, with syllables, with whole words? I structure the child's reading when I present these in different orders. Are words best taught as units or as built up from simpler parts like letters or syllables? Problems of structure are concerned with how behavior and its environment are organized.

Educators concerned mainly with function might try to improve a school system by changing what happens in the classroom, without worrying much about curriculum structure. Those concerned mainly with structure might try to improve the school system by changing the curriculum, without worrying much about what happens in the classroom. But obviously both are important. Any attempt to improve how children learn to read that ignores either one is likely to be deficient. Any that ignores both, as in concentrating mainly on instilling a vaguely defined trait such as self-esteem, has no hope at all. Let's not be sidetracked. We'll consider both function—given certain antecedents, what consequences are produced by responses?—and structure—how are environments and responses organized? Whatever we look at, it will be helpful to describe situations as ***Antecedents***, the circumstances leading up to behavior, the ***Behavior*** occurring in those circumstances, and the ***Consequences*** of the behavior. In these three terms we have our ABCs.

Behavior Analysis

How do we find out about behavior? Our world is complex and the things that influence our behavior don't occur in isolation. Thus, to understand a situation we must strip away what's not essential: we must analyze it. To analyze something is simply to break it down into its component parts. To do this we start in the laboratory, studying organisms simpler than ourselves, in simple environments, in a science called *behavior analysis*. Starting with simple events helps us to develop techniques applicable to complex ones. Yet even after we've studied behavior inside the laboratory, we can't expect to interpret correctly every instance of behavior outside. There are limits to what we can know. It's tempting to ask why someone did this or that, what led to a certain incident, how someone came to have certain interests, fears or attachments. But usually we have so little information that giving a plausible interpretation is the best we can do. We shouldn't expect too much.

In this respect, behavior analysis isn't much different from other sciences. If I see a leaf blow across cars on a busy street and land at the foot of someone sitting on a sidewalk bench, I couldn't say how or why it got there. But a failure to account for every twist and turn in the path of the falling leaf doesn't invalidate aerodynamics. We can't possibly measure the details of air currents, leaf surface and so on in enough detail. Similarly, the principles of behavior aren't invalidated when we can't account for what someone did on some occasion. We can't measure personal history and other factors in enough detail, so we must acknowledge what remains out of our reach. In what follows, it will usually be more useful to *describe* what an organism has learned or remembered than to try to *explain* its learning or its remembering.

ANTECEDENTS, BEHAVIOR, CONSEQUENCES

Behavior is no easier to define than learning. Should we count respiration or metabolism along with muscle movements and glandular secretions? We describe behavior with verbs: people walk, talk, think, do things. But we also distinguish between active and passive actions. We may say someone breathes, but are we likely to say someone heartbeats? Let's not try to resolve this problem. The phenomena of behavior are varied, and we can usually deal with specific examples without much risk of misunderstanding.

Stimuli and Responses

When we observe an organism, we see properties of its environment, *stimuli*, and properties of its behavior, *responses*. In the singular, we speak of a *stimulus* and a *response*. Neither is of interest by itself. An experimental analysis determines what kinds of relations exist between stimuli and responses and how those relations can be changed.

Imagine a pigeon in an experimental chamber. On one wall is an opening to a feeder that can dispense food. Above the feeder is a recessed translucent disk or key that can be lit from behind. The pigeon has learned to earn food by pecking the key whenever it's lit. Now suppose the pigeon hasn't eaten for a while, the key is lit, and a peck on the key immediately makes some food available. We need to know the context before we can guess what the pigeon will do. It's one thing if the alternative, not pecking, is never followed by food; it's another if not pecking is followed by a somewhat delayed but much larger amount of food. In each case a response, the key peck, is followed by a stimulus, food. But the contexts are very different. We would expect the pigeon to peck the key in the first case, but what about the second? If the pigeon doesn't peck, we might want to say that it shows self-control, forgoing the small amount of immediate food in favor of the larger but delayed amount. We'll discuss this type of situation in more detail later. For now, the point is that we must look at not only the moment-to-moment details of events but also their contexts over extended times.

Let's examine relations between environment and behavior further by observing a human infant. We might start by asking her what she feels, but that won't work. She isn't yet verbal and can't tell us. Even if she was an older child who could tell us, we'd have to wonder how she learned the words and whether they'd mean the same thing to us as to those who taught them to her. We'll eventually get to the role language plays in molding our knowledge of ourselves and others, but that won't help us here.

We know the infant is learning from the environment and interacting with it. But how do we find out what's going on? We watch for a while and see her move her hands or arms or legs. Perhaps at some point she starts to cry. If the crying stops without our intervention, she may sleep or lie quietly with her eyes open. We might see her eyes moving, though it might be difficult to judge what she's looking at, if anything. We might notice that some movements usually occur in specific sequences. But if we only watch, we can't say much more than that she does different things more or less often and more or less in certain orders.

Let's not stop at watching. We might touch or rock her, move objects in or out of her view, make sounds, offer a pacifier. We'd expect her to respond to each event in a characteristic way. If we touched her palm, for example, she'd most likely clench that fist, grasping whatever touched it. We call the touch to the palm a *stimulus*, and the grasping a *response*. Besides grasping produced by a touch to the palm, we could catalogue other examples of stimulus-response correlations: crying caused by a sudden loud noise; sucking produced by a nipple in the mouth; blinking triggered by a flash of light. We see the environment act on this infant when stimuli produce responses, but things can also go in the other direction. She can act on the environment. Her crying, for example, often brings a parent's attention. Crying, then, is a response that often produces a consequence: a parent's presence. This case involves stimuli and responses, but here the responses come first, not the stimuli; here behavior has consequences.

It can get more complicated. If her eyes move while the lights are on, what she sees changes. Eye movements can't do this with the lights off. Thus, she may come to look around in the light but not in the dark. During one stimulus, the light, moving the eyes produces other stimuli, new things seen. Eye movements can't have such consequences in the dark. The relation involves three terms: an **A**ntecedent stimulus, the light; **B**ehavior in its presence, eye movement; and a **C**onsequence, what's newly seen given this response in its presence. An organism's behavior

depends on both antecedents and consequences. When these **ABC** terms are listed as stimulus–response–consequence, we sometimes call the relation a *three-term contingency*.

An *antecedent* is simply something that comes before. This could be simply a stimulus, like a light or a sound, but it could involve other conditions, like whether an organism has recently eaten or had a drink of water. A *consequence* is simply what happens as a result of some event. Thus, everyday usage corresponds pretty closely to the technical senses of these terms. It's important to note that **consequences should not be identified with stimuli**. Responses can have many types of consequences. They sometimes produce stimuli that would otherwise have been absent, but they can also prevent things from happening or change the consequences of other responses. For example, food produced by a response is both a stimulus and a consequence, but food presented independently of behavior is a stimulus only; shock prevented by a response is a stimulus, but the consequence of the response is the absence of shock, which isn't a stimulus. Sometimes the consequence of one response is a change in the consequences of some other response, as when a light switch stops working and changing the light bulb restores the usual consequences of operating the switch.

For *stimulus* and *response*, the relations between technical and everyday usages aren't so simple. Stimuli are events in the world and responses are instances of behavior. The term *stimulus* is often restricted to specific physical events such as lights or sounds or touches. But organisms respond to varied features of the environment, including relations (e.g., to the left of, on top of), complex behavior (e.g., facial expressions, tones of voice), functional properties (e.g., edible, comfortable), and so on. We'll often speak of such environmental features as stimuli even when we can't specify their physical dimensions.

As for the term *response*, everyday usage often implies that it is *to* something (typically a stimulus). The term won't function that way here, however, because an account of what causes responses typically includes other factors along with or instead of the stimuli that precede them. We'll be especially interested in responses that aren't elicited by stimuli but are caused in other ways. Such responses are said to be *emitted*. Unfortunately *sponse*, a useful word for such cases, isn't a well-established term (but see Provine, 1976).

We encounter at least two further difficulties in describing responses. First, behavior isn't repeated exactly from one instance to the next. If an infant grasps an object on two different occasions, the grasping won't be the same each time. The difference may be small (for example, in the exact placement of the fingers). But if there is any difference at all, we must worry whether the grasps should be regarded as two instances of the same response or as two different responses. We must speak not of individual responses but of classes of responses having common properties.

Second, responses are sometimes adequately described as movements, but at other times the description must include the environment in which they occur. For example, suppose we want to compare an infant's grasp of an object with her clenching of a fist. If we look just at muscles, grasping with the right hand and clenching that fist have more in common than grasping with the right hand and grasping with the left hand. Yet sometimes it's more useful to speak of grasping, no matter which hand is used, than to speak of closing a hand.

Even in the absence of movement we sometimes conclude that behavior has occurred. We do many things that involve no obvious movement. For example, while listening to a song I may shift my attention back and forth between the vocalist and the accompaniment. Those shifts of attention are behavior even though we can't record them as movements. Many aspects of thinking and imagining involve no movement, but they count as varieties of behavior. Thus, **not all instances of behavior need be movements**. A useful criterion for whether something counts as behavior isn't its form but whether it varies depending on how it affects the environment. Whether behavior involves movement or not, it typically has consequences, and a significant

consequence of behavior is providing opportunities for other behavior.

Behavior Hierarchies

One way to classify behavior is as rankings in a *behavior hierarchy* (Hull, 1943), an ordering of an organism's responses according to the relative frequencies with which it engages in them. Suppose a rat has access to different stimuli in compartments containing a food hopper, a drinking tube, an activity wheel, and an electrified grid floor. From time to time the rat will enter the food compartment and eat, or the water compartment and drink, or the activity wheel compartment and run. But after only a few entries it will rarely enter the compartment with the electrified grid. If it becomes more likely to eat than to run at some times of day, we'd say that at those times eating ranks above running in its behavior hierarchy. Our compartments will tell us nothing about the rat's social or sexual behavior. If we wanted to know where interaction with other rats stood in the hierarchy, we'd have to add more compartments, with a male rat, a female rat, and different sized groups of rats of one or both sexes.

Behavior hierarchies are changeable, and with those changes come changes in the significance of stimuli. For example, food may change from attractive to aversive over the course of an unusually large holiday dinner. It's often convenient to speak of stimuli rather than of opportunities for responding. But in a behavior analysis we judge the significance of food by the likelihood of eating and not by its taste or its nutritive properties. We've now surveyed some general properties of stimuli and responses as they enter into the relations among antecedents, behavior and consequences. With these preliminaries behind us, we can move on to a *taxonomy* of behavior and learning, an organization based on different categories of interactions between stimuli and responses.