Part II

A Scientific Model of Behavior

To be clear and convincing about one's criticism of someone else's view, one must offer an alternative view that would be acceptable. To help see what is wrong with conventional mentalistic views of behavior, we need to consider explanations that might be scientifically acceptable. In chapters 4 through 8 we will take up some basic concepts in behavior analysis and use them to suggest alternatives to unscientific mentalistic notions.

A warning is in order, however. Like all scientific explanations, the ones that we shall take up are considered by scientists to be tentative, open to dispute and to change. Any of these explanations may come to be considered incorrect in the future or may be disbelieved by some behavior analysts even today.

For our purposes, the possibility that a particular scientific explanation may eventually be discarded is unimportant. We need only to see that scientific explanations of behavior are possible. As behavior analysis moves ahead, the explanations accepted will change as new ones are devised. We need only to see, as an alternative to mentalism, what sort of explanation is scientifically acceptable.

Understanding Behaviorism: Behavior, Culture, and Evolution, Third Edition. William M. Baum.

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Evolutionary Theory and Reinforcement

Modern evolutionary theory provides a powerful framework within which to talk about behavior. Indeed it no longer seems possible to discuss behavior outside this context because biologists since Darwin have increasingly claimed behavior as part of their subject matter. In keeping with the assumption of continuity of species (chapter 1), their attention has turned more and more to human behavior as well. Even more than in Watson's time, psychologists and behavior analysts who ignore evolutionary theory today risk isolation from the mainstream of scientific development.

Our concerns with evolutionary theory in this chapter are two-fold. First, the evolutionary history or *phylogeny* of any species—including our own—can help us understand its behavior. Most of the genes an individual inherits have been selected across many generations because they promote behavior that makes for successful interaction with the environment and reproduction. Second, evolutionary theory represents a type of explanation that is unusual among the sciences. Scientific explanations usually appeal to mechanism, or the way things are arranged at a certain time. The type exemplified by evolutionary theory, which we will call *historical* explanation, is central to behavior analysis because the scientifically acceptable alternative to mentalism is historical explanation.

Evolutionary History

When we talk about the phylogeny of a species, we are talking about no particular event, but a series or history of events over a long period. Physics offers a different sort of answer to the question, "Why does the sun rise in the morning?" than biology offers to the question, "Why do giraffes have long necks?" The explanation about the sun requires reference only to events occurring right at the moment—the rotation of the Earth at the time of sunrise. The explanation about giraffes' necks requires reference to the births, lives, and deaths of countless giraffes and giraffe ancestors over many millions of years.

Darwin's great contribution was to see that a relatively simple mechanism could help explain why phylogeny followed the particular course that it did. The history of giraffes' necks, Darwin saw, is more than a sequence of changes; it is a history of selection. What does the selecting? Not an omnipotent Creator, not Mother Nature, not the giraffes, but a natural, mechanical process: natural selection.

Natural Selection

Within any population of organisms, individuals vary. They vary partly because of environmental factors (e.g., nutrition), and also because of genetic inheritance. Among the giraffe ancestors that lived in what is now the Serengeti Plain, for instance, variation in genes meant that some had shorter necks and some had longer necks. As the climate gradually changed, however, new, taller types of vegetation became more frequent. The giraffe ancestors that had longer necks, being able to reach higher, got a little more to eat, on the average. As a result, they were a little healthier, resisted disease a little better, evaded predators a little better—on the average. Any one individual with a longer neck may have died without offspring, but on the average longer-necked individuals produced more offspring, which tended on the average to survive a little better and produce more offspring. As longer necks became frequent, new genetic combinations occurred, with the result that some of these offspring had still longer necks than those before, and they did still better. As the longer-necked giraffes continued to out-reproduce the shorter-necked ones, the population consisted more and more of longer-necked individuals, and the average neck length of the whole population grew.

Figure 4.1 diagrams the process. The horizontal axis represents neck length, increasing from left to right. The vertical axis going up represents the relative frequency of various neck lengths in the population of giraffes or giraffe ancestors. Curve 1shows the variation in short-necked giraffe ancestors. As selection proceeds, the distribution shifts to the right (Curve 2), indicating that neck length, while continuing to vary, got longer on the average. Curve 3 shows variation in present-day giraffes, a stable frequency distribution that no longer shifts toward longer necks.

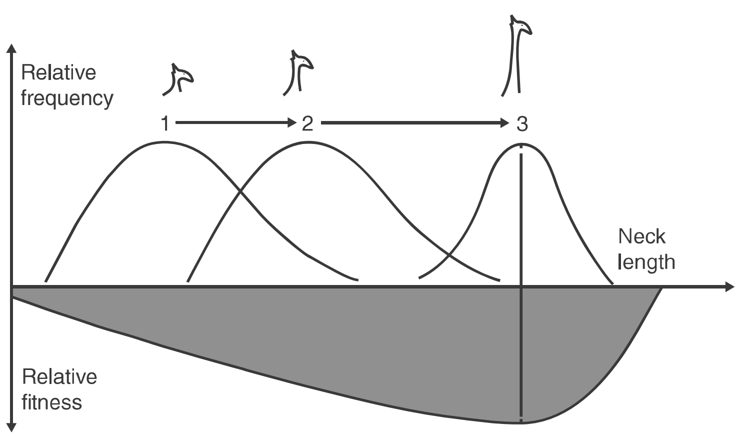

Figure 4.1 Evolution by natural selection.

For such a process of selection, three conditions must be met. First, whatever environmental factor makes having a longer neck advantageous (in our example, the tall vegetation) must remain present. Second, the variation in neck length must reflect, at least in part, genetic variation. Longer-necked individuals must tend to have more longer-necked than shorter-necked offspring. If, for example, all the variation in neck length were due to variation in diet, with no underlying variation in genes—the individuals that ate better had longer necks, instead of the other way around—selection would be impossible because generation after generation the same variation in diet and neck length would be repeated. Third, the different types must compete. Since an area's resources can support only a certain sized population of giraffes, and reproduction results in more giraffes than can survive, some offspring must die. The successful offspring will survive into the next generation to produce their own offspring.

These three factors are incorporated into the concept of *fitness*. The fitness of a genetic variant (a *genotype*) is its tendency to increase from one generation to the next relative to the other genotypes in the population. Any one genotype, even a short-necked one, could do well by itself, but in competition with others its fitness might be low. The greater the fitness of a genotype, the more that genotype will tend to predominate as generation succeeds generation. The vertical axis going downward in Figure 4.1 represents the fitness of the genotypes underlying the various neck lengths. The shaded curve shows how fitness varies with neck length. It remains the same throughout the selection process, because it represents the constant factors in the environment (the vegetation) that link neck length to reproductive success. Its maximum is at the vertical broken line, the same line that indicates the average neck length of today's giraffes. Once the average genotype in a population reaches the maximum fitness, the distribution of genotypes in the population stabilizes.

Once the population stabilizes, only the directional shift ceases; selection continues, selection that keeps the population stable. The fitness curve in Figure 4.1 passes through a maximum because too long a neck is a disadvantage. Birth complications and the strain on the heart of pumping blood to a great height, for example, might set an upper limit on fitness. Since the fitness curve passes through a maximum, selection will go against deviations from the maximum (the average of the population) in both directions.

Darwin himself, and many biologists since, recognized that behavior plays a central role in evolution. Selection occurs because individuals interact with their environment. Much of that interaction is behavior. In our example, giraffes have long necks because they eat. Turtles have shells because drawing into them affords protection. Reproduction, the key to the whole process, cannot occur without behavior such as courting, mating, and caring for young.

Those individuals that behave more effectively enjoy a higher reproductive success. The fitness of a genotype depends on its producing individuals that behave better than others—eating more, running faster, feeding offspring more, building a better nest, and so on. Better responses to the challenges presented by the environment are crucial to natural selection. Actions that better avoid being eaten when a predator appears, or better procure food when a prey item appears, or better care for young when they appear, or better appeal to a potential mate when one appears—all of these enhance reproductive success. Insofar as such behavior is affected by genotype, natural selection acts to change it and to stabilize it.

Reflexes and Fixed Action Patterns

Reflexes

Some behavioral traits are as much characteristics of a species as are anatomical traits. The simplest of these are called *reflexes*, because the earliest theory about them was that the bodily effect produced by a *stimulus*—an environmental event stimulating sense organs—was reflected by the nervous system into a *response*—an action. If your nose is tickled, you sneeze. If you are poked in the eye, you blink. If you are cold, you shiver. The tickle, poke, and cold are stimuli; the sneezing, blinking, and shivering are responses. They are actions in response to an environmental challenge—a foreign substance in the nose, a threat to vision, and a threat to body temperature.

Reflexes are a product of natural selection. They invariably seem to involve maintaining health, promoting survival, or furthering reproduction. Sneezing, blinking, shivering, release of adrenalin in danger, and sexual arousal are examples. Individuals in which these reflexes were strong tended to survive and reproduce better than individuals in which they were weak or nonexistent. In Figure 4.1, if we substituted force of sneeze reflex or readiness of penile erection instead of neck length, we can imagine a similar history of selection. The fitness curve would pass through a maximum, because too weak a sneeze is too little protection and too slow an erection means fewer offspring, but too strong a sneeze would be damaging and too swift an erection would be an obstruction (not to mention a social problem). Over many generations, genotypes promoting a stronger reflex would tend to reproduce more frequently on the average (frequency distributions 1 and 2), until the maximum fitness arrived (frequency distribution 3).

Fixed Action Patterns

More complex patterns of behavior also can enter into fixed relations to environmental events and be characteristic of a species. When a parent herring gull arrives at the nest, the chicks peck at a spot on its beak, and the parent responds by depositing food on the ground. In other species of birds, the chicks open their mouths wide and gape, and the parent puts the food into the open mouth. When a female stickleback (a small fish) with eggs enters a male's territory, the male begins a series of movements around her, and she responds by approaching the male's nest. Such complex behavioral reactions are known as *fixed action patterns*—the chicks' pecking and gaping, the parent's regurgitating food, and the male stickleback's courtship "dance" are examples. The environmental events that induce fixed action patterns are known as *sign stimuli* or *releasers*—the parent bird, the blows on the beak, the wide-open mouth, the female stickleback's egg-laden belly. As with reflexes, these behavioral reactions may be seen as important to fitness and, hence, as products of a history of natural selection. As with reflexes, those individuals in which fixed action patterns are too weak or too strong have less fit genotypes.

Although releasers and fixed action patterns may seem more complex than the stimuli and responses in reflexes, no clear dividing line separates the two types of reaction. Both can be considered relationships in which an environmental event (stimulus) induces an action (response). Both are considered characteristic of a species because they are highly reliable traits, as reliable as a giraffe's neck or a leopard's spots. Being so reliable, they are considered built-in, the result of genotype, and not initially modified by experience.

Reflexes and fixed action patterns are reactions that enhance fitness by being induced immediately when they are needed. When the silhouette of a hawk passes overhead, a baby quail crouches and freezes. If this reaction depended on experience with hawks, few quail babies would survive to reproduce. The pattern may be subject to refinement—gull chicks improve in their accuracy of pecking at the parent's beak, and the young vervet monkey's single alarm call eventually differentiates into distinct alarm calls to an eagle, a leopard, and a snake—but its great initial reliability derives from a history of selection for such reliability. The fitness of genotypes requiring that such patterns be learned from scratch would be less than genotypes that built in the basic form.

As with neck length or coloration, reflexes and fixed action patterns were selected over long periods of time in which the environment remained stable enough to maintain an advantage to those individuals that possessed the right behavior. The reflexes and fixed action patterns we see today were selected by the environment of the past. Although they enhanced fitness in the past, nothing guarantees that they continue to enhance fitness in the present; if the environment changed recently, selection will have had no chance to change the built-in behavior patterns.

Do human beings possess such reliable patterns? Among all species, ours seems to be the most dependent on experience. It would be a mistake, however, to imagine that human behavior is entirely learned. We have many reflexes: coughing and sneezing, startle, blinking, pupillary dilation, salivation, glandular secretion, and so on. What about fixed action patterns? These are hard to recognize in humans because they are so modified by later experience (as with the gull chicks and the young vervet monkeys). Some can be recognized because they occur universally. Responses to dangerous situations like a car speeding toward you, a mountain lion in the woods, or a large fire are always either to freeze, flee, or fight. One should flee an oncoming large object or a fire, but people sometimes freeze. One should stand still in front of a mountain lion, but people sometimes flee (which induces chase and capture in the cat).

The human face is richly endowed with small muscles that enable a huge variety of facial expressions. Many of these affect the behavior of those who see them. For example, disgust—curling the lips and expanding the nostrils—seems to be a universal reaction to an abhorrent food.

Another fixed action pattern is the smile—even people blind since birth smile. Another is the eyebrow flash of greeting: when one person sincerely greets another the eyebrows momentarily rise. Neither person is usually aware of the response, but it produces a feeling of welcome for the greeted person (Eibl-Eibesfeldt, 1975). It should come as no surprise that humans possess fixed action patterns, even though they are modified or suppressed by cultural training.

Indeed, we could hardly learn all the complex patterns we do without an elaborate base of built-in initial tendencies.

Respondent Conditioning

One simple type of learning that occurs with reflexes and fixed action patterns is *classical* or *respondent conditioning*. It is called "conditioning" because its discoverer, I. P. Pavlov, used the term *conditional reflex* to describe the result of the learning; he thought a new reflex formed that was conditional upon experience. Pavlov studied a variety of reflexes, but his best-known research focused on responses to food. He found that when a stimulus such as a tone or light regularly precedes feeding, behavior in the presence of the stimulus changes. A dog begins after a number of tone-food pairings to salivate and secrete digestive juices in the stomach in the presence of the tone by itself. If Zack begins to salivate when he sees the roast turkey brought in to dinner on Thanksgiving, it seems clear that he was not born having that reaction; he salivates because in the past such events preceded eating. If Zack had grown up in an orthodox Hindu home in India, vegetarian from birth, it is unlikely that the sight of a roasted turkey would make him salivate. If, having grown up in the United States, he were to visit an Indian home, he might fail to salivate at some of the food served for dinner there.

The same conditioning that governs simple reflex reactions also governs fixed action patterns. Researchers after Pavlov found that in any situation in which eating has occurred often in the past, all behavior related to food, not just salivation, becomes more likely. Dogs bark and wag their tails, behavior that accompanies group feeding in wild dogs. As the time of feeding draws near, pigeons become likely to peck at almost anything—a light, the floor, the air, or another pigeon—until food is available to peck at.

Behavior analysts debate the best way to talk about such phenomena. The older way, derived from Pavlov's idea of conditional reflexes, speaks of responses *elicited* by stimuli, suggesting a one-to-one causal relation. This may work for reflex reactions like salivation, but many researchers find it inadequate when applied to the variety of behavior that becomes likely around feeding. To talk about the whole cluster of food-related behavior, the behavior analyst Evalyn Segal (1972) introduced the term *induce*. Feeding in the presence of a tone induces food-related behavior in the presence of the tone. When a tone repeatedly accompanies feeding, the tone comes to induce the food-related behavior. For a dog, this means that salivation, barking, and tail-wagging all become likely when the tone is on.

What is true of food is true of other *phylogenetically important events*. Situations that accompany mating induce sexual arousal, a whole cluster of reflexes and fixed action patterns that varies widely from species to species. For humans, it entails changes in heart rate, blood flow, and glandular secretion.

Situations that accompany danger induce a variety of aggressive and defensive behavior. A rat that is given electric shocks in the presence of another rat attacks the other rat. Similarly, people in pain often become aggressive, and any situation in which pain has occurred in the past induces aggressive behavior. How many doctors, dentists, and nurses have had to wrestle with unwilling patients before any pain was ever actually inflicted! Such situations induce a host of reflex reactions and fixed action patterns varying from one species to another. Some of this behavior has more to do with escape than with aggression. Creatures may become likely to run in situations that signal danger. Sometimes, when a situation includes pain that in the past has been inescapable, the signs of danger induce extreme passivity, a phenomenon known as *learned helplessness* and sometimes speculated to resemble clinical depression in humans.

The debate over what all this means and how best to talk about it continues, but it need not detain us here. For our purposes, it is enough to note that a history of natural selection can have at least two sorts of result. First, it can ensure that events important to fitness (phylogenetically important events), such as food, a mate, or a predator, reliably induce behavioral reactions, both simple reflexes and fixed action patterns. Second, it can ensure the susceptibility of a species to respondent conditioning. Zack may not come into the world salivating at roast turkey, but he does come in so constructed that he may acquire this reaction if he grows up in the United States. If individuals that could flexibly react to a variety of possible signals produced more offspring, then individuals today will possess a genotype—typical of the species as the result of a history of natural selection—that enables this type of flexibility. In a sense the genotype makes for individuality, because the exact signals that induce the behavior depend on the individual's own special history of those particular signals accompanying a particular phylogenetically important event.

These events that we have been calling *phylogenetically important* tend to be important (in the sense of inducing behavioral reactions) to all the members of a species. This uniformity suggests an evolutionary history in which those individuals in the population for which these events were important (in the present sense) left more offspring. Those genotypes that made for individuals in whom food and sex failed to induce appropriate behavior (were unimportant) are no longer with us.

A distinction must be made between what was important long ago, during phylogeny, and what we consider important in our society today. The evolutionary history that made food, sex, and other events phylogenetically important extended over millions of years. The circumstances in the environment that linked the events with fitness a million years ago could be absent today because human culture can change enormously in only a few centuries, an amount of time that cannot produce any significant evolutionary change in our species. For example, if a new generation begins every 20 years, 300 years represents only 15 generations, far too few for much change in genotypes. All the changes that have occurred as a result of the Industrial Revolution—the growth of cities and factories, cars and airplanes, nuclear weapons, the nuclear family—can have had little effect on the behavioral tendencies supported by our genotypes. Thus, our evolutionary history may have prepared us poorly for some of today's challenges. When the doctor approaches to give you a shot, your tendency may be to tense up, prepare for the danger, be ready for flight or aggression, when the appropriate response is to relax. With nuclear weapons in our hands, how much more important it becomes to curb aggressive tendencies that evolved at a time when a stick would have been a powerful weapon!

Reinforcers and Punishers

Why do we submit meekly to injections? Behavior analysts explain our tendency to submit rather than resist by the consequences of these actions. Resistance might avoid some pain in the short run, but allowing the shot is linked to more important consequences, such as health and reproduction, in the long run. The tendency of consequences to shape behavior serves as the basis for a second type of learning, *operant conditioning*, which results in *operant behavior*.

Phylogenetically important events, when they are the consequences of behavior, are called *reinforcers* and *punishers*. Those events that during phylogeny enhanced fitness by their presence are called reinforcers, because they tend to increase behavior that produces them. They are "good" events like food, shelter, and sex. If food and shelter are obtained by working, then I work. If sex is obtained by performing courtship rituals special to my culture—dating—then I date. Those events that during phylogeny diminished fitness by their presence are called punishers, because they tend to suppress (punish) behavior that produces them. They are "bad" events like pain, cold, and illness. If I pet a dog and it bites me, I will be less likely to pet it again. If eating nuts makes me sick, I will be less likely to eat nuts. Such actions, acquired, because of their consequences, are examples of operant behavior.

Operant Behavior

Whereas respondent conditioning occurs as a result of a relation between two stimuli—a signal and a phylogenetically important event—operant behavior forms as a result of a relation between a stimulus and an activity—a phylogenetically important event and the behavior that affects its occurrence. Technically, such a relation is called a *contingency*. A consequence—reinforcer or punisher—is said to be contingent on an operant activity if the operant activity affects the likelihood of the consequence. Studying for an examination makes passing it more likely. Eating a good diet makes illness less likely.

Broadly speaking, behavior and consequences have two types of contingency: *positive* and *negative*. If you hunt or work for food, this behavior tends to produce food or makes it more likely. This is a positive contingency between a consequence (food) and an activity (hunting or working). If Gideon is allergic to nuts, he checks the ingredients of prepared foods before eating them to make sure they contain no nuts or nut oils in them and to avoid getting sick. This contingency is a negative one; the activity (checking) prevents the consequence (sickness) or makes it less likely.

With two types of activity-consequence contingency (positive and negative) and two types of consequence (reinforcers and punishers), the world contains four types of contingency that can engender operant behavior (Figure 4.2). The dependence between work and food is an example of positive reinforcement: *reinforcement*, because the relation tends to increase or maintain the activity (working), and *positive* because the activity makes the reinforcer (food) likely. The contingency between tooth-brushing and tooth decay is an example of negative reinforcement: *reinforcement*, because the relation tends to maintain tooth-brushing (the activity), and *negative* because brushing makes tooth decay

Action-consequence relation:	Consequence: Reinforcer	Consequence: Punisher
Positive	Positive reinforcement	Positive punishment
Negative	Negative punishment	Negative reinforcement

Figure 4.2 Four types of relations engendering operant behavior.

(the punisher) less likely. The contingency between walking on icy patches and falling is an example of positive punishment: *punishment*, because the relation makes walking on ice (the activity) less likely, and *positive* because the activity makes the punisher (falling) more likely. The contingency between making noise while hunting and catching prey is an example of negative punishment: *punishment*, because the relation tends to suppress making noise, and *negative* because making noise (the activity) makes catching prey less likely.

Phylogenetically important events are not the only reinforcers and punishers: The signals of phylogenetically important events that enter into respondent conditioning also function as reinforcers and punishers. A dog that has been trained to press a lever to produce food will press the lever also to produce a tone that is followed by food. As long as the tone continues to signal the food—the relation of respondent conditioning—the tone serves to reinforce the dog's lever pressing. This explains why people work for money as well as food itself; as in respondent conditioning, money is paired with food and other goods. When a reinforcer or punisher is the result of respondent conditioning like this, it is called *acquired* or *conditional*. The phylogenetically important events that bear directly on fitness are called *unconditional* reinforcers and punishers. Money and a tone signaling food are conditional reinforcers. Painful events in a doctor's office may make the office itself a conditional punisher.

In human society, the events that become conditional reinforcers and punishers are many and varied. They differ from culture to culture, from person to person, and from time to time within one's lifetime. When I was in the first grade, I strove for gold stars; when my children were in the first grade, I encouraged them to strive for happy-face stickers. In the United States, when we are ill we make appointments with physicians; in other cultures people make appointments with magicians and shamans. Gideon, who is allergic to nuts, finds the smell and sight of peanut butter disgusting and avoids the stuff; I, who eat it for lunch, buy it at the store all the time. My problem is with green peppers; when I am served salad in a restaurant, I pick them out.

Whether such a stimulus becomes or remains a conditional reinforcer or punisher depends on its signaling an unconditional reinforcer or punisher. Money remains a reinforcer only as long as it signals the availability of food and other unconditional reinforcers. In the early years of the United States, the government issued a currency called “Continentals” that became worthless because it was backed by too little gold—that is, redeeming the paper for reliable money was too unlikely. People refused to accept the paper money as payment—that is, it ceased to function as a reinforcer. My friend Mark, who is a skydiver, was terrified the first time he jumped from an airplane. However, after many jumps with no mishap, he began jumping without hesitation; jumping ceased to be a punisher. I, who have never jumped out of an airplane, can only marvel at the power of the conditional reinforcers that would maintain this behavior.

This last example illustrates an important point to remember when we are discussing reinforcement and punishment: behavior often has mixed consequences. Slogans like “No pain, no gain” and “Thank God it’s Friday” point to this fact of life. Life is full of choices between alternatives that offer different mixes of reinforcers and punishers. Going to work entails both getting paid (positive reinforcement) and suffering hassles (positive punishment), whereas calling in sick may forfeit some pay (negative punishment), avoid the hassles (negative reinforcement), allow a vacation (positive reinforcement), and incur some workplace disapproval (positive punishment). Which set of contingencies wins out depends on which relations are strong enough to dominate, and that depends on both the present circumstances and the person’s history of reinforcement and punishment.

Physiological Factors

Reinforcement and punishment need to be understood in light of the circumstances in which our species evolved. Since sensitivity to reinforcement and punishment enhances fitness only under some circumstances, and some such sensitivities enhance fitness more than others, phylogeny has provided us with physiology that both helps and hinders the action of reinforcement and punishment in various ways. Behavior analysis considers three sorts of physiological influence.

First, no reinforcer functions as a reinforcer all the time. If you have just eaten three slices of apple pie, and your gracious host offers yet a fourth, you are likely now to refuse. No matter how powerful the reinforcer, it is possible to have enough. If you have gone for a while without the reinforcer, it is likely to be powerful; this is *deprivation*. If you have had a lot of the reinforcer lately, it is likely to be weak; that is *satiation*. A reinforcer may even become a punisher, as anyone knows who has ever overeaten. If you have already satiated on apple pie, having to eat another slice would actually be too much of a good thing, a punisher. Medieval water torture exploited the punishing effects of forcing a person to drink water beyond capacity. These tendencies for reinforcers to wax and wane and even turn to punishers evolved because individuals that possessed them survived and reproduced better than those that lacked them.

Second, we may come into the world physiologically prepared for certain kinds of respondent conditioning. Some conditional reinforcers and punishers seem to be more easily acquired than others. Some require a lot of experience and some very little. Even some seemingly unconditional reinforcers and punishers appear to depend a bit on experience. When I was a child, I hated mushrooms, but today I put them raw in my salad. Likewise, the reinforcing power of sex seems to grow with experience. Conversely, some seemingly conditional reinforcers and punishers are so easily acquired that they hardly seem conditional. To children and some adults, candy is a powerful reinforcer. Our ancestors, who ate a lot of fruit, benefited from a predilection for sweet-tasting food, because ripe (sweet) fruit is more nutritious than unripe fruit. As a result, most humans seem to come into the world prepared to develop a sweet tooth—unfortunately for some of us, now that rapid cultural change has made sweets readily available.

Another example of such prepared learning is fear of snakes. Many children will handle snakes readily and show no fear of them, but show a special sensitivity to any suggestion that snakes are objects to be feared. The same child that a week ago handled a snake may today scream and hide at the sight of the same snake. To our ancestors snakes probably were a real hazard, and selection would have favored those individuals disposed to be fearful. Indeed, experiments with monkeys show that they have the same pattern of initial neutrality followed by extremely easy acquisition of snake fear (Mineka, Davidson, Cook, & Keir, 1984).

Humans seem to be particularly sensitive also to signs of approval and disapproval in others. Some of these signs, such as the smile and the frown, are universal; others vary from culture to culture. Approval and disapproval may be expressed by sounds, gestures, and even bodily postures too subtle for an outsider to notice, but apparent to all who grow up in that culture. In a social species like ours, the reproductive success of each individual depends on good relations with other members of the community. Our history of selection favored both a sensitivity to unconditional cues like smiles and frowns and an ability to learn any conditional cues especially easily.

Instead of trying to divide reinforcers and punishers into two categories, conditional and unconditional, we might speak of a continuum of conditionality, from highly conditional to minimally conditional. Sweets and snakes might be minimally conditional, whereas money and failing an exam would be more conditional. Smiles and frowns might be minimally conditional, whereas subtle slights and boosts might be highly conditional. Whichever view we adopt, two points seem clear: (1) The range of events that can be reinforcers and punishers is extremely wide, and (2) directly or indirectly all reinforcers and punishers ultimately derive their power from their effects on fitness—that is, from a history of evolution by natural selection.

The third physiological influence is to prepare the way for certain types of operant behavior. The structure of my body makes some learning unlikely. No matter how much I try to spread my wings, I never learn to fly. An eagle, on the other hand, is exceedingly likely to spread its wings and learn to fly. Of course, it learns partly because it has wings, but also because it is predisposed to use them. Our species, too, is predisposed to behave in certain ways and acquire certain skills. Children come into the world especially sensitive to speech sounds and begin to babble at an early age. Virtually all children, without special instruction, come to speak the language spoken around them by the age of two. Speaking develops because of its consequences, by the effects it has on other people, who provide reinforcement and punishment, particularly approval and disapproval. Children also learn to request things like cookies because that is how they get others to give them cookies. But this learning is highly prepared. For a human, speaking is so crucial to fitness that genes favoring the acquisition of speech would be strongly selected. As a result the physiology of our bodies makes it virtually certain that we will acquire this skill.

As a result of our physiology, some skills are acquired easily, whereas others, no matter how important in life today, will be less helped. Compare learning to speak with learning to read and write. The first requires no instruction; the other demands schools and teachers. Learning calculus can be helpful, but it remains a challenge to most people, whereas almost anyone can learn to drive a car. The sort of coordination of eyes, hands, and feet required for driving, also important in hunting prey and evading predators, comes easily to us, whereas abstract thinking takes more effort. Hunting and being hunted went on for millions of years, whereas calculus was invented in the seventeenth century. This means that all skills are not equally easy to acquire, and that some operant activities may develop more easily (speaking and driving) but others less easily (reading and calculus).

Overview of Phylogenetic Influences

A history of natural selection affects behavior in five ways.

1) It provides reliable patterns of behavior—reflexes and fixed action patterns—that are induced by phylogenetically important events and hence aid survival and reproduction.
2) It favors genotypes that provide the capacity for respondent conditioning, in which a variety of neutral stimuli become promises and threats of up-coming situations (releasers) that induce fixed action patterns. Since that capacity to learn enhanced fitness, the physiological equipment necessary for it was selected.
3) It favors genotypes that provide the capacity for the shaping of operant behavior by its consequences (reinforcers and punishers). Since operant learning enhanced fitness during phylogeny, natural selection provided the physiological equipment necessary for this type of flexibility. Those fixed action patterns that serve as a base for respondent conditioning (unconditional stimuli and responses, according to Pavlov) serve also as a base for shaping operant behavior, as unconditional reinforcers and punishers. The signals or conditional stimuli of respondent conditioning function as conditional reinforcers and conditional punishers for operant behavior.
4) It provided physiological mechanisms of deprivation and satiation, by which reinforcers and punishers wax and wane in their power to affect behavior.
5) It selects biases that favor conditioning of certain signals in respondent conditioning and reinforcing of certain operant activities. Since such signals and activities are important to fitness, but some flexibility is also good for fitness, physiological mechanisms are selected that make such learning especially easy.

History of Reinforcement

The term "history of reinforcement" in behavior analysis is really short for "history of reinforcement and punishment," an individual's history of operant learning from birth. In this section we will see that it is a history of selection by consequences analogous to phylogeny. Reinforcement and punishment shape behavior as it develops during an individual's lifetime (during the *ontogeny* of behavior) in the same way that reproductive success shapes the traits of a species during phylogeny.

Selection by Consequences

In Figure 4.1, individual giraffe ancestors that had shorter necks tended to produce fewer surviving offspring on the average than those with longer necks. The lesser and greater fitnesses (reproductive successes) were consequences of the shorter and longer necks. As long as those differential consequences remained (Curves 1 and 2 in Figure 4.1), average neck length in the population continued to grow. When the process reached its limit (Curve 3), variation in neck length still had differential consequences, except now either too short or too long a neck results in lower average reproductive success, because the variation in neck length spans the point of maximum fitness (the broken line in Figure 4.1). Now the differential consequences of neck length act to stabilize the population.

The general rule of thumb in phylogeny is that within a population of individuals that vary in genotype, those types that are more successful tend to become or remain the most frequent. An analogous rule holds for ontogeny by reinforcement and punishment; it is known as the *law of effect*.

The Law of Effect

Successful and unsuccessful behavior are defined by their effects. In everyday terms, successful behavior produces good effects, and unsuccessful behavior produces less good or bad effects. In operant learning, success and failure correspond to reinforcement and punishment. A successful activity is one that is reinforced; an unsuccessful activity is one that is less reinforced or punished.

The law of effect is the principle that underlies operant learning. It states that the more reinforced an activity is, the more it tends to occur, and the more punished an activity is, the less it tends to occur. The results of the law of effect are often spoken of as *shaping*, because as more successful types of behavior wax and less successful types wane, it is like a sculptor molding a lump of clay, building up here, pressing down there, until the lump takes desired shape. When you were first learning to write, even the crudest approximations to letters like *o* and *c* met with high praise. Some of these efforts were better than others, and the better ones were usually more praised. Really poor performance might even have produced disapproval. Gradually, your letters became better shaped. (Standards shifted, too; shapes that were praised at an early stage produced disapproved at a later stage.)

Shaping and Natural Selection

Behavior analysts think of the shaping of behavior as working in just the same way as the evolution of species. Just as differences in reproductive success (fitness) shape the composition of a population of genotypes, so reinforcement and punishment shape the composition of an individual's behavior. To make the parallel clear, we need to think of the collection of all behavior of a certain sort—say, driving a car to work—that a person engages in over a period of time—say, a month—as being like a population of giraffes. Driving to work is a species of behavior, just as giraffes are a species of animal, and all the driving I do in a month is a population of driving activity, just as all the giraffes in the Serengeti Plain are a population of giraffes. Just as some giraffes are more successful at producing offspring, so some of my driving episodes (actions; chapter 3) are more successful in getting me to work. Some include maneuvers that gain time; these are reinforced. Others lose time or prove dangerous; these are punished. The successful actions tend to become more frequent or at least are maintained from month to month, and the unsuccessful actions tend to become less frequent or at least remain rare from month to month, just as the more successful types of giraffes tend to remain more common and the less successful types of giraffes tend to remain rare. Just as more successful types of giraffes are selected by their success, so more successful types of driving are selected by their success. Over time, selection results either in evolution of driving or stabilization of driving.

All the repeating activities of life—work, play, socializing, caring for children, and so on—can be thought of this way—as populations of actions. For example, Shona works as a social worker, and her professional activities include seeing clients, traveling to and from the office, making notes, keeping up with continuing education credits, consultations, and so on, all of which take up time. Her work is important to her both because it enables her to make a living and because it is rewarding in other ways, like seeing her clients improve and receiving their appreciation. By themselves, these consequences might push Shona to work long hours, but she has other demands on her time that set limits: She needs to spend time with her family and her friends, to exercise, to relax, and so on. Shona needs to achieve what is commonly called “work-life balance.”

Achieving work-life balance means achieving a mix of activities that is maximally successful, in the sense that the mix of activities results in the best mix of consequences possible. If Shona works too little, she will fail to earn enough money and the social rewards of her work. If she works too much, she will get complaints from her family and friends, her health may suffer, and the mix of consequences will be less than optimal also. Different possible mixes of activities vary in how successful they are.

Suppose we take Figure 4.1 and substitute Shona’s weekly work hours for neck length and balance (successfulness of the mix of work with the rest of life) for fitness. Shona’s work hours per week, say, over the course of a year or two constitute a population, like the population of giraffes’ neck lengths in Figure 4.1. The result is Figure 4.3. The three frequency curves might refer to different stages in Shona’s career. When she first started her practice, she worked only around 20 hours per week—sometimes more hours, sometimes fewer—but too little for a good balance, because she wasn’t earning enough money and social reinforcers (Curve 1). If we take out the necessities of life like sleeping, eating, bathing, dressing, body care, and so on, the number of hours she could possibly work would total about 80, although if she actually worked 80 hours per week, scant time would remain for family and friends. The little pie chart above Curve 1 shows Shona averaging to about a quarter of the hours she could possibly work. As Shona built her practice, seeing more clients, her work hours came to vary

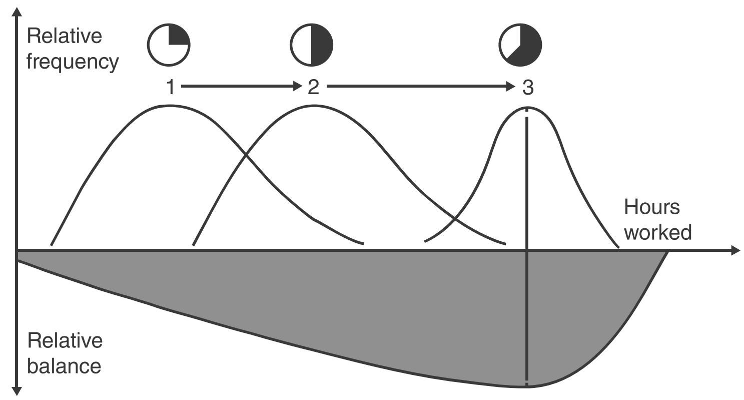

Figure 4.3 Shaping by reinforcement and punishment.

around 40 per week—sometimes more and sometimes fewer (Curve 2). Then Shona took a position as director of a community health program and kept some of her private practice too, shifting her work hours to around 50 per week (Curve 3), which was as high as she could go without throwing off work-life balance too far in favor of work. As Curve 3 suggests, some weeks she worked less than 50 hours and some weeks more than 50 hours.

Just as with natural selection, reinforcement and punishment operate on the population and on the average. When working was being shaped (say, Curve 2 in Figure 4.3), more hours meant more success only on the average. Sometimes more work was less successful; perhaps some clients failed to improve or a child didn't get help with homework. Sometimes more work was no more successful, because clients improved but Shona got no chance to exercise. Not every action of a type need be reinforced or punished for the type to be increased or suppressed; the type only needs to be reinforced or punished more *on the average* over time. On average, the more Shona worked while she was building her practice (going from Curve 1 to Curve 2), the more the work-life mix was successful. If she worked more than 50 hours in a week, however, sometimes the results might still be all right, but more often the effects on family, friends, and health would be disastrous; on the average working more than 50 hours per week was punished. The lower, shaded curve in Figure 4.3 represents the analog to fitness, relative work-life balance. When Shona's average work hours reached 50, directional selection ceased, and selection tended to stabilize it there, because above 50 hours resulted in less balance (fewer reinforcers and more punishers) and below 50 hours also resulted in less balance.

For evolution or stabilization of a population by natural selection, three ingredients are necessary: variation, reproduction, and differential success. (1) Selection among possibilities requires more than one possibility—that is, the individuals in the population must vary in the trait (neck length in Figure 4.1, but it could be speed, coloration, or a host of other traits). (2) The different variants must tend to reproduce themselves—that is, offspring should resemble their parents from generation to generation, resulting in the variants recurring from generation to generation. For natural selection, this recurrence results from genetic inheritance. Long- and short-necked giraffes inherit their long and short necks from their parents. (3) Among the variants, some must be more successful than others (i.e., there must be competition). If all variants were equally fit—if instead of the fitness curve shown in Figure 4.1 fitness were represented by a flat line—then the trait (neck length) would neither shift in a particular direction nor remain stable, but drift unpredictably from time to time. Since too short a neck lowers fitness, the population moves steadily toward longer necks; when too long a neck also lowers fitness, the population remains stable.

Shaping by reinforcement and punishment requires the same three ingredients: variation, recurrence, and differential success. (1) For shaping, the variation occurs within the population of actions that serve a similar purpose (working, in our example, which serves to earn money and social reinforcers). You hardly ever engage in the same activity exactly the same way twice. Some weeks Shona worked more, some weeks less. Sometimes you brush your teeth hard, sometimes easy. Sometimes you speak in a high pitch, sometimes in a low pitch. Sometimes I drive above the speed limit, sometimes below it. The population of harder and softer tooth brushings, higher- and lower-pitched utterances, or faster and slower drives varies just the same way as the population of shorter- and longer-necked giraffes. (2) For shaping to occur, activities must tend to recur (reproduce) from time to time. If I go rock-climbing once in my life, and never go again, my rock-climbing has no chance to be shaped. Since I brush my teeth every day, my tooth-brushing has plenty of chance to be shaped. Since Shona works every week, her work-life balance can be shaped. (3) For shaping, differential success means differential reinforcement and punishment. I speak loudly to my deaf grandmother because otherwise she cannot hear me and provide reinforcers for my speaking to her. If I speak too loudly, she reprimands me with, “Don’t you shout at me, young man.” Most of the time I find a loudness at which she and I can carry on a nice conversation; so, some loudnesses are more successful than others, just as in Figure 4.3 some work times are more successful than others. As in natural selection, population size is limited—you brush your teeth only two or three times a day and work only about 50 weeks in a year. Since the more successful variants tend to recur more often from day to day or year to year, the less successful variants tend to become less frequent. As long as some variants are reinforced or punished more than others, the action population will either shift or remain stable, as in Figure 4.3.

When one person dispenses reinforcers and punishers purposefully to change the behavior of another person, it is called training, teaching, or therapy. Whether we are talking about an athletic coach training a team, an animal trainer training a bear to dance, a teacher teaching a child to read, or a therapist helping a client to be more assertive with superiors, the same principles of reinforcement and punishment apply. The only difference is that these instances of shaping constitute *relationships*—that is, two people are involved, both of whose behavior is being shaped (more about this in chapters 7, 9, and 11).

Training, teaching, and therapy resemble selective breeding, the process in which reproductive success (which individuals get to breed) is determined by a person, rather than by the natural environment. When farmers breed only the cows that produce the most milk, they are capitalizing on the inheritance of milk production, just as natural selection capitalizes on the inheritance of advantageous traits in the natural environment. Darwin got the idea of natural selection in part from observing selective breeding. He saw that the same principles could apply on the farm and in nature. Similarly, the same principles of reinforcement and punishment apply in our "natural," unstructured environment and in situations structured especially for behavior change.

Historical Explanations

The parallel between natural selection and shaping is no accident, because both ideas exist to solve similar problems. In chapter 1, we saw how Darwin's theory of natural selection provided the first scientific account of evolution. Prior to that, even though many thinkers rejected the exact account in the Bible, evolution was commonly regarded as the result of God's design, intelligence, or purpose. From a scientific point of view, such an "explanation" is unacceptable, because it fails to advance understanding and impedes efforts at making true advances. Just as natural selection replaced divine design, intelligence, or purpose, selection by reinforcement and punishment replaces mentalistic "explanations" of behavior that refer to design, intelligence, or purpose inside the person or animal behaving.

Figure 4.4 shows a summary of the parallel between natural selection and shaping. Both ideas rely on the notion of gradual change through time—a history. In evolution by natural selection, the history is phylogeny, the gradual shift of genetically based traits. In behavior shaping, the history is the gradual shift of an individual's behavior due to interaction with the reinforcement and punishment relations in his or her environment (Figure 4.2). Your personal history of reinforcement and punishment includes all those times when your behavior produced food, money, approval, pain, or disapproval—all those consequences that shaped your behavior into what it is today. It is part of the ontogeny of your behavior.

Both ideas refer to a population within which variation occurs. In evolution, variation occurs within a population of individuals, the key variation being in the individuals' genotypes. In shaping, variation occurs within a population of action-types, all the different ways that an individual performs a certain task or activity, such as tooth-brushing, going to the store, or hours worked per week.

	History	Population (variation)	Recurrence	Selection	"Explanation" replaced
Natural selection	Phylogeny	Genotypes	Genetic inheritance	Differential fitness	God the creator
Shaping	History of reinforcement and punishment (ontogeny)	Action-types (behavior)	Repetition or "habit"	Differential reinforcement and punishment	Purpose, will, intelligence (mentalism)

Figure 4.4 Parallel between natural selection and shaping.

Both ideas require recurrence of types. In natural selection, genotypes are passed from generation to generation by genetic inheritance. In shaping, activities repeat because the occasions for them repeat. I brush my teeth every morning and every night because I get up every morning and go to sleep every night. Apart from vacations, Shona worked every week. People often call such repetition "habit." The exact mechanism underlying habit must lie in the nervous system, but much less is known about that than about the genetic transfer of characteristics from parents to offspring.

Both ideas attribute change to selection by differential success. In natural selection, change in the genotypes composing a population occurs due to differential fitness or reproductive success. In shaping, change in the ways an activity is performed (the action-types) is due to differential reinforcement and punishment, the differences in effectiveness of the different action-types (the shaded curve in Figure 4.3).

Finally, each idea replaces an earlier unscientific account. Natural selection replaces God the Creator, the hidden force guiding evolution, with an explanation in purely natural terms. The apparent intelligence and purposefulness of life forms are seen as the outcome of selection acting on variation. Giraffes benefit from long necks, but neither they nor the Creator need be given credit for this, because the environment made long necks good and selected them as well. Shaping by reinforcement and punishment also replaces hidden forces, the mentalistic causes of behavior, with explanations in purely natural terms. The intelligence and purposefulness of actions are seen as the outcome of selection (reinforcement and punishment) acting on variation. I benefit from skillful driving, but neither I nor any inner purpose or intelligence need be given any credit for this, because the environment made skillful driving good and selected it as well.

Historical explanations like natural selection and reinforcement differ from scientific explanations that rely on immediate causes. The sun's rising is explained by an immediate cause, the Earth's rotation. In historical explanation, the "cause" of the event is nowhere present, but is a whole history of past events. The long neck of a giraffe cannot be wholly explained by any event at its birth or even at its conception, but is explained by the long history of selection that produced it over millions of years. Similarly, Shona's work habits cannot be wholly explained by any event while she is working or even by the events of any one day or week, but are explained by the long history of shaping that produced them over many months or years.

Evolutionary biologists distinguish between *proximate* explanations and *ultimate* explanations (Alcock, 1998). The proximate explanation of a behavioral trait points to the physiological mechanisms that determine the trait's development from conception. An individual's genetic endowment explains, in a proximate way, why the individual sneezes, smiles, and is able to learn. But the larger question of why the individual has that genetic endowment in the first place cannot be explained by the moment of conception or any other moment. The ultimate explanation points to the individual's membership in a population or species and, strictly speaking, applies to the population and not to the individual at all. Human beings sneeze and learn because that reflex and that capacity enhanced reproductive success among humans and their ancestors over many millions of years; that is the ultimate explanation.

Ultimate explanations are historical explanations; proximate explanations are explanations in terms of immediate causes. If enough were known about the physiology of the nervous system, someone might be able to explain why I drove 55 miles per hour at 8:55 on the morning of June 10. That would be a proximate explanation of that particular instance of my behavior, just as molecular genetics and embryology might provide a proximate explanation of why I have two hands and feet. But why the population of my driving speeds is what it is month after month cannot be explained by the physiology of my nervous system, just as why human beings have two hands and feet cannot be explained by any one person's genetics or embryological development. The population requires an ultimate or historical explanation. On a particular occasion, I may hand over my wallet to a man with a gun; the historical explanation points to this event's membership in a population (activity), called, say, "complying with a threat," and the long history of reinforcement for complying with threats, from the playground to the classroom to the streets of New York City.

People seem to prefer proximate explanations, probably because events like billiard balls knocking into one another are simpler to think about than histories. When an action appears to have no immediate cause, instead of pointing to the history of reinforcement that produced the activity to which the action belongs, one might be tempted to provide an immediate cause by making one up. If the history of reinforcement responsible for Zack's going to a movie when he should be studying is obscure, one might be tempted to say his will power collapsed. That, of course, is mentalism.

Chapter 3 criticized mentalism at length, but never offered any alternative; now we are in a position to suggest a scientifically acceptable account of purpose and intention. As we noted at the beginning of this part of the book, particulars of the account will change as time goes on. We need only establish that a truly scientific account is possible. That is the subject of chapter 5.

Summary

The theory of evolution is important to behavior analysis in two ways.

First, much behavior originates in genetic inheritance derived from the species' evolutionary history (phylogeny). Natural selection provides reflexes and fixed action patterns, the capacity for respondent conditioning, the capacity for operant behavior, reinforcers and punishers that change in power with time and context, and biases that favor certain types of respondent conditioning and operant behavior.

Second, the theory of evolution provides an example of historical explanation, the type of explanation that applies to operant behavior. A history of reinforcement and punishment parallels a history of natural selection, except that the first operates on a type of behavior (population of actions) within the lifetime of an individual, whereas the second operates on a species (population of organisms) over many generations. Both concepts replace nonscientific accounts that refer to a hidden intelligent agent directing evolutionary or behavioral change.

Although explanations in physics and chemistry rely on immediate causes, historical explanations refer to the cumulative effects of many events over a long period of time. Changes produced in a population as a result of selection by consequences cannot be pinpointed at a particular moment. Like phylogeny, a history of reinforcement refers to many events of the past, all of which together produced present behavior.

Further Reading

Several books are available at various levels that treat the topics of this chapter in greater depth.

Alcock, J. (1998). *Approach animal behavior: An evolutionary approach* (6th ed.) Sunderland, MA: Sinauer Associates. This excellent introductory textbook covers evolutionary theory and sociobiology.

Barash, D. (1982). *Sociobiology and behavior* (2nd ed.) New York: Elsevier. This is a more advanced treatment than Alcock's, also excellent.

Eibl-Eibesfeldt, I. (1975). *Ethology: The biology of behavior* (2nd ed.) New York: Holt, Rinehart, and Winston. This book has an excellent treatment of fixed action patterns, particularly in human beings.

Gould, J. L. (1982). *Ethology: The mechanisms and evolution of behavior*. New York: Norton. This is a more up-to-date, though not necessarily better, book than the previous one.

Mazur, J. E. (2002). *Learning and behavior* (5th ed.) Englewood Cliffs, NJ: Prentice-Hall. This advanced textbook on behavior analysis provides a good overview of the field.

Mineka, S., Davidson, M., Cook, M., & Keir, R. (1984). Observational learning of snake fear in rhesus monkeys. *Journal of Abnormal Psychology*, 93, 355–372. This article reports a study of monkeys' easy acquisition of snake fear.

Segal, E. F. (1972). Induction and the provenance of operants. In R. M. Gilbert & J. R. Millenson (Eds.), *Reinforcement: Behavioral analyses* (pp. 1–34). New York: Academic Press. This article contains an excellent, but technical, review of induction, its interaction with reinforcement, and its effects on operant behavior.

Skinner, B. F. (1953). *Science and human behavior*. New York: Macmillan. This was the first textbook in behavior analysis, now of mostly historical interest, but containing many illuminating arguments and examples.

Keyterms

Classical conditioning
Conditional punisher
Conditional reflex
Conditional reinforcer
Conditional response
Conditional stimulus
Contingency
Elicit
Fitness
Fixed action pattern
Genotype
Historical explanation
Induce
Learned helplessness
Negative punishment
Negative reinforcement
Ontogeny
Operant conditioning

Operant learning
Phylogenetically important event
Phylogeny
Positive punishment
Positive reinforcement
Proximate explanation
Releaser
Reproductive success
Respondent conditioning
Shaping
Sign stimulus
Ultimate explanation
Unconditional punisher
Unconditional reflex
Unconditional reinforcer
Unconditional response
Unconditional stimulus