CHAPTER 12

Choice

Learning Objectives

After reading this chapter, you should be able to

- describe the matching law, and explain how it has been applied to different choice situations
- describe optimization theory, and discuss studies that compare its predictions to those of the matching law
- describe momentary maximization theory, and explain how it differs from optimization theory
- define the self-control choice situation, and give examples from the laboratory and from everyday life
- discuss techniques people can use to improve their self-control
- explain the phenomenon of the "tragedy of the commons," and discuss ways that it can be avoided

It is not much of an exaggeration to say that all behavior involves choice. Even in the most barren experimental chamber, an animal can choose among performing the operant response, exploring, sitting, standing, grooming, sleeping, and so on. Outside the laboratory, the choices are much more numerous. At any moment, an individual can choose to either continue with its current behavior or switch to another. Because both people and animals are constantly making choices, understanding choice is an essential part of understanding behavior itself.

One of the most remarkable characteristics of behavior in choice situations is its orderliness and predictability. The choice behavior of animals in laboratory experiments is often so orderly that it can be described by simple mathematical equations. One such equation is the matching law, one of the best-known principles that has arisen from behavioral research on choice.

THE MATCHING LAW

Herrnstein's Experiment

Herrnstein (1961) conducted an experiment with pigeons in a chamber with two response keys, one red and one white. Each key was associated with its own VI schedule of reinforcement. For example, in one condition, pecks at the left key were reinforced on a VI 135-second schedule, and pecks at the right key were reinforced on a VI 270-second schedule, so the left key delivered about twice as many food reinforcers. (Technically, when two or more reinforcement schedules are presented simultaneously they are called a **concurrent schedule**.) Herrnstein's main question was this: After the birds have learned all that they can about this choice situation, how will they distribute their responses? He therefore gave them many days of training with the same two VI schedules and then measured their responses. As is typical on VI schedules, the birds made many responses for each reinforcer they received. What is most interesting, however, is that in this condition, where two thirds of the reinforcers came from the left key, the birds made approximately two thirds of their responses on the left key. That is, the proportion of responses on the left key equaled, or *matched*, the proportion of reinforcers delivered by the left key.

In another condition, two birds received only about 15% of their reinforcers from the left key, and they made about 15% of their responses on this key. Once again, the percentage of left-key responses approximately matched the percentage of left-key reinforcers. Based these results, Herrnstein proposed the following general principle, now known as the **matching law**:

$$\frac{B_1}{B_1 + B_2} = \frac{R_1}{R_1 + R_2} \qquad (12.1)$$

B_1 is the number of responses of type 1 (left-key responses), and B_2 is the number of responses of type 2 (right-key responses). Similarly, R_1 is the number of reinforcers obtained by making response 1, and R_2 is the number of reinforcers obtained by making response 2. Equation 12.1 states that in a two-choice situation, the proportion of responses directed toward one alternative should equal the proportion of reinforcers delivered by that alternative.

Figure 12.1 plots the results from all of the conditions of Herrnstein's experiment. The x-axis represents the percentage of left-key reinforcers and the y-axis the percentage of left-key responses. According to the matching law, the data points should fall along the diagonal line because this is where these two percentages are equal. As can be seen, all the points are close to the line. The matching law provided a very good description of the pigeons' behavior.

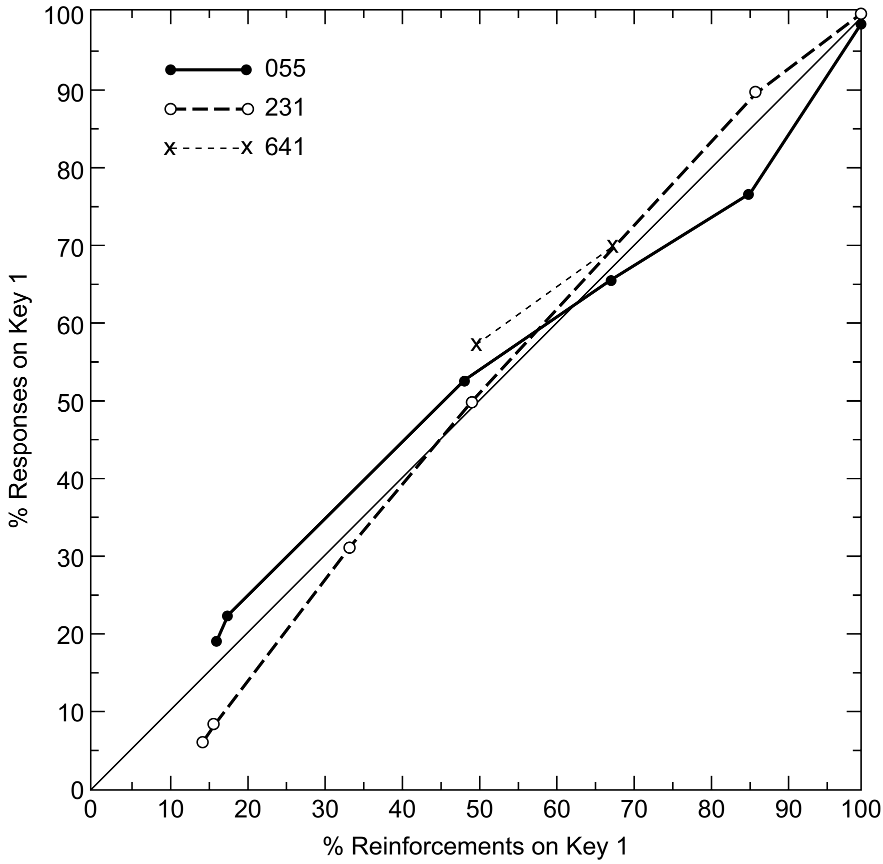

Figure 12.1 Results from three pigeons in Herrnstein's (1961) experiment on concurrent VI schedules. Each data point shows the results from a different condition. The diagonal line shows the predictions of the matching law, which predicts that response percentages will match reinforcement percentages. (From Herrnstein, R. J., Relative and absolute strength of response as a function of frequency of reinforcement, *Journal of the Experimental Analysis of Behavior, 4*, 267–272. Copyright 1961 by the Society for the Experimental Analysis of Behavior, Inc.)

Other Experiments on Matching

The matching law has been applied with reasonable success in a wide range of experiments with both animals and humans. One experiment found that the percentage of time people spent talking to another person in a group discussion approximately matched the percentage of verbal reinforcers delivered by that person (Conger & Killeen, 1974). Billington and DiTommaso (2003) showed how the matching law can be used to analyze classroom behavior. According to the matching law, the percentage of class time a child spends off-task versus on-task will depend on the relative amounts of reinforcement each provides. A teacher who wants to increase on-task behavior must find ways either to reduce the reinforcers for off-task behavior (which might be difficult) or to increase the reinforcers for on-task behavior (by providing praise, encouragement, special privileges, and so on). In other applications, the matching law has been used to analyze conflicts between career and family (Redmon & Lockwood, 1986) and to describe how consumers make choices when purchasing food items (Foxall, James, Oliveira-Castro, & Ribier, 2010).

The matching law has also been applied to choices made by individual athletes and entire teams. For example, Stilling and Critchfield (2010) examined the numbers of passing plays versus running plays used by different football teams during a season (which varied from team to team because of differences in talent, coaching strategies, etc.). They treated the choice of plays as the behaviors and yards gained as the reinforcers, and they found an approximate matching relation—the percentage of passing plays used by the different teams varied in accordance with the relative amounts of yardage the teams gained from these two types of plays.

Deviations From Matching

Not all experiments have produced results that are consistent with Equation 12.1. Baum (1974) listed three ways that the results of experiments have deviated from strict matching, each of which is depicted graphically in Figure 12.2. The most common of these deviations is **undermatching**, in which response proportions are consistently less extreme (i.e., closer to .5) than reinforcement proportions. In the example of undermatching shown in Figure 12.2, when the proportion of left reinforcers is .8, the proportion of left responses is only .6. When the proportion of left reinforcers is .3, the proportion of left responses is .45. In other words, undermatching describes the case where an individual's preferences are closer to indifference than they should be according to the matching law.

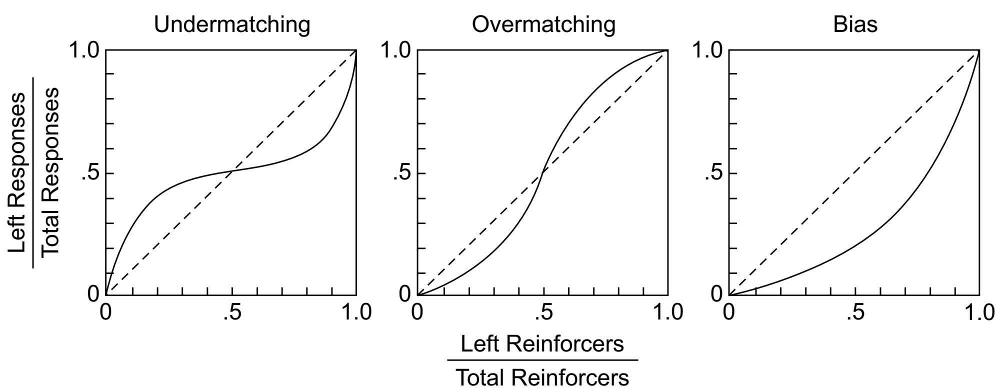

Figure 12.2 In each panel, the broken diagonal line shows where data points would fall if a subject's behavior conformed perfectly to the matching law (Equation 12.1). The solid curves illustrate three types of deviation from perfect matching.

One explanation of undermatching is that it can occur if the learner develops a habit of rapidly switching back and forth between the two options, a pattern that could be accidentally reinforced if food was delivered immediately after a switch. (To reduce the chance that switching behavior might be inadvertently reinforced, Herrnstein included a 1.5-second *changeover delay*—no food could be delivered during the first 1.5 seconds after a pigeon switched from one key to the other. This meant that a pigeon had to make two or more consecutive responses on the same key before collecting a reinforcer, thereby making the accidental reinforcement of switching behavior less likely.) Another hypothesis about undermatching is that animals may occasionally attribute a reinforcer to the wrong response (Davison & Jenkins, 1985). For instance, in the short time between making a response and collecting the reinforcer, a pigeon may forget which key it pecked.

The opposite of undermatching is **overmatching**, in which response proportions are more extreme than the reinforcement proportions. In the illustration of overmatching in Figure 12.2, a reinforcer proportion of .8 produces a response proportion of .9, and a reinforcer proportion of .3 produces a response proportion of .15. Overmatching is not as common as matching or undermatching, but it has been observed in situations where there is a penalty for switching between schedules. Baum (1982) found overmatching when pigeons had to walk around a barrier and over a hurdle to switch from one key to the other. As the effort involved in switching between keys was increased, the pigeons switched less and less and spent most of their time responding on the better VI schedule, which resulted in overmatching.

In the third type of deviation from matching, **bias**, an individual consistently spends more time on one alternative than predicted by the matching equation. The example in Figure 12.2 illustrates a bias for the right key: Regardless of the reinforcer proportion, there are more responses on the right key than predicted by the matching law. Many factors can produce a bias, such as a preference for a particular side of the chamber, for a particular response key (if one key requires a bit less effort than the other), or for a particular color (if the two response keys have different colors). In some cases, the reason for bias is easy to explain. In a study of college basketball players' choices between 2-point and 3-point shots, researchers found that the matching law described the players' shot selections quite well, except that there was a consistent bias for 3-point shots (Alferink, Critchfield, Hitt, & Higgins, 2009). The explanation for this bias is straightforward and obvious—3-point shots are worth more than 2-point shots.

Varying the Quality and Amount of Reinforcement

With some small modifications, the matching law can be used to measure an individual's preferences for reinforcers of different types. For instance, Miller (1976) presented pigeons with pairs of VI schedules that provided different types of grain as reinforcers. When the two reinforcers were wheat and buckwheat, the pigeons showed a strong preference (bias) for the wheat. Miller suggested that the matching equation could take this bias into account if it were modified in the following way:

$$\frac{B_1}{B_1 + B_2} = \frac{Q_1R_1}{Q_1R_1 + Q_2R_2} \tag{12.2}$$

where Q_1 and Q_2 stand for the qualities of the reinforcers available on the two keys. This equation states that a pigeon's behavior is determined by both the rate of reinforcement and the quality of reinforcement delivered by the different schedules. Miller arbitrarily assigned a value of 10 to Q_b, the quality of buckwheat, and he found that Equation 12.2 provided a good description of the results if Q_w, the quality of wheat, was given a value of about 14. He interpreted this number as meaning that each wheat reinforcer was worth about 1.4 times as much as each buckwheat reinforcer. Miller made similar calculations for conditions where the alternatives were hemp and buckwheat, and he estimated that Q_h, the quality of hemp, was about 9.1, or slightly less than that of buckwheat. Based on these numbers, Miller predicted that he should observe a preference (bias) of 14 to 9.1 when the pigeons had to choose between wheat and hemp, and this is approximately what he found. This experiment nicely demonstrates how the matching law can be used to scale animals' preferences for different types of reinforcers. The matching law has been used in other studies to measure preferences among reinforcers of different qualities, with subjects as different as humans (Neef, Mace, Shea, & Shade, 1992) and cows (Foster, Temple, Robertson, Nair, & Poling, 1996).

Besides the rate of reinforcement and the quality of reinforcement, another variable that can affect preference is the amount or size of each reinforcer. If one key delivers two food pellets as a reinforcer and the other key delivers only one, this should certainly affect a subject's choices. Baum and Rachlin (1969) suggested that when amount of reinforcement is the independent variable, it can be used in place of rate of reinforcement in the matching equation:

$$\frac{B_1}{B_1 + B_2} = \frac{A_1}{A_1 + A_2} \tag{12.3}$$

where A_1 and A_2 are the amounts of reinforcement delivered by the two alternatives. In some cases, Equation 12.3 has been quite accurate (Catania, 1963), but other studies have found substantial undermatching or overmatching when amount of reinforcement is varied (Davison & Hogsden, 1984).

MATCHING AND REINFORCEMENT RELATIVITY

The matching law makes a basic and important point about reinforcer effectiveness: We cannot predict how much behavior will be devoted to one option (e.g., on-task behavior by children in a classroom) just by knowing how much reinforcement is available for that behavior. We must also know how much reinforcement is available for other behaviors (e.g., off-task behaviors). Using a laboratory example, if pressing one lever delivers 20 reinforcers per hour, we cannot predict how much time a rat will spend pressing that lever unless we know whether pressing a second lever produces 60 reinforcers per hour or only 5 reinforcers per hour. The effects of reinforcement are relative: We must take into account the context—all the other reinforcers that are available for other behaviors.

As a real-world example, try to predict how a young child's behavior would be altered by giving him a new reinforcer—a yo-yo, for example. To make any sensible prediction, we need to know something about the context. If the yo-yo is given on an average rainy day in August, the child may play with the yo-yo for hours because he may be bored with all his other toys and indoor activities. On the other hand, if the yo-yo is given on Christmas and the context includes a host of new toys—trucks, video games, puzzles—the amount of time spent playing with the yo-yo will probably be small. The rich supply of other reinforcers will attract most of the child's time.

Other examples where the total reinforcement context plays a major role are easy to imagine. Many people claim that they tend to eat more when they are bored. This presumably happens not because the reinforcing value of food actually increases when one is bored, but rather because there are few reinforcers available to compete with eating. As another example, imagine that you are sitting in a reception area waiting for an appointment with someone who is running behind schedule (such as your mechanic or your optometrist). There is little to do but wait, and if you are like me, you may find yourself reading magazines you would not ordinarily spend your time on, such as 2-year-old issues of *Newsweek*, *Good Housekeeping*, or *Optometry Today*. What little reinforcement value these outdated magazines offer takes on added significance in the absence of any alternative sources of reinforcement.

THEORIES OF CHOICE BEHAVIOR

In many areas of science, it is important to distinguish between descriptions and explanations. For example, the statement that water increases in volume when it freezes is simply a description—it does not explain why this expansion occurs. Descriptive statements can be extremely useful in their own right because they can help us to predict and control future events (e.g., avoiding the bursting of outdoor water pipes by draining them before they freeze). On the other hand, a statement that attributes this expansion to the crystalline structure that hydrogen and oxygen molecules form when in a solid state can be called an explanation: It is a theory about the molecular events that underlie this phenomenon.

The matching equation can be viewed as either simply a description of choice behavior or a theory about the mechanisms of choice behavior. We have seen that as a description of behavior in certain choice situations, the matching equation is fairly accurate. We will now consider the possibility that the matching law is an explanatory theory and compare it to a few other theories that have been presented as possible explanatory theories of choice.

Matching as an Explanatory Theory

Herrnstein (1970) suggested that the matching equation is also a general explanatory theory of choice behavior. The theory is quite simple: It states that animals exhibit matching behavior because they are built to do so. That is, in any choice situation, an animal measures the value of the reinforcement it receives from each alternative (where "value" includes such factors as the rate, size, and quality of the reinforcers), and the animal then distributes its behavior in proportion to the values of the various alternatives. According this theory, matching is not just a description of behavior in concurrent VI schedules. It is a general principle that explains how animals and people make choices in all situations, in the laboratory and in the real world.

Optimization Theory

One major competitor for matching theory is **optimization theory**. As discussed in Chapter 8, some psychologists and economists have proposed that optimization theory is a general explanatory theory of choice for both humans and nonhumans, and many experiments have supported the predictions of this theory. Some psychologists have proposed that optimization theory can also explain why matching occurs on concurrent VI schedules (Silberberg, Thomas, & Berendzen, 1991). They propose that although the matching law may provide a satisfactory description of behavior in these situations, optimization theory actually provides an explanation of matching behavior.

To understand this logic, imagine a pigeon on a concurrent VI 30-second (left-key) VI 120-second (right-key) schedule. Rachlin, Green, Kagel, and Battalio (1976) used computer simulations to determine how different ways of distributing responses between the two keys would affect the total rate of reinforcement. The results of these simulations are presented in Figure 12.3. If a pigeon made all of its responses on the left key, it would obtain about 120 reinforcers per hour (which is shown by the point at the extreme right in Figure 12.3). If the pigeon responded only on the right key, it would collect about 30 per hour (the point at the extreme left in Figure 12.3). By making some responses on each

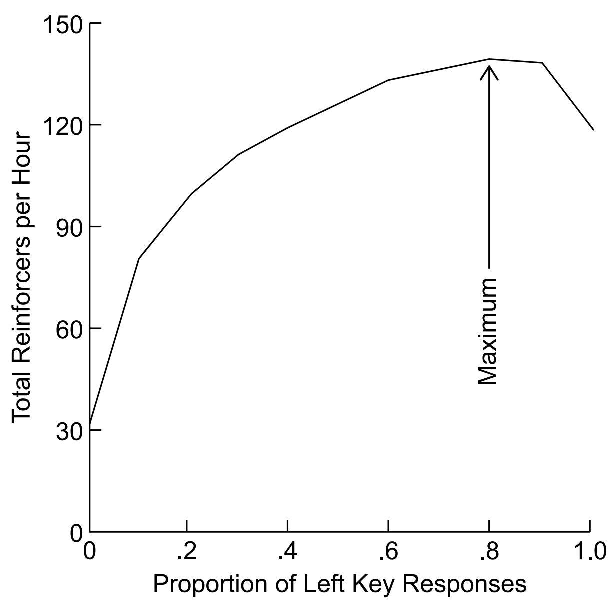

Figure 12.3 Predictions of the computer simulations of Rachlin et al. (1976) for a concurrent VI 30-second (left-key) VI 120-second (right-key) schedule. According to the predictions, a subject on this schedule would maximize the rate of reinforcement by making 80% of its responses on the left key.

key, however, the pigeon could collect many of the reinforcers from both schedules. The computer simulations showed that a pigeon could obtain the highest possible rate of reinforcement by making 80% of its responses to the left key, which is also the point of matching behavior (because in this example the left key delivers 80% of the reinforcers). Rachlin et al. claimed that with any typical pair of VI schedules, matching behavior will maximize the rate of reinforcement. To put it simply, they proposed that matching occurs with concurrent VI schedules because it is the optimal way to respond—matching produces the highest total rate of reinforcement.

Tests of Optimization Versus Matching

A common strategy when comparing scientific theories is to find a situation for which the theories make distinctly different predictions and then to conduct the appropriate experiment to see what actually happens. Quite a few experiments have examined choice situations for which the matching law makes one prediction and optimization theory makes a very different prediction.

An experiment with pigeons that I conducted was also designed to compare the two theories (Mazur, 1981). In many ways, my experiment was similar to Herrnstein's (1961) original experiment on matching. Pigeons could peck at either of two keys, one red and one green. Occasionally, a peck on one of the keys would cause the key lights to go off, and food was presented for 3 seconds. One main difference in my procedure, however, was that a single VI schedule randomly assigned the food deliveries to the two keys, whereas Herrnstein used two separate VI schedules. This was an important difference because whenever food was assigned to one key, the VI clock stopped until the food was collected. This meant that a pigeon had to respond on both keys frequently to keep the VI clock moving. Therefore, the optimal strategy was for the pigeon to make half of its responses on each key, switching back and forth frequently, because this kept the clock moving and kept the food deliveries coming.

In one condition, where the food deliveries per hour were equal for the two keys, the pigeons did perform optimally, making about 50% of their responses on each key (which was also matching, of course). However, a second condition provided the critical test between optimization and matching. In this condition, 90% of the food deliveries for the red key were replaced with "dark-key periods"—the keys went dark for 3 seconds, but no food was delivered. Despite this change, the optimal strategy was still to switch back and forth between the two keys frequently, making about 50% of one's responses on each key. This strategy would ensure that the VI timer would be running most of the time. However, the matching law predicted that the pigeons should now make many more responses on the green key, since this key now provided about 10 times as many food reinforcers. That is what happened: The pigeons shifted most of their responses to the green key and made an average of 86% of their responses on the green key (which delivered about 92% of the reinforcers). However, because they responded so little on the red key, the VI clock was often stopped, and as a result, the pigeons lost about 29% of their potential reinforcers. In other conditions, the pigeons lost three quarters or more of their potential reinforcers by matching rather than optimizing.

The procedure of this experiment may seem complex, but the results can be stated simply: Although optimization theory predicted that the birds should always make about 50% of their responses on each key, they consistently showed a preference for whichever key delivered more reinforcers, as predicted by the matching law. But by doing so, they slowed down the VI clock and lost many potential reinforcers, which is exactly the opposite of what optimization theory predicted should happen.

Psychologists have used a variety of other experimental procedures to compare the predictions of the matching law and optimization theory. For example, in choice situations involving both a VI schedule and a VR schedule, optimization theory predicts that animals should make most of their responses on the VR schedule because most of the responses on any VI schedule are wasted, whereas every response on a VR schedule brings the animal closer to reinforcement. Several experiments with animals failed to support this prediction, and the results were consistent with the predictions of the matching law (DeCarlo, 1985; Vyse & Belke, 1992). Similar results were obtained in a study with college students working for money: The students spent more time on the VI schedule than predicted by optimization theory, and their choices were closer to the predictions of the matching law (Savastano & Fantino, 1994).

Many other experiments, some with animals and some with humans, have been conducted to test the predictions of the matching law and optimization theory. Some have found evidence supporting the matching law and inconsistent with optimization theory (Jacobs & Hackenberg, 2000; Heyman & Herrnstein, 1986). However, others have supported optimization theory (MacDonall, Goodell, & Juliano, 2006; Sakagami, Hursh, Christensen, & Silberberg, 1989). With some evidence supporting each theory, some psychologists continue to favor optimization theory, whereas others favor matching theory.

Because they deal with an individual's overall distribution of responses over long periods of time (e.g., over an entire experimental session), matching theory and optimization theory can both be classified as molar theories (see Chapter 6). Some researchers now believe that more complete explanations of choice behavior will be found in molecular theories, which attempt to predict moment-to-moment behavior and which assume that short-term consequences have large effects on choice. One molecular theory of choice is presented in the next section.

Momentary Maximization Theory

Stated simply, the basic premise of **momentary maximization theory** is that at each moment, an individual will select whichever alternative has the highest value at that moment. Although both momentary maximization theory and optimization theory state that people and animals attempt to maximize the value of their choices, the two theories often make different predictions because the best choice in the short run is not always the best choice in the long run. As a simple example, consider a dieter who must choose between low-fat yogurt and a strawberry sundae for dessert. The strawberry sundae may appear more attractive at the moment, but the yogurt might be the better alternative for the dieter in the long run. Choices that involve a conflict between short-term and long-term benefits will be examined later in the chapter, but for now the point is that the strategies of momentary maximization and overall optimization may lead to very different decisions.

To understand how momentary maximizing theory works, a concrete example may help. Before reading further, try playing the hypothetical gambling game described in Box 12.1.

BOX 12.1 APPLYING THE RESEARCH

Can You Use a Momentary Maximizing Strategy?

Imagine that you are allowed to play this game for nine trials. You are seated in front of a panel with two small doors, and on each trial you are allowed to open one of the two doors. There may be a dollar behind the door (which you win) or there may be no money. The following rules determine whether a dollar is deposited behind a door or not: Behind the panel and out of sight, there is a modified roulette wheel for each door, which is spun before each trial begins. The probability of winning is 10% on the roulette wheel for Door 1 and 20% on the wheel for Door 2. Therefore, on Trial 1 of the game, there may be a dollar behind both doors, behind one door, or behind neither door, depending on the outcome of spinning the wheel for each door. Which door would you choose on Trial 1?

Two additional rules apply for the next eight trials:

1. Once a dollar is deposited behind a door, it will remain there until you collect it. So if a dollar is deposited behind Door 1 on Trial 4, it will remain there until the next time you choose Door 1.
2. There will never be more than one dollar behind a door at one time. For instance, if a dollar is deposited behind Door 1 on Trial 4 and you do not collect it until Trial 7, the spinning of the wheel is irrelevant on Trials 5, 6, and 7, since no more dollars will be deposited behind Door 1. However, the spinning of the wheel for Door 2 will continue to be important on these trials since it might pay off on any trial. In other words, Door 2 is not affected by what is happening at Door 1, and vice versa.

In the table below, decide what door you would choose on each of the nine trials:

Trial 1:	Door 1	or	Door 2
Trial 2:	Door 1	or	Door 2
Trial 3:	Door 1	or	Door 2
Trial 4:	Door 1	or	Door 2
Trial 5:	Door 1	or	Door 2
Trial 6:	Door 1	or	Door 2
Trial 7:	Door 1	or	Door 2
Trial 8:	Door 1	or	Door 2
Trial 9:	Door 1	or	Door 2

For many people, choosing the momentary maximizing strategy is not easy. Return to the text to get an explanation of the strategy for this game.

For situations like the game described in Box 12.1, momentary maximization theory predicts that the player will choose whichever alternative has the higher probability of reinforcement on each trial. On the first two trials, Door 2 has the higher probability of reinforcement, and so it should be chosen. However, it can be shown (using some elementary rules of probability theory that will not be explained here) that after two choices of Door 2, the probability of a dollar behind Door 2 is still 20%, but the probability of a dollar behind Door 1 is 27.1% (because there are now three trials on which a dollar might have been deposited at Door 1). A momentary maximizer would therefore choose Door 1 on Trial 3. After checking Door 1 on Trial 3, it is best to go back to Door 2 on Trial 4 because now its winning probability is again greater than for Door 1. The pattern followed by a momentary maximizer on the nine trials would be 2, 2, 1, 2, 2, 1, 2, 2, 1. How close did your choices come to the momentary maximizing strategy?

This hypothetical gambling game is quite similar to concurrent VI schedules. The two roulette wheels are similar to two independent VI timers, and like VI clocks, the roulette wheels will only store one reinforcer at a time. Therefore, you can probably see what momentary maximizing theory predicts for concurrent VI schedules: There should be an orderly and cyclical pattern to an animal's moment-by-moment choices. Of course, those who advocate momentary maximizing theory do not expect an animal's performance to show perfect momentary maximizing, but they do predict that animals will show at least some tendency to choose the alternative that has the higher probability of reinforcement. For example, after an animal has made several consecutive responses on the better of two VI schedules, it should show a tendency to switch to the other VI (because a reinforcer may have been stored on this VI during the interim). According to momentary maximizing theory, matching behavior is simply an incidental by-product of an animal's orderly moment-by-moment choices. In contrast, molar theories do not predict that an animal's moment-to-moment behavior will exhibit any orderly patterns because these theories assume that an animal's behavior is controlled by variables (e.g., total reinforcement rate) that do not change from moment to moment.

When animals exhibit matching behavior, are there orderly moment-by-moment patterns in their behavior? It seems that sometimes there are but not always. Some studies have found evidence for the sort of moment-by-moment changes predicted by momentary maximizing theory (Shimp, 1966; Silberberg, Hamilton, Ziriax, & Casey, 1978), but others have not (Heyman, 1979; Nevin, 1969). In one interesting study, Hinson and Staddon (1983) continuously recorded the time since a pigeon sampled (pecked at) each of two VI keys. They reasoned that time is the critical independent variable since on VI schedules it is the passage of time and not the number of responses that actually determines the availability of a reinforcer. They showed that their pigeons could follow a momentary maximizing strategy if they used a fairly simple rule: If schedule 1 delivers, for example, three times as many reinforcers as schedule 2, you should check schedule 2 if the time since you last checked it is more than three times longer than the time since you last checked schedule 1. Hinson and Staddon showed that their pigeons' behaviors were by no means perfect from the standpoint of momentary maximization theory, but a majority of their responses did follow this rule.

More recently, many other studies have found additional evidence that animals' moment-to-moment choices are influenced by a variety of short-term factors, such as the time since their last response (Brown & Cleaveland, 2009) or which response has just delivered a reinforcer (Aparicio & Baum, 2009). These results do not necessarily support momentary maximizing theory, but they conclusively show that animals' moment-tomoment choices are affected by molecular events, not just the molar reinforcement contingencies.

Over the years, many other behavioral theories of choice have been proposed, some of which might be called *hybrid theories* because they assume that both molar and molecular variables affect choice (Fantino & Silberberg, 2010; Grace, 1994; Killeen, 1982). These theories are mathematically quite complex, and we will not examine them here. Regardless of which theory of choice proves to be most accurate, no one can dispute the more general claim of molecular theories that short-term factors have a large effect on choice behavior. The next section shows that when a small but immediate reinforcer is pitted against a large but delayed reinforcer, the small, immediate reinforcer is frequently chosen.

PRACTICE QUIZ 1: CHAPTER 12

1. According to the matching law, if an animal receives 75% of its reinforcers from one schedule, it will make ______ of its responses on that schedule.
2. If an animal receives 20% of its reinforcers from one schedule, but makes 30% of its responses on that schedule, this is called ______.
3. _____ theory states that individuals will make choices that give them the greatest value in the long run.
4. In experiments designed to compare the predictions of optimization theory and the matching law, the results have usually supported ______.
5. According to ______ theory, an individual will choose whichever alternative has the highest value at that moment.

ANSWERS

1. 75% 2. undermatching 3. optimization 4. the matching law 5. momentary maximization

SELF-CONTROL CHOICES

Every day, people make many choices that involve a conflict between their short-term and long-term interests. Think of a college student who has a class that meets early Monday morning, and in this course it is important to attend each lecture. On Sunday evening, the student sets her alarm clock so that she can awaken early enough to get to class on time. She has chosen going to class (and the improved chances for a good grade this will bring) over an hour of extra sleep. This sounds like a prudent choice, but unfortunately she has plenty of time to change her mind. When the alarm clock rings on Monday morning, the warmth and comfort of the bed are more appealing than going to class, and the student turns off the alarm and goes back to sleep. Later in the day, she will probably regret her choice and vow not to miss class again.

This example is a typical **self-control choice** situation, that is, one involving a choice between a small immediate reinforcer and a larger but more distant reinforcer. The small reinforcer is the extra hour of sleep, and the larger, delayed reinforcer is the better grade that will probably result from going to class. An important characteristic of self-control situations is that a person's preferences can change systematically as time passes. On Sunday evening, the young woman evidently preferred going to class (and its long-term benefits) over an extra hour of sleep, since she set the alarm for the appropriate time. The next morning, her preference had changed, and she chose the extra hour of sleep. Later that day, she regrets this choice and decides to make a different decision in the future.

In case you are not convinced that self-control situations are commonplace, consider the following everyday decisions. You should be able to identify the small, more immediate reinforcer and larger, delayed reinforcer in each case:

1. To smoke a cigarette or not to smoke.
2. To keep the thermostat at 65°F during the winter months or set it at a higher temperature and face a larger fuel bill at the end of the month.
3. When on a diet, to choose between low-fat yogurt or ice cream for dessert.
4. To shout at your roommate in anger or control your temper and avoid saying something you do not really mean.
5. To save money for some big item you want (e.g., a car) or spend it on parties each weekend.

For each example, you should also be able to see how one's preference might change over time. It is easy to say you will begin a diet—tomorrow. On Monday or Tuesday, it is easy to decide you will have a frugal weekend and begin saving for that car. It is much harder, however, to keep these commitments when the time comes to make your final choice. Herrnstein and Mazur (1987) argued that this tendency to switch preferences over time in self-control choices is one of the strongest pieces of evidence against optimization theory. If people followed the strategy that optimized their satisfaction in the long run, they would consistently choose one alternative or the other.

BOX 12.2 SPOTLIGHT ON RESEARCH

Measuring Delay Discounting

Self-control choices illustrate quite dramatically how the strength or value of a reinforcer decreases as its delay increases. This effect is called **delay discounting**. To get an idea of how delay discounting works, imagine that you have won a prize in a lottery, and you can choose to receive either $1,000 in one year or a smaller amount of money today. Before reading further, take a moment to answer the questions below. There are no right or wrong answers; just try to answer as if these choices were real.

For each choice below, pick either A or B. Which would you rather have:

A. $1000 today	or	B. $1000 in 1 year
A. $950 today	or	B. $1000 in 1 year
A. $900 today	or	B. $1000 in 1 year
A. $800 today	or	B. $1000 in 1 year
A. $700 today	or	B. $1000 in 1 year

A. $600 today or B. $1000 in 1 year
A. $500 today or B. $1000 in 1 year
A. $400 today or B. $1000 in 1 year
A. $300 today or B. $1000 in 1 year
A. $200 today or B. $1000 in 1 year
A. $100 today or B. $1000 in 1 year
A. $50 today or B. $1000 in 1 year

When given a series of hypothetical choices like these, most people start by choosing Option A, but at some point their preference switches to Option B. For instance, suppose that a college student selected Option A when it was $700 today, but for the next question ($600 today), he chose Option B ($1000 in a year). Because his preference switched between $700 and $600, we can conclude that somewhere in between these two values there is an **indifference point**—a combination of delays and amounts that the student finds equally preferable. For this student, we could estimate that receiving $650 today would be about equal in value to receiving $1,000 in 1 year (because $650 is half-way between $700 and $600).

Questions like these have been used in numerous studies to measure delay discounting to estimate how the value of a reinforcer like money decreases with delay. Green, Fry, and Myerson (1994) compared three different age groups and found that the rates of delay discounting were fastest for 12-year-old children, slower for 20-year-old college students, and slowest for adults in their 60s. In other words, the older people were more willing to wait for the larger, delayed reward than were the younger people. Other studies have found faster rates of delay discounting for smokers than for nonsmokers (Mitchell, 1999), and it is also faster for individuals with addictions to drugs or alcohol (Bickel, Koffarnus, Moody, & Wilson, 2014) and for pathological gamblers (MacKillop et al., 2014). Many factors can affect the rate of delay discounting, and it varies both from person to person and from situation to situation (Odum, 2011).

The Ainslie–Rachlin Theory

The concept of delay discounting is not hard to understand, but we need to take this idea one step further to explain why a person's choices change as time passes. Why does a student set the alarm in the evening for an early morning class but then stay in bed the next morning and skip class? To answer questions like this, George Ainslie (1975) and Howard Rachlin (1970) independently developed similar ideas about self-control, which are known as the **Ainslie–Rachlin theory**.

Relying on the concept of delay discounting, the theory assumes that the value of a reinforcer decreases as the delay between making a choice and receiving the reinforcer increases. The upper panel of Figure 12.4 shows that the value of a good grade is high at the end of the term, but on the Sunday and Monday in question, its value is much lower because it is so far in the future. In the lower panel, the value of an hour of extra sleep at different points in time is also shown, and the same principle of delay discounting applies to this reinforcer: Its value decreases as its delay increases. The second assumption of the theory is that an individual will choose whichever reinforcer has the higher value at the moment a choice is made. Notice that the way the curves are drawn in Figure 12.4, the value of the good grade is higher on Sunday evening, which explains why the student sets the alarm with the intention of going to class. On Monday morning, however, the value of an hour of extra sleep has increased substantially because of its proximity. Because it is now greater than that of the good grade, the student chooses the more immediate reinforcer.

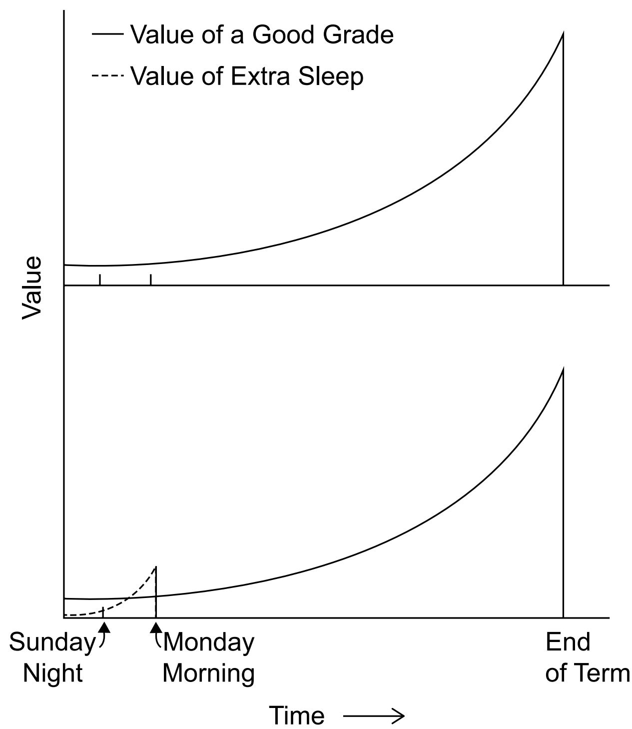

Figure 12.4 An application of the Ainslie–Rachlin model to the hypothetical example described in the text. The top panel shows how the subjective value of a good grade increases as the time of its delivery gets closer. The bottom panel shows that the value of a bit of extra sleep also increases as the time of its delivery gets closer. Because of these changes in value, a person may prefer the good grade at some times (e.g., Sunday evening) and the extra sleep at other times (say, Monday morning).

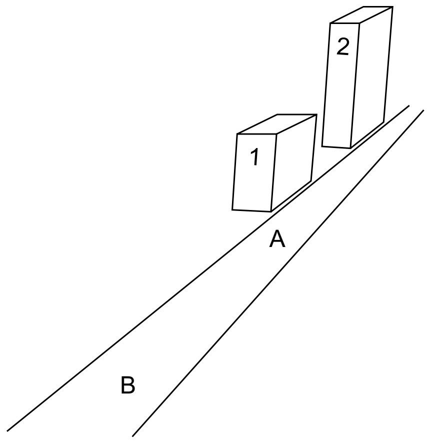

Figure 12.5 For a person standing at point A, building 1 subtends a larger visual angle than building 2. The opposite is true for a person standing at point B. This situation is somewhat analogous to a self-control situation if we replace physical distance with time and think of the large, distant building as a large, delayed reinforcer and the small, closer building as a small, more immediate reinforcer.

If you find the curves in Figure 12.5 difficult to understand, it may help to draw an analogy between time and distance. Figure 12.5 is a sketch of a long street with two buildings on the left. The buildings are analogous to the two reinforcers in a self-control situation. Building 2 is clearly larger, but for a person standing at point A, building 1 would subtend a greater visual angle. We might say that from the perspective of point A, building 1 appears larger. However, if the person walked to point B, both buildings would appear smaller, but now the visual angle subtended by building 2 would be the larger of the two. By stepping back from both buildings, a person can get a better perspective on their relative sizes. Similarly, by examining two reinforcers (say, an extra hour of sleep and a better grade) from a distance (e.g., the night before a class), a person "gets a better perspective" on the values of the two reinforcers and is more likely to choose the "larger" one.

As you can probably see, the student's problem is that she is free to change her mind on Monday morning, when the proximity of the extra hour of sleep gives her a distorted perspective on its value. One strategy for avoiding this problem is called **precommitment**: The individual makes a decision in advance, which is difficult or impossible to change at a later time. For example, on Sunday evening the student might ask a friend from the same class to come and get her on the way to class Monday morning and not to take "no" for an answer. This would make it more difficult and more embarrassing to stay in bed. In short, the student could make a precommitment to go to class by having a friend pick her up. The technique is a very effective way to avoid making an impulsive choice.

Animal Studies on Self-Control

Some of the research supporting the Ainslie–Rachlin theory has used animal subjects. A study by Green, Fischer, Perlow, and Sherman (1981) demonstrated the sort of preference reversals we would expect if the Ainslie–Rachlin theory is correct. Pigeons received many trials each day, and on each trial a bird made its choice by pecking just once at one of two keys. A peck at the red key delivered 2 seconds of grain, and a peck at the green key delivered 6 seconds of grain. There was, however, a short delay between a peck and the delivery of the grain. For example, in one condition there was a 2-second delay for the 2-second reinforcer and a 6-second delay for the 6-second reinforcer (Figure 12.6). In this condition, the birds showed impulsive behavior on nearly every trial, choosing the 2-second reinforcer. This choice did not speed up future trials because the trials occurred every 40 seconds regardless of which choice was made. This behavior is certainly inconsistent with optimization theory because the optimal solution would be to choose the 6-second reinforcer on every trial. By consistently choosing the smaller but more immediate reinforcer, the birds lost about two thirds of their potential access to grain. In another condition, the experimenters simply added 18 seconds to the delay for each reinforcer, so the delays were now 20 seconds and 24 seconds. When they had to choose so far in advance (similar to making a precommitment), the birds' behaviors were more nearly optimal: They chose the 6-second reinforcer on more than 80% of the trials. This shift in preference when both reinforcers are farther away is exactly what the Ainslie–Rachlin model predicts.

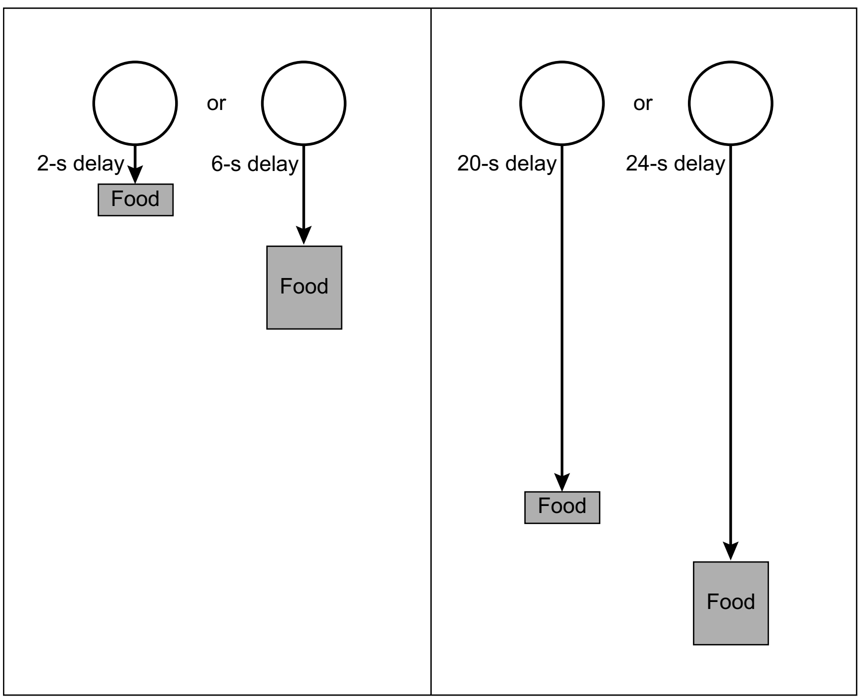

Figure 12.6 The procedure in two conditions used by Green et al. (1981). When the delays to the small and large reinforcers were 2 s and 6 s, pigeons usually chose the small reinforcer (left panel). When 18 additional seconds of delay were added to both options (right panel), pigeons usually chose the larger reinforcer.

When the alternatives in a self-control situation are punishers rather than reinforcers, they have the reverse effect on choice. In one study, rats tended to choose a large, delayed shock over a smaller but more immediate one. However, when they could make a precommitment a few seconds before the trial began to the smaller but more immediate shock, they frequently did so (Deluty, Whitehouse, Mellitz, & Hineline, 1983). This study provides one more example of how reinforcers and punishers have symmetrical but opposite effects on behavior.

Other research with animals has examined factors that may make them more or less likely to choose a more preferred but delayed reinforcer. Grosch and Neuringer (1981) gave pigeons choices between two different types of grain: A pigeon could either wait 15 seconds and then eat a preferred grain or peck a key and receive a less preferred type of grain immediately. The pigeons must have had a strong preference for the delayed reinforcer because Grosch and Neuringer found that they would wait for this reinforcer on about 80% of the trials. The experimenters then made one small change in the procedure: The two types of food were now placed where they were visible to the pigeons (behind a transparent barrier) throughout the waiting period. With the food in plain sight, the pigeons became much more impulsive, and they waited for the preferred type of grain on only about 15% of the trials. The sight of the food evidently provided too much of a temptation to resist. In another study, Grosch and Neuringer found that stimuli associated with the food reinforcers had a similar effect. In this case, no food was visible during the waiting interval, but the food hoppers were lit with the same colored lights that normally accompanied the presentation of food. Like the presence of food itself, the colored lights made the pigeons more likely to choose the immediate, less desirable grain.

Grosch and Neuringer (1981) also found that their pigeons were more likely to wait for the delayed reinforcer if they had the opportunity to engage in some other activity during the delay. They taught the birds to peck on a key in the rear of the chamber, which at first delivered food on an FR 20 schedule. Not surprisingly, the birds found it easier to wait for preferred grain when they could spend the delay working on the FR 20 schedule. More surprisingly, when the rear key no longer delivered any reinforcers, the birds continued to peck at it during the delays for the rest of the experiment with no signs of extinction.

These studies illustrate a few of the factors that have been found to affect the self-control choices of animal subjects. The next section shows that these same factors affect children's choices.

Factors Affecting Self-Control in Children

The experiments of Grosch and Neuringer were patterned after a series of experiments conducted with children by Walter Mischel and his colleagues. In one experiment (Mischel & Ebbesen, 1970), preschool children (tested one at a time) were given a choice between waiting 15 minutes for a preferred reinforcer (e.g., pretzels) versus receiving a less preferred reinforcer (e.g., cookies) immediately. During the 15-minute wait, a child could terminate the trial at any time and get the less preferred snack. Like the pigeons of Grosch and Neuringer, the children found it much more difficult to wait when the reinforcers were visible (in an open cake tin in front of the child). In another study, Mischel, Ebbesen, and Zeiss (1972) told some children that they could "think about the marshmallow and the pretzel for as long as you want." Other children were given no such instructions. The children who were encouraged to think about the reinforcers chose to terminate the trial and obtain the less preferred reinforcer more frequently. The researchers also found that children were more likely to wait for the preferred reinforcer when given an activity to engage in during the delay (some children were given a toy).

Just as with adults, there are substantial individual differences among children in their self-control abilities: Some children will wait for quite a while for a delayed reinforcer and others will not. It seems that some 2- or 3-year-olds have already learned the strategy of diverting their attention away from the desired objects as a way of avoiding an impulsive choice (Cournoyer & Trudel, 1991). Researchers have found that the tendency to wait for a large delayed reinforcer is related to a child's age, IQ, and other factors. One study reported that the quality of a toddler's interactions with his or her mother is related to self-control ability 4 years later. Children who had "responsive, cognitively stimulating parent–toddler interactions" (p. 317) at age 2 tended to be less impulsive at age 6 (Olson, Bates, & Bayles, 1990).

Mischel (1966) found that a child's behavior in a self-control situation can be influenced by observational learning. When choosing between an inferior product they could have immediately and a better product after a two-week delay, fourth and fifth graders tended to select whichever they saw an adult model choose. Fading procedures can also be used to help children learn to tolerate delays to reinforcement. Schweitzer and Sulzer-Azaroff (1988) taught a group of impulsive preschoolers to wait for a larger, delayed reinforcer by beginning with very short delays and progressively increasing the delays as the training proceeded. Similar procedures have been used for children with hyperactivity and attention-deficit disorder (Bloh, 2010) and for adults with developmental disabilities (Dixon, Rehfeldt, & Randich, 2003).

Techniques for Improving Self-Control

Behavior therapists can offer quite a few suggestions to clients who wish to avoid impulsive behaviors in such varied realms as dieting, maintaining an exercise program, studying regularly, saving money, and avoiding excessive drinking or smoking. The strategy of precommitment can be used in many self-control situations. People who wish to lose weight are advised to shop for food when they are not hungry and to purchase only foods that are low in calories and require some preparation before they can be eaten. (You cannot impulsively eat some high-calorie snack if there are no such snacks in the house.) People who habitually spend money impulsively are advised to make a list before they go shopping, to take only enough money to buy what they need, to destroy their credit cards, and to avoid going to a shopping mall without some definite purpose in mind. Similarly, people prone to excessive gambling should bring only a limited amount of money to the casino or use debit cards that set limits on how much they can lose before they are forced to stop (Nower & Blaszczynski, 2010). All of these strategies make it more difficult for the person to spend money on the spur of the moment because it seems appealing at the time (Figure 12.7).

Figure 12.7 Making arrangements to work out with friends is a type of precommitment which makes it less likely that you will back out at the last moment. (Visionsi/Shutterstock.com)

Anything that either increases the value of the delayed alternative or decreases the value of the immediate alternative should make the choice of the delayed reinforcer more likely. One useful strategy, therefore, is to provide an additional, immediate reward for choosing the large, delayed reinforcer. For instance, a dieter may make an agreement with himself that he will watch his favorite evening television program only if he skips dessert. A college student may allow herself to go out with friends for a snack only after she has studied in the library for two solid hours. A common problem with this strategy, however, is that it is easy to "cheat"—to give yourself the reinforcer even when you have failed to perform the appropriate behavior. For this reason, it is advisable to enlist the help of a friend or family member. The dieter's wife might make sure he only watches his television program if he did not have dessert. The college student may go to the library with a conscientious roommate who makes sure she has spent 2 hours studying before they go out for a snack.

The complementary strategy is to decrease the value of the impulsive option by attaching some form of punishment to it. Ross (1974) reported a case in which this technique was used to cure a woman of an impulsive nail-biting habit. As part of her treatment, the woman gave the therapist a deposit of $50 and agreed that the money would be donated to an organization she intensely disliked if her nails did not grow a certain length each week. Another strategy makes use of rule-governed behavior (see Chapter 6). The basic idea is that people can be taught to use verbal rules to guide their choices toward the larger, delayed reinforcer. For example, Benedick and Dixon (2009) taught individuals with developmental disabilities to exhibit more self-control simply by having them read out loud a card stating that it was better to pick the larger, delayed option.

Other strategies have a more cognitive flavor, because people are taught to use specific thought processes to improve their self-control. For instance, a person on a diet may be advised to visualize the attractive, healthy body he or she is striving for before sitting down to eat. A similar tactic is to tape on the refrigerator door a picture of an attractive person in a swimsuit to remind you of your long-term goal each time you have the urge for a snack. The idea behind this approach is that a picture or visual image somehow bridges the gap between the present and the long-term goal, thereby increasing the subjective value of that goal. Conversely, research on the treatment of drug addictions suggests that distracting the individual can be helpful, presumably because thinking about something else reduces the subjective value of the drug (Ashe, Newman, & Wilson, 2015).

All of these strategies show that there is more to self-control than simple determination and willpower. People who blame their impulsive behaviors on a lack of willpower may actually be lacking only the knowledge of how to apply the appropriate strategies.

OTHER CHOICE SITUATIONS

To conclude this chapter on choice behavior, we will examine a few other situations where people's or animals' decisions seem paradoxical. In some cases, their decisions appear to be inconsistent; in others, they are self-defeating.

Risk Taking

In many everyday decisions, the outcomes are not certain. If you invest in a company, you cannot be certain whether its stock will increase or decrease in value. If you leave home without your umbrella, you cannot be certain that it will not rain. If you go to a party, you cannot be certain whether you will enjoy yourself. An interesting fact about choices involving uncertain consequences is that sometimes people seem to prefer a risky alternative, and sometimes they prefer a safe alternative instead. The same has been found for animals. Researchers have tried to understand why individuals are sometimes risk prone (preferring a risky alternative) and sometimes risk averse (preferring a safer alternative).

In one experiment on this topic, Caraco, Martindale, and Whittam (1980) presented juncos (small birds) choices of the following type. Every trial, a junco could go to one of two feeding sites. If it went to one feeding site, it would receive one millet seed every time. If it went to the other feeding site, the bird had a 50% chance of finding two seeds and a 50% chance of finding none. If the trials followed one another rapidly (so there were plenty of opportunities to obtain food), the birds preferred the single, guaranteed millet seed. However, if the trials were separated by longer delays (so there were fewer opportunities to obtain food), the birds preferred the 50% chance of getting two seeds. Caraco concluded that these strategies maximize a junco's chances of survival in the wild. When food is plentiful, there is no need to take a risk because choosing small but certain food sources will guarantee that the bird has enough to eat. When food is scarce and the safe food sources do not provide enough food, the bird will choose riskier options with larger possible payoffs because the bird has nothing to lose—getting lucky with the risky option is the bird's only chance of survival.

Humans who need to earn a certain amount of money also tend to be risk prone when their resources are scarce and risk averse when their resources are plentiful (Pietras, Searcy, Huitema, & Brandt, 2008). March and Shapira (1992) suggested that both individuals (e.g., politicians) and groups (e.g., companies) are likely to take large risks when their survival (in a political campaign, in the marketplace) is at stake. However, they also proposed that besides being concerned merely with survival, individuals and groups also have aspiration levels (goals they wish to achieve), and their level of risk taking may depend on how close they are to their goals. For instance, a company may take large risks if its profits for the year are far below its goal, but if its profits are close to the goal, it may behave more conservatively. If the company's profits have exceeded the goal by a comfortable margin, the company may start to take greater risks once again. March and Shapira also proposed that other factors affect the level of risk taking by an individual or group, such as past habits, previous successes or failures, and self-confidence. Considering all of these factors, it is no wonder that it can be difficult to predict how a person will behave in a risky situation.

When it comes to games of chance, risk taking is always involved. Many people enjoy gambling—in casinos, in office pools, in state lotteries. Betting a few dollars a week may be harmless, but for some people gambling becomes excessive, and they create financial ruin for themselves and their families because of their gambling losses. Excessive betting on lotteries or in casinos makes little financial sense because the average gambler has to lose money (since state lotteries and casinos always make a profit). Why do people gamble, sometimes heavily, despite the fact that the odds are against them in the long run? Rachlin (1990) suggested that the preference for gambling is based on the possibility of obtaining an immediate reward. Consider the "instant lottery" games found in some states, in which you have a chance of winning money immediately (usually a fairly small amount) each time you buy a ticket. If you buy a ticket every day, you may sometimes go for weeks before you get a winner. But there is always a chance that you will win the very next time you play. Rachlin proposed that buying a lottery ticket is an attractive option for some people for the same reason that VR or VI schedules produce steady and persistent responding in the laboratory: In both cases, there is a chance that a reinforcer will be delivered almost immediately. As in so many choice situations, the power of immediate reinforcement is a crucial factor.

The Tragedy of the Commons

In an article entitled "The Tragedy of the Commons," Garrett Hardin (1968) described a situation that has far too many parallels in modern society. In many villages of colonial America, the commons was a grassland owned by the village, where residents could allow their cows to graze freely. The commons was therefore a public resource that benefited everyone as long as the number of grazing animals did not grow too large. This might not happen for decades or for centuries, but according to Hardin, it was inevitable that eventually there would be more animals than the commons could support. Then, because of overgrazing, the grass becomes scarce, erosion occurs, and the commons is destroyed, to the detriment of everyone.

Why did Hardin believe this unhappy scenario was inevitable? His reasoning was that it is to each herder's benefit to have as many cows as possible, for this will maximize one's income. Suppose a herder must decide whether to add one more cow to the herd. What are the benefits and costs to consider? The benefits are the profits to be earned from this cow, which go entirely to the owner of the cow. The cost is the extra strain imposed on the commons, but one additional cow will not make much of a difference, and besides, this cost is shared by everyone who uses the commons. Hardin therefore concluded that the herder will experience a net gain by adding the additional cow to the herd, and by adding a second cow, and so on: "But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all" (Hardin, 1968, p. 1244).

The **tragedy of the commons** is a scenario that has been acted out many times in our civilization. The buffalo herds on the American plains were hunted nearly to the point of extinction. Excessive fishing has ruined many of the world's richest fishing areas. With every acre of forestland that is turned into a highway or a shopping mall, there is less wilderness for everyone to enjoy.

Most problems of pollution have a similar structure. A company that must pollute the air in order to manufacture its product cheaply keeps the profits of its enterprise to itself; the air pollution is shared by everyone. Before we condemn big business, however, we should realize that individual people frequently make equally selfish decisions. Every person who drives to work in a large city (rather than walking, riding a bike, or taking public transportation) contributes to the air pollution of that city. The reason that many people behave selfishly in this situation is obvious: The driver alone receives the benefits of convenience and comfort that come from driving one's own car. If the driver chose to walk, the reduction in air pollution would be so slight as to be undetectable.

The tragedy of the commons can also be seen on a global level in the struggles among nations to develop international policies to deal with climate change (Murphy & Murphy, 2012). Even if national leaders are convinced that human activities are contributing to climate change, they may not want to change their own country's policies on greenhouse gases and other pollutants because this might hurt their country's economic prosperity. The short-term economic well-being of the country can seem more important than long-term global climate changes.

Another instance of the commons tragedy can be seen in the annual trade deficit of the United States, a consequence of the large amounts of foreign products that Americans buy. Most people know that the trade deficit hurts the economy and that it would be eliminated if people bought fewer foreign goods. Nevertheless, when an individual consumer is deciding which product to purchase, alleviating the trade deficit usually seems far less important than getting the best buy, regardless of whether the product is domestic or foreign.

Although there are many examples of the tragedy of the commons in modern life, Hardin (1968) and others have suggested several ways in which the tragedy can be averted (Platt, 1973; Sasaki, Brännström, Dieckmann, Sigmund, & Wachter, 2012). These suggestions will probably sound familiar, because in recent years our society has focused a good deal of attention on the problems of pollution, the extinction of wildlife, and the like, as well as on potential solutions. What is interesting, however, is the strong resemblance these remedies bear to the strategies that individuals can use to avoid impulsiveness in a self-control situation.

We saw that one powerful technique for improving self-control is the precommitment strategy in which an individual takes some action in advance that makes it difficult or impossible to make an impulsive choice later. Similarly, a society can decide to make it difficult or impossible for individuals to act selfishly. For example, a society can pass legislation that simply makes it illegal to dump dangerous chemicals where they might seep into the water supply, to pollute the air, or to kill a member of an endangered species.

Less coercive strategies for self-control situations are those that either attach a punisher to the small, immediate alternative or attach an additional (often immediate) reinforcer to the large, delayed alternative. These strategies do not make an impulsive choice impossible, only less likely. In a similar fashion, a city with traffic and pollution problems can punish the behavior of driving one's own car by prohibiting parking on city streets and by making it expensive to park in garages. Based on what we know about punishment, however, there should also be reinforcement for a desirable alternative behavior. For instance, the city should do all that it can to make public transportation convenient, reliable, safe, and inexpensive.

Finally, we should not underestimate the capacity of human beings to attend to and be influenced by the long-term consequences of their behaviors for society. Just as a picture on the refrigerator can remind a dieter of his or her long-term goal, educational programs and advertising campaigns can encourage individuals to alter their behaviors for the long-term benefits of the community (Figure 12.8). A good example is the personal sacrifices

Figure 12.8 Something as simple as a sign in a parking lot can help people make choices that are better for everyone in the long run.

civilians were willing to make for the war effort during World War II, not to mention the soldiers who gave their lives in the name of freedom. In some fishing communities, overfishing is avoided by informal agreements among individuals to limit their catches for the good of all (Leal, 1998). From a logical perspective, such behaviors may seem puzzling: Why should people behave in a way that is helpful to others but is harmful to them personally? One solution to this puzzle is simply to assert that, at least in certain circumstances, behaviors that benefit others can be inherently reinforcing for many people (just as eating, reading a novel, or exercising can be inherently reinforcing). Admittedly, this is not much of an explanation. But given the many examples of selfish behaviors we have been forced to consider, it is refreshing to remember that people will often make sacrifices when the only personal benefit from their behavior is the knowledge that they are promoting the common good.

PRACTICE QUIZ 2: CHAPTER 12

1. An individual who chooses a ______ reinforcer over a ______ reinforcer is said to be making an impulsive choice.
2. Making a choice of a large, delayed reinforcer in advance, so that later it is difficult to choose a smaller, more immediate reinforcer, is called ______.
3. In a self-control choice situation where the actual reinforcers are visible during a delay, both children and animals are more likely to choose the ______ reinforcer.
4. The rate of delay discounting is usually ______ for children than for adults.
5. If a person chooses an option with an uncertain outcome over one with a guaranteed outcome, the person is said to be ______.

ANSWERS

1. small, immediate; large, delayed 2. precommitment 3. smaller, more immediate 4. faster 5. risk prone

SUMMARY

The matching law states that the proportion of responses on each schedule tends to match the proportion of reinforcers delivered by that schedule. This law has been demonstrated with many different species of subjects, including people. However, three different types of deviations from exact matching are often found: undermatching, overmatching, and bias. The matching law has also been applied to other variables, such as reinforcer quality and amount. It follows from the matching law that the effects of a reinforcer on behavior are relative—they depend on what reinforcers are available for other behaviors.

Herrnstein proposed that matching is a fundamental property of behavior. A very different theory, optimization theory, states that individuals will distribute their responses in whatever way will maximize the reinforcement they receive. Most studies that compared the predictions of the matching law and optimization theory have favored the matching law; that is, subjects exhibited approximate matching even when this behavior decreased the overall amount of reinforcement. Momentary maximization theory states that, at each moment, an individual chooses whichever behavior has the highest value at that moment. Some experiments have found such moment-to-moment patterns in choice behavior that are predicted by this theory, but others have not.

In a self-control choice situation, an individual must choose between a small, fairly immediate reinforcer and a larger, more delayed reinforcer. Individuals frequently choose the small, immediate reinforcer, even though the larger reinforcer would be better in the long run. Studies with animals and children have demonstrated several factors that can affect choice in these situations. Making a precommitment to choose the larger, delayed reinforcer is an effective self-control strategy, as are adding additional reinforcers to the long-term alternative, adding punishers to the short-term alternative, or using cognitive strategies to focus attention on the long-term consequences of one's choices.

The effects of delay can also be seen in other choice situations, such as in risk-prone behavior (e.g., gambling when the odds are against winning). The tragedy of the commons occurs when individuals make decisions that benefit them in the short run but are harmful to society as a whole in the long run. Strategies similar to those used to improve self-control may also be helpful in such cases.

Review Questions

1. What is the matching law? Describe Herrnstein's experiment on matching, and discuss three ways that behavior can deviate from perfect matching.
2. Summarize the main differences between the matching law, optimization theory, and momentary maximizing theory. What has research found about the strengths and weaknesses of these competing theories?
3. Describe the Ainslie–Rachlin theory, and use an everyday example to show how it accounts for the reversals in preference that occur in self-control choices.
4. Describe several techniques a person could use to help him avoid eating foods that are high in fat and cholesterol.
5. What is the tragedy of the commons? Give a few modern-day examples of this problem and describe some strategies that can be used to overcome the problem.

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