

- b. What recording method would you have James use to record Sara's out-of-seat behavior?
  - c. What instrument would you have James use to record the behavior? Will this instrument be practical for James to use as a teacher?
3. Eve plans to start a weight-lifting program. She wants to record her behavior once she starts the program so that she can measure the changes in her behavior as the program progresses. Describe how Eve could use frequency recording, duration recording, and intensity recording to measure her weight-lifting behavior.

### MISAPPLICATIONS

1. Gloria is taking a behavior modification class and has to do a self-management project. The behavior she has chosen to modify is her hair-twirling. She has defined this behavior as any instance in which she reaches up to the back of her head and wraps hair around her finger. The first step in her self-management project is to develop a behavior recording plan. Because she usually does the hair-twirling in her classes, she decides to record the behavior immediately after each class period. She will keep a  $3 \times 5$ -inch note card in her purse, and as soon as she leaves the classroom, she will get the note card out of her purse and write down the number of times that she twirled her hair in the class.
  - a. What is wrong with this behavior recording plan?
  - b. What changes would you make to improve it?
2. Ralph is going to implement a self-management project to help him decrease the number of cigarettes he smokes per day. He will define the behavior of smoking a cigarette as any instance in which he takes a cigarette out of the pack in his pocket, lights it, and smokes any part of it. He will record the number of cigarettes he smokes each day by counting the cigarettes left in his pack at the end of the day and subtracting this number from the number of cigarettes that were in the pack at the start of the day.
  - a. What is wrong with this behavior recording plan?
  - b. What would you do to improve it?
3. Below are examples of behavioral definitions of target behaviors in students' self-management programs. What is wrong with each of these behavioral definitions?
  - a. Losing my temper will be defined as getting mad at my husband and yelling at him, walking into the bedroom and slamming the door, or telling him to "shut up" when he says something that frustrates me.
  - b. Overeating will be defined as any time I eat more than I wanted to eat at a meal, or any time I eat so much that I feel bloated or my belt is too tight.
  - c. Studying will be defined as any time I have my books open in front of me in the library or at my desk, the TV is off, and there are no other distractions.

# 3



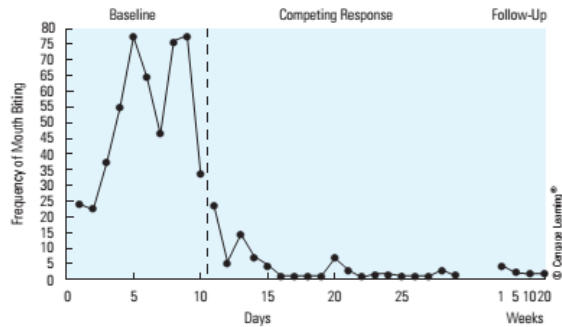
## Graphing Behavior and Measuring Change

- What are the six essential components of a behavior modification graph?
- How do you graph behavioral data?
- What different dimensions of behavior can be shown on a graph?
- What is a functional relationship, and how do you demonstrate a functional relationship in behavior modification?
- What different research designs can be used in behavior modification research?

**A**s we saw in Chapter 2, people who use behavior modification define their target behavior carefully, and directly observe and record the behavior. In this way, they can document whether the behavior has indeed changed when a behavior modification procedure is implemented. **The primary tool used to document behavior change is the graph.**

A **graph** is a visual representation of the occurrence of a behavior over time. After instances of the target behavior are recorded (on a data sheet or otherwise), the information is transferred to a graph. A graph is an efficient way to view the occurrence of the behavior because it shows the results of recording during many observation periods.

Behavior analysts use graphs to identify the level of behavior before treatment and after treatment begins. In this way, they can document changes in the behavior during treatment and make decisions about the continued use of the treatment. The graph makes it easier to compare the levels of the behavior before, during, and after treatment because the levels are presented visually for comparison. In Figure 3-1, for example, it is easy to see that the frequency of the behavior is much lower during treatment (competing response) than before treatment (baseline). This particular graph is from a student's self-management project. The student's target behavior involved biting the insides of her mouth when she studied. She recorded the behavior on a data sheet each time it occurred. After 10 days of recording the behavior without any treatment (baseline), she implemented a behavior modification plan in which she used a competing response (a behavior that is incompatible with mouth-biting and interrupts each occurrence of mouth-biting) to help her control the mouth-biting behavior. After implementing this competing response procedure, she continued to record the behavior for 20 more days. She then recorded the behavior four more times, after 1, 5, 10, and 20 weeks. The long period after treatment has been implemented is called the follow-up period. From this graph, we can conclude that the mouth-biting behavior (as recorded by the student) decreased substantially while the student implemented the treatment. We can also see that the behavior continued to occur at a low level up to 20 weeks after treatment was implemented.



**FIGURE 3-1** This graph shows the frequency of mouth-biting during baseline and treatment (competing response) phases and follow-up.

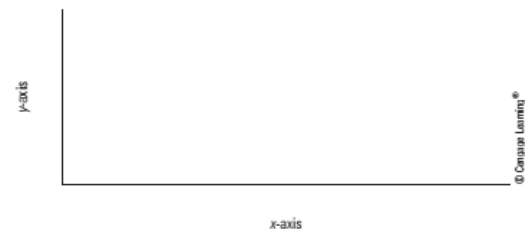
## Components of a Graph

In the typical behavior modification graph, time and behavior are the two variables illustrated. Each data point on a graph gives you two pieces of information: It tells you when the behavior was recorded (time) and the level of the behavior at that time. Time is indicated on the horizontal axis (also called the x-axis, or the abscissa), and the level of the behavior is indicated on the vertical axis (also called the y-axis, or the ordinate). In Figure 3-1, the frequency of mouth-biting is indicated on the vertical axis, and days and weeks are indicated on the horizontal axis. By looking at this graph, you can determine the frequency of mouth-biting on any particular day, before or after treatment was implemented. Because follow-up is reported, you can also see the frequency of the behavior at intervals of up to 20 weeks.

Six components are necessary for a graph to be complete.

- **The y-axis and the x-axis.** The vertical axis (y-axis) and the horizontal axis (x-axis) meet at the bottom left of the page. On most graphs, the x-axis is longer than the y-axis; it is usually one to two times as long (Figure 3-2).

- **The labels for the y-axis and the x-axis.** The y-axis label usually tells you the behavior and the dimension of the behavior that is recorded. The x-axis label usually tells you the unit of time during which the behavior is recorded. In Figure 3-3, the y-axis label is “Hours of Studying” and the x-axis label is “Days.”



**FIGURE 3-2** The y-axis and the x-axis.



**FIGURE 3-3** Labels for the y-axis and the x-axis.

Thus, you know that the hours of studying will be recorded each day for this particular person.

- **The numbers on the y-axis and the x-axis.** On the y-axis, the numbers indicate the units of measurement of the behavior; on the x-axis, the numbers indicate the units of measurement of time. There should be a hash mark on the y-axis and the x-axis to correspond to each of the numbers. In Figure 3-4, the numbers on the y-axis indicate the number of hours the studying behavior occurred, and the numbers on the x-axis indicate the days on which studying was measured.

- **Data points.** The data points must be plotted correctly to indicate the level of the behavior that occurred at each particular time period. The information on the level of the behavior and the time periods is taken from the data sheet or other behavior-recording instrument. Each data point is connected to the adjacent data points by a line (Figure 3-5).

- **Phase lines.** A phase line is a vertical line on a graph that indicates a change in treatment. The change can be from a no-treatment phase to a treatment phase, from a treatment phase to a no-treatment phase, or from one treatment phase to another treatment phase. A phase is a period in which the same treatment (or no treatment) is in effect. In Figure 3-6, the phase line separates baseline (no treatment) and treatment phases. Data points are not connected across phase lines. This allows you to see differences in the level of the behavior in different phases more easily.

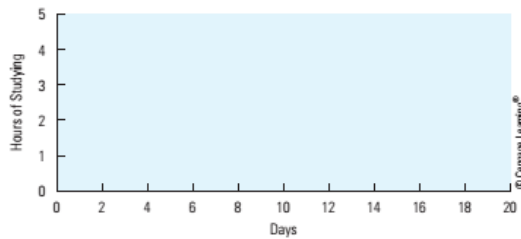


FIGURE 3-4 Numbers on the y-axis and the x-axis.

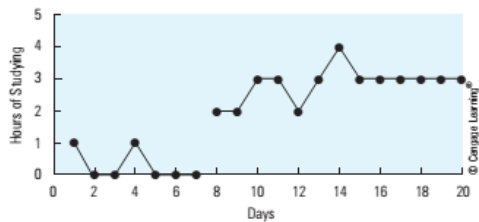


FIGURE 3-5 Data points plotted on a graph.

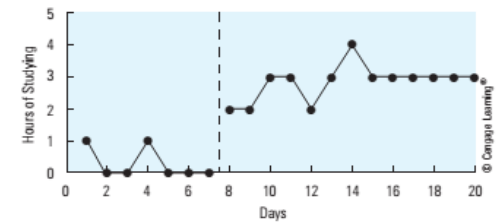


FIGURE 3-6 Phase line on a graph.

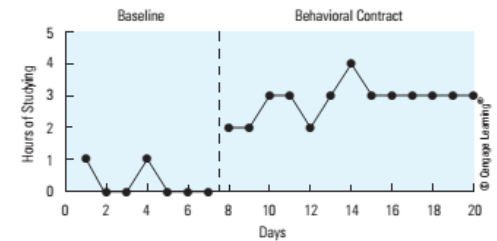


FIGURE 3-7 Phase labels on a graph.

- **Phase labels.** Each phase in a graph must be labeled. The phase label appears at the top of the graph above the particular phase (Figure 3-7). Most behavior modification graphs have at least two phases that are labeled: the no-treatment phase and the treatment phase. “Baseline” is the label most often given to the no-treatment phase. The label for the treatment phase should identify the particular treatment being used. In Figure 3-7, the two phase labels are “Baseline” and “Behavioral Contract.” The behavioral contract is the particular treatment the student is using to increase studying. Some graphs have more than one treatment phase or more than one baseline phase.

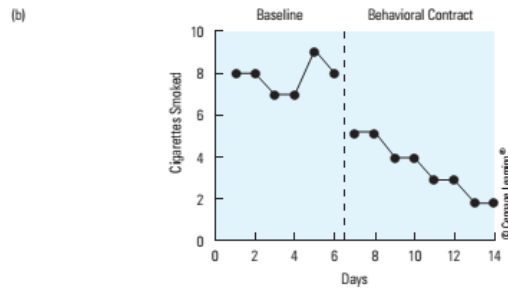
### Graphing Behavioral Data

As discussed in Chapter 2, behavioral data are collected through direct observation and recording of the behavior on a data sheet or other instrument. Once the behavior has been recorded on the data sheet, it can be transferred to a graph. For example, Figure 3-8a is a frequency data sheet that shows 2 weeks of behavior recording, and Figure 3-8b is a graph of the behavioral data from the data sheet. Notice that days 1–14 on the data sheet correspond to the 14 days on the graph.

(a)

Days	1	2	3	4	5	6	7	8	9	10	11	12	Daily Total
1	X	X	X	X	X	X	X	X					8
2	X	X	X	X	X	X	X	X					8
3	X	X	X	X	X	X	X						7
4	X	X	X	X	X	X	X						7
5	X	X	X	X	X	X	X	X	X				9
6*	X	X	X	X	X	X	X	X					8
7	X	X	X	X	X								5
8	X	X	X	X	X								5
9	X	X	X	X									4
10	X	X	X	X									4
11	X	X	X										3
12	X	X	X										3
13	X	X											2
14	X	X											2

\*Day 6 was the last day of baseline and day 7 was the first day of treatment.



**FIGURE 3-8** A completed frequency data sheet is shown in (a); the number of cigarettes smoked each day is recorded on the sheet. The graph of the behavioral data from the data sheet (b) is also shown. The treatment involved a behavioral contract in which the client agreed to smoke one fewer cigarette per day every second day. Behavioral contracts are described in Chapter 23.

Also notice that the frequency of the behavior listed on the data sheet for each day corresponds to the frequency recorded on the graph for that day. As you look at the graph, you can immediately determine that the frequency of the behavior is much lower during treatment than during baseline. You have to look more closely at the data sheet to be able to detect the difference between baseline and treatment. Finally, notice that all six essential components of a graph are included in this graph.

Consider a second example. A completed duration data sheet is shown in Figure 3-9a, and Figure 3-9b is a table that summarizes the daily duration of the behavior recorded on the data sheet. Notice that the duration of the behavior

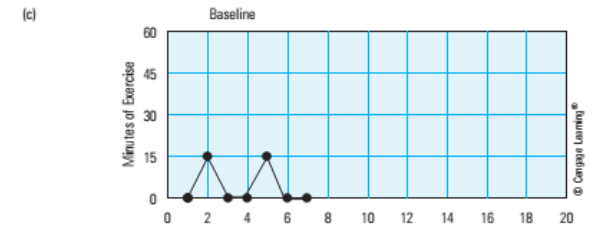
(a)

Days	Onset	Offset	Onset	Offset	Onset	Offset	Daily Duration
1							0
2	7:00	7:15					15
3							0
4							0
5	7:10	7:25					15
6							0
7*							0
8	7:00	7:15					15
9	7:30	8:00					30
10	7:30	8:00					30
11	6:30	6:45					15
12	6:45	7:15					30
13							0
14	7:00	7:30					30
15	6:30	6:45	7:00	7:30			45
16	6:45	7:15					30
17	6:30	7:15					45
18	7:00	7:30	7:45	8:00			45
19							0
20	6:45	7:15	7:30	8:00			60

\*Baseline ended on day 7. On day 8, the subject implemented treatment involving a behavioral contract.

(b)

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Duration (minutes)	0	15	0	0	15	0	0	15	30	30	15	30	0	30	45	30	45	45	0	60



**FIGURE 3-9** A completed duration data sheet is shown (a); the sheet is used to record the duration of exercise each day. The completed data summary table (b) is also shown. The incomplete graph (c) is for the student to complete using the behavioral data in (b).

listed in the summary table for each of the 20 days corresponds to the duration that was recorded each day on the data sheet.

?

Below the data summary table (see Figure 3-9b) is a graph that is only partially completed (see Figure 3-9c). Using the information provided in the data summary table, complete this graph. Be sure that the completed graph includes all six components discussed earlier.

To complete Figure 3-9c, you must add four components. First, you should add the data points for days 8–20 and connect them. Second, include the phase line between days 7 and 8. Data points on days 7 and 8 should not be connected across the phase line. Third, add the phase label “Behavioral Contract,” to the right of the phase line. Fourth, add the label “Days” to the x-axis. When these four components are added, the graph includes all six essential components (Figure 3-10).

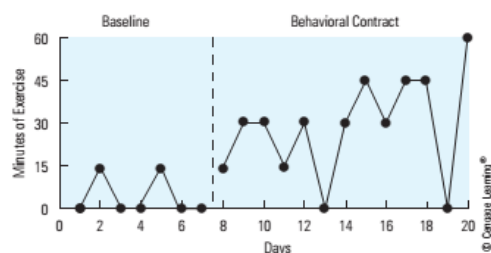


FIGURE 3-10 Completed graph using data from the data summary table in Figure 3-9b.

#### FOR FURTHER READING

##### Graphing in Excel

Although it is easy to construct a graph with a piece of graph paper, a ruler, and a pencil, there are graphing programs that allow you to construct a graph on your computer. Graphs can be constructed in two different Microsoft Office programs; PowerPoint and Excel (Vaneslow & Bourret, 2012). Carr and Burkholder (1998) and Dixon et al. (2007) published articles in the *Journal of Applied Behavior Analysis* providing step-by-step instructions on how to use Microsoft Excel for constructing the types of graphs used in applied behavior analysis or behavior modification. Vaneslow and Bourret (2012) described how to use an online tutorial about constructing graphs using Microsoft excel. Students interested in learning how to construct graphs in Excel are encouraged to read these articles.

### Graphing Data from Different Recording Procedures

Figures 3-8 and 3-10 illustrate graphs of frequency data and duration data, respectively. Because other types of data can be recorded, other types of graphs are possible. Regardless of the dimension of behavior or type of data that is being graphed, however, the same six components of a graph must be present. What will change

with different recording procedures are the y-axis label and the numbering on the y-axis. For example, if you are recording the percentage of math problems a student completes correctly during each math class, you would label the y-axis “Percentage of Correct Math Problems” and number the y-axis from 0% to 100%. As you can see, the y-axis label identifies the behavior (correct math problems) and the type of data (percentage) that is recorded.

Consider another example. A researcher is studying Tourette’s syndrome, a neurological disorder in which certain muscles in the body twitch or jerk involuntarily (these are called motor tics). The researcher uses an interval recording system and records whether a motor tic occurs during each consecutive 10-second interval in 30-minute observation periods. At the end of each observation period, the researcher calculates the percentage of intervals in which a tic occurred. The researcher labels the y-axis of the graph “Percentage of Intervals of Tics” and numbers the y-axis from 0% to 100%. Whenever an interval recording system is used, the y-axis is labeled “Percentage of Intervals of (Behavior).” The x-axis label indicates the time periods in which the behavior was recorded (e.g., “Sessions” or “Days”). The x-axis is then numbered accordingly. A session is a period in which a target behavior is observed and recorded. Once treatment is started, it is also implemented during the session.

Other aspects of a behavior may be recorded and graphed, such as intensity or product data. In each case, the y-axis label should clearly reflect the behavior and the dimension or aspect of the behavior that is recorded. For example, as a measure of how intense or serious a child’s tantrums are, you might use the label “Tantrum Intensity Rating” and put the numbers of the rating scale on the y-axis. For a measure of loudness of speech, the y-axis label might be “Decibels of Speech,” with decibel levels numbered on the y-axis. To graph product recording data, you would label the y-axis to indicate the unit of measurement and the behavior. For example, “Number of Brakes Assembled” is a y-axis label that indicates the work output of a person who puts together bicycle brakes.

### Research Designs

When people conduct research in behavior modification, they use research designs that include more complex types of graphs. The purpose of a **research design** is to determine whether the treatment (independent variable) was responsible for the observed change in the target behavior (dependent variable) and to rule out the possibility that extraneous variables caused the behavior to change. In research, an **independent variable** is what the researcher manipulates to produce a change in the target behavior. The target behavior is called the **dependent variable**. An extraneous variable, also called a confounding variable, is any event that the researcher did not plan that may have affected the behavior. For a person with a problem, it may be enough to know that the behavior changed for the better after using behavior modification procedures. However, a researcher also wants to demonstrate that the behavior modification procedure is what caused the behavior to change.

When a researcher shows that a behavior modification procedure causes a target behavior to change, the researcher is demonstrating a **functional relationship** between the procedure and the target behavior. That is, the researcher demonstrates that the behavior changes as a function of the procedure.

A functional relationship is established if:

- a target behavior changes when an independent variable is manipulated (a procedure is implemented), while all other variables are held constant, and
- the process is replicated or repeated one or more times and the behavior changes each time.

A behavior modification researcher uses a research design to demonstrate a functional relationship. A research design involves both treatment implementation and replication. **If the behavior changes each time the procedure is implemented and only when the procedure is implemented, a functional relationship is demonstrated.**

In this case, we would say that the researcher has demonstrated experimental control over the target behavior. It is unlikely that an extraneous variable caused the behavior change if it changed only when the treatment was implemented. This section reviews research designs used in behavior modification (for further information on behavior modification research designs, see Bailey, 1977; Barlow & Hersen, 1984; Gast, 2009; Hayes, Barlow, & Nelson-Gray, 1999; Kazdin, 2010; Poling & Grossett, 1986).

### A-B Design

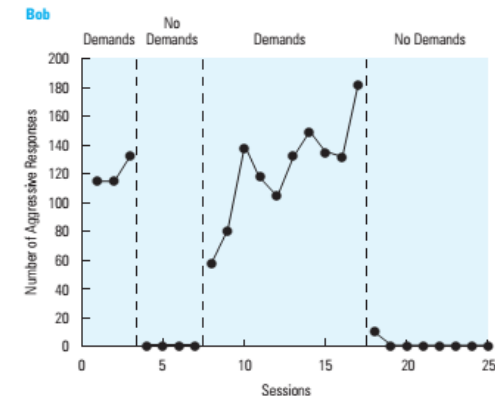
The simplest type of design used in behavior modification has just two phases: baseline and treatment. This is called an **A-B design**, where A = baseline and B = treatment. A-B designs are illustrated in Figures 3-1, 3-7, 3-8b, and 3-10. By means of an A-B design, we can compare baseline and treatment to determine whether the behavior changed in the expected way after treatment. **However, the A-B design does not demonstrate a functional relationship because treatment is not replicated** (implemented a second time). Therefore, the A-B design is not a true research design; it does not rule out the possibility that an extraneous variable was responsible for the behavior change. For example, although mouth-biting decreased when the competing response treatment was implemented in Figure 3-1, it is possible that some other event (extraneous variable) occurred at the same time as treatment was implemented. In that case, the decrease in mouth-biting may have resulted from the other event or a combination of treatment and the other event. For example, the person may have seen a TV show about controlling nervous habits and learned from that how to control her mouth-biting.

**The A-B design is not a true research design.** Because the A-B design does not include a replication and thus does not demonstrate a functional relationship, it is rarely used by behavior modification researchers. It is most often used in applied, nonresearch situations, in which people are more interested in demonstrating that behavior change has occurred than in proving that the behavior modification procedure caused the behavior change. You probably would use an A-B graph in a self-management project to show whether your behavior changed after you implemented a behavior modification procedure.

### A-B-A-B Reversal Design

The **A-B-A-B reversal design** is an extension of the simple A-B design (where A = baseline and B = treatment). In the A-B-A-B design, baseline and treatment phases are implemented twice. It is called a reversal design because after the first treatment phase, the researcher removes the treatment and reverses back to baseline. This second baseline is followed by replication of the treatment. Figure 3-11 illustrates an A-B-A-B design.

The A-B-A-B graph in Figure 3-11 shows the effect of a teacher's demands on the aggressive behavior of an adolescent with intellectual disability named Bob. Carr and his colleagues (Carr, Newsom, & Binkoff, 1980) studied the influence of demands on Bob's aggressive behavior by alternating phases in which teachers made frequent demands with phases in which teachers made no demands. In Figure 3-11, you can see that the behavior changed three times. In the baseline phase ("Demands"), the aggressive behavior occurred frequently. When the treatment phase ("No Demands") was first implemented, the behavior decreased. When the second "Demands" phase occurred, the behavior returned to its level during the first "Demands" phase. Finally, when the "No Demands" phase was implemented a second time, the behavior decreased again. The fact that the behavior changed three times, and only when the phase changed, is evidence that the change in demands (rather than some extraneous variable) caused the behavior change. When the independent variable was manipulated (demands were turned on and off each time), the behavior changed accordingly. It is highly unlikely that an extraneous variable was turned on and off at exactly the same time as the demands, so it is highly unlikely that any other variable except the independent variable (change in demands) caused the behavior change.



**FIGURE 3-11** This A-B-A-B graph shows the frequency of aggressive behaviors by an adolescent with intellectual disability during baseline phases involving demands and treatment phases involving no demands. (From Carr, E. G., Newsom, C. D., & Binkoff, J. A. [1980]. Escape as a factor in the aggressive behavior of two retarded children. *Journal of Applied Behavior Analysis*, 13, 101–117. Copyright © 1980 University of Kansas Press. Reprinted by permission of the author and the publisher.)

Variations of the A-B-A-B reversal design may be used in which more than one treatment is evaluated. Suppose for example, you implemented one treatment (B) and it did not work, so you implemented a second treatment (C) and it did work. To replicate this treatment and show experimental control, you might use an A-B-C-A-C design. If the second treatment (C) resulted in a change in the target behavior each time it was implemented, you are demonstrating a functional relationship between this treatment and the behavior.

A number of considerations must be taken into account in deciding whether to use the A-B-A-B research design. First, it may not be ethical to remove the treatment in the second baseline if the behavior is dangerous (e.g., self-injurious behavior). Second, you must be fairly certain that the level of the behavior will reverse when treatment is withdrawn. If the behavior fails to change when the treatment is withdrawn, a functional relationship is not demonstrated. Another consideration is whether you can actually remove the treatment after it is implemented. For example, if the treatment is a teaching procedure and the subject learns a new behavior, you cannot take away the learning that took place. (For a more detailed discussion of considerations in the use of the A-B-A-B design, see Bailey [1977], Bailey and Burch [2002], Barlow and Hersen [1984], Gast [2009], and Kazdin [2010].)

### Multiple-Baseline Design

There are three types of multiple-baseline designs.

- In a **multiple-baseline-across-subjects design**, there is a baseline and a treatment phase for the same target behavior of two or more subjects.
- In a **multiple-baseline-across-behaviors design**, there is a baseline and treatment phase for two or more behaviors of the same subject.
- In a **multiple-baseline-across-settings design**, there is a baseline and treatment phase for two or more settings in which the same behavior of the same subject is measured.

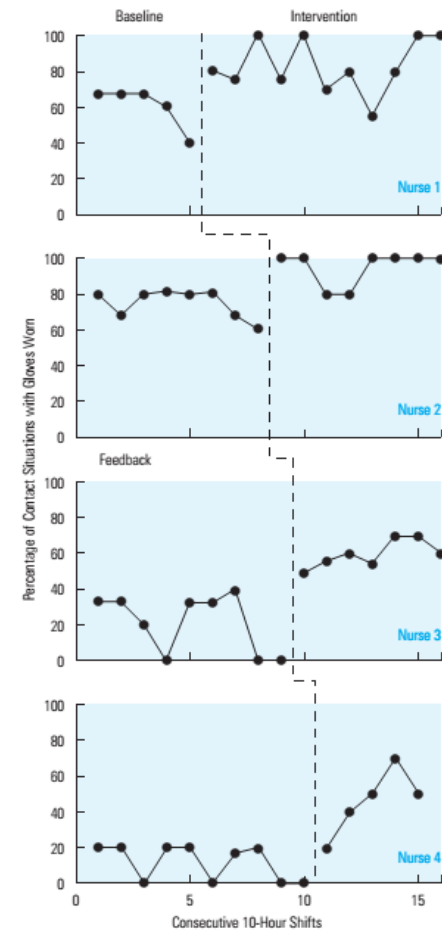
Remember that the A-B-A-B design can also have two baseline phases and two treatment phases, but both baseline and treatment phases occur for the same behavior of the same subject in the same setting. With the multiple-baseline design, the different baseline and treatment phases occur for different subjects, or for different behaviors, or in different settings.

A multiple-baseline design may be used:

- (a) when you are interested in the same target behavior exhibited by multiple subjects,
- (b) when you have targeted more than one behavior of the same subject, or
- (c) when you are measuring a subject's behavior across two or more settings.

A multiple-baseline design is useful when you cannot use an A-B-A-B design for the reasons listed earlier. The multiple-baseline design and the appropriate time to use it are described in more detail by Bailey (1977), Bailey and Burch (2002), Barlow and Hersen (1984), Gast (2009), and Kazdin (2010).

Figure 3-12 illustrates the *multiple-baseline-across-subjects design*. This graph, from a study by DeVries, Burnette, and Redmon (1991), shows the effect of an



**FIGURE 3-12** This multiple-baseline-across-subjects graph shows the percentage of time that four emergency department nurses wear rubber gloves when they have contact with patients. The intervention, which involves feedback from their supervisor, is staggered over time and results in an increase in the behavior for each of the four nurses. (From DeVries, J. E., Burnette, M. M., & Redmon, W. K. [1991]. AIDS prevention: Improving nurses' compliance with glove wearing through performance feedback. *Journal of Applied Behavior Analysis*, 24, 705–711. Copyright © 1991 University of Kansas Press. Reprinted by permission of the author and the publisher.)

intervention involving feedback on the percentage of time that emergency department nurses wore rubber gloves when they had contact with patients. Notice that there is a baseline and treatment phase for four different subjects (nurses). Figure 3-12 also illustrates a critical feature of the multiple-baseline design: The baselines for each subject are of different lengths. Treatment is implemented for subject 1, while subjects 2, 3, and 4 are still in baseline. Then, treatment is implemented for subject 2, while subjects 3 and 4 are still in baseline. Next, treatment is implemented for subject 3 and, finally, for subject 4. When treatment is implemented at different times, we say that treatment is staggered over time. Notice that the behavior increased for each subject only after the treatment phase was started for that subject. When treatment was implemented for subject 1, the behavior increased, but the behavior did not increase at that time for subjects 2, 3, and 4, who were still in baseline and had not yet received treatment. The fact that the behavior changed for each subject only after treatment started is evidence that the treatment, rather than an extraneous variable, caused the behavior change. It is highly unlikely that an extraneous variable would happen to occur at exactly the same time that treatment started for each of the four subjects.

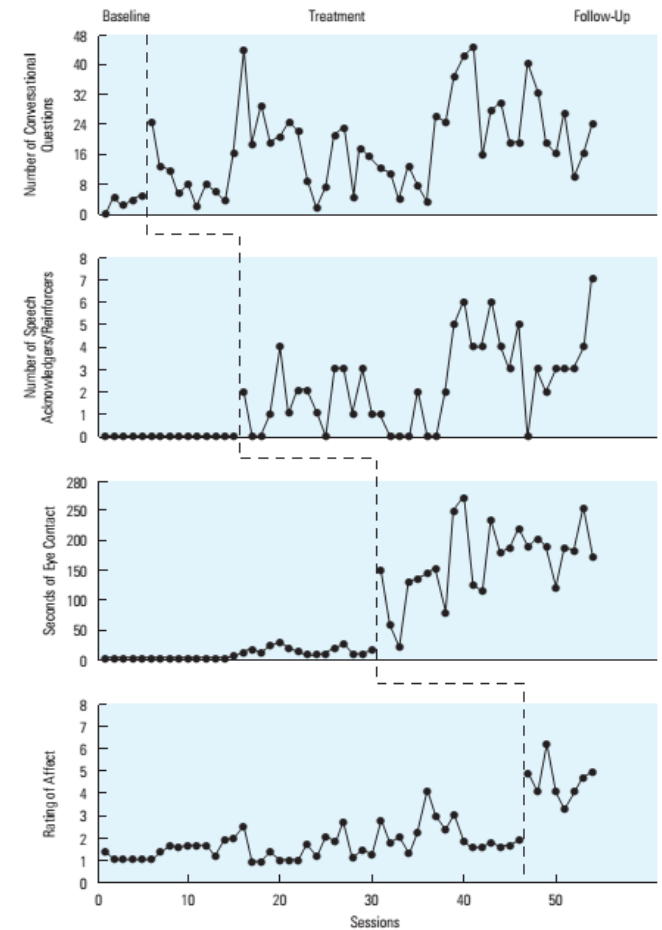
A *multiple-baseline-across-behaviors design* is illustrated in Figure 3-13. This graph, from a study by Franco, Christoff, Crimmins, and Kelly (1983), shows the effect of treatment (social skills training) on four different social behaviors of a shy adolescent: asking questions, acknowledging other people's comments, making eye contact, and showing affect (e.g., smiling). Notice in this graph that treatment is staggered across the four behaviors, and that each of the behaviors changes only after treatment is implemented for that particular behavior. Because each of the four behaviors changed only after treatment was implemented for that behavior, the researchers demonstrated that treatment, rather than some extraneous variable, was responsible for the behavior change.

A graph used in a *multiple-baseline-across-settings design* would look like those in Figures 3-12 and 3-13. The difference is that in a multiple-baseline-across-settings graph, the same behavior of the same subject is being recorded in baseline and treatment phases in two or more different settings, and treatment is staggered across the settings.

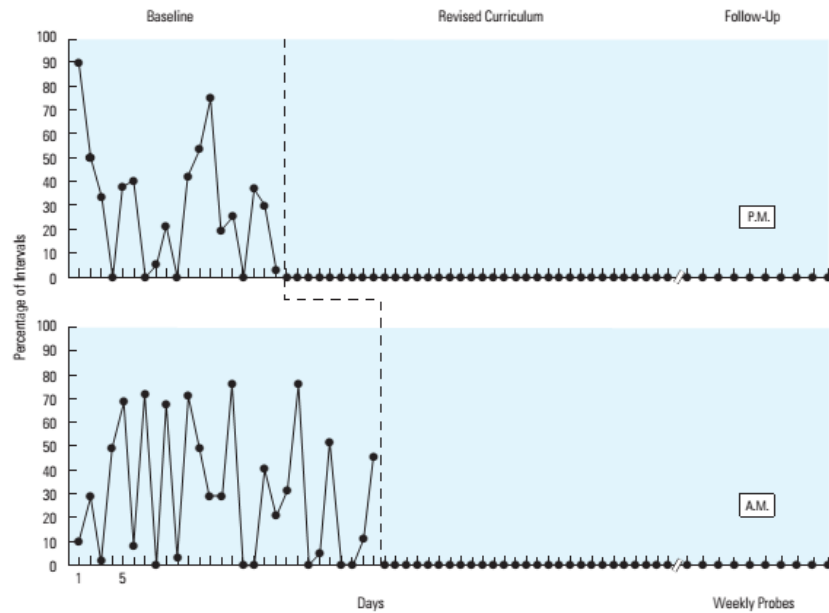


*Draw a graph of a multiple-baseline-across-settings design with hypothetical data. Be sure to include all six components of a complete graph. Assume that you have recorded the disruptive behavior of a student in two different class rooms using an interval recording system. Include baseline and treatment across two settings in the graph.*

The graph in Figure 3-14, from a study by Dunlap, Kem-Dunlap, Clarke, and Robbins (1991), shows the percentage of intervals of disruptive behavior by a student during baseline and treatment (revised curriculum) in two settings, the morning and afternoon classrooms. It also shows follow-up, in which the researchers collected data once a week for 10 weeks. Notice that treatment is staggered across settings; it was implemented first in one setting and then in the other, and the student's disruptive behavior changed only after treatment was implemented in each setting. Your graph of a multiple-baseline-across-settings design would look like Figure 3-14.



**FIGURE 3-13** This multiple-baseline-across-behaviors graph shows four social behaviors exhibited by a shy adolescent. A social skills training intervention is applied to each of these four behaviors, and each behavior increases when the intervention is applied to it. (From Franco, D. P., Christoff, K. A., Crimmins, D. B., & Kelly, J. A. [1983]. Social skills training for an extremely shy young adolescent: An empirical case study. *Behavior Therapy*, 14, 568–575. Copyright © 1983. Reprinted by permission of Jeffrey Kelly.)



**FIGURE 3-14** This multiple-baseline-across-settings design shows the effect of a revised curriculum on the disruptive behavior of an adolescent in a classroom setting in the morning (A.M.) and in another classroom setting in the afternoon (P.M.). The authors used interval recording and put the percentage of intervals of disruptive behavior on the graph. (From Dunlap, G., Kern-Dunlap, L, Clarke, S., & Robbins, F. [1991]. Functional assessment, curricular revision, and severe behavior problems. *Journal of Applied Behavior Analysis*, 24, 387–397. Copyright © 1991 Society for the Experimental Analysis of Behavior. Reprinted with permission of the Society for the Experimental Analysis of Behavior.)

**FOR FURTHER READING**

**Nonconcurrent Multiple-Baseline-Across-Subjects Design**

In a multiple-baseline-across-subjects design, data collection starts in each of the baselines (for each of the subjects) at around the same time and the treatment phase is then staggered across time. However, in a nonconcurrent multiple baseline (MBL) across subjects design (Carr, 2005; Watson & Workman, 1981) the subjects do not participate in the study concurrently. In a nonconcurrent MBL design, the baselines for two or more subjects may begin at different points in time. The nonconcurrent MBL is equivalent to a number of different A-B designs with each participant having a different baseline length. Treatment is then staggered across baselines of different lengths rather than across time. As long as each of the subjects has a different number of baseline data points before treatment is implemented, the research design is considered a nonconcurrent MBL. The advantage of a nonconcurrent MBL is that participants may be evaluated at different points in time; they may be brought into the study consecutively rather than concurrently, which is often more practical for researchers to carry out (Carr, 2005).

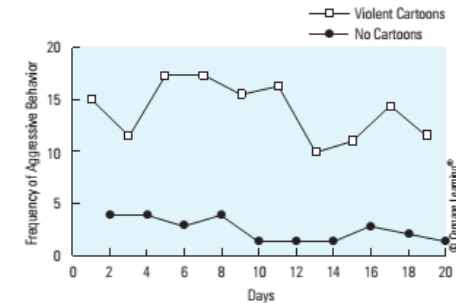
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**Alternating-Treatments Design**

The alternating-treatments design (ATD), also called a multi-element design, differs from the research designs just reviewed in that baseline and treatment conditions (or two treatment conditions) are conducted in rapid succession and compared with each other. For example, treatment is implemented on one day, baseline the next day, treatment the next day, baseline the next day, and so on. In the A-B, A-B-A-B, or multiple-baseline designs, a treatment phase occurs after a baseline phase has been implemented for a period of time; that is, baseline and treatment occur sequentially. In these designs, a baseline or treatment phase is conducted until a number of data points are collected (usually at least three) and there is no trend in the data. A trend means the data are increasing or decreasing across a phase. In the ATD, two conditions (baseline and treatment or two different treatments) occur during alternating days or sessions. Therefore, the two conditions can be compared within the same time period. This is valuable because any extraneous variables would have a similar effect on both conditions, and thus an extraneous variable could not be the cause of any differences between conditions.

Consider the following example of an ATD. A teacher wants to determine whether violent cartoons lead to aggressive behavior in preschool children. The teacher uses an ATD to demonstrate a functional relationship between violent cartoons and aggressive behavior. On one day, the preschoolers do not watch any cartoons (baseline) and the teacher records the students' aggressive behavior. The next day, the students watch a violent cartoon and the teacher again records their aggressive behavior. The teacher continues to alternate a day with no cartoons and a day with cartoons. After a few weeks, the teacher can determine whether a functional relationship exists. If there is consistently more aggressive behavior on cartoon days and less aggressive behavior on no-cartoon days, the teacher has demonstrated a functional relationship between violent cartoons and aggressive behavior in the preschoolers. An example of a graph from this hypothetical ATD is shown in Figure 3-15.

In this graph, the number of aggressive behaviors occurring per day is graphed on days when the children watched violent cartoons (odd-numbered days) and on days



**FIGURE 3-15** This alternating-treatments design shows the frequency of aggressive behavior on days when children watched violent cartoons compared with days when they did not watch cartoons. The level of the aggressive behavior is greater on days with violent cartoons than on days with no cartoons.

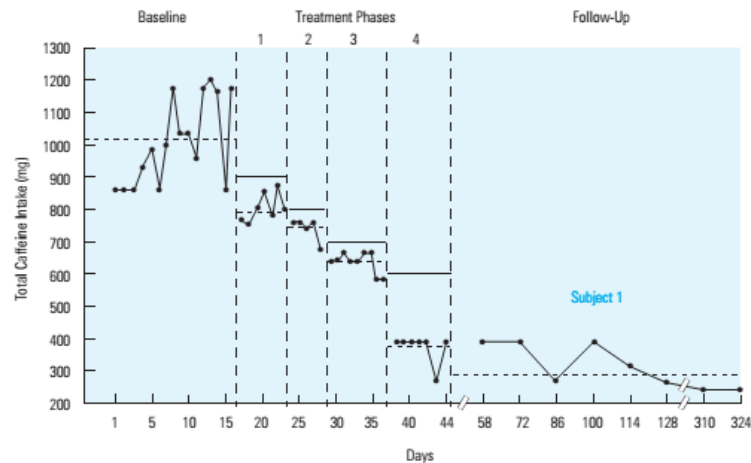
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when they did not (even-numbered days). Notice that the aggressive behavior occurs more frequently on days when the children watched cartoons. We would say there is separation in the data when the data are consistently higher in one condition than the other. Because the aggressive behavior is always greater on cartoon days (there is separation in the data), the researchers have demonstrated a functional relationship and conclude that the aggressive behavior occurred as a function of watching violent cartoons.

### Changing-Criterion Design

A **changing-criterion design** typically includes a baseline and a treatment phase. What makes a changing-criterion design different from an A-B design is that, within the treatment phase, sequential performance criteria are specified; that is, successive goal levels for the target behavior specify how much the target behavior should change during treatment. The effectiveness of treatment is determined by whether the subject's behavior changes to meet the changing performance criteria. That is, does the subject's behavior change each time the goal level changes? A graph used in a changing-criterion design indicates each criterion level so that when the behavior is plotted on the graph, we can determine whether the level of the behavior matches the criterion level.

Consider the graph in Figure 3-16, from a study by Foxx and Rubinoff (1979). These researchers helped people reduce their excessive caffeine



**FIGURE 3-16** This changing-criterion graph shows that caffeine consumption decreased to a level below the criterion each time the criterion was reduced. The solid horizontal bars in treatment phases 1-4 are the criterion lines. The dashed lines show the mean level of the behavior in each phase. (From Foxx, R. M., & Rubinoff, A. [1979]. Behavioral treatment of caffeineism: Reducing excessive coffee drinking. *Journal of Applied Behavior Analysis*, 12, 335-344. Copyright © 1979 University of Kansas Press. Reprinted by permission of Richard Foxx and the publisher.)

consumption through a positive reinforcement and response cost procedure. (These procedures are discussed in Chapters 15 and 17.) As you can see in the graph, they set four different criterion levels for caffeine consumption, each lower than the previous level. When subjects consumed less caffeine than the criterion level, they earned money. If they drank more, they lost money. This graph shows that treatment was successful: This subject's caffeine consumption level was always below each of the criterion levels. Because the subject's behavior changed each time the performance criterion changed, the researchers demonstrated a functional relationship—it is unlikely that an extraneous variable was responsible for the change in behavior. DeLuca and Holborn (1992) used a changing-criterion design in a study constructed to help obese boys exercise more. The boys rode exercise bikes and received points for the amount of pedaling that they did on the bikes. They later exchanged the points for toys and other rewards. In this study, each time the exercise performance criterion was raised (the boys had to pedal more to earn points), the boys' exercise level increased accordingly, thus demonstrating a functional relationship between treatment and the amount of pedaling.

### CHAPTER SUMMARY

1. The six essential features of a complete behavior modification graph are the y-axis and x-axis, labels for the y-axis and x-axis, units for the y-axis and x-axis, data points, phase lines, and phase labels.
  2. To graph behavioral data, you plot the data points on the graph to reflect the level of the behavior on the vertical axis (y-axis) and the unit of time on the horizontal axis (x-axis).
  3. The different dimensions of behavior you can show on a graph include the frequency, duration, intensity, and latency of the behavior. A graph may also show the percentage of intervals of the behavior derived from interval recording or time sample recording or the percentage of opportunities in which the behavior occurred (e.g., percentage correct).
  4. A functional relationship between the treatment (independent variable) and the target behavior (dependent variable) exists when the treatment causes the behavior to change. A functional relationship or experimental control is demonstrated when a target behavior changes after the implementation of treatment and the treatment procedure is repeated or replicated one or more times and the behavior changes each time.
  5. The different research designs you can use in behavior modification research include the following:
    - The A-B design shows baseline and treatment for the behavior of one subject. It is not a true research design.
    - The A-B-A-B design shows two baseline and treatment phases repeated for the behavior of one subject.
    - A multiple-baseline design presents baseline and treatment phases for one of the following options: multiple behaviors of one subject, one behavior of multiple subjects, or one behavior of one subject across multiple settings. In each type of multiple-baseline design, treatment is staggered across behaviors, subjects, or settings.
    - The alternating-treatments design presents data from two (or more) experimental conditions that are rapidly alternated (baseline and treatment or two treatments).
    - Finally, in the changing-criterion design, a baseline phase is followed by a treatment phase in which sequential performance criteria are specified.
- All research designs, except the A-B design, control for the influence of extraneous variables, so that the effectiveness of a treatment can be evaluated.

## KEY TERMS

A-B design, 52  
 A-B-A-B reversal design, 53  
 abscissa, 45  
 alternating-treatments design (ATD), 59  
 baseline, 47  
 changing-criterion design, 60

dependent variable, 51  
 functional relationship, 52  
 graph, 43  
 independent variable, 51  
 multiple-baseline-across-behaviors design, 54

multiple-baseline-across-settings design, 54  
 multiple-baseline-across-subjects design, 54  
 ordinate, 45  
 research design, 51

## PRACTICE TEST

- Why are graphs used in behavior modification to evaluate behavior change? (p. 44)
- What two variables are illustrated in a behavior modification graph? (p. 45)
- What is the y-axis? What is the x-axis? (p. 45)
- What is labeled on the y-axis? On the x-axis? (p. 45)
- What is a phase? (p. 46)
- Why are data points not connected across phase lines? (p. 46)
- Draw a hypothetical graph that illustrates the six essential components of a behavior modification graph. Label all six components on this hypothetical graph. (pp. 45–47)
- What will you label the y-axis of a graph based on interval recording? (p. 51)
- What is an A-B design? What do A and B refer to? (p. 52)
- What is an A-B-A-B reversal design? Draw a hypothetical A-B-A-B graph. Be sure all six components are included. (p. 53)
- What is a multiple-baseline design? Identify three types of multiple-baseline designs. Draw a hypothetical graph of a multiple-baseline-across-subjects design. Be sure to include all six essential components. (pp. 54–58)
- What is an extraneous variable? How does an A-B-A-B design help you rule out extraneous variables as the cause of the behavior change? (pp. 51, 53–54)
- What does it mean to say that treatment is staggered in a multiple-baseline design? (p. 56)
- What is an alternating-treatments design (ATD)? Draw a graph with hypothetical data illustrating an ATD. Be sure to include all six essential components. (p. 59)
- How do you judge the effectiveness of treatment in an ATD? (pp. 59–60)
- Describe the changing-criterion design. Draw a hypothetical graph of a changing-criterion design. Include all six components. (pp. 60–61)
- How do you determine that treatment is effective in a changing-criterion design? (p. 60)
- What is a functional relationship? How do you determine that a functional relationship exists between a target behavior and a treatment procedure? (p. 52)

## APPLICATIONS

- In the application exercise in Chapter 2, you developed a self-monitoring plan as the first step in your self-management program. Once you start to record your own target behavior, the next step is to develop a graph and plot your behavior on the graph each day. Some

people prefer to use a computer program to generate a graph, but all that is really necessary is a sheet of graph paper, a ruler, and a pencil (you can download a sheet of graph paper from the Internet). Using a sheet of graph paper, prepare the graph that you will use to plot the target

Months	Baseline				Intervention				
	1	2	3	4	5	6	7	8	9
Kilowatts (rounded to nearest 100)	4100	3900	4100	4200	3100	3000	2900	3000	2900

Months	Baseline			Intervention			
	10	11	12	13	14	15	16
Kilowatts (rounded to nearest 100)	3800	3900	3800	2900	2900	2800	2900

**FIGURE 3-17** Data summary table showing kilowatts of electricity used per month across two baseline and two intervention phases.

behavior from your self-management project. As you develop your graph, be sure to observe the following rules.

- Label the y-axis and x-axis appropriately.
  - Put the appropriate numbers on the y-axis and the x-axis.
  - Ensure that the time period on the x-axis covers at least 3 or 4 months so that you can record the behavior for an extended period.
  - Plot the behavior on your graph every day as you record the behavior.
  - Continue the baseline period for at least a couple weeks so that any reactivity of the self-monitoring stabilizes.
- The data summary table in Figure 3-17 shows the monthly total kilowatts of electricity used by a fraternity house. In the two baseline phases, no intervention was in place. In the two intervention phases, the fraternity president gave daily reminders to the fraternity brothers at breakfast to turn out lights and turn off appliances. Develop a graph from the data summary table to show the effects of daily reminders on the kilowatts of electricity used each month.
  - Winifred worked with two children with autism who engaged in self-injurious behavior (SIB) involving head-slapping. She recorded the frequency of the SIB during baseline for both children, Kale and Bud, and then implemented a treatment involving reinforcement of alternative behavior (see Chapter 15) and continued to collect data for a period of time. The frequency of SIB for Kale was 25, 22, 19, 19, 22, 22, and 23 in baseline and 12, 10, 5, 6, 5, 2, 1, 1, 1, 0, 0, 1, 1, 0, 0, 0, and 0 during treatment. The frequency of SIB for Bud was 12, 12, 15, 14, 13, 12, 12, 13, 10, 12, 14, and 17 in baseline and 5, 3, 4, 2, 0, 2, 0, 0, 0, 2, 0, 0, and 0 during treatment. Draw the graph of the SIB data for Kale and Bud. What kind of research design did Winifred use when she provided treatment for the SIB?

## MISAPPLICATIONS

- The Acme Widget Company was near bankruptcy. Ace Consultants were called in to help. They collected baseline data on employee productivity for 4 weeks and determined that the

employees were assembling widgets only half as fast as they were able to work. They implemented an incentive system, and employee productivity doubled. After 8 weeks of doubled

productivity, the Acme Company was making a profit again. Ace Consultants decided to take away the incentive system and return to baseline for 4 weeks, and then re-implement the incentive system (A-B-A-B research design) so that they could determine whether the incentive system caused the increase in productivity or whether some extraneous variable was responsible.

- a. What is wrong with the use of an A-B-A-B research design in this case?
  - b. What would you do if you worked for Ace Consultants?
2. Alice was starting a self-management project to increase the amount of running she did each week. She planned to record her behavior for 2 or 3 weeks as a baseline before she implemented an intervention. She decided that she would keep a log of the distance that she ran every day and plot her running distance on a graph each week. She kept the log on her desk and wrote down the duration of her run immediately after she ran.

She put her graph on the door to her room, and at the end of each week, on Sunday night, she plotted the number of miles she had run for the last 7 days. What was Alice doing wrong?

3. Dr. Pete was investigating an intervention for improving social skills in socially anxious college students. He identified three important types of social behavior that he wanted to increase in his subjects: initiating conversations, answering questions, and smiling. He decided to use a multiple-baseline-across-behaviors design in his experiment. He would record all three behaviors in each subject in a baseline before intervention. He would then implement the intervention for all three behaviors at one time and continue to record the behaviors to see whether they increased after the intervention was implemented.
  - a. What mistake did Dr. Pete make in his multiple-baseline design?
  - b. What should he do differently?



## Reinforcement

- What is the principle of reinforcement?
- How is positive reinforcement different from negative reinforcement?
- How are unconditioned reinforcers different from conditioned reinforcers?
- What factors influence the effectiveness of reinforcement?
- What are intermittent schedules of reinforcement, and how do they affect the rate of behavior?

**T**his chapter focuses on the basic behavioral principle of **reinforcement**. Scientific research has established a number of basic principles that explain the behavior of people and other animals. Reinforcement is one of the first basic principles that were systematically investigated by behavioral scientists, and it is a component of many applications of behavior modification described in this text. Reinforcement is the process in which a behavior is strengthened by the immediate **consequence** that reliably follows its occurrence. When a behavior is strengthened, it is more likely to occur again in the future.