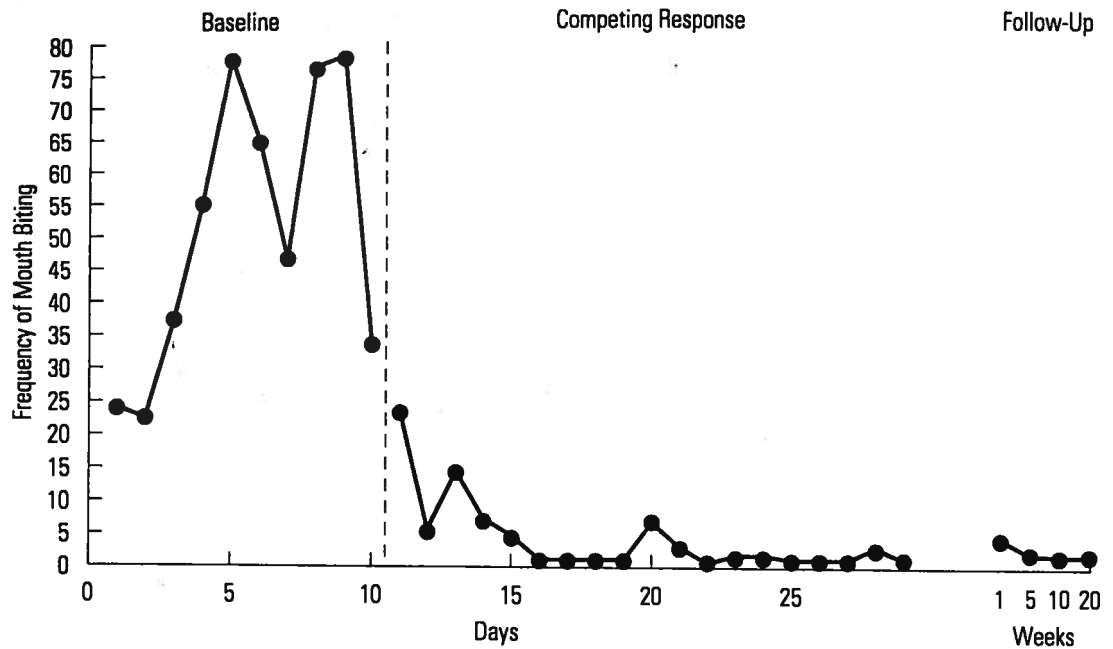# THREE

Graphing Behavior and Measuring Change

As 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 of time 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

- What are the six essential components of a behavior modification graph?

- How do you graph behavioral data?

- What different dimensions of behavior can you show on a graph?

- What is a functional relationship, and how do you demonstrate a functional relationship in behavior modification?

- What different research designs can you use in behavior modification research?

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

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.

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)
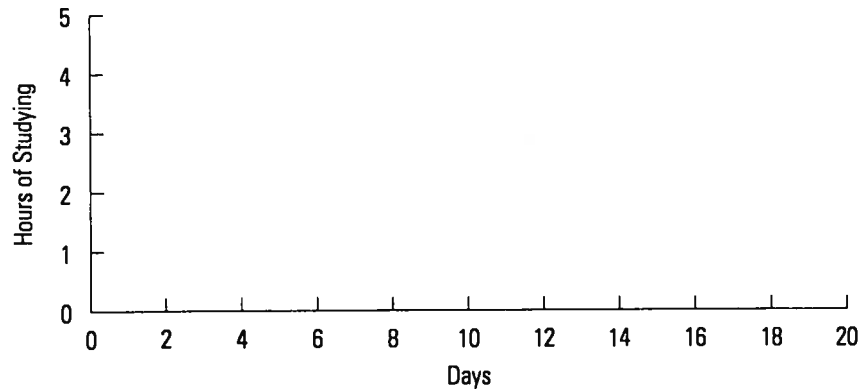
■ *The labels for the y-axis and the x-axis.* The *y*-axis label usually tells you the behavior and the dimension of the behavior that is recorded. The *x*-axis label usually tells you the unit of time during which the behavior is recorded. In Figure 3-3, the
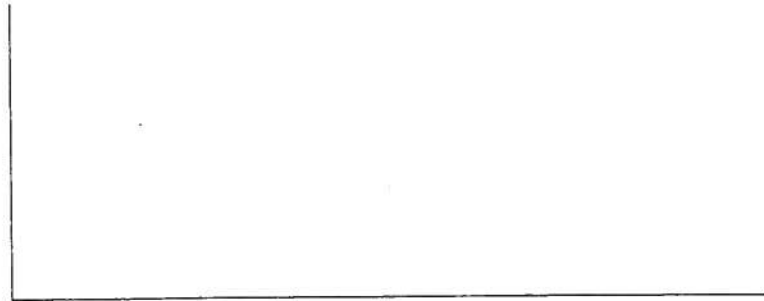
FIGURE 3-2   The *y*-axis and the *x*-axis.
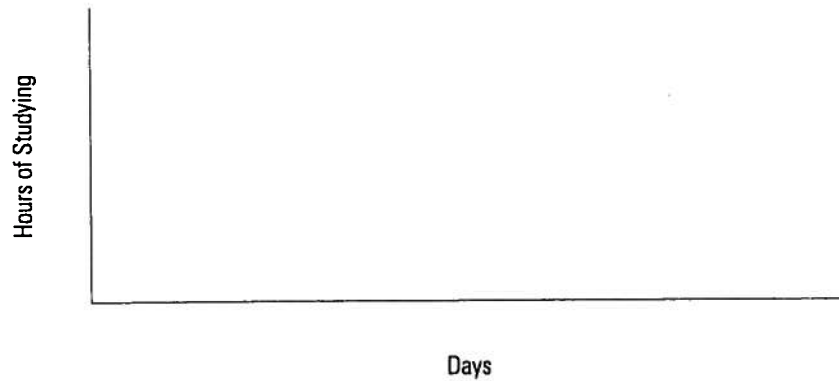
Days

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

Days

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

y-axis label is "Hours of Studying" and the *x*-axis label is "Days." 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
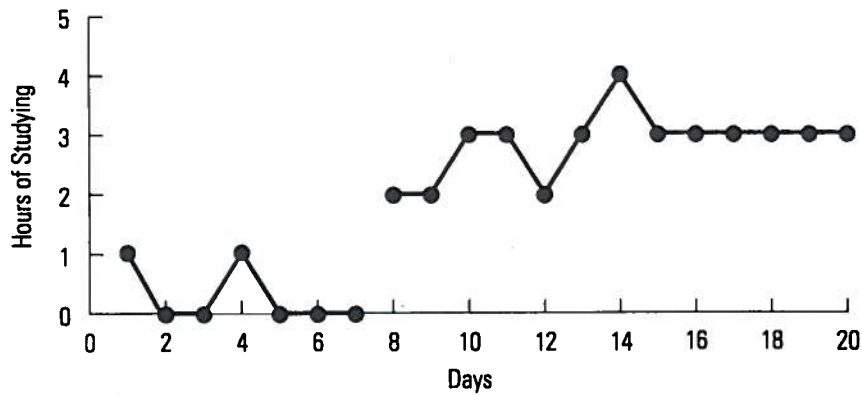
FIGURE 3-5 Data points plotted on a graph.
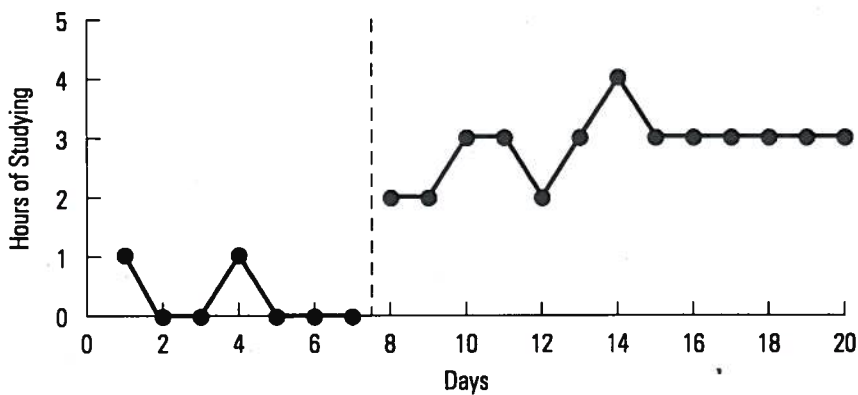
FIGURE 3-6 Phase lines on a graph.

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 behavior that occurred at each particular time period. The information on the level of 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 of time 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.

■ *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 modifi-
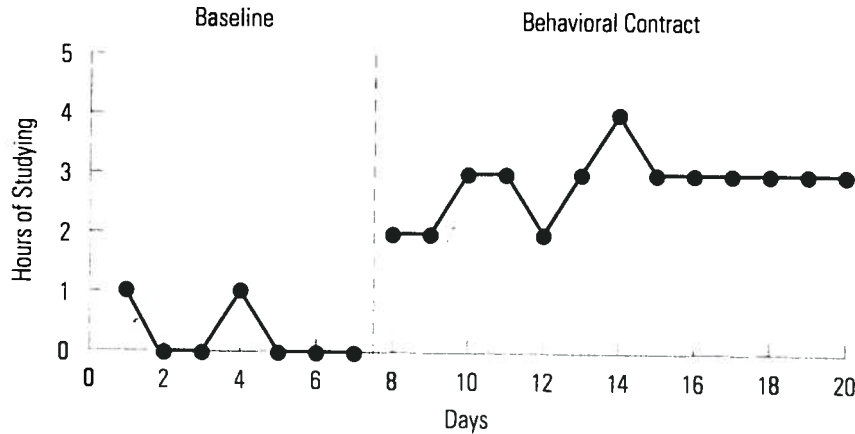
FIGURE 3-7   Phase labels on a graph.

cation 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 you recall from 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. 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 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 (Figure 3-9b) is a graph that is only partially completed (Figure 3-9c). Using the information provided in the data summary table,

(a)   Frequency

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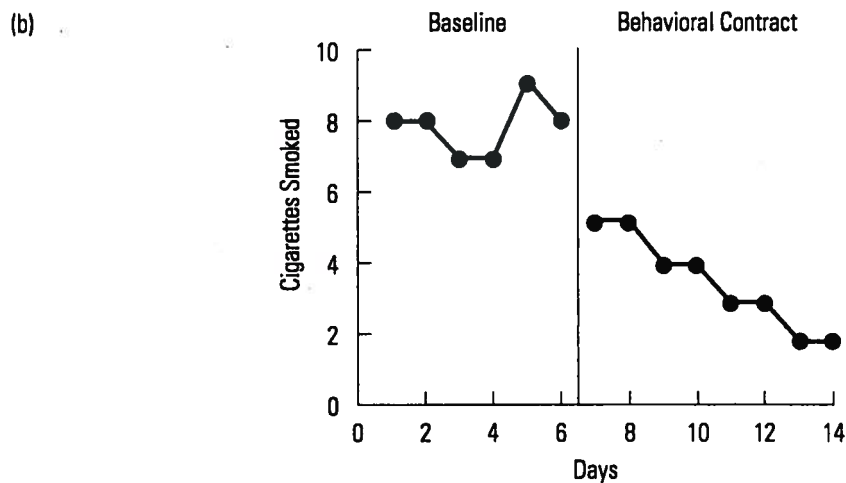
FIGURE 3-8   A completed frequency data sheet is shown in (a); the number of cigarettes smoked each day is recorded on the sheet. The graph of the behavioral data from the data sheet (b) is also shown. The treatment involved a behavioral contract in which the client agreed to smoke one fewer cigarette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

complete this graph. Be sure that the completed graph includes all six components that were 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

(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

(c)
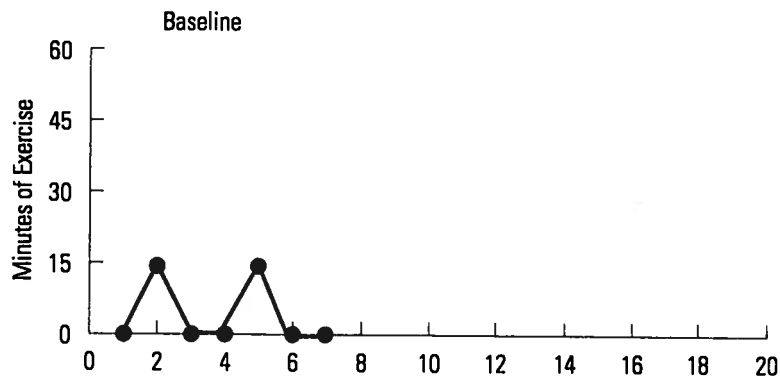
FIGURE 3-9 A completed frequency data sheet is shown in (a); the sheet records the duration of exercise each day. The completed data summary table (b) is also shown. The incomplete graph (c) is for the student to complete using the behavioral data in (a).
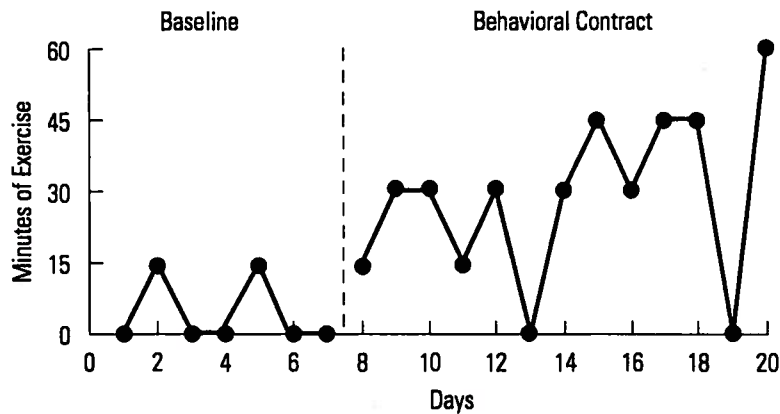
FIGURE 3-10 Completed graph using data from the data summary table in Figure 3-9c.

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).

GRAPHING DIFFERENT DIMENSIONS OF BEHAVIOR

Figures 3-8 and 3-10 illustrate graphs of frequency data and duration data, respectively. Because other dimensions of behavior data also exist, other types of graphs are possible. Regardless of the dimension of behavior that is being graphed, however, the same six components of a graph must be present. What will change with different dimensions of behavior 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 dimension (percentage) of the behavior that is recorded.

Consider another example. A researcher is studying Tourette disorder, 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 of time in which a target behavior is observed and recorded. Once treatment is started, it is implemented during the session also.

Other aspects of a behavior may be recorded and graphed, such as intensity or outcome. 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 was responsible for the observed change in the target behavior and to rule out the possibility that extraneous variables caused the behavior to change. 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. In other words, 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. 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; Hayes, Barlow, & Nelson-Gray, 1999; 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 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 the mouth-biting behavior 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. Because the A-B design does not rule out other causes, 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 mental retardation 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 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 change in demands caused the behavior change.

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 (for example, 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

Bob
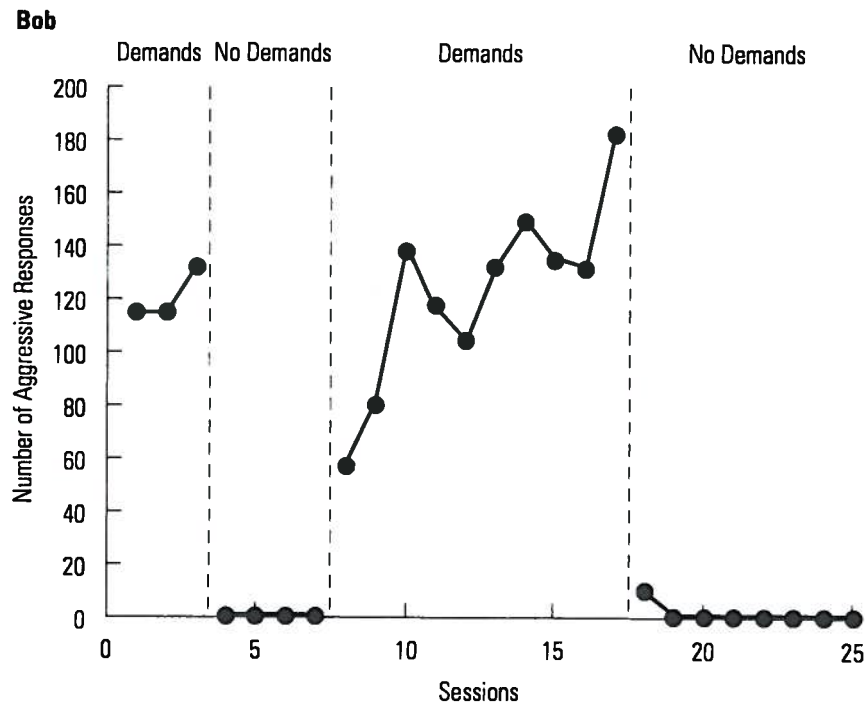
FIGURE 3-11 This A-B-A-B graph (from the study by Carr, Newsom, & Binkoff, 1980) shows the frequency of aggressive behaviors by an adolescent with mental retardation during baseline phases involving demands (A) and treatment phases involving no demands (B).

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) and Barlow and Hersen (1984).

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 different subjects.

■ In a **multiple-baseline-across-behaviors** design, there is a baseline and treatment phase for two or more different 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.

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 intervention involving feedback on the percentage of time that emergency room 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 design may be used when you are interested in the same target behavior exhibited by multiple subjects, when you have targeted more than one behavior of the same subject, or 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 previously. The multiple-baseline design and the appropriate time to use it are described in more detail by Bailey (1977) and Barlow and Hersen (1984).
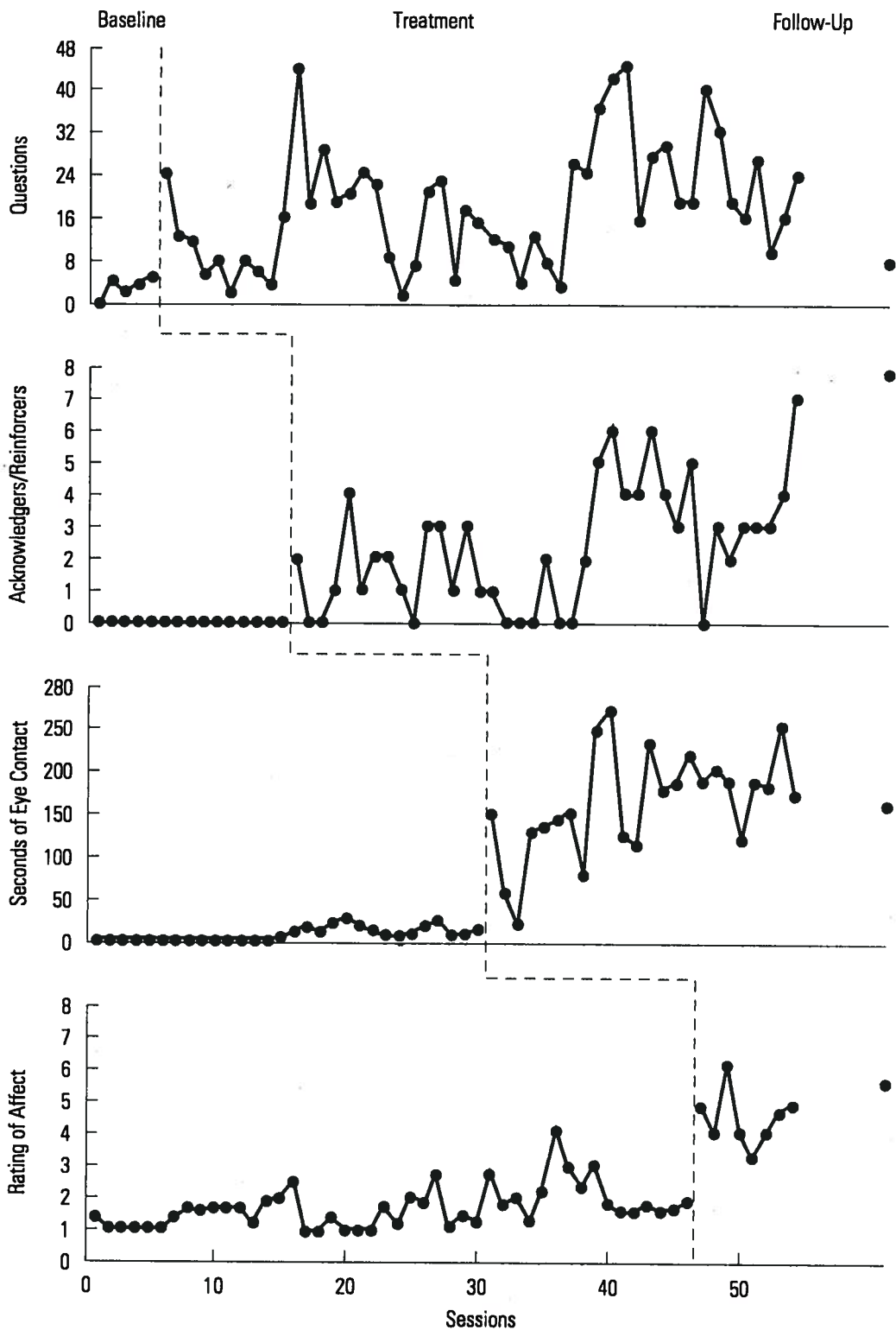
A multiple-baseline-across-behaviors design is illustrated in Figure 3-13. This graph, from a study by Franco, Christoff, Crimmins, and Kelly (1983), shows the effect of treatment (social skills training) on four different social behaviors of a shy adolescent: asking questions, acknowledging other people's 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 classrooms using an interval recording system. Include baseline and treatment across two settings in the graph.
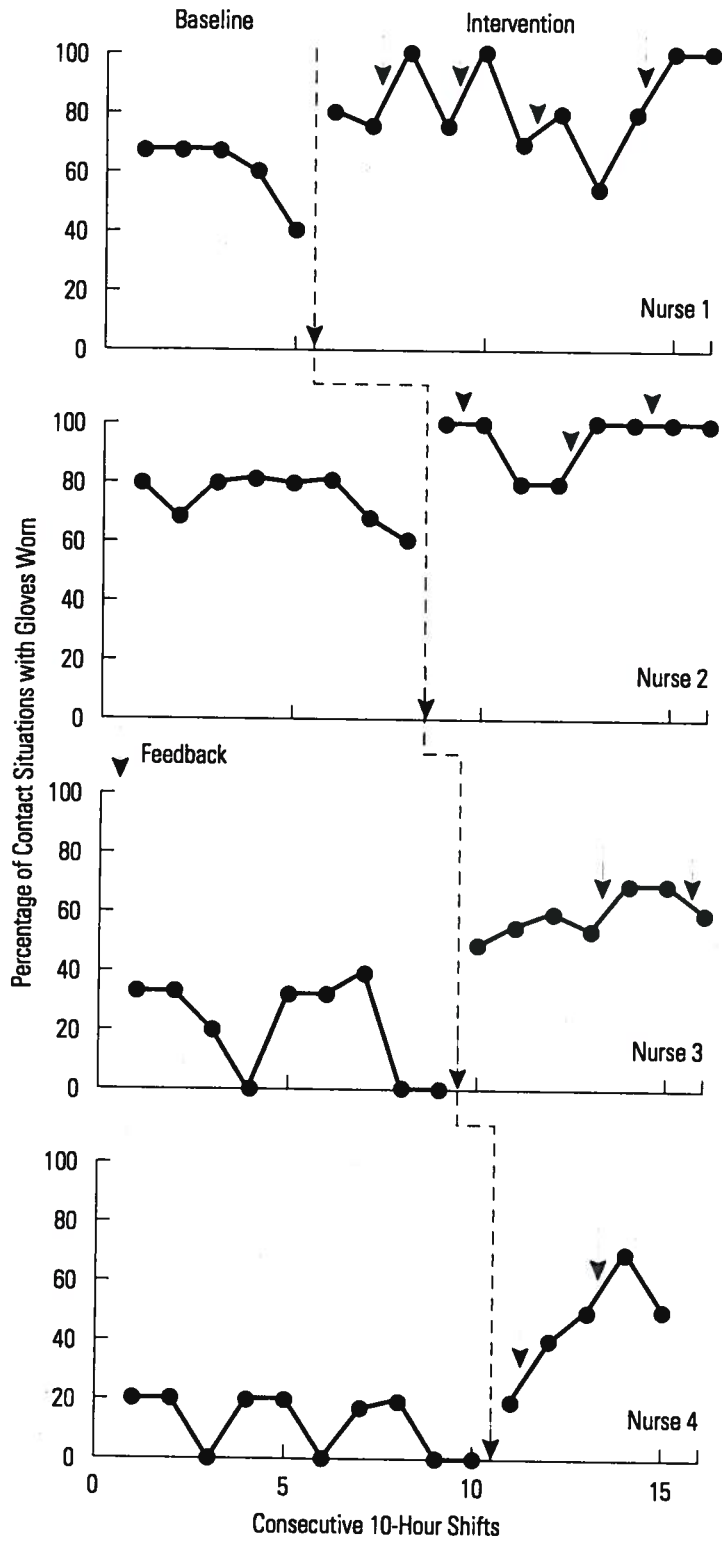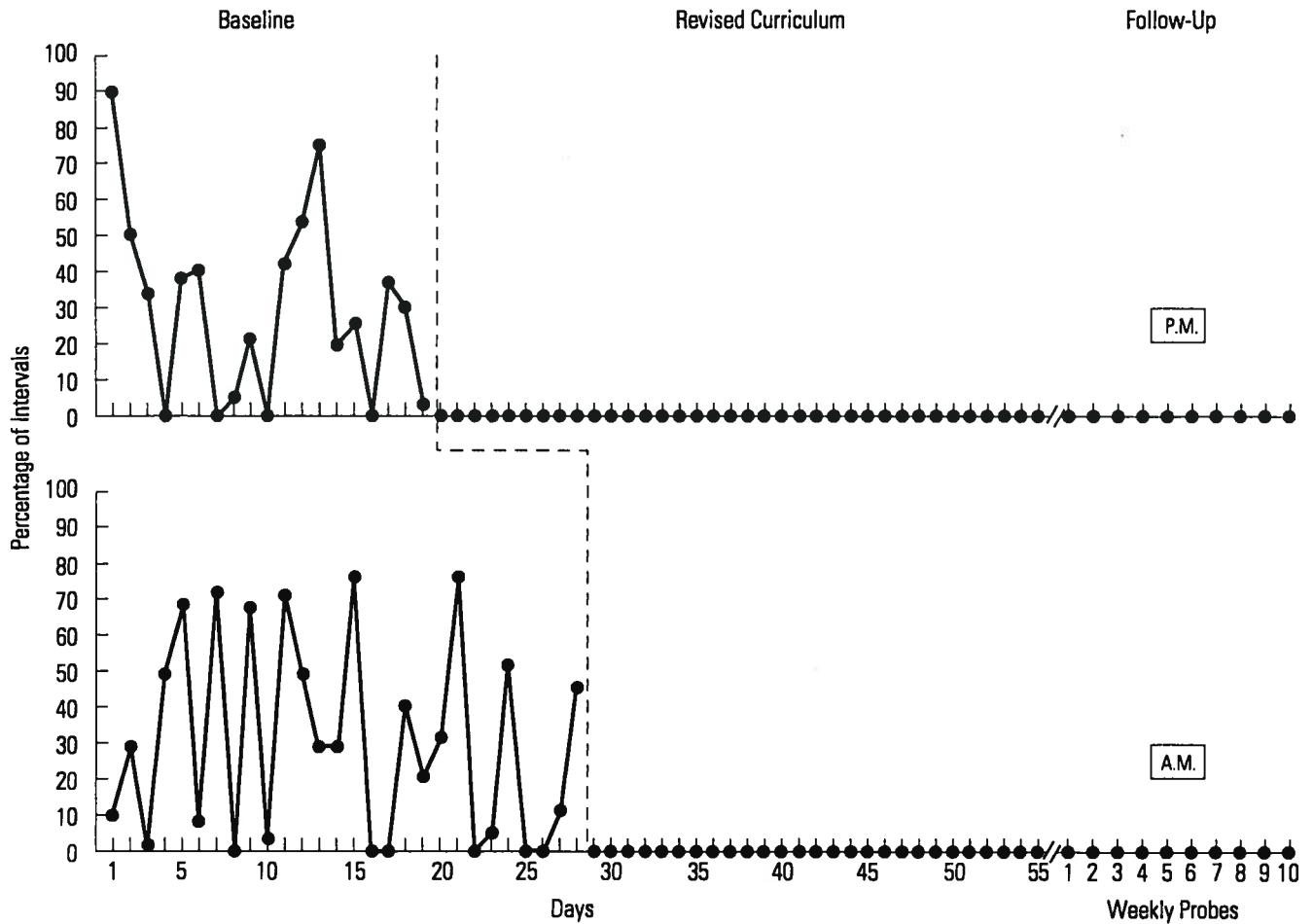
FIGURE 3-12 This multiple-baseline-across-subjects graph (from the study by DeVries, Burnette, & Redmon, 1991) shows the percentage of time that four emergency room nurses wear rubber gloves when they have contact with patients. The intervention, which involves feedback from their supervisor, is staggered over time and results in an increase in the behavior for each of the four nurses.

FIGURE 3-13   This multiple-baseline-across-subjects graph (from the study by Franco, Christoff, Crimmins, & Kelly, 1983) 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.

FIGURE 3-14   This multiple-baseline-across-settings design (from the study by Dunlap, Kern-Dunlap, Clarke, & Robbins, 1991) showing the effect of a revised curriculum on the disruptive behavior of an adolescent in a classroom setting in the morning (A.M.) and 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.

The graph in Figure 3-14, from a study by Dunlap, Kern-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 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.

Alternating-Treatments Design

The **alternating-treatments design (ATD)**, also called a multielement 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; in other words, baseline and treatment occur sequentially. 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 when they did not (even-numbered days). Notice that the aggressive behavior occurs more frequently on days when the children watched cartoons. Because the aggressive behavior is always higher on cartoon days, the researchers conclude that the aggressive behavior occurred as a function of watching violent cartoons.
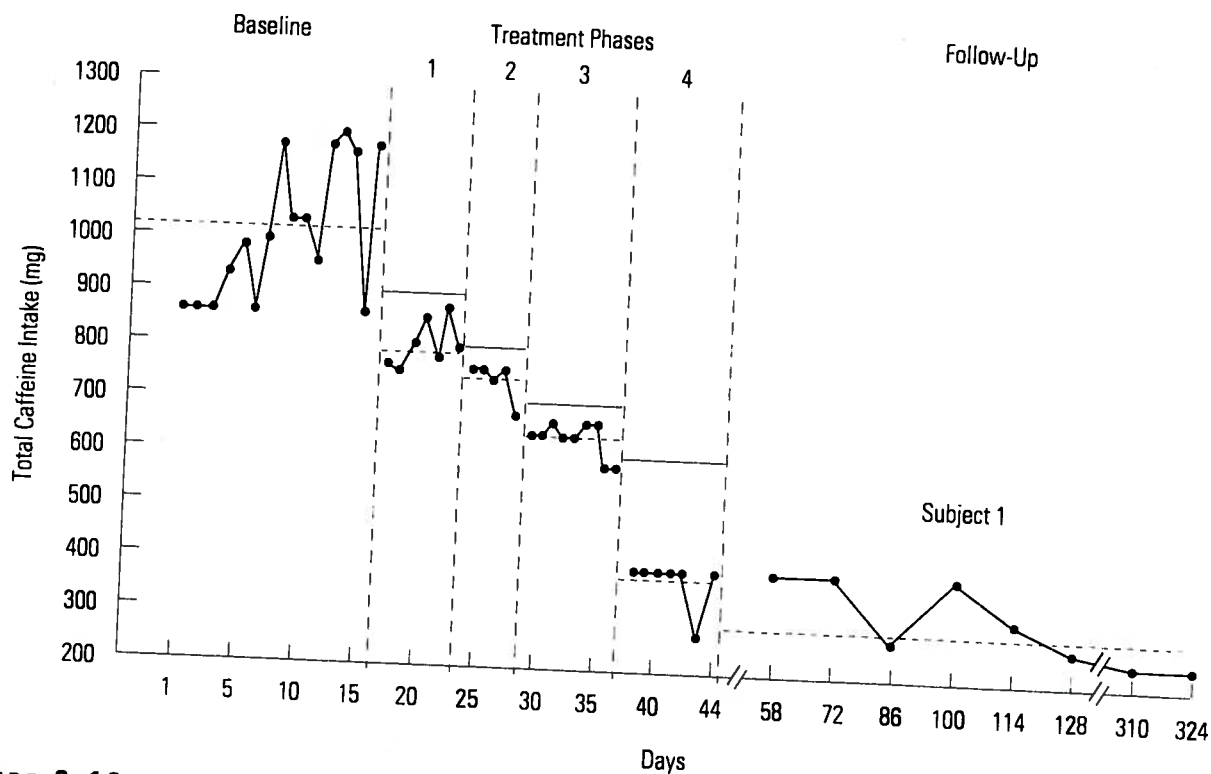
Changing-Criterion Design

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. In other words, 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 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
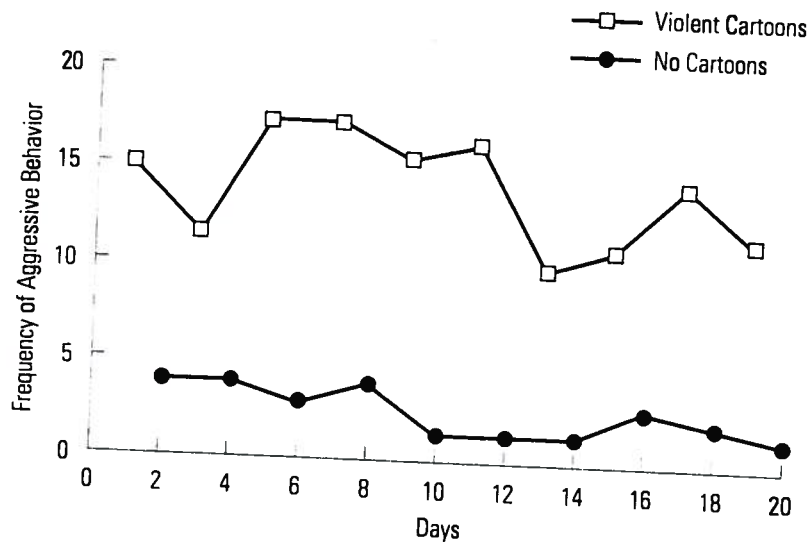
FIGURE 3-15 This graph is from an alternating-treatments design showing the frequency of aggressive behavior on days when children watched violent cartoons compared to days when they did not watch cartoons. The level of the aggressive behavior is higher on days with violent cartoons than on days with no cartoons.

FIGURE 3-16 This changing-criterion graph is from a study by Foxx and Rubinoff (1979). They found that caffeine consumption decreased to a level below the criterion each time the criterion was lowered. The solid horizontal bars in treatment phases 1–4 are the criterion lines.

SUMMARY OF RESEARCH DESIGNS

A-B	One baseline and one treatment phase. Not a true research design.
A-B-A-B	Two (or more) baseline phases and two (or more) treatment phases for the same behavior of one subject. Also called a reversal design.
Multiple-baseline-across-behaviors	Baseline and treatment phases for two or more different behaviors of one subject. Treatment is staggered across behaviors.
Multiple-baseline-across-subjects	Baseline and treatment phases for the same behavior of two or more subjects. Treatment is staggered across subjects.
Multiple-baseline-across-settings	Baseline and treatment phases for the same behavior of the same subject in two or more settings. Treatment is staggered across settings.
Alternating-treatment design	Baseline and treatment sessions are alternated rapidly. Baseline and treatment sessions may occur on alternating days or may occur in different sessions on the same day.
Changing-criterion design	A baseline phase and treatment phase for one subject. In the treatment phase, there are progressive performance criteria or increasing goal levels of the behavior.

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, 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 designed 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 the effect of treatment.

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 -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.

4. A functional relationship between the treatment and the target behavior exists when the treatment causes the behavior to change. A functional relationship 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.

   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 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.

PRACTICE TEST

1. Why are graphs used in behavior modification to evaluate behavior change? (p. 39)
2. What two variables are illustrated in a behavior modification graph? (p. 40)
3. What is the y-axis? What is the x-axis? (p. 40)
4. What is labeled on the y-axis? On the x-axis? (pp. 40–41)
5. What is a phase? (p. 42)
6. Why are data points not connected across phase lines? (p. 43)
7. Draw a hypothetical graph that illustrates the six essential components of a behavior modification graph. Label all six components on this hypothetical graph. (p. 43)
8. What will you label the y-axis of a graph based on interval recording? (p. 46)
9. What is an A-B design? What do A and B refer to? (pp. 47–48)
10. What is an A-B-A-B reversal design? Draw a hypothetical A-B-A-B graph. Be sure all six components are included. (pp. 48–49)
11. 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. 49–53)
12. 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. 47–48)
13. What does it mean to say that treatment is staggered in a multiple-baseline design? (p. 50)
14. What is an alternating-treatments design (ATD)? Draw a hypothetical graph of an ATD. Be sure to include all six essential components. (pp. 53–55)
15. How do you judge the effectiveness of treatment in an ATD? (p. 54)
16. Describe the changing-criterion design. Draw a hypothetical graph of a changing-criterion design. Include all six components. (pp. 54–56)

17. How do you determine that treatment is effective in a changing-criterion design? (p. 54)

18. What is a functional relationship? How do you determine that a functional relationship exists between a target behavior and a treatment procedure? (p. 47)

APPLICATIONS

1. 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 to generate a graph, but all that is really necessary is a sheet of graph paper, a ruler, and a pencil. Using a sheet of graph paper, prepare the graph that you will use to plot the target behavior from your self-management project. As you develop your graph, be sure to observe the following rules.

   a.   Label the *y*-axis and *x*-axis appropriately.
   b.   Put the appropriate numbers on the *y*-axis and the *x*-axis.
   c.   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 of time.
   d.   Plot the behavior on your graph every day as you record the behavior.
   e.   Continue the baseline period for at least a couple weeks so that any reactivity of the self-monitoring stabilizes.

2. 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.

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

	Baseline			Intervention			
Months	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.

3.   Winifred worked with two autistic children 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, 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

1.   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. 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 reimplement 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?