5

Experimental Questions

When researchers decide to conduct an experiment, they usually start with some type of experimental question—that is, some general statement about what type of question will be asked when conducting an experiment. For example, the researcher may be interested in a new method for teaching young children with autism to produce more complex language. A general experimental question might ask whether a naturalistic language-instruction technique, such as milieu therapy (Garfinkle & Kaiser, in press), increases the length and complexity of a child's utterances. The basic question in this instance takes the form of "Is the teaching technique effective?"

Formulating an experimental question is important for a number of reasons. First, it requires the researcher to clarify the goal of the experiment. Research often starts with an innovative idea and a great deal of enthusiasm. However, in the rush to analyze the new idea, researchers may not adequately define what they are about to do. This is important, because a range of issues need to be dealt with when moving from an exciting idea to a successful experiment. Issues that need to be addressed include:

1. Has another research team conducted a similar investigation?
2. What were the procedural details of related experiments that might provide important information about what to include or avoid in conducting a related study?
3. Is the new idea tractable—that is, could the experiment actually be conducted in a reasonable amount of time?

Asking questions such as these before an experiment is begun substantively increases the probability of conducting a successful, interpretable, and important study.

Prematurely starting an experiment can also result in problems implementing the study and developing procedures that will allow for the demonstration of a functional relation. Most experienced researchers have learned the hard way that rushing to conduct a new experiment often leads to a flawed investigation and uninterpretable findings. Following up on an innovative idea with a carefully crafted experimental question can help avoid such errors. The reason for this is that explicitly stating an experimental question forces the researcher to think through various procedural issues that might not have been initially considered.

TABLE 5.1 *(Continued)*

Parametric
What effect will incremental increases in the level of the independent variable have on the dependent variable?
What changes in reading fluency will result from 7.5 minutes, 15 minutes, or 30 minutes of peer-mediated instruction?
What effect will VI 6-second, VI 12-second, VI 30-second, and VI 60-second schedules of reinforcement have on the math performances of students with ADHD?
What effect will 5 seconds or 15 seconds versus 45 seconds of escape from instruction have on the rate of negatively reinforced problem behavior?
Component
Will removal of one element from a multicomponent intervention change the level of the dependent variable?
Will removal of the "rule statements" component from the "good behavior game" change the frequency of students' problem behaviors?
Will adding an response-extinction component to functional communication training reduce the self-injury of a child?
Will removal of public posting from a goal-settings-plus-public-posting intervention alter the tackling accuracy of collegiate football players?

Figure 5.1 presents an illustrative example. Thiemann and Goldstein (2001) studied the effect of a multicomponent intervention on the social behavior of children with autism. The independent variable used by the authors included written cues of when and how to socially interact, videotaped feedback of the child's social interaction, and the use of children's stories to teach appropriate social skills. The behavioral measures included social skills such as securing the attention of another child, initiating a comment about the play

BOX 5.1 • *The Problem with Being Effective*

One of the hallmarks of behavior analysis is its effectiveness (see Baer, Wolf, & Risley, 1968). Multiple examples exist of the substantive progress that has been made by researchers working in this tradition over the last several decades. However, there is an important concern with being so effective. Because so much progress is being made in demonstrating the effectiveness of new techniques, less experimental attention is focused on why the techniques are effective. Hayes, Rincover, and Solnick (1980) referred to this as the "technical drift" of applied behavior analysis. The concern is that new techniques are being described and their effects on behavior documented, but researchers do not understand the behavioral processes that cause these techniques to be effective (i.e., why they work). The concern is that behavior analysis may be developing a "bag of tricks" that cannot be related back to basic learning processes. Discovering why interventions are effective and why they are not effective may allow researchers to develop a science of learning that will be more effective than a simple catalog of techniques. This is particularly the case for instances where complex interactions among behavioral processes will need to be identified and analyzed. It is likely that many of our current failures to change behavior may be due to these unknown complex behavioral processes. It may seem paradoxical, but in the short term, being successful in changing behavior may result in limited effectiveness in the long term.

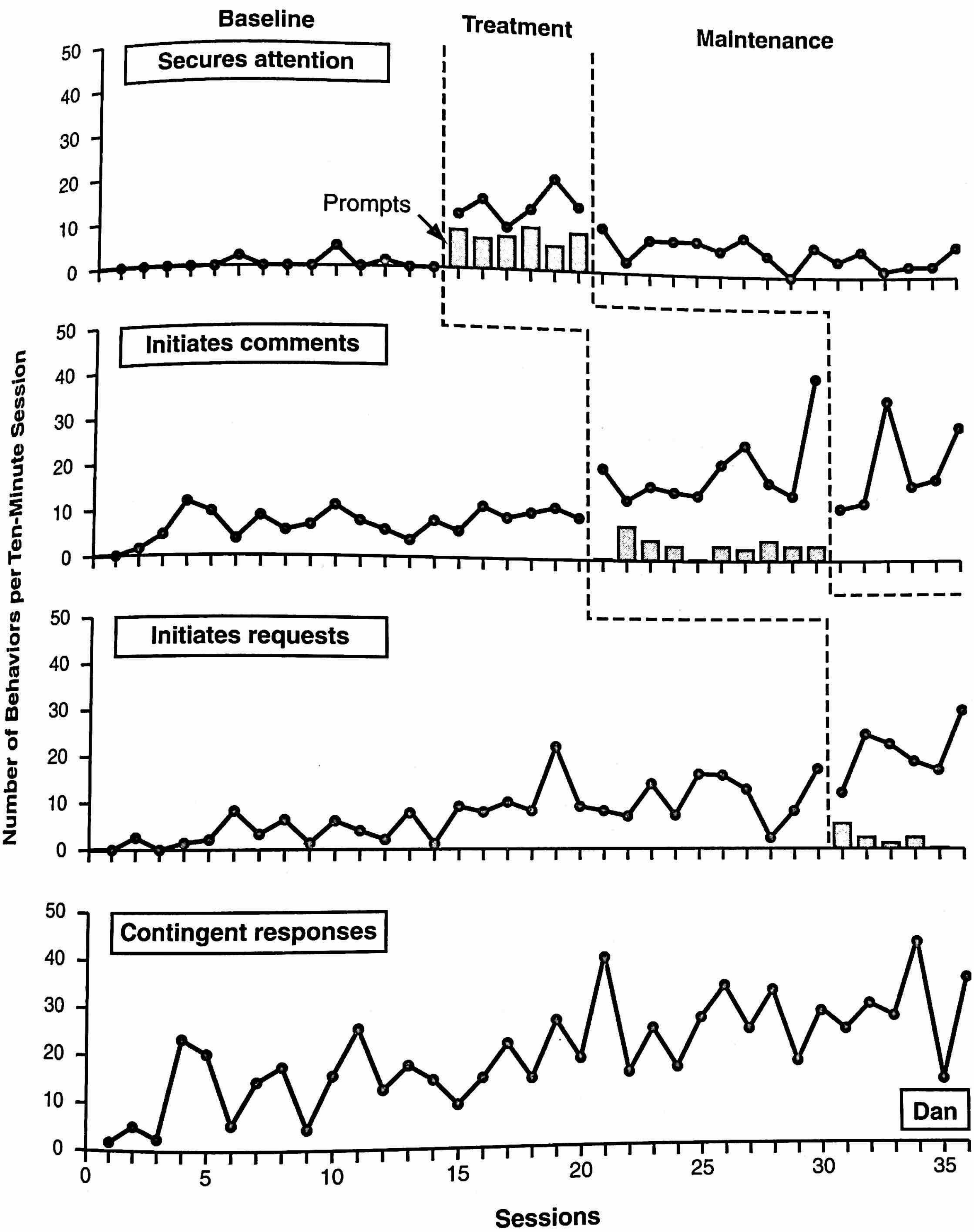

FIGURE 5.1 ***Example of demonstration question.*** Researchers measured the number of times a child with autism used appropriate social skills to interact with a playmate without disabilities. The behaviors included Secures Attention, Initiates Comments, Initiates Requests, and Contingent Responses. Closed circles represent the number of times each behavior occurred during a ten-minute session. The shaded bars represent the number of prompts provided by a teacher.

Source: From K. S. Thiemann and H. Goldstein, "Social Stories, Written Text Cues, and Video Feedback: Effects on Social Communication of Children with Autism," *Journal of Applied Behavior Analysis,* 2001, *34,* fig. 2, p. 436. Copyright 2001 by the Society for the Experimental Analysis of Behavior. Reproduced by permission.

activity, inviting the other child to play, and responding to the other child's requests. The former three dependent variables each increased only when the multicomponent intervention was introduced by the research team, indicating a functional relation between intervention and social behavior. The only response that increased without intervention was responding to the other child's requests. As a result of this analysis, Thiemann and Goldstein concluded that "following implementation of the visually mediated treatment, the children with social impairments demonstrated improved and more consistent rates of targeted social behaviors compared to baseline performance" (p. 442).

Such experimental questions are used to demonstrate whether an intervention changes behavior in some way. Such questions are the foundation of an empirically based educational literature. These types of questions allow researchers to study how a particular independent variable will change a learner's performance. The cumulative effect of asking such questions is the ability of researchers to respond to practitioners', families', and administrators' requests for information about various educational practices by showing them which interventions work and which do not. This type of experimental question also allows researchers to describe the type of effect that an intervention can be expected to have on responding. In addition, this type of experimental question sets the stage for more complex analyses of how and why interventions change behavior (see below).

Comparative Analysis

Another approach to experimental questions is comparing independent variables. Typically, two or more independent variables are studied in relation to a fixed set of dependent variables. That is, two or more distinct environmental arrangements are studied in relation to the same set of behaviors. For example, researchers might study the effects of two different interventions on the communicative development of children who are deaf. One intervention might be comprised of learning to communicate using American Sign Language (ASL). A second intervention might be comprised of ASL and spoken English (i.e., "total communication"). The experimental question might be "Do the two different interventions produce differential effects on receptive and/or expressive communication?"

Figure 5.2 shows another example of a comparative analysis. In a study of spelling performance, Vargas, Grskovic, Belfiore, and Halbert-Ayala (1997) compared two approaches for teaching English to Hispanic students whose first language was Spanish. The first strategy had students write each word three times while viewing a correct example (referred to as the "traditional" approach). The second strategy required students to correct their spelling errors after comparing their performance with a correct example (referred to as the "error correction" approach). The dependent variable was the number of words spelled correctly. In addition, for one student correct letter sequences were also measured (Jose). The two approaches were alternated across days with a list of words. This comparison strategy was replicated across three word lists. As can be seen in the figure, the error correction procedure was more effective for Sixto and Consuelo and generally more effective for Jose when letter sequences were analyzed. Such a finding led Vargas et al. (1997) to recommend that teachers use an error correction procedure for students who speak English as a second language when teaching them to spell English words.

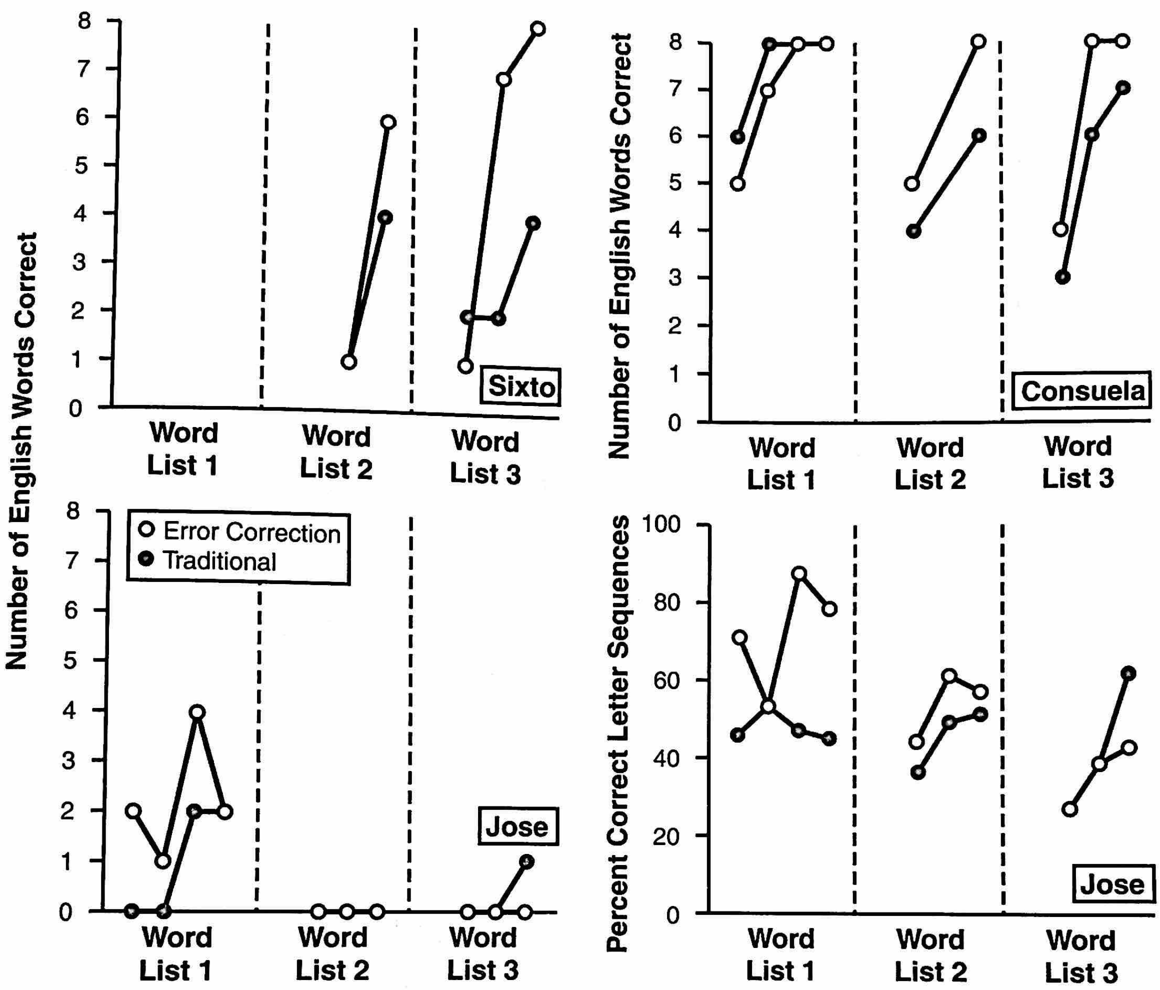

FIGURE 5.2 ***Example of comparative analysis.*** Number of words correctly spelled by three students were measured. Closed circles represent reading sessions that used a traditional approach to sight word reading; open circles represent reading sessions that used an error correction procedure to teach sight word reading.

Source: From A. U. Vargas, J. A. Grskovic, P. J. Belfiore, and J. Halbert-Ayala, "Improving Migrant Students' Spelling of English and Spanish Words with Error Correction," *Journal of Behavioral Education,* 1997, *7,* fig. 1a, p. 19. Copyright 1997 by Human Sciences Press, Inc. Reproduced by permission.

Researchers use comparative analyses for a number of reasons. One reason is to study the effectiveness of different educational interventions. A practical reason for comparing independent variables is to find out which intervention is more effective in changing behavior. How effective an intervention is refers to the absolute changes in behavior that result from being exposed to the independent variable. That is, after repeated exposures to the intervention, how much behavior change has occurred? For example, Baer, Wolf, and Risley (1968) noted that an intervention that raised a child's grades from Ds to As is more desirable than a strategy that changed the same child's grades from Ds to Cs.

Researchers are also interested in the efficiency of interventions. An important concern in educational contexts is the amount of time or effort required to teach students specific elements of the curriculum. Because educational resources, including time, are limited, the faster a student can be taught something, the more time the student has for learning additional material. Or, in instances such as self-injurious behavior, the faster an intervention has an effect, the less self-harm the individual can cause. When researchers are interested in analyzing both the effectiveness and efficiency of interventions, the term *efficacy* is used. In these cases, comparative analyses are conducted both in terms of overall level of behavior change and how rapidly that change occurs.

Another reason why researchers ask comparative questions is to explore the behavioral processes that are responsible for behavior change. As noted in Box 5.1, being effective (or efficacious) is important, but such efforts are ultimately limited if researchers do not know the behavioral processes that bring about changes in responding. Comparative analyses provide researchers with a tool for exploring why behavior is changing. For example, if a research team believes that task difficulty is the reason a child avoids doing math problems, they could compare conditions in which task difficulty is varied. If the child attempts to escape instruction when difficult math problems are presented but not when easy math problems are provided, then task difficulty may be the noxious stimulus dimension that is negatively reinforcing the child's avoidance behavior (Kern, Childs, Dunlap, Clarke, & Falk, 1994; Smith, Iwata, Goh, & Shore, 1995). By carefully arranging conditions that compare possible variables responsible for behavior change, a researcher can discover the causes of behavior.

Parametric Analysis

One of the most important analyses a researcher can conduct is to identify how behavior changes in relation to parametric variations in some dimension of the independent variable. Such an analysis establishes a far more thorough understanding of the relation between an intervention and behavior than can be accomplished through asking whether an intervention is effective or not. For instance, consider the example of peer-mediated instruction provided in Chapter 4 (Figure 4.4). The investigators originally focused on demonstrating that 15 minutes of peer-mediated instruction could improve reading performance by 50% above the baseline practices used in the classroom. This finding is important but does not provide any information about the interrelation between the intervention and behavior change. It is an all-or-nothing finding. However, when the researchers parametrically varied the amount of time spent in peer-mediated instruction, a more complete picture emerged. The functional relation that was established showed that 7.5 minutes of instruction produced a 20% gain in performance (but with increased variability in those gains) and 30 minutes produced only a 5% gain over 15 minutes of exposure to the independent variable. Such a finding demonstrates that there is not a linear relation between the intervention and behavior change. This finding is significant because it means that more is not necessarily better. In addition, the parametric analysis suggests, from a practical standpoint, that 15 minutes seems to provide the best outcome for the effort involved.

The hallmark of parametric analyses is the systematic increase or decrease in the value of some dimension of the independent variable. Figure 5.3 shows such a manipulation in relation to the use of methylphenidate (Ritalin®) for a child with ADHD named Derrek. The dependent variable was the number of math problems solved by Derrek per

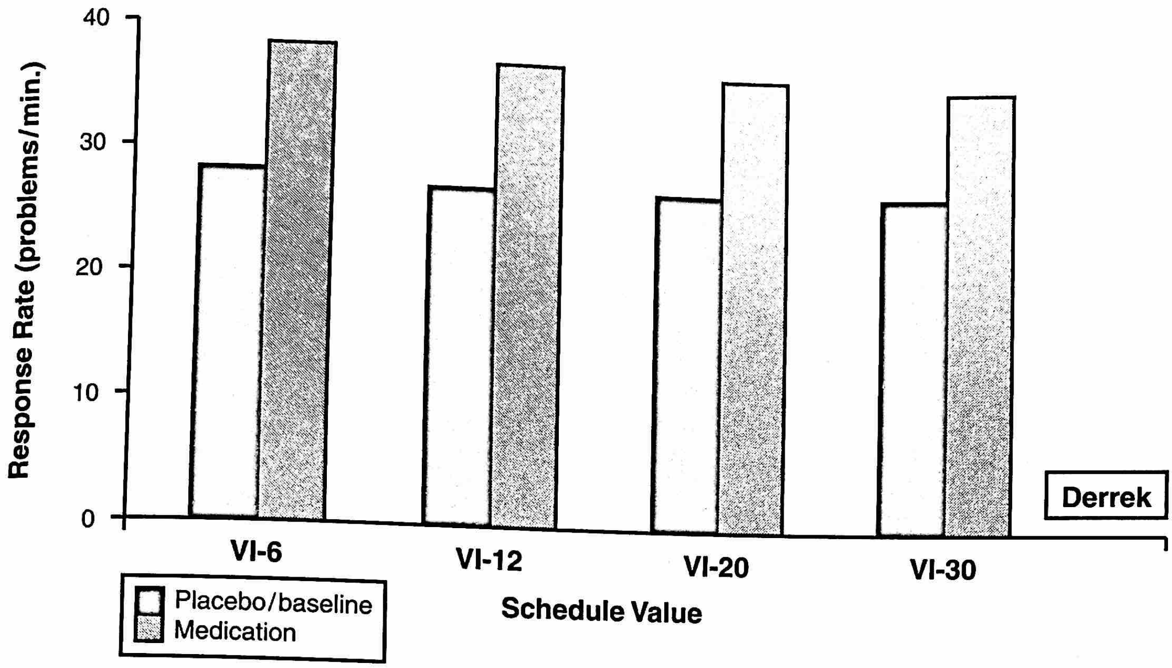

FIGURE 5.3 ***Example of parametric analysis.*** Problem responses per minute emitted by a child (Derrek) with attention deficit hyperactivity disorder were recorded. Black bars in the histogram represent instructional sessions in which Derrek received a placebo pill. Shaded bars represent instructional sessions in which Derrek received methylphenidate (MPH). The effects of the psychoactive drug were studied across parametric variations in the schedule of reinforcement for appropriate behavior (VI 6 seconds, VI 12 seconds, VI 30 seconds, or VI 60 seconds).

Source: From L. K. Murray and S. H. Kollins, "Effects of Methylphenidate on Sensitivity to Reinforcement in Children Diagnosed with Attention Deficit Hyperactivity Disorder: An Application of the Matching Law," *Journal of Applied Behavior Analysis,* 2000, *33,* fig. 2, p. 581. Copyright 2000 by the Society for the Experimental Analysis of Behavior. Reproduced by permission.

minute. In addition, the researchers (Murray & Kollins, 2001) alternated across school days between the child receiving a placebo and methylphenidate (MPH). What Murray and Kollins were particularly interested in was how the schedule of positive reinforcement that maintained Derrek's math work would interact with the placebo and MPH conditions. To accomplish this analysis, the authors parametrically varied the variable interval (VI) schedule of reinforcement (i.e., 6 seconds, 12 seconds, 30 seconds, or 60 seconds). The researchers found that MPH interacted with the VI schedule of reinforcement so that the denser the schedule of reinforcement, the more problems solved per minute. However, the different VI values of the reinforcement schedule had no differential effect on problem solving during placebo conditions.

Any aspect of the independent variable can be quantified and subjected to a parametric analysis. Possible dimensions for a parametric analysis might include the amount of exposure, the magnitude of exposure, or the density of exposures, among others. In addition, two (or more) different dimensions of an independent variable can be parametrically manipulated in relation to each other to establish how the dimensions interact. For example, researchers could vary the temporal dimension of VI reinforcement schedules and reinforcer magnitude (see Fisher & Mazur, 1997).

How a specific dimension of an independent variable is parametrically altered is another matter. Typically, researchers opt for a systematic approach to parametric variations in interventions. Options for how to vary the metric being analyzed include the following manipulations:

1. additive progression (e.g., 10 seconds, 20 seconds, and 30 seconds)
2. multiplicative progression (e.g., 10 seconds, 20 seconds, or 40 seconds)
3. logarithmic progression (e.g., 1 seconds, 10 seconds, or 100 seconds)

In general, which sequence is used depends primarily on logistical constraints on levels of the independent variable, sensitivity of the dependent variable metric, and the nature of the experimental question.

Often, parametric analyses follow from initial demonstrations of the effectiveness of a particular intervention. In this sense, they constitute a form of systematic replication. The reasons for conducting a parametric analysis are multiple. In some cases, a researcher may want to simply establish the form of a functional relation between responding and the environment. In other cases, a researcher may want to find out if a complex functional relation discovered in the laboratory also holds in applied settings (e.g., the effects of deprivation-induced shifts in dose-effect functions). In yet other cases, a researcher may want to know the cost-benefit ratio between the amount of an intervention and how much educational progress results. Each of these is a valid experimental question that makes use of parametric variations in the independent variable.

Component Analysis

Researchers also find it useful to "pull apart" independent variables. This approach is referred to as component analysis. The reason this type of question is asked is typically to discover what makes an independent variable work and/or why it works. When trying to identify what aspect of an intervention is necessary, researchers often remove one or more components of the independent variable. This is particularly important in educational research, because most interventions have multiple components. By removing a select number of elements, researchers can determine how that particular component(s) affects behavior.

Component analyses can be used to conduct efficiency experiments in the sense that they can identify the necessary components of an intervention. An example of a component analysis is provided in Figure 5.4. Medland and Stachnik (1972) studied an intervention called the "good behavior game" (Barrish, Saunders, & Wolf, 1969). This game was developed in the 1960s but is still used today because it is effective. In the Medland and Stachnik experiment, the independent variable was comprised of (1) rule statements, (2) a light box that signaled when the class was being "good" or "bad," and (3) a group contingency that provided differential reinforcement for meeting goals. The experiment was conducted in a fifth-grade general education classroom that had twenty-eight students. As shown in Figure 5.4, a baseline was established, with problem behaviors frequently occurring (e.g., talking out in class or not being in the assigned seat). The good behavior game was then introduced, with problem behaviors virtually eliminated. In session 36, one com-

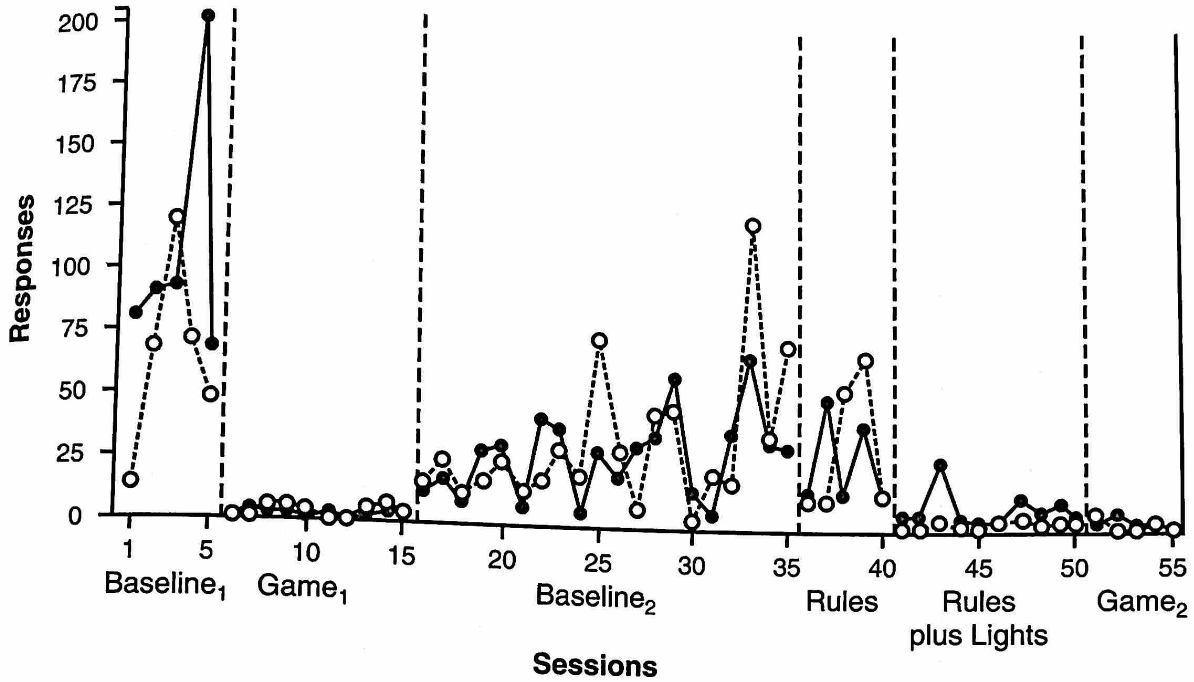

FIGURE 5.4 ***Example of component analysis.*** The experiment measured number of problem behaviors occurring during a class period. Each data symbol represents a different class "team." The component analysis occurred between Sessions 36 and 55. The treatment package (games 1 and 2) consisted of "rules," "lights," and access to a reward.

Source: From M. B. Medland and T. J. Stachnik, "Good-Behavior Game: A Replication and Systematic Analysis," *Journal of Applied Behavior Analysis,* 1972, *5,* fig. 1, p. 49. Copyright 1972 by the Society for the Experimental Analysis of Behavior. Reproduced by permission.

ponent of the intervention was introduced alone (i.e., rule statements), with little effect on classroom behavior. However, when two components of the original intervention were used (i.e., rule statements plus performance feedback), problem behaviors occurred at near zero levels and were the same as when the entire treatment package was used. These findings suggest that only two of the three intervention components were necessary for the independent variable to be effective. Although this analysis does not show why the intervention was effective in terms of specific behavioral processes influencing behavior, it does show which components are necessary for the intervention to be useful.

An example of a component analysis that did identify why an intervention was effective is provided in Figure 5.5 (page 74). In this experiment, Wacker and colleagues (1990) initially conducted an assessment that identified a child's problem behavior as occurring as a function of positive reinforcement in the form of access to a tangible object (i.e., a favored toy). Following this assessment, a treatment was developed called "functional communication training" (FCT) that prompted and reinforced the child to sign for the toy and placed hand biting on a schedule of negative punishment (i.e., removal of access to the toy). The results show that by session 18, the child was independently signing to gain access to the toy and not biting his hand. During sessions 19 through 29, a component analysis was conducted. The first component removed was the differential reinforcement and negative punishment contingencies, resulting in the child once again resorting to hand

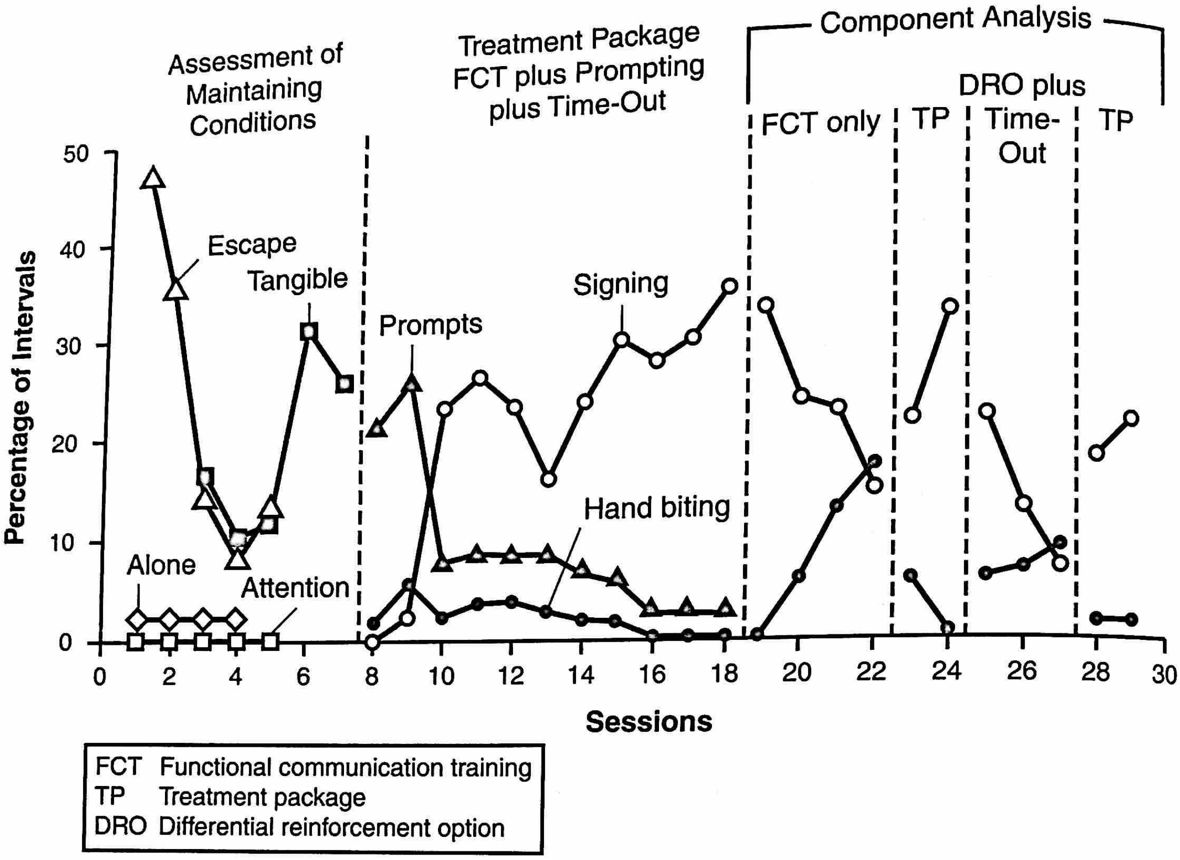

FIGURE 5.5 ***Example of component analysis that identified why intervention was effective.*** The figure indicates the percentage of intervals in which various responses occurred. The responses included hand biting, signing, and prompting by an adult. The component analysis occurred between sessions 19 and 29. The treatment package (TP) included functional communication training (FCT) and differential reinforcement of other behavior plus time-out.

Source: From D. P. Wacker, M. W. Steege, J. Northup, G. Sasso, W. Berg, T. Reimers, L. Cooper, K. Cigrand, and L. Donn, "A Component Analysis of Functional Communication Training across Three Topographies of Severe Behavior Problems," *Journal of Applied Behavior Analysis,* 1990, *23,* fig. 1, p. 424. Copyright 1990 by the Society for the Experimental Analysis of Behavior. Reproduced by permission.

biting. This effect was reversed when the reinforcement and punishment components were reinstated. Then, when the prompting and signing components were removed, a similar increase in problem behavior was observed. This analysis showed that each component of the intervention was necessary for it to have a beneficial effect on communication and problem behavior. Removing any one of these components rendered the intervention ineffective, suggesting that each of the behavioral processes that comprised the intervention was necessary. That is, the reason the FCT intervention worked was because it placed problem behavior on extinction and differentially reinforced the occurrence of signing.

The general process is the same whether a research team uses component analyses to identify (1) necessary versus superfluous components of an intervention or (2) the behavioral processes that make an intervention effective. The independent variable needs to be operationalized and the individual elements identified. Then, the researchers need to decide on an experimental plan for which component(s) will be removed and when (see Part Four).

This decision can be complex, because some elements of an independent variable are dependent on the presence of other elements. In such cases, the removal of one component may necessitate the removal of another component. Such situations will necessary constrain what can ultimately be said about the intervention, but at the same time they clearly identify for the researchers and future readers what interdependencies exist within the intervention package. This is important, because as with parametric analyses, component analyses typically follow demonstrative and comparative analyses. In the latter type of experiments, the focus is more on being effective than in systematically analyzing each aspect of an intervention.

Conclusion

When conducting research, a range of experimental questions can be posed. In this chapter, we have reviewed four general types of experimental questions: demonstration, comparative, parametric, and component. Explicitly stating experimental questions assists investigators to improve what they propose to study. Such a process typically results in refinements in the initial experimental question and an increased likelihood of experimental success. In addition, different types of experimental questions can be combined to pursue even more complex experimental analyses. The posing of experimental questions is an often-overlooked aspect of the experimental process but one that is integral to the process.