JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2005, **38,** 257–278 NUMBER 2 (SUMMER 2005)

A REVIEW OF REINFORCEMENT CONTROL PROCEDURES

RACHEL H. THOMPSON
UNIVERSITY OF KANSAS

AND

BRIAN A. IWATA
UNIVERSITY OF FLORIDA

A demonstration of the effects of reinforcement requires comparison of response rates in the presence of a contingency with those in another condition that controls for the influence of extraneous variables. We describe several control conditions that have been used in evaluating the effects of positive and negative reinforcement. The methodological rigor and practical utility of each type of control condition are discussed, and recommendations for the use of these conditions are presented.

DESCRIPTORS: experimental design, extinction, differential reinforcement of alternative behavior, differential reinforcement of other behavior, contingency reversal, noncontingent reinforcement, reinforcement control procedures, reversal designs

The primary interest in applied research has been the identification of variables that produce behavior change, and a fundamental part of this process involves ruling out the influence of competing (confounding) variables. Thus, the demonstration of experimental control is an essential feature of applied behavior analysis that contributes to the advancement of both science and practice. Toward that end, researchers have made extensive use of single-subject designs (see Barlow & Hersen, 1984; Kazdin, 1982) to evaluate the effects of a wide range of therapeutic interventions on socially significant behaviors. These designs are based on the steady-state strategy described by Sidman (1960), in which repeated measures of a subject's behavior are taken under experimental and control conditions until stable performance is observed. A convincing demonstration of the effects of the independent variable occurs when changes in performance are observed across conditions and are replicated within a given subject's data; in other words, each subject's performance serves as his or her own control.

When treatment involves the application of a contingency, its introduction often involves stimulus changes that may themselves influence behavior independent of the contingency. For example, aside from the arranged contingency, reinforcement conditions may differ from baseline in that a new stimulus is presented (e.g., praise delivered as positive reinforcement) or removed (e.g., academic demands terminated as negative reinforcement), which can influence the target response either directly or by increasing or decreasing responses that interfere with performance of the target behavior. For example, the stimulus change may elicit responses, occasion responses (through stimulus control) that have been reinforced previously in the presence of the stimulus, or evoke responses (as an establishing operation). Thus, it is important to isolate the effects of mere stimulus change from those of the reinforcement contingency through the use of a control procedure.

We thank Marc Branch, Cecil Mercer, Scott Miller, and Timothy Vollmer for their helpful comments.

Reprints may be obtained from Rachel Thompson, Department of Applied Behavioral Science, University of Kansas, 1000 Sunnyside Avenue, Room 4001, Lawrence, Kansas 66045 (e-mail: rthomps@ku.edu).

doi: 10.1901/jaba.2005.176-03

This review focuses on the design of control procedures for examining the effects of reinforcement, the independent variable studied most often in applied behavior analysis research. A reinforcement contingency is a relation between a response and some stimulus change (presentation or removal) that follows the response and is based on the probability of the stimulus change given the occurrence versus nonoccurrence of the response (Catania, 1992; Lattal & Shahan, 1997). Most reinforcement contingencies are arranged such that there is a high probability of a particular stimulus change (e.g., presentation of food) given a response and a very low (or zero) probability of the stimulus change given no response. Thus, the ideal control condition for examining the effects of reinforcement should eliminate the contingency between the response and reinforcer, and several approaches to constructing such a control condition have been reported in the literature. Some control procedures have involved simply terminating the stimulus change by withholding delivery of the purported reinforcer (extinction). A second strategy has been to program the stimulus change independent of the occurrence of the target response (noncontingent reinforcement [NCR]). Two other strategies that are very similar involve presentation of a stimulus change contingent on the absence of the target response (differential reinforcement of other behavior [DRO]) or the occurrence of an alternative response (differential reinforcement of alternative behavior [DRA]).

The following review discusses the strengths and limitations of these control procedures with respect to both positive- and negative-reinforcement arrangements. From a methodological standpoint, we consider the adequacy of each control procedure in eliminating extraneous variables as sources of influence over the dependent variable. From a practical standpoint, we examine the extent to which these control procedures have effectively produced changes in the dependent variable sufficient to allow demonstration of a reinforcement effect.

PROCEDURAL VERSUS FUNCTIONAL REVERSIBILITY

Control conditions such as those described above are designed to reverse the behavioral effects observed during the experimental condition and, in doing so, to establish a functional relation between the independent and dependent variables. Distinctions have been made, however, based the way in which the reversal effect is produced. Leitenberg (1973), for example, recommended using the term *reversal design* to describe only those situations in which control is demonstrated through a reversal of the contingency in effect during the experimental condition (i.e., the contingency is removed from the target behavior and is applied to a different behavior, as in DRA). This strategy has been contrasted with one in which the experimental procedure is simply discontinued (Barlow & Hersen, 1984), and has led some authors to refer to most ABAB designs based on the extinction control as *withdrawal designs* (e.g., Poling & Grossett, 1986). This distinction, however, is based largely on the procedures that are used to produce reversibility. Moreover, it does not accommodate the NCR or DRO control procedures because neither constitutes a reversal as described by Leitenberg, and both involve more than a withdrawal of the experimental contingency.

If one considers the demonstration of behavioral reversibility (Cumming & Shoenfeld, 1959) to be the fundamental element of these control procedures, all designs using control procedures examined in this review are reversal designs, and differences among them are simply a matter how the reversal effect is produced. This applies to most ABA and ABAB designs, as well as to multielement designs, in which the rapidly alternating experimental and control conditions also rely on behavioral reversibility as the basis for demonstrating experimental effects.

CHARACTERISTICS OF CONTROL PROCEDURES

A control procedure should contain all features of the experimental condition except for the independent variable, such that results can be attributed more readily to the experimental variable under study (Barlow & Hersen, 1984). Rescorla (1967) outlined this approach to experimental control in behavioral research many years ago in the context of respondent-conditioning arrangements. During respondent conditioning, a neutral stimulus (NS) is paired with an unconditioned stimulus (US) whose presentation elicits an unconditioned response (UR). This history establishes the NS as a conditioned stimulus (CS) whose presentation elicits a conditioned response (CR) that is very similar to the UR. Traditionally, the effects of stimulus pairings were demonstrated by comparing levels of responding to the CS alone after conditioning (i.e., CS-US pairing) with levels of responding to the CS alone after exposure to a control condition. Typical control conditions consisted of repeated presentation of (a) CS only, (b) US only, (c) CS and US never presented contiguously (explicitly unpaired), (d) US presented prior to CS (backward conditioning), or (e) a CS+ that was paired with the US and a CS– that was never paired with the US (discriminative conditioning).

These procedures were designed to eliminate the contingency between the CS and US, but Rescorla (1967) noted that all were inadequate because they excluded potentially important features of, or included extraneous features that were not present in, the experimental condition. For example, both the CS-only and US-only conditions involve not only the absence of the contingency between CS and US but also the absence of a stimulus that was presented during conditioning. In the explicitly unpaired and backward-conditioning procedures, both the CS and the US are presented; however, the effects are confounded by the introduction of a new contingency because the presentation of the CS always precedes a period in which the US is absent. Finally, discriminative conditioning introduces a stimulus that was not present in the original experimental arrangement. As an alternative, Rescorla proposed the "truly random" control procedure, which involved the random presentation of the CS and the US. This procedure differs from the other control procedures in that (a) all extraneous features (i.e., features other than the independent variable) of the experimental condition are maintained, (b) only the independent variable (the contingency between the CS and US) is discontinued, and (c) no additional contingency is added to the arrangement.

The logic that Rescorla (1967) applied to respondent conditioning is relevant to operant conditioning as well because, although the processes differ procedurally, both involve the arrangement of environmental contingencies. Therefore, we will consider the methodological rigor of operant control procedures using Rescorla's analysis as a model.

CONTROL PROCEDURES FOR POSITIVE REINFORCEMENT

The key feature of a positive-reinforcement contingency is the presentation of a stimulus contingent on the occurrence of a target response (Catania, 1992). Thus, the ideal control procedure for positive reinforcement eliminates the contingent relation between the occurrence of the target response and the presentation of the stimulus while controlling for the effects of the mere stimulus presentation.

Termination of Reinforcer Presentations

The most common control procedure is the conventional extinction condition, which involves the termination of stimulus delivery. That is, the response–reinforcer contingency is eliminated by discontinuing delivery of the presumed reinforcer. For example, in a study by Hopkins, Schutte, and Garton (1971), elementary school students were given access to

a playroom following completion of a writing assignment. This reinforcement condition was compared with an extinction condition in which access to the playroom was unavailable (children were required to remain at their desks until the next task was presented). Contingent access to the playroom was associated with an increase in the number of letters printed per minute relative to the control condition. Similarly, Hermann, de Montes, Dominguez, Montes, and Hopkins (1973) compared the arrival times (punctuality) of 12 workers under a condition in which on-time arrival earned a small monetary reward with those under a condition in which the monetary reward was not delivered, and observed that punctuality was better under the reward condition. Results such as these have been reported in a number of studies in which extinction was used as the control condition (e.g., Coleman, 1970; DeLeon & Iwata, 1996; Kazdin, 1973; Van Houten & Nau, 1980).

There is little question as to whether conventional extinction produces reductions in target responses that have been exposed to positive reinforcement. Occasionally, however, extinction may be difficult to implement due to its potentially negative side effects (Lerman & Iwata, 1996) or the inability to eliminate reinforcement (e.g., teacher attention) entirely. In addition, it is unclear whether extinction is an adequate means of eliminating extraneous variables as sources of control over responding. The extinction control is analogous to the CS-only and US-only controls in respondent conditioning. All of these conditions terminate a previously established contingency by eliminating the presentation of a stimulus that was part of the experimental arrangement; therefore, all of the conditions fail to isolate the contingency as the variable responsible for behavior change. As noted by Catania and Keller (1981), the transition from contingent reinforcement delivery to conventional extinction may involve two behavioral effects: the effects of contingency termination and the effects of terminating the delivery of a reinforcing stimulus. The conventional extinction condition confounds these effects.

This criticism seems reasonable given that reinforcer termination itself may produce significant behavioral effects that are not attributable to the elimination of the contingency between the target response and reinforcer. For example, Azrin, Hutchinson, and Hake (1966) found that a transition from a fixed-ratio (FR) 1 schedule of reinforcement to extinction consistently resulted in increases in pigeons' attack responses. Azrin et al. determined whether this aggressive responding resulted from the termination of the reinforcement contingency or the elimination of food presentations by recording levels of aggression during transitions from noncontingent (response independent) food presentations to extinction. Aggression occurred when noncontingent food deliveries were terminated as well, suggesting that the termination of the stimulus delivery per se was responsible for the increased aggression. In fact, Catania (1992) suggested that a number of the negative side effects commonly associated with extinction (see Lerman & Iwata, 1996, for an extensive review) may be attributable to the termination of reinforcer deliveries and not to the termination of the contingency between response and reinforcer.

In addition to having indirect behavioral effects such as increases in aggression, the presentation or termination of a reinforcing stimulus may have more direct effects on the target response that are not attributable to a contingency. For example, researchers studying operant control of early infant social responses have pointed to the potential eliciting functions of stimuli presented as reinforcers in typical conditioning arrangements. Rheingold, Gewirtz, and Ross (1959) evaluated the effects of social reinforcement (e.g., smiling, physical interaction) on infant vocalizations by comparing a reinforcement condition in which social

stimulation was presented contingent on infant vocalization to a control condition in which the experimenter "remained expressionless." Although the reinforcement condition was associated with higher levels of infant vocalization, suggestive of a positive-reinforcement effect, the authors noted that the extinction control did not rule out entirely the alternative explanation that infant vocalization was elicited by the presentation of social stimulation per se.

Pointing to the same limitation, Bloom and Esposito (1975) and Rescorla and Skucy (1969) suggested that the use of improper control procedures may result in an overestimation of the effects attributable to operant reinforcement. Thus, although conventional extinction has often been successful in reversing the behavioral effects of positive reinforcement, its use as a control procedure presents interpretive difficulties. Essentially, extinction does not adequately isolate the reinforcement contingency as the variable controlling the target response, because mere stimulus presentation cannot be ruled out as an equally viable explanation.

Noncontingent Reinforcement

A control condition that separates the effects of stimulus presentation from those produced by a positive reinforcement contingency would involve continued presentation of stimuli delivered in the experimental condition in the absence of a contingency between the target response and the presentation of those stimuli. In essence, this condition represents the operant equivalent of the truly random control for respondent conditioning described by Rescorla (1967). With respect to positive reinforcement, the truly random control has been referred to as noncontingent reinforcement or response-independent reinforcement (see Poling & Normand, 1999, and Vollmer, 1999, for comments on terminology). Procedurally, this technique involves the presentation of a stimulus according to a schedule that is not influenced by responding; this separates the effects of stimulus presentation from those of the contingency.

The NCR control condition was first reported by Lane (1960) in a study on vocal responding in chickens. He compared levels of vocalization under a contingent reinforcement condition (FR 20 schedule) with those obtained under several other conditions, two of which were NCR controls. One NCR condition was presented prior to any arranged contingency and consisted of continuous free feeding; the other was presented after exposure to contingent reinforcement and involved the delivery of food on a fixed-time (FT) schedule that was based on the mean rate of reinforcement obtained in the contingent reinforcement (FR 20) condition. Rates of responding were elevated in the contingent reinforcement condition relative to both of the NCR controls. This study illustrates two distinct variations of the NCR control condition. The first NCR condition, involving the continuous presentation of food, ruled out food presentation per se as the variable responsible for high levels of responding observed when reinforcement was presented contingent on vocalizations. The second NCR condition further strengthened the demonstration by ruling out the rate of reinforcer delivery as a potential source of control.

In addition to the methodological advantage already noted, NCR has at least one practical advantage that has made it the control condition of choice in a number of applied studies. This advantage was illustrated by a study on access to swimming as a reinforcer for children's toothbrushing at a summer camp (Lattal, 1969). In the reinforcement condition, campers were allowed to go swimming only after toothbrushing. Because it was not possible to completely eliminate swimming from the camp program, an NCR control condition was implemented in which campers were allowed to participate in swimming whether or not they had brushed their teeth. Noncontingent access to swimming was evaluated prior to and

following exposure to the reinforcement contingency, and campers were observed to brush their teeth more consistently during the contingent reinforcement condition.

In applied research, the NCR control condition has been used most often to evaluate the effects of contingent teacher attention on student behavior because, presumably, it would be difficult (and probably unacceptable) to eliminate all teacher–student interactions, a requirement for the conventional extinction control. Hart, Reynolds, Baer, Brawley, and Harris (1968) used an NCR control in a study on social reinforcement of cooperative play exhibited by a young girl. During reinforcement conditions, teachers delivered attention contingent on cooperative play, which resulted in teacher attention during approximately 20% of the observation time. Levels of play obtained under this condition were compared with those observed during an NCR condition (conducted before and after exposure to the reinforcement contingency) in which teacher attention was available for approximately 80% of the observation period and was presented at random intervals. This study is interesting methodologically as one of the first applied demonstrations of the NCR control condition. However, it is important to note that this early application of the NCR control contained a methodological limitation. The contingent and noncontingent reinforcement conditions differed with respect to two potentially influential variables: (a) the presence of a contingency between cooperative play and teacher attention and (b) the amount of teacher attention presented. Therefore, differences in responding evident when the contingent reinforcement and NCR conditions were compared may be attributed either to the reinforcement contingency or to the amount of teacher attention. For example, if teacher attention interfered with cooperative play, increased levels of teacher attention (regardless of whether it was delivered contingently or noncontingently) might account for low levels of responding observed under the NCR condition.

Reinforcer density was equated across experimental and control conditions in a subsequent study on cooperative play by Redd (1969). The reinforcement condition consisted of the presentation of candy contingent on cooperative play, and the control condition involved the delivery of candy according to an FT schedule that was matched to the rate of reinforcer delivery during the contingent reinforcement condition. Contingent reinforcement conditions consistently produced higher levels of responding than did NCR conditions, even though rates of reinforcement were similar in the two conditions.

Results different than those described above were reported by Konarski, Johnson, Crowell, and Whitman (1980) in a study involving application of the response-deprivation hypothesis (Timberlake & Allison, 1974) to academic behaviors. The reinforcement contingency involved access to a low-probability academic behavior (the contingent response) as a consequence for increased performance of a high-probability academic behavior (the instrumental response). Responding under this arrangement was compared with that under a subsequent matched control condition involving noncontingent access to the low-probability academic behavior. Unfortunately, this "matched" NCR condition was not consistently associated with decreases in responding relative to the experimental condition.

Results of the Konarski et al. (1980) study are consistent with those of several others in which response maintenance was observed during NCR control conditions (e.g., Goetz, Holmberg, & LeBlanc, 1975; Osborne, 1969). For example, Bloom and Esposito (1975) compared rates of vocal responding by 8 infants when social stimulation was provided contingent on the response (continuous reinforcement schedule) with those by another group of 8 infants who received response-independent

social stimulation according to a matched schedule. No clear differences were observed between levels of responding under the contingent and noncontingent reinforcement conditions, suggesting that infant vocal responses were not under the control of the arranged contingency. The results of this study and others (e.g., Sheppard, 1969; Weisberg, 1963) in which maintenance of infant social behavior was observed during NCR control conditions have led some researchers to question the role of operant contingencies in the development of these responses (see Poulson, 1983, for a discussion). However, response maintenance during NCR conditions does not necessarily rule out behavioral sensitivity to reinforcement, because maintenance may be related to unprogrammed reinforcement contingencies (i.e., accidental reinforcement).

A number of studies have shown that more gradual or modest response decrements in the target behavior are produced with NCR than with conventional extinction. For example, Rescorla and Skucy (1969) compared the effects of conventional extinction with those observed under variable-time (VT) reinforcement schedules and found that the VT schedule produced more gradual reductions in responding. This pattern has been replicated with VT schedules in a multiple-schedule arrangement (e.g., Lattal & Maxey, 1971) and with FT schedules (e.g., Edwards, Peek, & Wolf, 1970; Herrnstein, 1966).

Thompson, Iwata, Hanley, Dozier, and Samaha (2003) compared the effects of an NCR control condition with those obtained using a conventional extinction control, following exposure to an FR 1 reinforcement condition. Extinction produced more rapid reductions in responding in 4 of the 5 participants, and NCR failed to produce a significant reduction in responding in 2 of these.

Persistence of responding under NCR schedules has often been attributed to unprogrammed contiguity between the target response and reinforcer delivery (Catania & Keller, 1981). This phenomenon was first described by Skinner (1948), who observed the emergence of stereotyped patterns of responding in pigeons, which he described as "superstitious" behaviors. Similarly, Neuringer (1970) found that responding persisted under a VT schedule of food presentation following only three response-contingent food presentations, suggesting that a very brief reinforcement history was sufficient to produce superstitious maintenance under response-independent reinforcement schedules.

Although a number of researchers have highlighted the role of accidental reinforcement under response-independent schedules, results of some studies suggest that persistence of responding under NCR might be partially attributed to stimulus characteristics of the arrangement. Support for this account can be found in studies in which persistence of responding was observed even when a negative contingency (i.e., when the target response decreases the probability of reinforcer delivery) was arranged between the target response and reinforcer delivery, thus eliminating the possibility of accidental reinforcement (Koegel & Rincover, 1977; Rescorla & Skucy, 1969; Thompson et al., 2003; Williams & Williams, 1969). Based on these findings, Rescorla and Skucy suggested that the presentation of reinforcers might (a) elicit responses (e.g., general activity) that increase the probability of the target response, (b) occasion the target response because of a previous correlation with response-contingent reinforcement, or (c) decrease discriminability of the change in conditions.

Regardless of the specific variables responsible for the effect, persistence of responding under NCR represents a limitation to its use as a control procedure. That is, although the NCR control procedure offers clear methodological advantages, there are practical difficulties associated with its use. Given that response

decrement typically occurs more slowly with NCR than with conventional extinction, NCR control conditions may require lengthy exposure. In addition, researchers should be prepared to implement alternative control conditions (discussed below) in the event that a decrement in responding is not achieved during the NCR control condition.

Contingency Reversals

Another procedure that separates the effects of a reinforcement contingency from those of reinforcer presentation per se involves reversing the contingency. The most common contingency reversal is DRO, a term first introduced by G. S. Reynolds (1961) to describe a schedule in which a reinforcer is delivered when the interresponse time exceeds a specified value. Although the term implies that a behavior other than the original target response is explicitly reinforced, the only requirement for reinforcer delivery is the absence of the target response. As a result, some have recommended adoption of terms other than DRO that more accurately describe the schedule requirements (e.g., Lattal, 1991; Uhl & Garcia, 1969; Zeiler, 1970); however, the term DRO continues to be used widely throughout the field.

DRO most closely resembles the explicitly unpaired control strategy for respondent conditioning (Rescorla, 1967), in that the original positive contingency between two events is eliminated and is replaced with a negative contingency between the same events. As Rescorla noted, this technique allows for continued presentation of stimuli delivered within the experimental arrangement, but it also introduces a new (negative) contingency that is not common to the experimental condition.

Baer, Peterson, and Sherman (1967) conducted one of the first applied studies incorporating a DRO control condition. The reinforcement condition was one in which imitation of a model's response resulted in praise and food according to an FR 1 schedule on some trials and no programmed consequences on other (probe) trials. This procedure was associated with high levels of reinforced and unreinforced imitative behavior. Next, a DRO control condition was introduced in which reinforcement was delivered contingent on the absence of imitation for 20 s. This procedure was successful in decreasing previously reinforced and previously unreinforced responses, and a return to the reinforcement condition resulted in an increase in all imitative behavior. Thus, a comparison of the contingent reinforcement and DRO conditions showed that (a) the delivery of reinforcement contingent on imitation was responsible for increases in that behavior, and (b) contingent reinforcement also resulted in increases in unreinforced responses within the same session. More recently, Poulson (1983) compared levels of infant vocalization under an experimental condition in which social stimulation was delivered contingent on vocalization according to an FR 1 schedule with those observed under a DRO control condition in which social stimulation was presented every 2 s in the absence of vocalization (vocalization delayed stimulus delivery by 4 s). This arrangement produced higher densities of stimulus delivery under the DRO schedule relative to the FR 1 schedule. Nevertheless, the infants engaged in higher levels of responding under experimental (FR 1) conditions, suggesting that vocalization was sensitive to the social reinforcement delivered contingent on the response. The alternative explanation, that responses in the experimental condition were elicited by the stimulation presented, was ruled out because lower levels of vocalization were observed under the condition in which the stimulus was presented more frequently (i.e., the DRO condition).

Like NCR, the DRO control has been used frequently in studies on the effects of teacher attention due to practical difficulties associated with implementing conventional extinction (i.e., withholding reinforcement entirely). For example, N. J. Reynolds and Risley (1968) used

a DRO condition as a control for the reinforcing effects of teacher attention on a student's verbalizations. In the treatment condition, teachers provided continuous attention when the child was talking. In the DRO control condition, teacher attention was delivered at levels similar to those during the treatment condition; however, attention was contingent on the absence of vocalization. High rates of vocalizations observed under treatment conditions were decreased under the DRO procedure, suggesting that vocalization was sensitive to teacher attention as a reinforcer.

Several studies have directly compared the effects of DRO with either NCR or conventional extinction. DRO has often produced more rapid and larger reductions in responding than NCR does (J. Davis & Bitterman, 1971; Goetz et al., 1975), which has been attributed to the fact that DRO is designed to eliminate accidental reinforcement of responding. By contrast, Rescorla and Skucy (1969) found that conventional extinction, NCR, and DRO all produced substantial reductions in responding, but conventional extinction produced the largest and most rapid decrements. Because reductions in responding were similarly delayed in the NCR and DRO conditions, suggesting that response maintenance was not a function of adventitious reinforcement, the authors attributed higher levels of responding observed in the NCR and DRO conditions to stimulus characteristics of food presentation.

In a more recent study, Thompson et al. (2003) compared the effects of conventional extinction and DRO following exposure to an FR 1 schedule of reinforcement and found that extinction produced more rapid reductions in responding for 4 of 5 participants. One additional participant was exposed to extinction, NCR, and DRO, but only the extinction condition produced a decrease in responding. These results suggested that responding may have been occasioned by the mere presence of the reinforcer (which was absent in the extinction condition but present in the NCR and DRO conditions). Next, an extinction condition was conducted in which the reinforcer was present but was never delivered. Responding never occurred in this condition; thus, it appeared that behavior was occasioned by stimulus delivery and not by the mere presence of the reinforcer.

These results are consistent with those obtained by Uhl and Garcia (1969), who found that a conventional extinction procedure produced more rapid decrements in responding than did a DRO schedule. The authors suggested that reinforcement arrangements may produce a chain in which consumption of a reinforcer becomes discriminative for responding in the absence of either a programmed or adventitious contingency. Support for this account was provided by an experiment in which differences in the efficiency of DRO and extinction were reduced when the opportunity to respond immediately following reinforcer delivery was eliminated from the DRO condition (by retracting the lever).

Results of the studies reviewed here suggest that, from a practical standpoint, DRO might produce decrements in responding more efficiently than the NCR control but less efficiently than conventional extinction. However, DRO is a less rigorous control than NCR because DRO introduces a negative contingency between the target response and reinforcer delivery (Rescorla, 1967). That is, when NCR is compared with a contingent reinforcement condition, differences in responding observed between the two conditions can be attributed to the contingency present in the experimental condition. Differences observed when reinforcement conditions are compared with DRO conditions may be attributed to either the reinforcing effects of the contingency present in the experimental condition or the suppressive effects of the omission contingency present in the DRO condition.

If the omission contingency associated with DRO were primarily responsible for reductions

in behavior, one might expect that DRO would produce larger decrements in responding than the conventional extinction procedure. By contrast, if the omission contingency is not responsible for reductions in behavior and DRO simply eliminates reinforcement for the target response (i.e., extinction), one might expect DRO to produce reductions similar to those obtained with the conventional extinction procedure. Given that results of several studies (e.g., Rescorla & Skucy, 1969; Thompson et al., 2003; Uhl & Garcia, 1969) have shown that DRO is less effective in decreasing the target behavior relative to conventional extinction (see Zeiler, 1971, for an exception), it seems unlikely that the DRO omission contingency contributes to the reductions that the procedure produces. However, studies have also demonstrated behavioral sensitivity to the parameters of the DRO schedule (e.g., Zeiler, 1977, 1979), suggesting that the omission contingency may be an important component of DRO. Additional research is needed to identify the functional components of DRO; however, researchers must consider the possible contribution of the omission contingency when considering the use of a DRO control condition.

Another contingency reversal technique involves DRA, which is similar to DRO in that both eliminate reinforcement for the behavior targeted in the experimental condition and provide the reinforcer contingent on some other characteristic of behavior. However, whereas reinforcement is delivered contingent on the absence of the target response (no specific response is required) in the DRO arrangement, a specific alternative response is targeted with DRA. In most applied studies in which the DRA strategy has been used, the response that produces reinforcement in the experimental condition is an appropriate response, and the response that produces reinforcement in the control condition is an inappropriate response. Control by the contingency is demonstrated with this strategy when a change is reliably observed only in the response to which the contingency is applied, and this effect is reversed when the contingency is reversed.

Lutzker and Sherman (1974) illustrated the DRA control in training children to describe pictures using singular and plural subject–verb forms (*is* and *are* sentences). During training, praise and tokens were delivered contingent on the use of correct singular or plural forms according to an FR 1 schedule. Each child's behavior was then evaluated in probe sessions in which novel pictures and those presented during training were presented without reinforcement. One participant also was exposed to a DRA reversal in which incorrect singular or plural forms were taught, and his probe performance varied as a function of the contingency in effect during training sessions. That is, when correct forms were trained, the child used correct forms to describe trained and novel stimuli during probes. When incorrect forms were trained, the child used incorrect forms during probes.

A similar strategy was used in a study by Rowbury, Baer, and Baer (1976). Two arbitrary tasks (placing chips in a box and placing disks on a pole) were available to children, who earned tokens exchangeable for access to a play area. In baseline, tokens were presented after 10 s without task completion (DRO). Next, reinforcement was delivered contingent on completion of the task that was performed less frequently during baseline (Task A). The contingency was then reversed such that only completion of the other task (B) produced tokens. Children allocated their responding to the task that produced reinforcement.

The above examples show that the contingency-reversal strategy can be an effective means of demonstrating the effects of reinforcement, but there are some methodological problems associated with this strategy. First, the contingency reversal (DRO and DRA) has the same limitation as the explicitly unpaired control because it introduces a new contingency that

was not present in the original experimental arrangement. As a result, reductions in the target response under a contingency reversal might be attributed to either (a) termination of the contingency between the target response and the reinforcer or (b) introduction of reinforcement for the absence of the target response or for the occurrence of a competing response. In addition, given that reinforcement is provided contingent on some characteristic of responding during the contingency reversal, it may be difficult to control for the rate of stimulus presentation across experimental and control conditions. If responding is not quickly reduced (DRO) or reallocated toward responses that produce reinforcement (DRA), the rate of reinforcement in the control condition may be low relative to the rate of reinforcement in the experimental conditions. When this occurs, the contingency-reversal strategy is functionally similar to the conventional extinction procedure.

Recommendations

NCR is the control condition of choice whenever possible because it provides the most rigorous comparison in evaluating the effects of positive reinforcement, although extended exposure to NCR may be required to produce optimal effects. If practical considerations preclude lengthy exposure to NCR or if NCR does not produce reductions in the target response, the contingency-reversal strategy might then be considered (e.g., Osborne, 1969), although interpretation based on comparisons with a contingency-reversal control should tempered, given the limitations described above.

Given the methodological superiority of NCR, researchers might consider an additional strategy for incorporating the NCR control that may prevent the occurrence of problems such as response maintenance or control by the presence of the reinforcer. Studies of the effects of positive reinforcement typically begin with a baseline condition in which there are no programmed consequences for the target behavior. An NCR condition implemented following or in place of this conventional baseline condition but prior to the contingent reinforcement condition would still provide a test of the effects of mere stimulus presentation before establishing a history of contingent reinforcement for the target response. The finding that NCR was associated with response maintenance after, but not before, exposure to contingent reinforcement would support the conclusion that the target response was sensitive to the positive reinforcement contingency.

CONTROL PROCEDURES FOR NEGATIVE REINFORCEMENT

The key features of a typical negative-reinforcement arrangement are (a) the presentation or scheduled presentation of a stimulus that is (b) terminated, postponed, or deleted (c) contingent on the occurrence of a response (Catania, 1992). Thus, an appropriate control procedure for a negative reinforcement arrangement should involve the elimination of the contingent relation between the response and stimulus removal while relevant stimuli continue to be presented and removed.

Termination of Aversive Stimulus Presentations

The conventional extinction control for negative reinforcement was illustrated in a study by Zarcone, Crosland, Fisher, Worsdell, and Herman (1999), which was designed to identify stimuli that evoked escape behavior in 5 children with developmental disabilities. Participants were first trained to perform a target response that produced a 30-s break from an ongoing activity. Next, six different tasks were presented singly during 10-min sessions, in which performance of the target response resulted in a brief break from the task. Responding in the presence of these potentially aversive tasks was compared (for 4 of the 5 children) to that in a control condition in which no tasks were presented. All children engaged in

the target response when the tasks were presented, whereas none engaged in the target response during the control condition. Although this type of control condition has been used in a number of studies on negative reinforcement, it poses several problems.

First, it contains the same methodological limitation as does the conventional extinction condition for positive reinforcement. Because aversive stimuli presented and removed during the experimental condition are no longer present during the control condition, the procedure does not isolate the effects of the contingency from those of mere stimulus presentation and removal (Catania, 1992). This limitation is particularly problematic because several studies have shown that the presentation of aversive stimuli has significant behavioral effects independent of any arranged contingency. For example, Hake and Campbell (1972) observed that bar pressing and tube biting were maintained when inescapable shocks were delivered to squirrel monkeys, suggesting that some portion of the responses that occur under a negative reinforcement arrangement may result from mere stimulus presentation rather than the arranged contingency. Thus, negative-reinforcement studies in which the conventional control condition is used do not permit an evaluation of the independent effects of aversive stimulation versus negative reinforcement because both of these features are removed from the control condition. As a result, the conventional control may overestimate the contribution of the negative-reinforcement contingency in the maintenance of observed responding. This possibility is supported by additional findings of the Hake and Campbell study: Higher rates of key pressing and tube biting were observed under a response-independent inescapable shock condition relative to a no-shock condition.

An additional limitation of the conventional control was noted by Hineline (1977), who suggested that the discontinuation of aversive stimulation removes reinforcement only indirectly through "suspension of the drive operation on which reinforcement is based" (p. 378). Michael (1993) expanded on this point in his discussion of establishing operations, suggesting that an aversive stimulus presented under a negative reinforcement arrangement establishes its own termination as a reinforcer. Thus, the relevant establishing operation is absent when aversive stimulation is entirely removed, producing a "behaviorally neutral" condition that does not function as extinction. This limitation is not found in the conventional extinction control for positive reinforcement because the relevant establishing operation (i.e., deprivation) remains in effect when reinforcer deliveries are terminated. Thus, although the conventional control conditions for positive and negative reinforcement are procedurally similar (i.e., there are no stimulus presentations), these conditions are functionally different.

Another limitation of the conventional extinction control for negative reinforcement is a practical one that stems from reports indicating that the procedure, when implemented following a negative reinforcement condition, may have little effect on behavior (Catania, 1992). For example, Solomon, Kamin, and Wynne (1953) used a conventional control procedure with dogs that were exposed to shock-avoidance training. Training took place in a two-compartment shuttle box. At the start of each avoidance trial, a light over the compartment was turned off, and a gate separating the two compartments was raised. The dogs received a shock 10 s after this stimulus change (warning stimulus) but avoided the shock if they jumped the gate into the other compartment within 10 s of the warning stimulus. The dogs later were exposed to a conventional control condition in which the presentation of shocks was eliminated. Although this control condition was implemented for 20 days (200 trials), a reduction in

responding was not observed for any of the 13 dogs. In fact, there was a general tendency for response latencies to decrease rather than increase during the control condition. The authors suggested that maintenance of responding under this control condition may have resulted from insufficient contact with the change in contingencies. That is, because the dogs engaged in jumping almost immediately when the warning stimulus was presented, they did not experience the absence of shock for remaining in the first compartment.

Noncontingent Presentation and Removal of Aversive Stimuli

A control condition for negative reinforcement that separates the effects of stimulus presentation and removal from those produced by the contingency involves the noncontingent presentation and removal of the aversive stimulus (Catania, 1992); this is the methodological equivalent of Rescorla's (1967) truly random control. Because the aversive stimulus is presented during this type of control condition, the relevant establishing operation (aversive stimulation) remains present while the consequence (stimulus removal) is delivered independent of behavior.

This type of control was used by Azrin and Powell (1969) to establish pill taking under the control of negative reinforcement. The authors developed a pill dispenser that sounded an alarm 30 min after the previous pill had been dispensed. The alarm could be avoided or terminated by turning a knob that dispensed a pill. The effects of this procedure were compared with those observed in two control conditions. In one control condition, subjects were given a standard pill container and were asked to monitor their own pill-taking behavior using a watch. This control condition might be classified as a conventional control condition because the alarm was eliminated entirely. In a second condition, the alarm was presented and removed noncontingently. That is, the subjects used an apparatus that presented a fixed 3-s alarm at the end of each 30-min interval such that both the presentation and termination of the alarm were unaffected by responding. Pill taking was observed to occur most consistently with the experimental apparatus, suggesting that the negative reinforcement contingency, and not just the presentation of the alarm, was responsible for increases in pill taking.

A similar strategy was used by Davenport, Coger, and Spector (1970), who trained rats on a shock-delay procedure in which shocks were presented every 15 s in the absence of responding (shock–shock interval), whereas responding postponed shock by 15 s (response–shock interval). They compared results obtained under this condition with those obtained in a control condition in which shocks were presented every 15 s independent of the target response and observed that this procedure was effective in eliminating avoidance responding in 4 of 5 subjects.

Researchers studying the effects of negative reinforcement have often attempted to equate the rate of stimulus presentation (and removal) across experimental and control conditions by presenting the aversive stimulus at its maximum frequency during the control condition (Hineline, 1977). For example, in the Davenport et al. (1970) study, the number of shocks presented during the control condition was equivalent to the number that would have been presented in the experimental condition in the absence of responding. However, because the control condition is usually implemented after stable rates of responding are observed in the experimental condition, the transition from the escape or avoidance contingency to a control condition in which aversive stimulation is presented at its maximum frequency would result in an abrupt increase in the number of aversive stimulus presentations experienced by the subject. Thus, it is not clear that the presentation of the aversive stimulus at maximum frequency is the most effective method of equating rates of stimulus presentation.

Coulson, Coulson, and Gardner (1970) used an alternative "matched-shock" procedure, in which the aversive stimulus was presented at frequencies identical to those actually experienced by rats in the experimental session that immediately preceded exposure to the control condition. Results showed that this procedure was effective in producing decrements in responding. However, when compared to a conventional control condition in which no shocks were presented, more gradual and modest reductions were obtained. It is interesting to note that, for subjects that were successful in avoiding all shock presentations in the experimental condition, this matched-shock condition is functionally equivalent to the conventional control condition.

H. Davis and Burton (1975) attempted to equate exposure to shock across experimental and control conditions in a shock-escape arrangement. Rats were exposed initially to a shock-escape arrangement in which shocks were presented every 30 s and were terminated contingent on bar presses. Next, subjects were divided into two groups and were exposed to one of two extinction procedures. Subjects in the response-independent termination condition continued to experience shock every 30 s, the duration of which was equal to the median latency to escape during the last six training sessions with each participant. A second group of subjects experienced a conventional no-shock extinction condition. Both of these procedures produced extinction of escape responses, although extinction occurred more slowly with response-independent shock termination.

Results of other studies have shown response maintenance under noncontingent shock presentation (e.g., Herrnstein & Hineline, 1966; Kelleher, Riddle, & Cook, 1963). For example, Powell and Peck (1969) trained rats under conditions in which responding reduced the intensity of scheduled shocks but did not terminate or postpone shock. The subjects were then exposed to a noncontingent shock condition in which responding had no effect on either shock intensity or frequency. Responding persisted under noncontingent shock, and the authors suggested that these responses were shock elicited because (a) responses tended to occur immediately after shock presentation, and (b) responding also began to occur in the presence of a tone that preceded the presentation of shock, indicating that the tone acquired properties similar to those of shock.

It is important to note that, if responding is elicited by the noncontingent presentation of aversive stimuli under control conditions, it is likely that some proportion of responding maintained under experimental conditions might also be elicited (Hake & Campbell, 1972). Thus, control procedures involving noncontingent presentation of aversive stimuli provide the most conservative estimate of the influence of a negative reinforcement contingency, although researchers using this control should be prepared (a) to provide a lengthy period of exposure to the condition (e.g., Herrnstein & Hineline, 1966) and (b) to develop alternative control strategies in the event that the responding is maintained.

Contingency Reversals

This type of control condition involves a reversal of the negative-reinforcement contingency such that the aversive stimulus is removed contingent on the absence of the target response (DRO) or the occurrence of an alternative response (DRA). Although the contingency-reversal strategy allows for the continued presentation (and removal) of stimuli that were present in the experimental condition, it (like the explicitly unpaired control) adds a new contingency that was not present in the original experimental arrangement.

Although the DRO control strategy has not been used frequently in research on the effects of negative reinforcement, there are a few interesting examples. Pisacreta (1982) implemented DRO for escape in a condition in which both avoidance of and escape from shock were

available. In all conditions, responding in the absence of shock delayed future presentations (avoidance); however, the escape contingency was manipulated across conditions. In the FR 1 condition, a single lever press terminated the shock; in the DRO condition, the shock was terminated contingent on 5 s without responding; and in the differential reinforcement of low rate (DRL) condition, the first response after 5 s terminated the shock (the DRL timer was reset contingent on responding prior to the end of the 5-s interval). Escape responding (responses emitted in the presence of shock) was lower in the DRO and DRL conditions than in the FR 1 condition, suggesting behavioral sensitivity to the arranged contingencies.

When conventional extinction is applied following discriminated avoidance training, shocks are typically eliminated but responding continues to terminate the warning stimulus that preceded shock during training. Thus, although responding is no longer reinforced by shock avoidance, responding may continue to be reinforced by termination of a conditioned aversive stimulus (the warning stimulus). Katzev (1967) developed an alternative control condition to eliminate this potential source of reinforcement by introducing a DRO contingency in which the termination of the warning stimulus was delayed for 20 s contingent on responding. The DRO condition produced more rapid and larger response reductions compared to the extinction condition in which the warning stimulus was terminated contingent on responding.

A DRA contingency reversal was used by Azrin, Rubin, O'Brien, Ayllon, and Roll (1968) in a study on the control of human posture. Participants wore an apparatus that automatically detected slouching. In the experimental (treatment) condition, failure to maintain correct posture (slouching) resulted in an immediate click (warning signal) followed 3 s later by a 55-dB tone. The tone could be avoided if participants corrected their posture within 3 s of the warning signal. Once the tone sounded, it could be terminated only by the initiation of correct posture. Two participants were exposed to a contingency-reversal condition in which the tone sounded contingent on correct posture and was removed contingent on slouching. Participants consistently engaged in the response (correct posture or slouching) that produced avoidance of or escape from the noise.

Iwata (1987) suggested that studies involving response-contingent presentation of aversive stimulation might also be categorized as contingency reversals. According to Iwata, punishment procedures for negatively reinforced behavior may be a functional complement of DRO for positively reinforced behavior because termination or prevention of the aversive stimulus (negative reinforcement) is contingent on the absence of the target response. In fact, a few researchers have used punishment to produce reductions in responding maintained by negative reinforcement. For example, Powell and Peck (1969) found that rats trained under a procedure in which responding reduced the intensity of scheduled shocks continued to respond under a noncontingent-shock condition in which responding did not influence the schedule or intensity of shock. However, responding was reduced when each response resulted in additional shock. The authors suggested that the reductions in responding under contingent shock conditions provided evidence that the arranged contingency, and not just the mere presentation of aversive stimuli, controlled responding. In other investigations, however, the contingent presentation of aversive stimulation has failed to produce reductions in responding following exposure to a negative-reinforcement arrangement (Migler, 1963).

Although the contingency reversal is not commonly used in negative-reinforcement arrangements, the studies described here illustrate how this strategy might be employed to

control for the effects of negative reinforcement. However, interpretation must be qualified because the contingency reversal involves two changes: termination of the negative-reinforcement contingency and the addition of a new negative-reinforcement contingency (i.e., DRO or DRA). For example, the omission contingency might be particularly problematic when DRO is used in demonstrations of negative reinforcement because responding results in the presentation or continuation of aversive stimuli, which could produce decreases in responding maintained by a variety of reinforcers. Therefore, DRO provides relatively weak evidence of the effects of the negative-reinforcement contingency on responding. In addition, because reinforcer delivery is dependent on some aspect of responding during the contingency reversal, it can be difficult to equate rates of reinforcer delivery across experimental and control conditions.

Recommendations

Because much more applied research has been conducted on the effects of positive reinforcement relative to those of negative reinforcement (Iwata, 1987), few applied studies have been published on control procedures for the latter type of contingency. Nevertheless, available information suggests that the most methodologically sound control condition for negative reinforcement is one in which the aversive stimulus is presented and removed noncontingently. However, extended exposure to this condition may be required to produce substantial decreases in the target response. The contingency reversal appears to be the most appropriate alternative to the noncontingent presentation and removal of aversive stimuli and often has been used when other control conditions have failed (e.g., Powell & Peck, 1969; Solomon et al., 1953). Finally, given the substantial limitations associated with the conventional control condition (simply removing the aversive stimulus), this strategy should be considered as a last resort.

CONTROLS FOR OTHER EXTRANEOUS INFLUENCES

Isolating a reinforcement contingency as the sole variable responsible for a particular behavior change requires control over all extraneous features of the experimental arrangement. Many of the techniques discussed thus far were designed to control for the effects of the presentation and removal of stimuli under positive- and negative-reinforcement arrangements, respectively. However, in applied settings, experimental conditions may also include a variety of other procedural features whose effects must be ruled out in order to isolate the variables responsible for behavior change. For example, when a reinforcement program involves the delivery of preferred items, activities, or privileges contingent on appropriate behavior, the delivery of these stimuli often coincides with the delivery of some form of attention (e.g., praise). In these cases, it may be unclear which feature of the reinforcement contingency (e.g., preferred items or praise) is responsible for the behavior change.

An excellent example of this can be found in a study by Bailey, Wolf, and Phillips (1970) on the effects of a home-based token economy to improve the classroom behavior of "predelinquent" boys. In the experimental ("yes" and "no") condition, the students' teacher indicated whether the students had obeyed classroom rules and studied by marking "yes" or "no" for these categories on a daily report card. The students brought the report cards home and earned points exchangeable for privileges for receiving a "yes" in both categories. Thus, the reinforcement program involved both teacher approval and access to privileges. The authors isolated the effects of individual features of this reinforcement contingency with two control conditions. First, a yes-only condition was implemented in which the teacher indicated that all students had performed well in both areas, regardless of their behavior in the classroom, and all students received points

exchangeable for privileges. This condition was essentially an NCR control for the delivery of positive teacher feedback and points. In the second control condition, teacher feedback was provided contingent on student performance; however, privileges were available to all students regardless of their performance as indicated on the report card. This condition served as an NCR control for access to privileges. Results indicated that improvement in the experimental condition could not be attributed to either differential teacher feedback or to access to privileges. Thus, the contingency between student performance in class and delivery of points exchangeable for privileges was identified as the functional component of the intervention.

In a more recent study, Hanley, Iwata, Thompson, and Lindberg (2000) evaluated an intervention designed to increase the leisure-item manipulation of 3 individuals with developmental disabilities. The intervention involved providing access to stereotypic behavior (e.g., body tapping, hand mouthing) contingent on leisure-item manipulation (e.g., holding a massager). The authors noted that this contingency introduced two potential sources of influence: (a) restricted access to stereotypy and (b) a contingency between leisure-item manipulation and access to stereotypy, either of which might result in increased leisure-item manipulation. To separate these effects, the authors designed a control condition in which access to stereotypy was restricted (the behavior was physically interrupted) while no consequences were provided for leisure-item manipulation. Participants were exposed to this control condition prior to experiencing the treatment condition. In 2 of the 3 individuals, increases in object manipulation and decreases in stereotypy were observed simply by restricting access to stereotypy. Similar changes were not observed in the 3rd participant's behavior until access to stereotypy was made contingent on leisure-item manipulation. Thus, for this participant only, the reinforcement contingency, and not restriction of stereotypy per se, was responsible for behavior change.

The Bailey et al. (1970) and Hanley et al. (2000) studies illustrate control strategies for sources of influence attributable to individual components of reinforcement-based interventions. The inclusion of these types of control procedures provides not only a convincing demonstration of experimental control but also information about those features of the treatment that were instrumental in producing the desired effect. This strategy is appealing from a practical standpoint because it allows researchers to eliminate those features of the intervention that may be unnecessary or time consuming to implement.

CONCLUSIONS

Researchers have developed a number of control procedures to evaluate the effects of reinforcement, not all of which convincingly isolate the influence of the independent variable. The most appropriate control procedure for positive reinforcement is an NCR condition in which the rate of reinforcement is matched to that delivered in the experimental condition. Similarly, the most appropriate control for negative reinforcement involves the noncontingent presentation and removal of the aversive stimulus according to a schedule that is matched to that used in the experimental condition.

These control conditions should be used whenever possible because they take into account the effects of contingency, stimulus presentation or removal, and scheduling. Their implementation, however, may pose some difficulties. For example, both NCR and the noncontingent presentation and removal of aversive stimuli have been associated with response maintenance, which may represent the most significant barrier to the use of these methodologically superior control conditions. Therefore, researchers should continue their attempts to identify the conditions that produce

maintenance of responding when stimuli are presented and removed noncontingently. This information might allow researchers to alter slightly the schedule of stimulus presentation to prevent response maintenance. When the NCR control fails to produce the desired reversal effect, alternative control strategies should be selected based on those features of the contingency that are most important to isolate. For example, if the presentation of a reinforcer may influence behavior, the DRO control (reinforcer present) would be preferred over extinction (reinforcer absent).

Selection of alternative control conditions might also be influenced by practical considerations. For example, extinction of behavior maintained by positive reinforcement may produce negative side effects such as response bursting or aggression. Applied researchers have begun to examine more carefully the extent to which extinction, NCR, and DRO are associated with negative side effects when used to treat problem behavior (e.g., Cowdery, Iwata, & Pace, 1990; Lerman & Iwata, 1995; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). However, it is unclear whether these procedures produce the same effects when they are arranged as control conditions to evaluate the effects of reinforcement on appropriate behavior. For example, it is possible that extended response bursting during extinction might be more likely when problem behaviors have a lengthy history of reinforcement but less likely when responses have been newly acquired. Future research is needed to determine whether negative side effects are reliably associated with these control techniques.

Information about control procedures for negative reinforcement in applied situations is particularly lacking, given that there are few documented applications of negative reinforcement to increase appropriate behavior (Iwata, 1987). Therefore, additional research is needed to determine the extent to which various negative-reinforcement control procedures are effective in producing reductions in the target response under applied conditions. In addition, these studies should attempt to document the occurrence of any negative side effects that might be associated with various control conditions.

Applied researchers must balance methodological considerations with practical concerns. The goal, of course, is to choose the most rigorous demonstration that can be achieved given the practical constraints of an experiment. For example, if a very limited amount of time is available for the experiment, it may be diffficult to demonstrate control using an NCR condition that requires extended exposure to reduce the target behavior. In this case, researchers may choose to implement the conventional extinction or contingency-reversal strategies.

Although we have recommended the use of control procedures in which stimuli presented or removed during reinforcement conditions continue to be presented or removed at a similar rate, we have not made specific recommendations for the schedule of presentation during the control condition. For example, during an NCR control condition, stimuli could be presented according to an FT schedule, a VT schedule, or in some cases, according to the exact temporal distribution of presentation during reinforcement conditions (e.g., Bloom & Esposito, 1975). By equating the rate of reinforcer deliveries across experimental and control conditions, one can isolate the effects of stimulus presentation. However, in some cases, the temporal distribution of stimulus presentation may be an influential variable. For example, Lerman, Iwata, Zarcone, and Ringdahl (1994) demonstrated that stereotypic responses were induced by specific reinforcement schedules, suggesting that these may have been adjunctive responses. Adjunctive behavior has not been well studied in the applied literature and should be examined more thoroughly to determine whether it commonly occurs under control conditions.

The most complete understanding of behavior may be produced by examining behavior under multiple control conditions (e.g., Lane, 1960; Rowbury et al., 1976). This strategy is commonly used in the functional analysis of severe problem behavior (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994), in which behavior is observed under multiple conditions to test the effects of social reinforcement. At least two of the conditions (play and alone) typically included in a functional analysis may be considered control conditions (Kahng & Iwata, 1998) in that they allow for the observation of behavior in the absence of the relevant contingency (play and alone) and discriminative stimuli (alone). As in this example, interpretation of data may be facilitated by observing behavior under several control conditions conducted both before and after exposure to the reinforcement contingency.

Researchers should also attempt to evaluate the influence of extraneous features of the experimental arrangement to the extent that it is feasible. Because implementation of a reinforcement contingency often is correlated with a number of environmental changes that are potential sources of control over the target response (e.g., Bailey et al., 1970; Hanley et al., 2000), control conditions should include these procedural features but eliminate the reinforcement contingency. As noted previously, this strategy may yield more practical interventions because ineffective components of the intervention can be discarded. For example, social reinforcement is often delivered in the form of descriptive praise (e.g., Goetz & Baer, 1973), yet this reinforcement contingency also involves the presentation of a potentially effective discriminative stimulus (i.e., instruction) that may be effective in changing behavior in the absence of a contingency. Isolating the effects of instruction from those of contingent attention would improve our understanding of the behavior under study and permit the implementation of the less effortful and more effective intervention.

It is important to recognize that an experimental analysis should be designed to rule out alternative explanations for observed changes in the dependent variable. Thus, the plausibility of alternative explanations may also guide the researcher's choice of control condition. For example, elicitation by presentation of social stimulation may be considered, by some, to be a plausible alternative explanation for increases in infant vocalization (see Poulson, 1983), whereas it may be considered unlikely that the presentation of a preferred food would lead to an increase in microswitch pressing (e.g., DeLeon & Iwata, 1996). Therefore, the continued presentation of the reinforcing stimulus would be considered to be an important component of a control condition in the former case but not the latter.

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Received December 12, 2003
Final acceptance January 18, 2005
Action Editor, Louis Hagopian