

*DEVELOPING A TECHNOLOGY FOR THE USE OF  
OPERANT EXTINCTION IN CLINICAL SETTINGS:  
AN EXAMINATION OF BASIC AND APPLIED RESEARCH*

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Extinction of operant behavior, which involves terminating the reinforcement contingency that maintains a response, is important to the development, generalization, and reduction of behavior in clinical settings. We review basic and applied research findings on variables that influence the direct and indirect effects of extinction and discuss the potential value of a general technology for the use of extinction. We suggest that current research findings are not sufficient for the development of a comprehensive, applied technology of extinction and provide extensive guidelines for further studies on factors that may affect the course of extinction in clinical settings.

DESCRIPTORS: extinction, behavior disorders, reinforcement

Extinction of operant behavior involves terminating the reinforcement contingency that maintains a response, which results in a reduction in the behavior's occurrence over time.<sup>1</sup> Results of basic research (e.g., Ferster & Skinner, 1957; Skinner, 1938) have revealed much about its direct and indirect effects, including a number of variables that influence the general course of responding during extinction. These findings have important implications for the use of extinction in applied settings, in which behavior is of-

ten acquired and eliminated through procedures involving extinction. In fact, the efficacy of many procedures used as treatment for severe behavior disorders may depend on the inclusion of extinction (e.g., W. Fisher et al., 1993; Mazaleski, Iwata, Vollmer, Zarcone, & Smith, 1993; Wacker et al., 1990; Zarcone, Iwata, Smith, Mazaleski, & Lerman, 1994).

Recent improvements in methodologies for identifying the reinforcement contingencies that maintain a number of behavior disorders have facilitated the use of extinction in applied settings. However, further progress in the treatment of behavior disorders, as well as in the development of adaptive behavior, could be achieved through the development of a comprehensive, general technology for the use of extinction. The objective of this paper is to extend the most recent review on the use of extinction to treat behavior disorders (Ducharme & Van Houten, 1994) by providing a broader overview of basic research findings; discussing the relevance of extinction to the acquisition, main-

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<sup>1</sup> Although there is some disagreement as to whether extinction involves termination of the response–reinforcer contingency per se versus termination of the contingency plus nondelivery of the reinforcer (Catania, 1992; Rescorla & Skucy, 1969), the majority of studies reviewed in this paper used the latter procedure to examine extinction. Thus, for the purposes of this paper, we consider extinction to include both termination of the contingency and nondelivery of the reinforcer.

tenance, and generalization of behavior; and presenting detailed suggestions for future research.

At first glance, the voluminous basic literature on extinction appears to provide a solid foundation for technological development; in fact, many texts and chapters on application cite basic research findings when discussing extinction (e.g., Grant & Evans, 1994; Kazdin, 1994). However, a careful examination of this research indicates that it may not provide a sufficient basis for direct translation into an applied technology. Although hundreds of basic studies on extinction have been conducted during the past 5 decades, most were designed to support or refute particular theoretical positions and, as a result, did not thoroughly examine variables relevant to application. In fact, a number of important research findings appeared to depend on the use of specific laboratory preparations. For these reasons, translation of basic findings into an applied technology of extinction requires both replication with and extension to human behavior in clinical settings.

The need for additional research on extinction has gone relatively unnoticed in applied behavior analysis. Studies have focused almost exclusively on the utility of extinction in treating maladaptive behavior, often ignoring more detailed but equally practical examinations of the basic process. In particular, the role of extinction in the development (e.g., response shaping) and generalization of adaptive behavior has received little attention in applied research. The lack of applied research on extinction may be due, at least in part, to the seemingly comprehensive collection of basic research studies and the assumption that results of these studies are completely generalizable to applied problems.

Initially, research on the use of extinction to treat behavior disorders was impeded by difficulties in identifying the source of rein-

forcement to be withheld. Prior to the development of assessment procedures based on functional analysis methodology, the design and implementation of extinction as treatment for problem behavior often emphasized procedural form (e.g., ignoring inappropriate behavior) rather than function (i.e., withholding maintaining reinforcers). These practices most likely resulted in numerous investigations of procedures erroneously described as extinction because they involved withholding irrelevant reinforcers while failing to disrupt the existing contingency between responding and reinforcement. Procedural variations of extinction that are not matched to behavioral function (e.g., ignoring behavior that is not maintained by attention) are generally ineffective in reducing maladaptive behavior, whereas properly designed extinction procedures can produce robust treatment effects (Iwata, Pace, Cowdery, & Miltenberger, 1994; Repp, Felce, & Barton, 1988). Admonitions against the use of extinction, still commonly found in some textbooks and articles on the treatment of problem behavior (e.g., LaVigna & Donnellan, 1986), may be based on the results of incorrect applications of extinction that occurred in early applied work (for reviews of this literature, see Ducharme & Van Houten, 1994; W. Johnson & Baumeister, 1981). Advances in functional analysis technology during the past 10 years have permitted a clearer distinction between procedural and functional variations of extinction, which has led to more effective treatment (e.g., Iwata et al., 1994).

#### CHARACTERISTICS OF RESPONDING DURING EXTINCTION

Basic research studies have delineated several characteristics of behavior exposed to extinction, including the extinction burst, general pattern of responding, indirect effects,

spontaneous recovery, and disinhibition. Although some of these characteristics have also been demonstrated in applied research, few studies have systematically examined these phenomena. Because most of these characteristics can be altered by changes in variables associated with the acquisition, maintenance, and extinction of behavior (e.g., reinforcement schedules, intertrial intervals), the generality of basic findings to behavior in applied settings may be limited.

#### EXTINCTION BURST

##### *Basic (Nonclinical) Research*

Results of basic research with both humans and nonhumans indicate that responding during extinction is often characterized by an initial increase in response frequency (Alessandri, Sullivan, & Lewis, 1990), duration (Margulies, 1961), amplitude (Holton, 1961), and variability (Antonitis, 1951). Initial increases in the variability of a response during extinction can occur in terms of its duration (Trotter, 1957), location (Antonitis, 1951), interresponse time (Millenson & Hurwitz, 1961), latency (Stebbins & Lanson, 1962), and amplitude (Morris, 1968). Extinction has also been associated with an increase in the variability of response sequences (e.g., Schwartz, 1980, 1981, 1982). For example, Schwartz (1982) demonstrated that college students who received points (exchangeable for money) for pressing two keys in any order exhibited a particular response sequence on almost every trial by the end of acquisition training. However, exposure to extinction was immediately associated with a decrease in subjects' dominant response sequences and an increase in the number of novel sequences.

##### *Applied Research and Implications*

The extinction burst is the most frequently noted characteristic of extinction in applied texts and literature reviews (e.g., Ducharme & Van Houten, 1994; Kazdin,

1994; Martin & Pear, 1992) and has been observed as a temporary increase in response frequency in a number of clinical studies (e.g., France & Hudson, 1990; Iwata, Pace, Kalsher, Cowdery, & Cataldo, 1990; Laws, Brown, Epstein, & Hocking, 1971; Neisworth & Moore, 1972; Salend & Meddaugh, 1985). In nearly all of these cases, the burst was relatively brief (lasting a few sessions) and caused no notable problems. Clinicians are often cautioned to expect bursting during treatment (e.g., Cooper, Heron, & Heward, 1987; Drabman & Jarvie, 1977), advised about ways to ensure the safety of the individual and others while continuing treatment (e.g., Ducharme & Van Houten, 1994), and urged to implement alternative treatments when potential bursts are considered unmanageable (e.g., Benoit & Mayer, 1974). However, the extinction burst may not be as common as previously assumed. Lerman and Iwata (1995) recently examined the prevalence of the extinction burst in applied research by analyzing 113 sets of extinction data and found that initial increases in response frequency occurred in only 24% of the cases. Further studies should directly examine the extinction burst, particularly characteristics other than increases in response frequency (e.g., increases in amplitude and variability), the prevalence of bursts during the treatment of problem behavior, and the potential association of bursts with acquisition procedures that involve extinction (e.g., shaping and differential reinforcement).

Although most applied researchers have emphasized the negative aspects of bursting, extinction bursts might be desirable in certain situations. While establishing behavior via response shaping (i.e., differentially reinforcing successive approximations to a target response), extinction might induce the desired rates, amplitudes, or topographies of appropriate behavior. For example, withholding reinforcement for appropriate be-

havior that occurs at a low amplitude (e.g., speech loudness) could induce instances of higher amplitude behavior, which then could be maintained through reinforcement. Several studies have examined the use of extinction to increase behavioral variability (e.g., Carr & Kologinsky, 1983; Duker & van Lent, 1991; Lalli, Zanolli, & Wohn, 1994). For example, Duker and van Lent increased the number of different gesture requests exhibited by 6 individuals with developmental disabilities by withholding reinforcement for high-rate requests. The experimenters first identified two or three requests that subjects exhibited most frequently during a baseline condition in which all gesture requests were reinforced. They then continued to reinforce all but these high-rate requests, and results demonstrated increases in different gesture requests for all subjects. During the treatment of problem behavior, extinction-induced variability may sometimes lead to increases in alternative, more appropriate responses, and clinicians should be prepared to detect and reinforce these appropriate behaviors as soon as they occur. Further studies should examine the practical aspects of extinction bursts during both the acquisition and the reduction of behavior.

#### GENERAL COURSE OF RESPONDING

##### *Basic (Nonclinical) Research*

With the exception of bursting, extinction produces a relatively gradual change in responding compared to that observed during the initial acquisition of the behavior (Skinner, 1938). However, reductions in response rate do not always follow a monotonic function; instead, individuals exposed to extinction tend to respond sporadically during the sessions, gradually pausing for longer periods of time (e.g., Herrick, 1965; Hurwitz, 1962; Warren & Brown, 1943). That is, they tend to allocate less and less time to the response,

but when they engage in the behavior, they do so at rates similar to those in acquisition. Skinner (1933a, 1933b, 1938), who first noted this characteristic of extinction by describing the typical extinction curve as "wave like," speculated that these fluctuations were due to intervening emotional reactions, which eventually "adapt out" across the extinction period. However, Miller and Stevenson (1936), who obtained similar waves in the response curves of rats exposed to extinction of a runway response, found no relationship between these waves and measures of agitated (i.e., emotional) behavior.

##### *Applied Research and Implications*

Few applied studies have examined within-session patterns of responding during exposure to extinction. In a notable exception, Dorsey, Iwata, Reid, and Davis (1982) examined the response patterns of a subject's self-injurious behavior (SIB) that was effectively treated with the continuous application of protective equipment. Cumulative records of within-session responding, which showed the typical wave-like pattern of the extinction curves obtained in basic studies, suggested that the reduction in SIB was due to an extinction effect. Many texts and articles simply describe extinction as an extremely gradual reduction in behavior (e.g., W. Johnson & Baumeister, 1981; Miron, 1973; Romanczyk, Kistner, & Plenis, 1982) and recommend that extinction not be used as the sole intervention if rapid treatment effects are desired (e.g., Favell et al., 1982; R. D. Horner & Barton, 1980; Muttar, Peck, Whitlow, & Fraser, 1975). Results of many early studies supported the contention that extinction was a relatively inefficient treatment procedure (e.g., Duker, 1975; Jones, Simmons, & Frankel, 1974; Lovaas & Simmons, 1969; Wright, Brown, & Andrews, 1978). Jones et al. (1974), for example, found that the extinction of an autistic girl's SIB required more than 160 2-hr

treatment sessions during which thousands of nonreinforced responses occurred. By contrast, data from other studies have shown fairly rapid extinction of problem behavior (e.g., Forehand, 1973; Iwata et al., 1990; Pinkston, Reese, LeBlanc, & Baer, 1973; Repp et al., 1988; Rincover, Cook, Peoples, & Packard, 1979). These numerous exceptions suggest that the inefficiency of extinction as treatment for severe behavior disorders may be overemphasized. For example, Iwata et al. (1990) observed that the SIB of 3 subjects was decreased to near-zero levels by the fifth 15-min session of extinction. It is possible that specific factors present during the acquisition, maintenance, or extinction of behavior are responsible for the varied resistance to extinction found in applied research. These variables, which will be described in some detail, have received surprisingly little attention in the literature.

#### INDIRECT EFFECTS

##### *Basic (Nonclinical) Research*

Several apparent side effects of extinction have been identified in both human and nonhuman subjects. These include increases in other behaviors, such as aggression and previously learned responses, and increases in the target behavior in contexts unassociated with extinction.

*Aggression.* An increase in aggressive responses (called *extinction-induced aggression*) has been observed during extinction following contingent or noncontingent reinforcement (e.g., Azrin, Hutchinson, & Hake, 1966; Frederiksen & Peterson, 1974; J. F. Kelly & Hake, 1970; Todd, Morris, & Fenza, 1989), as well as during discrimination learning (Rilling, 1977). Researchers have suggested that removal of reinforcement constitutes an aversive event, which elicits an emotional reaction in the form of aggression similar to that seen in the presence of shock, intense heat, and physical blows (Azrin et al., 1966).

Levels of extinction-induced aggression generally are highest at the beginning of the extinction period (often following an initial burst in the frequency of the previously reinforced response) and gradually decrease across the extinction session (Azrin et al., 1966; Thompson & Bloom, 1966; Todd et al., 1989). In addition, this indirect effect can continue to occur despite repeated exposure to alternating periods of reinforcement and extinction.

*Agitated or emotional behavior.* Extinction also has been associated with an increase in nonaggressive responses, often called *agitated behaviors* (e.g., Zeiler, 1971). In nonhumans, these behaviors include escape responses (Davis & Donenfeld, 1967); increases in general activity, such as sniffing, ambulating, and whisker cleaning (e.g., Gallup & Altomari, 1969); and increases in responses that are topographically similar to those undergoing extinction (I. Mackintosh, 1955). This increase in activity has been interpreted as frustration associated with exposure to extinction rather than as the resurgence of previously reinforced behavior. In humans, this behavior includes crying, pouting, fussing, rocking, and leaving or attempting to escape the experimental situation (e.g., Baumeister & Forehand, 1971; Rovee-Collier & Capatides, 1979; Sullivan, Lewis, & Alessandri, 1992; Verplanck, 1955).

*Previously reinforced responses.* Few studies with nonhumans and no studies with humans have systematically examined the resurgence of previously reinforced behavior during extinction. Epstein (1983) followed the reinforcement and extinction of a pigeon's key-peck response with the reinforcement and extinction of an alternative, incompatible response (wing raising, turning). During extinction of the alternative response, the pigeons suddenly began to peck the key following a decrease in the frequency of the alternative response. Absence of responding on an available control key indi-

cated that the resumption of responding was not the result of frustration (Amsel, 1958) or an increase in the variability of the behavior (Antonitis, 1951).

*Behavioral contrast.* Many studies with humans and nonhumans have shown a relation between extinction and a phenomenon called *behavioral contrast*. Exposure to extinction (or less favorable conditions of reinforcement) in the presence of one stimulus can lead to an increase in the occurrence of behavior in the presence of a different stimulus associated with continued reinforcement of the response. This occurs when the two schedules are available concurrently (Catania, 1969; Rachlin, 1973) or alternated successively (Reynolds, 1961). For example, studies have found that when a multiple variable-interval (VI) VI schedule is switched to a multiple extinction (EXT) VI schedule, the response rate in the altered component (EXT) decreases, and the response rate in the unaltered component (VI) increases (e.g., Fagen, 1979; McSweeney & Melville, 1993). This effect, called *positive contrast*, is relatively persistent across time. Although the amount of contrast is greatest when the time interval between components of a multiple schedule is small (N. Mackintosh, Little, & Lord, 1972), the effect has been obtained when the components are separated by as much as 23 hr (Bloomfield, 1967). Positive contrast has even been obtained with nonhumans when different reinforcing stimuli and different response topographies were associated with the two components of a multiple or concurrent schedule (e.g., Beninger & Kendall, 1975; Premack, 1969).

#### *Applied Research and Implications*

Despite the potential problems associated with the use of extinction in applied settings, few studies have examined its varied indirect effects, and the prevalence of effects such as extinction-induced aggression and behavioral contrast is unknown. Some have suggested

that, due to the potential occurrence of adverse indirect effects, extinction should not be used as treatment for severe behavior disorders (e.g., LaVigna & Donnellan, 1986). However, such admonitions are premature in the absence of thorough investigations on the prevalence and severity of these problems. Although several studies that have implemented extinction during acquisition procedures or as treatment for problem behavior have anecdotally noted increases in inappropriate behavior, such as aggression (e.g., Herbert, Pinkston, Cordua, & Jackson, 1973; Rekers & Lovaas, 1974; P. Scott, Burton, & Yarrow, 1967), crying (E. Fisher, 1979), complaining (McDowell, Nunn, & McCutcheon, 1969), and leaving or requesting to leave the experimental setting (e.g., Lambert, 1975), few studies have presented data that clearly link these types of behavior with exposure to extinction. Three notable exceptions in the applied literature include Goh and Iwata (1994), who demonstrated increases in aggression during extinction of SIB; Lovaas, Freitag, Gold, and Kassorla (1965), who obtained increases in SIB during extinction of appropriate behavior (clapping and singing); and Sajwaj, Twardosz, and Burke (1972), who showed that increases in both appropriate and inappropriate behaviors (cooperative play and disruption) were associated with removal of reinforcement for student-teacher interactions. These indirect effects could be attributed to either the occurrence of extinction-induced frustration behavior or the resurgence of previously reinforced behavior. In each of the three studies, the inappropriate behavior was eliminated with continued exposure to extinction (Goh & Iwata, 1994; Lovaas et al., 1965) or the application of an additional treatment procedure (Sajwaj et al., 1972). It is somewhat surprising that extinction-induced aggression, which is usually listed among the disadvantages of extinction in texts and ar-

ticles on application, has rarely been reported in applied research.

Another potential indirect effect of extinction, behavioral contrast, has received even less attention in the applied literature. Results of basic research suggest that problem behavior exposed to extinction in only some contexts (e.g., in certain settings or with certain therapists) might worsen in contexts associated with continued reinforcement of the response, even if the contexts are separated by large amounts of time (Bloomfield, 1967). The possibility of contrast effects is particularly important because extinction often is not implemented in all situations. For example, teachers sometimes implement treatment for problem behavior at school, even though caregivers or parents are unwilling or unable to implement the procedure at home. Results of several studies show some evidence of contrast effects during the treatment of problem behavior (Forehand et al., 1974; S. Johnson, Bolstad, & Lobitz, 1976; J. A. Kelly & Drabman, 1977; Wahler, 1975). However, it is unclear if extinction was included in any of these treatment procedures. Koegel, Egel, and Williams (1980), for example, implemented a time-out procedure to reduce an autistic child's aggression at school. The child was placed in isolation time-out for 20 s contingent on each occurrence of aggression on the school playground. Findings showed that treatment-related reductions in aggression at school were associated with increases in aggression at a day-care center, where the time-out procedure was not implemented. Additional research is necessary to determine if extinction is associated with behavioral contrast in applied settings, the characteristics of contrast effects (e.g., persistence across time), and the specific factors responsible for the occurrence of such effects (Gross & Drabman, 1981).

Although clinicians and caregivers should be wary of various indirect effects when im-

plementing extinction during the acquisition and reduction of behavior, these effects sometimes may be desirable, particularly if they are associated with increases in appropriate behavior (e.g., France & Hudson, 1990; Sajwaj et al., 1972). Various strategies to promote such positive indirect effects could be incorporated into an extinction technology. Prior to extinguishing problem behavior, for example, caregivers could reinforce an alternative response that occurs consistently, if not frequently, using the same consequence that maintains the problem behavior. This procedure might increase the efficacy of subsequent treatment (e.g., extinction combined with differential reinforcement of alternative behavior [DRA]) if it results in the resurgence of the previously reinforced alternative response. As another example, teachers might induce higher frequencies of a child's appropriate behavior (e.g., saying "please" before a request) that occurs rarely at school but frequently at home by asking the parent to terminate reinforcement for the behavior at home. The potential occurrence of these desirable indirect effects, however, is hypothetical in the absence of supportive research data.

#### SPONTANEOUS RECOVERY

##### *Basic (Nonclinical) Research*

After extinction of a behavior appears to be completed (i.e., it does not occur for a specified period of time), responding can temporarily reappear. Such spontaneous recovery can occur in both humans and non-humans from a few minutes (e.g., Sheppard, 1969) to more than 1 month (Youtz, 1938) following extinction. Although as much as 50% of the initial response strength may return during the first instance of spontaneous recovery, this amount appears to depend on particular characteristics of acquisition and the length of time that passes between the last extinction session and the test for recov-

ery (Kimble, 1961). Continued exposure to extinction during periods of spontaneous recovery results in similar but smaller extinction curves relative to the original response curve (Skinner, 1938). This phenomenon, which has not been found to occur with differential reinforcement of other behavior (DRO) (Topping & Ford, 1974; Zeiler, 1971) or punishment (Holz & Azrin, 1963), appears to be exclusively associated with extinction.

#### *Applied Research and Implications*

Detailed investigations of the characteristics and prevalence of spontaneous recovery in applied settings are nonexistent. Although spontaneous recovery is frequently described in texts and reviews (e.g., Ducharme & Van Houten, 1994; Kazdin, 1994; Malott, Whaley, & Malott, 1991; Martin & Pear, 1992), few studies have reported its occurrence (e.g., Forehand, 1973; Jones et al., 1974; Wolf, Birnbrauer, Williams, & Lawler, 1965). For example, C. Williams (1959) and Durand and Mindell (1990) noted the reoccurrence of infants' bedtime tantrums after the parents successfully extinguished the behavior. However, recovery of behavior in both studies was associated with the presence of an adult who had not previously implemented extinction, suggesting that the tantrums reoccurred because treatment effects failed to generalize across caregivers. Few studies that reported the reoccurrence of behavior after successful treatment have provided information about events that occurred prior to or following instances of this recovery. Thus, it is unclear if these cases actually involved spontaneous recovery as demonstrated in basic research or if other variables (e.g., lack of generalization, program inconsistency) could account for treatment relapse.

Although most authors emphasize the potential occurrence of spontaneous recovery during treatment of inappropriate behavior,

recovery could also be problematic during acquisition procedures. For example, topographies of behavior that previously met the reinforcement criterion during response shaping could reappear and disrupt performance. Potential problems associated with spontaneous recovery in applied settings should be examined in future research.

### DISINHIBITION

#### *Basic (Nonclinical) Research*

In a manner somewhat similar to spontaneous recovery, responding during extinction can temporarily increase when a novel (extraneous) stimulus is introduced into the setting. Stimuli that have occasioned this increase in responding (called *disinhibition*) include buzzers, lights, white noise, and electric shock (e.g., Baumeister & Hawkins, 1966; Brimer, 1970a; Horns & Heron, 1940). Disinhibition is relatively transient and has not been observed consistently with either humans or nonhumans (cf. Skinner, 1936; Spradlin, Fixsen, & Girardeau, 1969; Warren & Brown, 1943). However, its occurrence may depend on a number of factors, including the type (Horns & Heron, 1940), duration (Brimer, 1970a), and novelty (Yamaguchi & Ladoray, 1962) of the stimulus and the length of time the behavior has been exposed to extinction prior to the introduction of the stimulus (Brimer, 1970a). Research on disinhibition is relatively limited, and conditions that reliably produce this phenomenon have not yet been identified.

#### *Applied Research and Implications*

Disinhibition is rarely discussed in texts or articles on application, and no studies have reported its occurrence. Although results of basic research suggest that some types of stimuli produce disinhibition, this phenomenon may not be prevalent in applied settings. Future studies should attempt to determine which stimuli (if any) produce



disinhibition and if it occurs consistently across subjects in particular situations. Although transient increases in behavior characteristic of disinhibition may be relatively innocuous, caregivers may want to limit an individual's exposure to unusual or novel stimuli if disinhibition is found to be a common phenomenon during the acquisition and reduction of behavior. At the least, caregivers should be prepared for possible increases in extinguished behavior when extraneous stimuli (e.g., loud noises, new staff members) are introduced into the setting.

#### DETERMINANTS OF BEHAVIORAL ACQUISITION AND MAINTENANCE THAT INFLUENCE RESPONDING DURING EXTINCTION

Results of basic research indicate that a number of variables that are present during the acquisition or maintenance of behavior can influence the extinction process. These factors include amount, magnitude, delay, and schedule of reinforcement; variation in the conditions associated with acquisition and maintenance (e.g., presence of certain environmental stimuli); and exposure to aversive stimulation. As part of an extinction technology, these variables could be manipulated prior to extinction to improve the efficacy of treatment aimed at both behavioral acquisition and reduction. For example, factors that minimize resistance to extinction, response bursts, or spontaneous recovery could be incorporated into treatment programs for problem behavior. This strategy would also be useful when reinforcing and extinguishing appropriate behavior during response shaping procedures. Alternatively, variables that increase resistance could be manipulated to enhance response maintenance and stimulus generalization, which can be weakened by extinction effects. Techniques that comprise the current generalization technology (see Stokes & Baer, 1977,

for a review) already incorporate some of these variables (e.g., delayed reinforcement, variable acquisition conditions), suggesting that this technology could be expanded to include a variety of factors that alter resistance to extinction. In fact, a similar mechanism may account for both resistance to extinction and the occurrence of certain types of generalization. In basic research, the effects of variables on resistance often have been explained in terms of the similarity between reinforcement and extinction conditions (N. Mackintosh, 1974), or the extent to which the individual can discriminate the transition from reinforcement to extinction. In a similar manner, articles on application often emphasize the use of procedures designed to alter discrimination or stimulus control when generalization across nontraining conditions (stimulus generalization) or time (maintenance) is desired (Stokes & Baer, 1977; Stokes & Osnes, 1988).

Although these variables appear to have important implications for the acquisition, maintenance, generalization, and reduction of behavior, few applied studies have directly examined their effects on responding during extinction. Such investigations are imperative due to the limited generality of basic research findings and the complexity of variables that tend to operate in the natural environment. Most applied strategies involve manipulating preexisting variables prior to extinction, an operation that has been examined infrequently in basic studies. In addition, the effects of these variables on many characteristics of extinction, including response bursting, extinction-induced aggression, and spontaneous recovery, have received limited attention in basic research.

#### NUMBER OF REINFORCERS

##### *Basic (Nonclinical) Research*

Studies with humans and nonhumans have shown that more reinforcers or trial

presentations may alter the course of extinction in several ways. First, lengthier acquisition training or the presentation of response-independent reinforcers during acquisition has been found to increase resistance to extinction (e.g., Nevin, Tota, Torquato, & Shull, 1990; Perin, 1942; Siegel & Foshee, 1953). Although these findings generally suggest that the increase in resistance does not continue beyond 100 reinforcers (i.e., the increase in resistance reaches an asymptote), some studies have obtained increases in resistance with up to 1,000 reinforcers (e.g., Furomoto, 1971).<sup>2</sup>

Reinforcement number also may affect the occurrence and intensity of the extinction burst, behavioral contrast, spontaneous recovery, and disinhibition. Results of several studies suggest that exposure to a larger number of reinforcers during acquisition may increase the magnitude of the extinction burst (e.g., Holton, 1961), spontaneous recovery (e.g., Homme, 1956), and disinhibition (e.g., Brimer, 1970b), but may decrease the likelihood of contrast effects (Gutman, 1978).

### *Applied Research and Implications*

The effects of reinforcement number on responding during extinction are particularly relevant in applied settings, where inappropriate behavior often has a long history of reinforcement. Although many texts and articles on application have stated that resistance to extinction will increase as the number of reinforcers (or length of time a behavior has been reinforced) increases (e.g., Cooper et al., 1987; Grant & Evans, 1994; Kazdin, 1994; Mercer & Snell, 1977), no studies have examined this variable, and the

generality of basic research findings is somewhat limited. In particular, the specific reinforcement parameters compared in most basic studies (e.g., 50 vs. 100 reinforcers; 5-min vs. 15-min acquisition phases) may not be relevant to responses that have been reinforced for several months or even years. In fact, results of basic research indicate that resistance may fail to change beyond a certain number of reinforcers. For example, behavior that has been maintained for several years may be no more resistant to extinction than behavior that has been maintained for several weeks.

Future studies should examine the effects of reinforcement number by manipulating the length of acquisition or maintenance phases, as well as the presentation of additional reinforcement (either noncontingently or for alternative responses) during maintenance. Results of a study by Nevin et al. (1990) suggest that additional reinforcement (e.g., DRA, noncontingent reinforcement [NCR]) during response maintenance can lead to an increase in resistance to extinction. This finding has an important applied implication because clinicians sometimes implement treatment programs for problem behavior without first identifying and terminating the reinforcement contingency that maintains the behavior. Such a strategy (i.e., implementing DRO, DRA, or NCR without extinction) is not only unlikely to produce substantial treatment effects (cf. Mazaleski et al., 1993) but may produce further treatment difficulties if the problem behavior is subsequently exposed to extinction.

If research findings suggest that reinforcement number is positively related to resistance across a broad range of parameters, behavior disorders should be exposed to extinction in a timely manner, and treatment with DRO, DRA, or NCR should not be implemented prior to extinction. During response shaping, changes in the reinforcement criteria should proceed fairly rapidly so

<sup>2</sup> In some cases, resistance to extinction may actually decrease with extended acquisition training, a phenomenon called the *overtraining extinction effect* (see N. Mackintosh, 1974, and Sperling, 1965, for reviews). This effect may have limited relevance to application because it has been demonstrated with temporal measures of responding only (i.e., latency, duration, or speed).

that resistance to extinction does not hinder the acquisition of new response topographies. Alternatively, reinforcement number could be manipulated when increased resistance to extinction is the desired outcome. For example, acquisition programs for adaptive behavior could be conducted during extended training conditions to promote response maintenance and stimulus generalization. In addition, maintenance conditions could be combined with procedures that involve delivery of additional reinforcement (e.g., NCR, DRA). Although these alternative sources of reinforcement probably would decrease response rates during acquisition, they might in turn enhance response persistence (cf. Nevin et al., 1990). The effects of reinforcement number on other characteristics of extinction (e.g., bursting, behavioral contrast, spontaneous recovery) should also be examined in future studies and the results incorporated into the developing extinction technology.

#### MAGNITUDE OF REINFORCEMENT

##### *Basic (Nonclinical) Research*

Results of basic research with humans and nonhumans suggest that reinforcement magnitude during acquisition or maintenance conditions can influence resistance to extinction. However, the precise nature of this relationship appears to depend on the manner in which reinforcement magnitude is defined and altered. For example, increases in the number of food pellets or cigarettes or the weight of food have been inversely associated with resistance (e.g., Ellis, 1962; Lamberth & Dyck, 1972; Skjoldager, Pierre, & Mittleman, 1993; Wagner, 1961). That is, smaller reinforcement magnitudes produced more resistance to extinction than larger magnitudes.<sup>3</sup> By contrast, other stud-

ies in which reinforcer intensity (e.g., level of sucrose concentration in water) rather than its physical amount was manipulated reported that a larger reinforcement magnitude was associated with more resistance to extinction than was a smaller magnitude (e.g., Barnes & Tombaugh, 1970; Lewis & Duncan, 1957).

##### *Applied Research and Implications*

Many texts on application have suggested that the use of large reinforcement magnitudes during acquisition or maintenance increases resistance to extinction (e.g., Grant & Evans, 1994; Kazdin, 1994), although results of basic research in this area have been inconsistent. In fact, results of the only applied study in which responding during extinction was examined following different reinforcement magnitudes showed an inverse relationship between magnitude and resistance (E. Fisher, 1979). In this study, 13 psychiatric patients received either one token or five tokens for brushing teeth during weekly phases that were alternated with extinction phases in a reversal design. Results showed that 11 subjects exhibited more brushing during extinction after receiving the smaller magnitude of reinforcement (one token) than after receiving the larger magnitude (five tokens). The effect was demonstrated twice for each subject, with the larger reinforcement magnitude always presented prior to the smaller magnitude. Although this design failed to control for possible sequence effects, the author obtained consistent results across repeated presentations of reinforcement and extinction. These findings also replicate those of basic studies that defined reinforcement magnitude as the number of reinforcers delivered for each response.

Future studies should examine the effects of this variable on all characteristics of responding during extinction and assess the utility of altering reinforcement magnitude

<sup>3</sup> This relationship depends on the use of a continuous schedule of reinforcement during acquisition. The interaction between reinforcement schedule and reinforcement magnitude will be discussed below.

prior to extinction. This research should incorporate a variety of behaviors, reinforcers, and reinforcement magnitudes. In particular, reinforcement magnitude should be manipulated across a number of dimensions (e.g., duration, number, intensity). For example, the magnitude of social reinforcement (praise) could be increased by lengthening the duration of each interaction or by enhancing the intensity of the interaction (e.g., praising more enthusiastically). These various dimensions of magnitude may influence responding during extinction in different ways. For example, results of basic studies appear to indicate that lengthy durations of social interaction may reduce resistance to extinction, whereas high-intensity praise may produce the opposite effect (cf. Barnes & Tombaugh, 1970; Wagner, 1961).

In some cases, reduction in magnitude per se might be associated with a decrease in responding due to a concomitant decrement in reinforcer potency, as exemplified in a study by Lawton, France, and Blampied (1991), who treated night wakings in 6 children. They instructed parents to gradually decrease the duration of attention delivered contingent on night wakings from baseline levels to zero across 28 days. This procedure, which the authors termed *graduated extinction*, produced decreases in night wakings for 3 subjects. Treatment effects were obtained before reinforcement for night wakings was completely eliminated, and data for 2 of the 3 subjects showed evidence of bursting (i.e., initial increases in the frequency of night wakings). These results suggest that even slight reductions in reinforcement magnitude could reduce the efficacy of reinforcing stimuli. Although this effect may be beneficial during treatment of problem behavior, it would be problematic for studies that examine basic processes or behavioral acquisition or maintenance.

If results of further studies indicate that reinforcement magnitude influences re-

sponding in predictable ways, this variable could be altered prior to extinction. For example, reinforcement magnitudes that are likely to increase resistance to extinction could be provided when establishing appropriate behavior, a strategy that might enhance response maintenance and stimulus generalization. In addition, the efficacy of treatment for problem behavior might be increased by altering the magnitude of its maintaining reinforcer prior to extinction. If behavior is maintained by escape, for example, the duration of escape could be increased (or decreased) to reduce resistance to extinction or the likelihood of other undesirable indirect effects. If the behavior is maintained by social positive reinforcement, the intensity or duration of contingent attention could be manipulated prior to extinction.

#### DELAY OF REINFORCEMENT

##### *Basic (Nonclinical) Research*

Numerous studies with nonhumans have reported that reinforcement delay during acquisition can increase resistance to extinction (e.g., Capaldi & Bowen, 1964; Crum, Brown, & Bitterman, 1951; Fehrer, 1956; Logan, Beier, & Kincaid, 1956; E. Scott & Wike, 1956; Tombaugh, 1966). Results of these studies suggest that the reinforcement delay should be at least 20 s to 30 s long and should occur intermittently (partial reinforcement delay) rather than following every response (constant reinforcement delay). In fact, a number of studies examining constant reinforcement delay have reported *decreases* in resistance (e.g., Nevin, 1974, Experiment IV; Renner, 1965; Tombaugh, 1970; Wike, Mellgren, & Cour, 1967). For example, Tombaugh (1970) compared the effects of no reinforcement delay (i.e., immediate reinforcement) to both constant and partial delays on the extinction of bar pressing in rats. Results demonstrated that partial

delays were positively related to resistance, whereas constant delays were negatively related to resistance.

#### *Applied Research and Implications*

The effects of reinforcement delay have important implications for the use of extinction in schools and institutional settings, where low staff-to-client ratios often result in delayed consequences for inappropriate behavior. If a parent or caregiver is not present when problem behavior occurs, the maintaining consequences may be provided at a later time. For example, parents may receive reports about the occurrence of inappropriate behavior at school and deliver reinforcement (e.g., attention in the form of verbal reprimand) when the child returns home from school.

Results of several applied studies suggest that delayed reinforcement may increase resistance to extinction and promote stimulus generalization (e.g., Fowler & Baer, 1981; Mayhew & Anderson, 1980). For example, Mayhew and Anderson compared the effects of immediate and delayed reinforcement on the appropriate work behavior of 2 individuals with developmental disabilities. The two reinforcement conditions were alternated with extinction within a reversal design, and each extinction phase was terminated when behavior had decreased to 50% of the previous baseline level. During immediate reinforcement, the subjects received tokens on a VI 30-s schedule for appropriate work behavior in a math class. During delayed reinforcement, the subjects were videotaped during math class but received no tokens. Immediately following class, they viewed the recording while receiving tokens on a VI 30-s schedule for engaging in appropriate behavior on the videotape. Both subjects required more sessions to reach the extinction criterion following delayed reinforcement than following immediate reinforcement. However, sequence effects could partially ac-

count for their findings because delayed reinforcement was implemented first. In addition, exposure to the videotape during the delayed reinforcement condition could have influenced resistance to extinction.

Further research is needed to demonstrate the reliability and generality of these findings. In particular, studies should investigate the effects of both consistent and intermittent delays, which have been found to produce opposite effects on resistance. If delayed reinforcement increases resistance to extinction or the likelihood of undesirable indirect effects, parents or clinicians could deliver more immediate reinforcement for problem behavior prior to treatment with extinction. Alternatively, reinforcer delivery could be systematically delayed when long-term maintenance (i.e., increased resistance) is the desired outcome. Comparable but opposite strategies involving constant reinforcement delay could be implemented if further research suggests that this variable decreases resistance.

#### SCHEDULE OF REINFORCEMENT

##### *Basic (Nonclinical) Research*

Exposure to intermittent or partial schedules of reinforcement can increase resistance to extinction, a phenomenon that has been termed the *partial reinforcement extinction effect* (PREE; see Lewis, 1960; N. Mackintosh, 1974, for reviews). A target response is maintained by partial reinforcement (PRF) if only some instances of the response are followed by a reinforcer; by contrast, every occurrence of the response is followed by a reinforcer under a continuous reinforcement (CRF) schedule. In general, the amount of resistance to extinction, as measured by response rate, number of responses, or time to meet a prespecified extinction criterion, is positively related to the intermittence of the reinforcement schedule (Ferster & Skinner, 1957). The PREE has been demonstrated

using a variety of subjects, responses, and reinforcers, as well as with both free-operant and discrete-trial procedures, although almost always with between-subject designs. By contrast, many attempts to replicate the effect using within-subject designs have failed (e.g., Adams, Nemeth, & Pavlik, 1982; Pittenger & Pavlik, 1988, 1989; but see Hearst, 1961, for a notable exception).

The effect of reinforcement schedules on resistance to extinction is somewhat complex. Most investigations of the PREE manipulated the percentage of reinforced responses or trials during acquisition and demonstrated that resistance was inversely related to these percentages. However, results of studies with both humans and nonhumans, conducted primarily by Capaldi and colleagues, suggest that resistance to extinction is determined by other factors related to reinforcement schedules, such as the number of consecutive nonreinforced trials preceding a reinforced trial (*N* length), the number of different *N* lengths, and the number of each *N* length (e.g., Capaldi, 1964; Halpern & Poon, 1971; Litchfield & Duerfeldt, 1969; Meyers & Capaldi, 1970). In addition, the PREE is more likely to occur when PRF is combined with other variables, including lengthy acquisition training (Uhl & Young, 1967), large reinforcement magnitudes (Amstel, Hug, & Surridge, 1968), delayed reinforcement (L. Peterson, 1956), and massed acquisition trials (Sheffield, 1949). Reinforcement schedules also can influence the effect of reinforcement magnitude on resistance to extinction. Specifically, results of studies in which amount of reinforcement (e.g., number of food pellets) was manipulated showed that large reinforcement magnitudes increased resistance following PRF schedules but decreased resistance following CRF schedules (e.g., Wagner, 1961).

Recent research findings also suggest that the effects of PRF schedules on resistance to extinction may depend on the particular

measure used to reflect resistance. In most studies, resistance is measured by calculating response rate or total number of responses during extinction, or the amount of time to meet an extinction criterion (e.g., no responses for 5 min). Results of these studies generally demonstrated greater resistance to extinction following PRF than following CRF schedules. However, others have argued that data on the PREE should be transformed to adjust for differences in response rates associated with different schedules of reinforcement (e.g., Nevin, 1988). Rate of responding under PRF schedules is generally much higher than rate of responding under CRF, a difference in response rates that will carry over into the subsequent extinction phase. As such, Nevin argued that traditional measures of resistance (e.g., response rate, number of responses) should not be compared following baselines with PRF and CRF schedules because response rates are necessarily much higher during extinction following PRF schedules than following CRF. Instead, data on the PREE should be expressed as a proportion of the response rate during baseline or during the initial extinction sessions, and rate of decrease in responding (i.e., slopes of extinction curves) should be examined. Using this measure of resistance, Nevin reanalyzed data from previous studies on the PREE and found greater resistance following CRF than following PRF schedules (i.e., a reversed PREE).<sup>4</sup>

Results of other research on the PREE have also been inconsistent with both humans and nonhumans. Findings suggest that implementing a period of CRF following a period of PRF might decrease resistance to extinction (Dubanoski & Weiner, 1978; Moreland, Stalling, & Walker, 1983; Pittenger, Pavlik, Flora, & Kontos, 1988), increase

<sup>4</sup> Nevin (1988, 1992) suggested that the reversed PREE will occur when the CRF schedule produces a higher rate of reinforcement than the PRF schedule, which may often be the case in the natural environment.

resistance (H. Jenkins, 1962; Shigley & Gufey, 1978), or have no effect (E. Quartermain & Vaughan, 1961; Sutherland, Mackintosh, & Wolfe, 1965). Numerous procedural differences among these studies make comparisons difficult. Results of studies that have examined the effects of switching from CRF to PRF schedules prior to extinction have been more consistent, demonstrating increases in resistance compared to acquisition training with CRF only (e.g., Nation & Boyajian, 1980; Pittenger et al., 1988).

Reinforcement schedules may influence characteristics of extinction other than resistance. For example, the extinction burst is less likely to occur during extinction following PRF compared to CRF schedules (Keller, 1940; Skinner, 1938). In addition, the response curves of behavior maintained by PRF often fail to show the wave-like character during extinction (W. Jenkins & Rigby, 1950; Skinner, 1938). Although the occurrence of spontaneous recovery appears to be unrelated to reinforcement schedules during acquisition (e.g., Lewis, 1956), results of several studies suggest that reinforcement intermittency is positively related to levels of disinhibition (e.g., Baumeister & Hawkins, 1966; Brimer, 1970b).

#### *Applied Research and Implications*

Although behavior is often maintained on PRF schedules in the natural environment, few applied studies have examined the effects of this variable on responding during extinction. Results of basic studies suggest that certain characteristics of extinction, such as the response burst, may be less likely to occur in the natural environment if behavior has been maintained on PRF rather than on CRF schedules. In addition, reinforcement schedules may increase the likelihood or amount of other characteristics of responding, including resistance to extinction and disinhibition, and may alter the effects of reinforcement magnitude on resis-

tance. Nevertheless, only a few applied studies have examined the PREE (e.g., R. Baer, Blount, Detrich, & Stokes, 1987; Kazdin & Polster, 1973; Koegel & Rincover, 1977), and each contains some potential limitations that prevent clear interpretation of the data (see Lerman, Iwata, Shore, & Kahng, 1996, for a detailed discussion of these problems).

For example, Kazdin and Polster (1973), who reinforced the social interactions of 2 men diagnosed with mild retardation during three daily break periods at a sheltered workshop, compared the effects of two reinforcement schedules on response maintenance during extinction. Reinforcement conditions were alternated with extinction conditions within a reversal design. Initially, both subjects received tokens immediately following each break period (continuous reinforcement) for conversing with peers. They were then exposed to extinction for 3 weeks, and the social interactions of both subjects decreased to near-zero levels by the 2nd week. Following extinction, 1 subject received tokens on the CRF schedule for conversing with peers, and the other subject received tokens after either one or two of the three break periods (intermittent reinforcement). Both subjects then were exposed to extinction for 5 weeks. The subject who had received tokens on the CRF schedule exhibited few social interactions by the 2nd week of extinction, whereas the subject who had received tokens on the PRF schedule showed no reduction in behavior across the 5 weeks of extinction. These results provide one of the few demonstrations of the PREE in applied research. It is possible, however, that results may have been partially a function of reinforcement delay, another variable that was included in the procedure (i.e., the subjects received reinforcement after the break period rather than immediately following each interaction). When combined with PRF schedules, reinforcement delay can enhance the PREE (L. Peterson, 1956).

A recent study by Lerman et al. (1996) examined the PREE with severe behavior disorders using two different experimental designs and measures of resistance recommended by Nevin (1988). After sources of reinforcement that were maintaining 3 subjects' self-injury, aggression, or disruption were identified via functional analyses, the individuals were exposed to extinction following baseline conditions with CRF or PRF schedules alternated within reversal or multielement designs. Responding during extinction following the two reinforcement conditions was compared by examining response rate expressed as a proportion of baseline. Results suggested that problem behaviors may *not* be more difficult to treat with extinction if they have been maintained on PRF rather than CRF schedules and replicated basic research findings by showing that reinforcement schedules can produce different effects on responding during extinction, depending on the particular measure of resistance.

Further studies should investigate the relationship between reinforcement intermittency and resistance to extinction and potential interactions of other variables that commonly occur in the natural environment (e.g., different reinforcement magnitudes, delays, acquisition lengths). In addition, the effects of PRF on other characteristics of responding during extinction (e.g., bursting, aggression) should be examined. Results might indicate various strategies for altering reinforcement schedules prior to treatment with extinction. However, such strategies should be examined in further studies because results of basic research in this area have been inconsistent (cf. H. Jenkins, 1962; Theios & McGinnis, 1967).

Although several applied studies have attempted to examine the benefits of altering reinforcement schedules while treating problem behavior (e.g., Foxx & McMorro, 1983; Neisworth, Hunt, Gallup, & Madle,

1985; Schmid, 1986), conclusions about the effects of switching from PRF to CRF schedules prior to extinction cannot be formed on the basis of their findings. In these studies, the contingencies that were maintaining subjects' inappropriate behavior (stereotypy) were not identified, and it was assumed that the behavior was maintained by PRF schedules of automatic reinforcement. Because sources of automatic reinforcement are difficult to manipulate, arbitrary reinforcers (e.g., food items) were delivered following each occurrence of stereotypy (i.e., on a CRF schedule) and then removed in an attempt to decrease the behavior. Results suggested that the procedure produced short-term reductions in stereotypy for some of the subjects. However, these studies demonstrated the effects of introducing and removing an arbitrary reinforcer on behavior maintained by an unidentified reinforcer, not the effects of switching reinforcement schedules prior to extinction. Studies in this area must involve identification of the maintaining reinforcers for inappropriate behavior and a comparison of responding during extinction following delivery of the relevant reinforcer on PRF schedules versus a switch from PRF to CRF schedules. Lerman et al. (1996), who implemented this strategy with 1 subject, found that switching from a PRF to a CRF schedule prior to extinction lowered the total number of responses exhibited during extinction. However, this outcome was attributed to the differences in baseline response rates associated with the different reinforcement conditions (responding under the CRF schedule was much lower than responding under the PRF schedule).

#### OTHER TYPES OF VARIATION IN ACQUISITION

##### *Basic (Nonclinical) Research*

Irregularity of training conditions per se, including changes in the response topogra-



phy required for reinforcement, presence of environmental stimuli, and variables related to reinforcement (e.g., location, delay, quantity), appear to increase resistance to extinction in nonhumans. The effects of both single and multiple sources of variability on resistance to extinction have been investigated (e.g., Logan et al., 1956; McNamara & Wike, 1958; Tombaugh, 1970). For example, McNamara and Wike, who examined a large number of varied components (e.g., specific stimuli associated with the alley, reinforcement delay, target response, reinforcement schedule, deprivation level, type of reinforcer), found that the greater the irregularity in training conditions, the greater the resistance to extinction under constant conditions.

#### *Applied Research and Implications*

Although behavior in applied settings probably is often exposed to variable acquisition and maintenance conditions, their potential influence on responding during extinction is rarely mentioned in texts and articles on application, and no applied studies have systematically investigated these factors. However, results of several studies examining generalization techniques categorized by Stokes and Baer (1977) as "train loosely" and "train sufficient exemplars" suggest that variability in training conditions could increase resistance to extinction. In these studies, subjects exposed to varied conditions (i.e., different settings, times, experimenters, or other environmental stimuli) during the acquisition of behavior showed both stimulus generalization and response maintenance in situations that were not associated with reinforcement (e.g., Dunlap & Johnson, 1985; Sprague & Horner, 1984; Stokes, Baer, & Jackson, 1974).

In a study by Stokes et al. (1974), for example, generalization and maintenance of a greeting response in children diagnosed with severe or profound retardation were fa-

cilitated by altering the number of experimenters associated with the training procedure. For some subjects, initial training with a single experimenter failed to produce maintenance of the greeting response (i.e., hand wave) in the presence of individuals who did not implement the procedure. When the training procedure was implemented by two experimenters, the subjects' behavior generalized and was maintained across more than 20 other members of the institution staff who did not participate in training. Further, the subjects continued to exhibit the wave for up to 6 months. Although variable training might account for initial generalization and maintenance, natural reinforcement contingencies provided by the staff may be responsible for the extended response maintenance obtained in this study. As discussed by the authors, the subjects' greeting response may have contacted these social consequences more frequently after training. That is, the behavior may have been introduced to a "natural shaping environment" (p. 609) as a result of variable training.

Further research specifically designed to examine the effects of variation on resistance to extinction and other characteristics of responding, such as the extinction burst, extinction-induced aggression, behavioral contrast, and spontaneous recovery, might suggest strategies that could be incorporated into an extinction technology. Prior to treating problem behavior with extinction, for example, clinicians could attempt to reduce sources of variation related to reinforcement delivery (e.g., reinforcement magnitude, schedule, delay) and environmental stimuli correlated with reinforcement delivery (e.g., specific location or caregiver associated with reinforcement). Conversely, variation could be manipulated to promote maintenance and generalization of appropriate behavior.

## EXPOSURE TO AVERSIVE STIMULI

*Basic (Nonclinical) Research*

Results of studies with both humans and nonhumans suggest that exposure to punishment or noncontingent aversive stimulation during acquisition can increase resistance to extinction (e.g., Brown & Wagner, 1964; Chen & Amsel, 1982; Deur & Parke, 1970). For example, Brown and Wagner found that rats exposed to both a CRF reinforcement schedule (contingent food) and an intermittent punishment schedule (contingent shocks) during acquisition of a runway response were more resistant to extinction than were rats exposed to reinforcement alone. However, this effect of punishment or noncontingent aversive stimulation on resistance has not been consistently demonstrated (e.g., Dyck, Mellgren, & Nation, 1974; Haddad & Mellgren, 1976; Halevy, Feldon, & Weiner, 1987).

*Applied Research and Implications*

The effects of previous exposure to punishment or noncontingent aversive stimulation on responding during extinction have not been examined in applied research, and this variable is rarely discussed in texts and literature reviews on extinction. However, this factor may be particularly relevant to the use of extinction in clinical settings. Behavior disorders are often exposed to a plethora of treatment interventions, including punishment, before an effective program is identified (e.g., Bird, Dores, Moniz, & Robinson, 1989). In addition, parents, caregivers, and teachers may inadvertently deliver both reinforcement and punishment following inappropriate behavior (Katz, 1971). For example, parents may deliver verbal reprimands followed by comforting statements contingent on the child's disruptive behavior. When the reinforcers that are maintaining problem behavior eventually are identified and withheld, previous exposure to pun-

ishment may influence treatment efficacy. However, additional studies are necessary due to the inconsistent findings of basic research.

DETERMINANTS OF BEHAVIOR  
REDUCTION THAT  
INFLUENCE RESPONDING  
DURING EXTINCTION

Results of basic research suggest that some characteristics of behavior that is exposed to extinction, particularly resistance, can be altered when variables are manipulated during extinction. These variables include stimulus change, response effort, intertrial-interval (ITI) length, and the use of other behavior reduction procedures and should be considered when developing and implementing acquisition procedures or treatment programs in applied settings.

## STIMULUS CHANGE

*Basic (Nonclinical) Research*

Resistance to extinction is positively related to the similarity between conditions of reinforcement and extinction, a phenomenon that may be responsible for the effect of other variables (e.g., reinforcement magnitude, delay, and schedule) on resistance to extinction (N. Mackintosh, 1974). During acquisition and maintenance, a variety of events or features of the environment can acquire stimulus control properties due to their contiguity with reinforcement delivery. These stimuli can then occasion responding during extinction. Thus, resistance will decrease if these discriminative stimuli are altered or removed simultaneously with the introduction of extinction. Studies directly investigating this variable have manipulated ITI length (e.g., Teichner, 1952), the subject's drive level (e.g., Hatton, 1965), and other stimuli associated with reinforcement, such as goal box color (e.g., Bitterman, Feddersen, & Tyler, 1953; May & Beauchamp,

1969; Morris, 1968). This variable may also be responsible for the efficacy of a procedure called *errorless discrimination learning*, in which stimuli associated with nonreinforcement are initially made as distinct as possible from stimuli associated with reinforcement (e.g., Terrace, 1963).

Instead of changing the parameters of a single variable (e.g., ITI length), some studies have manipulated the proportion of stimuli that are common to both acquisition and extinction (e.g., Hulicka, Capehart, & Viney, 1960). However, the stimuli in these studies may have altered resistance because they were established as conditioned reinforcers rather than as discriminative stimuli during acquisition. For example, Viney, Hulicka, Bitner, Raley, and Brewster (1968) manipulated the number of stimuli that were common to both acquisition and extinction conditions with 60 kindergarten children who were taught a two-choice discrimination task. When a subject responded correctly in acquisition, delivery of the reinforcer (a marble) was accompanied by an audible click, a red light, a blue light, a bell, and a buzzer. During extinction, different groups of subjects were exposed to varying numbers of these stimuli following occurrences of the target response. They reported that subjects' persistence on this task was a direct function of the number of stimuli that were common to both acquisition and extinction. In a similar study, however, N. Johnson (1973) varied the number of stimuli present during acquisition and extinction while keeping the number of stimuli constant across the two phases for individual subjects (i.e., no stimulus change); results showed that resistance was positively related to the number of stimuli present during extinction, which supports a conditioned reinforcement interpretation for the findings of Viney et al. Most likely, both processes (stimulus control and conditioned reinforcement) can operate to enhance resistance

when identical stimuli are present during acquisition and extinction.

#### *Applied Research and Implications*

Although this variable may be one of the most prominent factors that influence resistance to extinction, few applied studies have systematically manipulated stimulus change during extinction, and this variable is rarely mentioned in texts and articles on application. However, results of studies that have examined a generalization technique classified by Stokes and Baer (1977) as "program common stimuli" are consistent with the findings of basic studies suggesting that stimulus change might alter resistance to extinction. For example, results of several studies demonstrated that adaptive behavior persisted longer during extinction or was more likely to generalize to a setting associated with extinction when the therapist who implemented the acquisition procedure was present in the environment rather than absent (e.g., Peterson, Merwin, Moyer, & Whitehurst, 1971; Stokes & Baer, 1976). Further, results of studies by Redd (1970) and Cameron, Luiselli, McGrath, and Carlton (1992) showed that responding was less likely to occur in the therapist's presence when other stimuli paired with reinforcement delivery, such as the container holding the reinforcers, were removed from the setting.

In an interesting study by Rincover and Koegel (1975), 4 autistic children who were taught to follow simple instructions (e.g., "touch your nose") did not respond correctly when a new therapist delivered the instructions in a novel setting. After certain stimuli that had been present during acquisition were introduced into the generalization setting (e.g., therapist's hand movement, touch prompts, table and chairs), correct responding suddenly occurred and was maintained across repeated extinction trials. Stimulus change might also explain the results of studies demonstrating that variation in acquisition can enhance response maintenance and stimulus generaliza-

tion (e.g., Sprague & Horner, 1984; Stokes et al., 1974). By exposing subjects to a variety of exemplars during behavioral acquisition, the experimenters increased the likelihood that similar stimuli were present in both the training and the generalization settings.

Results of these studies suggest that behavior may be difficult to extinguish when the transition from reinforcement to extinction involves no change in the stimulus conditions other than termination of the response–reinforcer contingency, which is frequently the case in applied settings. For example, teachers and caregivers often implement treatment with extinction by simply ignoring problem behaviors that have been maintained by attention, or by continuing ongoing instructional activities if the behaviors have been maintained by escape from these activities. Instead, various strategies designed to increase or decrease stimulus change could be implemented when behavior is exposed to extinction. Certain features of the environment, such as the therapist's appearance, ITI length, and color or texture of task materials, could be altered or removed during treatment of problem behavior. When response maintenance or stimulus generalization is the desired outcome, stimuli associated with reinforcement should remain unchanged (cf. Rincover & Koegel, 1975), and resistance may be further enhanced by pairing additional stimuli with reinforcement and introducing them during extinction (cf. Viney et al., 1968). Further studies should investigate the efficacy of these strategies as well as the effects of stimulus change on other characteristics of the extinction process.

#### RESPONSE EFFORT

##### *Basic (Nonclinical) Research*

The amount of physical exertion or effort required to complete a response has been shown to influence resistance to extinction in some studies with nonhumans (e.g., Ap-

plezweig, 1951; Mowrer & Jones, 1943). For example, Mowrer and Jones trained groups of rats to press a weighted lever with varying loads (0.5 g, 42.5 g, or 80 g) and then extinguished the response with just one load. They found that resistance was inversely related to the weight of the lever during extinction. Similar results have been demonstrated by altering runway inclines (e.g., N. Johnson & Viney, 1970) and jumping distance (e.g., Solomon, 1948); however, other studies have failed to demonstrate this effect (e.g., Haralson, Gillman, & Ralph, 1965; Maatsch, Adelman, & Denny, 1954; D. Quartermain, 1965). Procedural differences probably account for these inconsistent findings; results of several studies suggest that variables that are present during acquisition, including response effort, reinforcement number, and reinforcement schedule, can influence the effects of response effort during extinction (e.g., Aiken, 1957; Young, 1966). For example, Aiken (1957) manipulated the weight of a swinging door during both acquisition and extinction and found that rats that were switched from low effort in acquisition to high effort in extinction demonstrated less resistance to extinction than rats that were exposed to high effort in both conditions. Rats that were switched from high effort in acquisition to low effort in extinction demonstrated greater resistance to extinction than rats that were exposed to low effort in both conditions. Further, resistance was similar for the groups of rats that were exposed to either high or low effort in both conditions.

Results of studies on response effort also may be difficult to interpret because procedures designed to manipulate effort may simultaneously influence other important variables. For example, subjects exposed to a weighted bar during acquisition tend to exhibit many partial responses, which alter the reinforcement schedule (Eisenberger, 1992).

If these partial responses are not counted during extinction, heavy bar weights necessarily appear to produce less resistance to extinction than do light bar weights. In a study by Applezweig (1951), for example, the effect of effort on resistance was less significant when these partial responses were included in the analysis. Other variables that may change when effort is manipulated include reinforcement number, reinforcement delay, and complexity of the target response (Maatsch et al., 1954).

#### *Applied Research and Implications*

Results of basic research suggest that procedures designed to manipulate response effort could be combined with extinction to increase or decrease resistance. Although no applied studies on extinction have examined this variable, several studies have obtained extinction-like decrements in behavior by increasing response effort without terminating the response–reinforcement contingency (e.g., R. H. Horner & Day, 1991; Luiselli, 1991; Schroeder, 1972; Van Houten, 1993). Van Houten, for example, placed soft wrist weights on a subject who engaged in self-injurious face slapping after results of a functional analysis had indicated that the behavior was maintained by sensory (automatic) reinforcement. Results showed an immediate decrease in self-injury during treatment sessions with the wrist weights, as well as a gradual reduction in self-injury during the 5 min immediately preceding and following treatment sessions. R. H. Horner and Day (1991) obtained decreases in appropriate behavior (signing and complying to instructions) by reducing response efficiency (i.e., increasing the work requirement for reinforcement, delaying reinforcement delivery) while reinforcing problem behavior on a CRF schedule. The process responsible for these findings may be somewhat similar to those involved in ratio strain, a decrease in responding that is sometimes observed when

behavior is exposed to relatively thin intermittent reinforcement schedules.

These findings suggest that, when combined with extinction, procedures designed to increase response effort might improve the efficacy of extinction. However, further research is necessary to clarify the relationship between effort and resistance and to examine potential interactions with other variables that may influence behavior in the natural environment (e.g., PRF schedules, long maintenance conditions).

Response effort could be manipulated in a variety of ways, depending on the type of response under investigation and the precise definition of the term *effort*. For example, effort could refer to the level of physical exertion that is required to complete a response, as well as the complexity of a particular task (e.g., one requiring relatively fine discriminations) (cf. Eisenberger & Leonard, 1980). In terms of physical exertion, responses could be made more effortful by attaching weights to relevant appendages like legs or wrists (cf. Van Houten, 1993) or by partially restraining movement in some manner. If the response involves movement of objects in the environment (e.g., task materials), features of these items could be altered so that they are more difficult to grasp or move (e.g., by attaching a weight to the object, removing the handles from an object that must be carried). Alternatively, effort could be reduced by physically assisting the individual to complete the response or by manipulating features of an object that must be moved or carried. In terms of task complexity, effort could be manipulated by providing or removing extra prompts and cues.

Results of this research might suggest various strategies for implementing extinction in applied settings. Basic research findings indicate that response effort should be relatively minimal during reinforcement but high during extinction when a rapid decrease in behavior is the desired outcome. Thus,

treatment programs for problem behavior could be combined with procedures that increase response effort during extinction. Conversely, responding during extinction should be relatively effortless compared to responding during acquisition when resistance to extinction is desirable. Prior to tests for response maintenance and stimulus generalization, for example, therapist prompts and cues could be removed from the situation. When the contingency between responding and reinforcement is eventually terminated, these prompts and cues could be reintroduced into the setting, thereby decreasing response effort.

#### LENGTH OF INTERTRIAL OR INTERSESSION INTERVAL

##### *Basic (Nonclinical) Research*

Results of studies with nonhumans generally have found that massed trials (i.e., short ITI lengths) during extinction will reduce resistance to extinction (e.g., Birch, 1965; Krane & Ison, 1971; Teichner, 1952).<sup>5</sup> Capaldi, Berg, and Sparling (1971), who examined ITI lengths ranging from 3 min to 24 hr, further demonstrated that the PREE can be eliminated by switching from spaced trials during acquisition to massed trials during extinction, an effect that was not entirely attributable to stimulus change (the performance of subjects exposed to massed trials during acquisition but spaced trials during extinction was similar to that of subjects exposed to spaced trials in both conditions). Kurke (1956) examined the effect of manipulating the interval between practice sessions (rather than trials) on the extinction of free-operant bar pressing in rats. Subjects received extinction sessions spaced 22, 46, or 70 hr apart after receiving training

sessions spaced 24 hr apart. In general, he found that resistance to extinction was positively related to the amount of time between extinction sessions.

In addition to influencing resistance, ITI or intersession interval length may affect other characteristics of responding during extinction, particularly spontaneous recovery. Results of some studies have demonstrated that spontaneous recovery was greater when more time elapsed between the first and second extinction periods (e.g., Ellson, 1938; Lewis, 1956; Skinner, 1938).

##### *Applied Research and Implications*

Behavior in the natural environment often occurs during discrete time periods rather than continuously throughout the day. That is, opportunities to reinforce and extinguish both appropriate and inappropriate behavior may be restricted to specific settings or activities, or may be determined by the presence of certain individuals (e.g., parents, teachers, etc.). Results of basic research on ITI (or intersession interval) lengths suggest that massing trials within sessions or decreasing the time between sessions might decrease resistance to, or attenuate the undesirable indirect effects associated with, extinction. If so, various strategies could be incorporated into treatment programs for problem behavior. During extinction of escape behavior, for example, the therapist could deliver the aversive stimuli (e.g., instructions) using fairly short ITI lengths. In addition, treatment sessions could be implemented frequently throughout the day. When opportunities to respond appropriately are restricted to discrete trials (e.g., following delivery of "Do . . ." instructions), resistance to extinction might be enhanced if the trials are separated by relatively large amounts of time. In this case, however, similar ITI lengths probably should be implemented during both acquisition and extinction, because simply altering this variable when switching from rein-

<sup>5</sup> At least one exception should be noted due to its potential relevance to application. Massed trials during extinction may not decrease resistance when the response is exposed to both PRF and massed trials during acquisition (cf. Capaldi, Berg, & Sparling, 1971).

forcement to extinction could decrease resistance (e.g., Teichner, 1952). Thus, an appropriate ITI length should be selected and implemented prior to extinction if resistance to extinction is the desired outcome.

#### COMBINING EXTINCTION WITH OTHER PROCEDURES

##### *Basic (Nonclinical) Research*

Results of studies in which extinction was implemented in conjunction with alternative procedures (e.g., NCR, DRO, DRA) indicate, with some exceptions, that the use of alternative procedures decreases resistance to extinction and the likelihood of certain indirect effects. The effects of NCR have been examined by providing reinforcement (e.g., free food) either continuously or intermittently throughout the extinction session. In general, results of these studies have demonstrated that continuous availability of response-independent reinforcement decreased responding during extinction (e.g., Enkema, Slavin, Spaeth, & Neuringer, 1972). On the other hand, delivery of NCR on fixed or variable-time schedules often increased resistance to extinction or produced resurgences in responding when the reinforcement was introduced after extinction of the behavior appeared to be completed (e.g., Baker, 1990; Lattal, 1972; Neuringer, 1970; Rescorla & Skucy, 1969; Spradlin, Girardeau, & Hom, 1966). Results of these studies suggested that response-independent reinforcement increased resistance because the reinforcer adventitiously followed responding (e.g., Neuringer, 1970) or because the reinforcer acquired stimulus control properties during acquisition (e.g., Baker, 1990; Rescorla & Skucy, 1969). Results of several studies also indicated that intermittent delivery of NCR during extinction reduced the likelihood of behavioral contrast (e.g., Boakes, 1973; Halliday & Boakes, 1971).

Results of studies in which DRA was im-

plemented during extinction have consistently demonstrated that DRA eliminates the response burst and reduces resistance to extinction (e.g., Leitenberg, Rawson, & Bath, 1970; Timmons, 1962; Vyse, Rieg, & Smith, 1985). Results of a study by Leitenberg, Rawson, and Mulick (1975) further demonstrated that the effectiveness of DRA depended on the reinforcement schedule for the alternative response. Specifically, a relatively lean schedule (i.e., VI 4 min vs. VI 30 s) failed to decrease resistance to extinction.

On the other hand, studies that examined the effects of DRO during extinction have reported somewhat mixed findings with both human and nonhuman subjects. Although results of some studies demonstrated that DRO attenuated the response burst, decreased resistance to extinction, enhanced generalization, and reduced the likelihood of behavioral contrast and spontaneous recovery (e.g., Moss, Ruthven, Hawkins, & Topping, 1983; Nevin, 1968; Topping & Ford, 1974; Zeiler, 1971), others demonstrated quicker reduction in behavior when extinction was implemented without DRO (e.g., Cross, Dickson, & Sisemore, 1978; Uhl, 1973). Some authors have suggested that delivery of the reinforcer for not responding during extinction can occasion the target behavior due to the stimulus control properties of the reinforcer. However, results of a recent study by Rieg, Smith, and Vyse (1993) demonstrated that the effectiveness of DRO relative to extinction depended on the relationship between two contingencies involved in DRO procedures, the response–reinforcement interval and the reinforcement–reinforcement interval. The response–reinforcement interval is the amount of time that reinforcement delivery is postponed after each occurrence of the target response, whereas the reinforcement–reinforcement interval is the time between each reinforcement delivery if no responses occur. Rieg et al. found that DRO was more effective than extinc-

tion when the response–reinforcement interval was longer than the reinforcement–reinforcement interval.

Studies that examined the effects of punishment during extinction have consistently reported that punishment decreases resistance (e.g., Azrin & Holz, 1961; D. Baer, 1966; Boe & Church, 1967; Weiner, 1964). Although results suggested that the effectiveness of the punishing stimuli, which included electric shock, point loss, and time-out from positive reinforcement, was directly related to the intensity level, combining extinction with punishment reduced the number of responses even with the mildest intensity level examined.

#### *Applied Research and Implications*

Although many texts and articles on application suggest that combining extinction with other procedures, such as NCR, DRA, and DRO, decreases resistance to extinction and the likelihood of other undesirable indirect effects (e.g., Ducharme & Van Houten, 1994; Kazdin, 1994; Martin & Pear, 1992), few applied studies have directly compared the effects of extinction with and without alternative procedures. Nevertheless, results of these studies have replicated those of basic research, suggesting that combining extinction with NCR, DRA, DRO, or punishment can decrease resistance to extinction. In most cases, the reinforcing stimuli delivered as part of the alternative procedures were those that had maintained the target response prior to treatment.

Several studies have examined the effects of NCR by delivering reinforcers either continuously or periodically throughout the extinction session. Results of studies that examined the continuous delivery of NCR demonstrated a reduction in responding compared to extinction alone. For example, Mason and Iwata (1990) provided continuous social interaction (e.g., praise, pats on the head or back) as part of treatment for

SIB that was maintained by attention. NCR was alternated with an extinction-only condition in which a therapist was present but did not interact with the subject. Results showed immediate suppression of SIB during the NCR condition. On the other hand, levels of responding remained similar to those during baseline (reinforcement) when extinction alone was implemented prior to and following treatment with NCR. The authors concluded that the presence of the therapist during the extinction sessions was discriminative for SIB and that continuous delivery of attention reduced the motivation to engage in the behavior.

Two studies have examined the effects of escape extinction with and without instructional fading on SIB maintained by escape from instructions (Pace, Iwata, Cowdery, Andree, & McIntyre, 1993; Zarcone et al., 1993). For the fading procedure, all instructions were initially removed from the session and later were faded into the sessions by gradually increasing the rate of instructions across the treatment condition. This procedure is somewhat analogous to NCR because subjects are provided with noncontingent access to escape, which is gradually eliminated as more instructions are introduced into the sessions. Pace et al. compared the effects of extinction combined with fading to those of extinction alone using a reversal design during the initial stages of treatment for 1 subject. In the study by Zarcone et al., subjects were exposed to both treatment procedures alternated within a multielement design. Results of these studies demonstrated an immediate suppression of SIB with the introduction of the fading procedure. In addition, fewer self-injurious responses were exhibited in the extinction-plus-fading condition than in the extinction-only condition. Zarcone et al. further demonstrated that implementing extinction in conjunction with fading eliminated the extinction burst for 2 subjects. It is important



to note, however, that the subjects in both studies were frequently exposed to instructions during the negative reinforcement baseline; results of basic studies suggest that if individuals successfully avoid most instructions during baseline, responding may continue to persist during the initial stages of instructional fading (cf. Malloy & Lewis, 1988; Solomon, Kamin, & Wynne, 1953). For these individuals, extinction without instructional fading may be the treatment of choice.

Results of studies in which NCR was delivered continuously rather than intermittently replicated the findings of basic research by demonstrating increases in resistance. For example, Waxler and Yarrow (1970) exposed groups of nursery school children to extinction with or without NCR (praise) after reinforcing imitative responses during a storytelling session. They examined the data for male and female subjects separately. Imitative responses extinguished more slowly for the group of male subjects exposed to the NCR-plus-extinction condition than for the group of male subjects exposed to the extinction-only condition. This finding, however, was not replicated with the female subjects, who responded similarly in the two conditions. The authors did not offer possible explanations for the increased resistance associated with NCR or the different outcomes for male and female subjects. The male subjects exposed to NCR may have demonstrated an increase in resistance because the reinforcer adventitiously followed responding during the storytelling sessions. On the other hand, results of this between-group comparison could simply reflect different extinction rates for the two groups of male subjects.

Findings of another study suggest that NCR may enhance resistance because the reinforcer can acquire stimulus control functions during acquisition and subsequently occasion responding during extinction. Koe-

gel and Rincover (1977) presented response-independent reinforcers periodically after the appropriate behaviors of 2 children diagnosed with autism failed to be maintained in settings that were not associated with the treatment contingencies. When the children no longer responded correctly to "Do . . ." instructions in the absence of contingent reinforcement, the therapist delivered a piece of candy and then continued to present additional instructional trials. Results for both subjects showed temporary but significant increases in correct responding immediately following NCR presentations. In another component of this study, 2 other subjects received a piece of candy every 20 consecutive extinction trials regardless of their previous responding. Their performance was compared to that of 2 subjects who were exposed to extinction without NCR. For the 2 subjects in the extinction-plus-NCR condition, correct responding was maintained for 540 and 450 trials before extinguishing. On the other hand, correct responding of the other 2 subjects was extinguished within 100 trials. The authors concluded that the discriminative stimulus functions of reinforcement were responsible for the enhanced response maintenance demonstrated in this study. However, adventitious reinforcement or different extinction rates among the children could also account for the findings in the second part of the study.

To summarize, results of both basic and applied studies have demonstrated that continuous delivery of NCR can decrease resistance to extinction, whereas delivery of NCR on intermittent schedules can increase resistance. These findings suggest that treatment of problem behavior with NCR should involve, at least initially, nearly continuous presentation of reinforcement. The amount of response-independent reinforcement eventually could be faded as treatment progresses. In two recent studies (Hagopian, Fisher, & Legacy, 1994; Vollmer, Iwata, Zar-

cone, Smith, & Mazaleski, 1993), delivery of NCR during extinction was gradually thinned from almost continuous (fixed-time [FT] 10-s) to FT 5-min schedules while low levels of self-injury were maintained. The effects of combining extinction with NCR using arbitrary reinforcers could also be examined in further studies. Delivery of arbitrary reinforcers on intermittent schedules should not occasion responding during extinction, because no previous contingency existed between the target response and the reinforcer. (This procedure could nevertheless result in adventitious reinforcement during extinction.) The relative effectiveness of this NCR procedure compared to extinction alone probably will depend on the identification of reinforcers that substitute for those that were previously maintaining the target response. When response maintenance and stimulus generalization are desirable, however, intermittent delivery of response-independent reinforcement could be used to enhance resistance to extinction.

Several studies have implemented DRA in conjunction with extinction and compared the effects to a baseline condition in which extinction was implemented alone. Results of these studies consistently demonstrated that DRA reduced resistance to extinction, replicating basic research findings. In a study by Carr and Durand (1985), 5 children were taught to exhibit a verbal response to receive the same reinforcer that previously maintained their disruptive behavior (i.e., either attention or escape from instructions), and treatment with DRA was alternated with a baseline condition in a reversal design. During baseline, the therapist provided no consequences for either disruptive or verbal responses. Results showed immediate suppression of disruption during the DRA condition, whereas high to moderate levels of disruption persisted when extinction was implemented without DRA. In a similar study, Steege et al. (1990) implemented treatment

for SIB maintained by negative reinforcement (escape from grooming activities) using a procedure that combined escape extinction with DRA. Two children who had been diagnosed with profound mental retardation were provided a brief (10-s) escape from grooming activities for pressing a microswitch that activated the prerecorded message "Stop." For 1 subject, treatment was alternated with a baseline condition in which neither response (SIB or microswitch press) produced escape. For the other subject, DRA with and without extinction were compared using a multiple baseline across tasks design. Results for both subjects showed lower levels of SIB in the extinction-plus-DRA condition than in the extinction-alone condition. The specific effects of DRA on SIB were not clear, however, because treatment also included a contingent guided compliance component that was not implemented during baseline (extinction alone).

Although results of these studies showed that DRA decreased resistance, a similar outcome was not obtained in a study that directly examined the effects of DRO on responding during extinction. Following a functional analysis indicating that the SIB of 2 subjects was maintained by attention, Mazaleski et al. (1993) compared the effects of extinction with and without DRO by alternating the treatment procedures with a baseline (reinforcement) condition in a reversal design. The order of the treatment conditions was counterbalanced across the subjects, and results demonstrated similar reductions in SIB during the extinction-plus-DRO and extinction-only conditions. As suggested by the findings of Rieg et al. (1993), however, a different reinforcement schedule might have increased the relative efficacy of treatment with DRO. The DRO schedule used by Mazaleski et al. involved identical response-reinforcement and reinforcement-reinforcement intervals (both were 15 s). DRO may have been more

effective than extinction if the response-reinforcement interval had been longer than 15 s.

Although relatively few applied studies have compared the effects of extinction alone to extinction combined with alternative sources of reinforcement, results have consistently demonstrated that responding during extinction was reduced substantially when NCR or DRA was implemented in conjunction with extinction. Lerman and Iwata (1995) examined the prevalence of the extinction burst in 113 sets of data and further noted that the occurrence of bursting was reduced when extinction was combined with other treatment components. These findings suggest that treatment with extinction should be implemented in conjunction with NCR, DRA, or DRO as recommended by various authors (e.g., Ducharme & Van Houten, 1994; Kazdin, 1994). On the other hand, these results also indicate that reinforcement delivery should be withheld if maintenance of appropriate behavior during extinction is the desired outcome. That is, behavior may rapidly extinguish when the reinforcer that previously maintained the target response is delivered noncontingently or for other responses.

Not surprisingly, results of several studies have also demonstrated that punishment can decrease resistance to extinction. In a study by W. Fisher et al. (1993), the disruptive behavior of 2 individuals who had been diagnosed with profound mental retardation persisted during treatment with extinction (1 subject) or extinction combined with DRA (the other subject). For both subjects, combining extinction with punishment (either contingent effort or contingent restraint) produced immediate decreases in disruptive behavior. Results of three studies that examined extinction of SIB with and without punishment (contingent electric shock) also demonstrated the superiority of punishment combined with extinction rela-

tive to extinction alone as treatment for problem behavior (Baroff & Tate, 1968; Lovaas & Simmons, 1969; D. Williams, Kirkpatrick-Sanchez, & Iwata, 1993). These findings suggest that extinction combined with punishment may be the treatment of choice when behavior is extremely resistant to extinction. However, the prevalence of such cases may be reduced dramatically with the development of a comprehensive technology for the use of extinction in applied settings.

## CONCLUSIONS

Results of basic research indicate that a number of variables may influence responding during extinction. In general, behavior that is exposed to aversive stimuli, variable maintenance conditions, and large, intermittent, delayed reinforcers may be highly resistant to extinction. This resistance may be further enhanced if extinction is implemented with spaced trials or sessions and a reduction in response effort, if the transition from reinforcement to extinction involves minimal stimulus change, and if extinction is not combined with alternative procedures such as NCR, DRA, and DRO.

These findings are based, in large part, on experiments done in laboratory settings with nonhuman subjects, yet they suggest that problem behavior, which is often exposed to factors like intermittent reinforcement in the natural environment, may be difficult to treat with extinction. Such a conclusion appears to be incongruent with results of numerous applied studies during the past 10 years that have demonstrated that extinction can produce fairly immediate, large, and durable reductions in problem behavior if the procedure involves withholding relevant (maintaining) reinforcers (e.g., Iwata et al., 1994). However, the baseline (reinforcement) and extinction conditions implemented in most applied studies incorporated (ei-

ther by design or accident) variables that were associated with reduced resistance. For example, behavior typically was maintained by continuous, immediate reinforcement under constant (nonvarying) conditions prior to treatment, and the extinction procedures often included relatively massed trials and delivery of the relevant reinforcer for either nonresponding or the occurrence of alternative responses.

The present analysis of basic and applied research indicates the potential value of a comprehensive technology of extinction, provides a number of guidelines for future research, and suggests strategies that might facilitate the acquisition, maintenance, and reduction of behavior in applied settings. In the case of problem behavior, for example, treatment efficacy might be enhanced if caregivers or therapists alter several variables prior to extinction. Specifically, the therapist could switch from a PRF to a CRF schedule, shorten the latency between the occurrence of a response and reinforcer delivery, alter the reinforcement magnitude (the direction may depend on the reinforcer and how this variable is modified), and eliminate any variation in the conditions associated with reinforcement. If a target response is maintained by escape from instructional activities, for example, the therapist could deliver escape immediately following each occurrence of problem behavior while ensuring that the maintenance conditions are fairly consistent (e.g., the setting, therapist, task materials, and other stimuli associated with reinforcement delivery remain unchanged). Future research should determine if, in fact, these procedures increase the clinical efficacy of extinction.

With the transition from reinforcement to extinction, ITI length could be shortened, response effort could be increased, a variety of environmental stimuli could be modified, and additional procedures (e.g., DRO, DRA) could be incorporated into the treat-

ment program. During escape extinction, for example, the therapist could conduct numerous instructional sessions throughout the day, alter a variety of environmental stimuli (e.g., appearance of the setting), increase response effort by modifying the task materials, and provide escape from instructions for alternative behaviors such as compliance. Treatment of problem behavior could also be combined with methods designed to facilitate the occurrence of desirable indirect effects that are associated with extinction (e.g., increases in appropriate behavior due to behavioral contrast or the resurgence of previously reinforced responses).

Parallel strategies could be constructed to facilitate generalization and long-term maintenance of appropriate behavior. Applied behavior analysts generally agree that a pragmatic approach to therapeutic behavior change incorporates strategies designed to promote change across time, people, and settings (Stokes & Baer, 1977). Procedures that strengthen resistance to extinction are appropriate when response maintenance and stimulus generalization may be undermined by extinction effects. After a response is acquired, the probability of long-term maintenance might be increased if the reinforcement schedule, delay, and magnitude are altered; other stimuli associated with reinforcement delivery are varied (e.g., different therapists and settings are incorporated into maintenance sessions); response effort is reduced; and the relevant reinforcer is delivered for alternative responses or independent of behavior.

The development of an applied technology of extinction will require thorough examination of these variables (singly and in combination), their potential effects on other characteristics of responding during extinction (e.g., extinction-induced aggression, spontaneous recovery, disinhibition), and the efficacy of the numerous strategies outlined in this paper. However, the benefits of this

technology should be considered in relation to the costs of conducting this research and of implementing such complex strategies in applied settings (along with the formidable task of identifying the maintaining variables of problem behavior). In particular, this technology may be largely superfluous if other interventions can reduce problem behavior without the use of extinction.

Results of numerous studies have, in fact, demonstrated that a variety of reinforcement and punishment procedures can effectively treat problem behavior (see reviews by Cooper et al., 1987; Favell et al., 1982; Matson & DiLorenzo, 1984). However, procedures such as DRO, DRA, and punishment typically include an implicit extinction component, and the potential contribution of extinction to the utility of these alternative treatments is generally overlooked. In fact, results of several recent studies indicate that the effects of reinforcement-based interventions may be limited unless extinction is included as part of the treatment (e.g., W. Fisher et al., 1993; Mazaleski et al., 1993; Williamson, Coon, Lemoine, & Cohen, 1983; Zarcone, Iwata, Mazaleski, & Smith, 1994). In addition, data from a number of studies suggest that even restrictive interventions (implemented without extinction), such as time-out, water mist, manual restraint, verbal reprimands, mouthwash, and the noncontingent application of protective equipment, can be less effective than properly designed extinction procedures (e.g., Dorsey et al., 1982; Iwata et al., 1994; Luiselli, 1988).

These research findings suggest that extinction, which is rarely recommended as a single intervention, may be a critical component in the treatment of severe behavior disorders. Further, extinction appears to play an influential role in the development and generalization of adaptive behavior. In light of the potential contribution of an extinction technology to such a broad array of ap-

plied problems, it seems that time would be well spent conducting both comparative and component analyses to identify key factors that affect the course of extinction in applied settings.

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