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ANTECEDENT INFLUENCES ON BEHAVIOR DISORDERS

RICHARD G. SMITH
UNIVERSITY OF NORTH TEXAS

AND

BRIAN A. IWATA
UNIVERSITY OF FLORIDA

The influence of antecedent events on behavior disorders has been relatively understudied by applied behavior analysts. This lack of research may be due to a focus on consequences as determinants of behavior and a historical disagreement on a conceptual framework for describing and interpreting antecedent variables. We suggest that antecedent influences can be described using terms derived from basic behavioral principles and that their functional properties can be adequately interpreted as discriminative and establishing operations. A set of studies on assessment and treatment of behavior disorders was selected for review based on their relevance to the topic of antecedent events. These studies were categorized as focusing on assessment of antecedent events, antecedent treatments for behavior disorders maintained by either positive or negative reinforcement, and special cases of antecedent events in behavior disorders. Some directions for future research on antecedent influences in the analysis and treatment of behavior disorders are discussed.

DESCRIPTORS: antecedent events, behavior disorders, establishing operations, functional analysis

In a seminal article published over 25 years ago, Baer, Wolf, and Risley (1968) proposed several dimensions of applied behavior analysis. These characteristics were to be guideposts for the study of socially significant behavior and are largely accepted as standards for the conduct of applied research. One dimension of applied behavior analysis is its relation to a conceptual system. That is, procedures and interpretations in research should be derived from basic principles in order to establish and maintain a conceptually coherent applied science. The extent to which research published in journals such as the *Journal of Applied Behavior Analysis* reflects adherence to this standard has been the subject of ongoing discussion (e.g., see the special section entitled "Science, Theory, and Technology," Vol. 24, No. 3). In fact, a criticism of applied behavior analysis is a perceived failure to relate the many procedures generated for changing socially significant behavior to basic behavioral principles.

A conceptual issue that has received relatively little attention in applied research is the influence of antecedent events on problematic behavior. A recent review of research on behavior disorders indicates that only 11.1% of subjects treated for maladaptive behavior received treatment primarily based upon manipulation of antecedent variables (Lennox, Miltenberger, Spengler, & Erfanian, 1988).[1] At least two factors might ac-

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Correspondence regarding this paper should be directed to Richard G. Smith, Department of Behavior Analysis, P.O. Box 13438, University of North Texas, Denton, Texas 76203 (E-mail: Rsmith@scs.unt.edu).

[1] The percentage of subjects who had received antecedent-based treatments was derived by dividing the number of subjects who had received antecedent-based treatments (61) by the number of subjects surveyed

count for this lack of emphasis on antecedent control. First, a primary goal of applied research is socially significant behavior change. A central thesis of behavior analysis is that operant behavior occurs (or does not occur) as a function of its consequences. The most direct method to produce changes in behavior is to manipulate its consequences. The search for interventions, then, naturally focuses on well-established consequent operations, such as reinforcement and punishment, rather than on antecedent events, whose influence on behavior is often considered to be both secondary to and derived from consequences.

In addition, there is a lack of consensus at the theoretical level on how best to describe or classify antecedent variables (Catania, 1993; Marr, 1993; Michael, 1993b; Morris, 1993). At least three theoretical frameworks currently exist: Skinner's operant theory (Skinner, 1953), Kantor's interbehavioral account of setting events (Kantor, 1970), and Michael's system of evocative functions (Michael, 1982). Although the latter accounts are derived from and are consistent with operant theory, they represent significant extensions of Skinner's original account, and the relative contributions and limitations of each for improving our understanding of antecedent events remain unclear. Thus, attempts to relate the outcomes of antecedent manipulations in applied work to behavioral principles find little in the way of a unifying system of interpretation.

The objectives of this article are to describe the major accounts of antecedent processes in operant behavior, to offer a conceptual review of applied research on antecedent events in behavior disorders, and, finally, to identify some promising areas for future investigation.

(548) and multiplying the result by 100. The number of subjects who had received antecedent-based treatment was derived by summing the total number of subjects treated by procedures categorized as environmental change ($n = 13$), antecedent control ($n = 7$), instructions ($n = 23$), role play ($n = 14$), and satiation ($n = 4$); this estimate may artificially inflate the actual number of antecedent-based interventions, because it is unclear that categories such as "environmental change," "instructions," and "role play" represent antecedent interventions exclusively.

SKINNER

Although Skinner's account of behavior is often characterized primarily as *reinforcement theory,* with major emphasis on consequences as determinants of behavior (e.g., Roediger, Capaldi, Paris, & Polivy, 1991), his writings contained extensive consideration of the environmental conditions under which behavior may occur. These antecedent influences include such processes as discrimination, deprivation and satiation, emotion, and aversive stimulation.

Discriminative Stimuli

Skinner defined the discriminative contingency as "the occasion upon which a response . . . is followed by reinforcement" (Skinner, 1953, p. 108). That is, stimulus control[2] over behavior is developed through differential reinforcement of responding in the presence of discriminative stimuli (S^Ds). Skinner emphasized the probabilistic nature of the behavior that resulted and contrasted this with the one-to-one relationship between eliciting stimuli and behavior in the respondent paradigm.

Skinner claimed that virtually all operant behavior falls under stimulus control, asserting that "if all behavior were equally likely

[2] The term *stimulus control* is used here and throughout this article to describe conditions under which behavior is altered due to a correlation between responses and consequences. This usage is consistent with the commonplace characterization of stimulus control operations as "signaling" occasions on which responses will result in particular consequences (Catania, 1992, p. 21). Thus, stimulus control is viewed as equivalent to *discriminative control,* and the terms are used interchangeably throughout this article.

to occur on all occasions, the result would be chaotic" (Skinner, 1953, p. 108). He believed that a description of the discriminated operant was incomplete without specification of the conditions under which responding was likely to result in reinforcement, the response requirement, and the reinforcing event; these were major organizing principles of operant behavior. However, he suggested that discrimination may be irrelevant for behavior maintained independent of the extrinsic environment (i.e., behavior that is "automatically reinforced by the organism's own body without respect to external circumstances," Skinner, 1953, p. 108), presumably because no conditions are *differentially* correlated with these consequences.

Discrimination describes a specific functional relationship among antecedent events, behavior, and consequences that applies to a wide range of circumstances. However, discriminative stimuli do not always evoke relevant responses. Apparently, variables that are unrelated to the availability of reinforcement may also affect the likelihood that behavior will occur. Skinner proposed several processes to account for such variability in the discriminated operant.

Deprivation and Satiation, Emotional Stimuli, and Other Antecedent Variables

Skinner suggested that, with access to reinforcement held constant, operant behavior could be increased or decreased through deprivation or satiation, respectively. If an organism is sufficiently deprived of a given reinforcer, responses maintained by that reinforcer will be emitted at the first opportunity. By contrast, satiation will reduce responding even when the reinforcer is freely available. Although the adaptive significance of these operations is most evident in the consumption of substances necessary to sustain life (i.e., food, water, etc.), Skinner (1953) suggested that deprivation also could strengthen behaviors such as physical exercise, social interaction, and sexual activity.

Skinner's account of emotions and emotional stimuli suggests a similar effect, stating that "we define an emotion—insofar as we wish to do so—as a particular state of strength or weakness in one or more responses induced by any one of a class of operations" (Skinner, 1953, p. 166). Emotions such as rage, love, fear, anger, joy, sorrow, frustration, and phobic responses share common features in that they (a) are induced by some environmental condition, (b) are typically accompanied by reflex responses, and (c) alter the probability of a class of behaviors distinguished by a "common consequence" (Skinner, 1953, p. 166). Emotional behavior thus appears to be primarily operant in nature; emotional stimuli simultaneously elicit reflex responses and evoke responses that belong to a specific functional class.

Other events can similarly alter response probabilities; classic examples of the ways in which drinking may be increased, including induction of sweating through heat or exercise, increased excretion through the ingestion of salt, or the loss of blood, all take their effects independent of the availability of water (Skinner, 1953). That is, given continuous access to water, the probability of drinking can be changed through these procedures.

Thus, deprivation and satiation, emotions, and certain other events can have effects on behavior that cannot be described in terms of discriminative control. Although Skinner recognized a common "motivational" aspect among all these operations, the precise mechanisms of control were not stated. These antecedent influences were defined according to their *structural* rather than their *functional* properties. This absence of unifying function forced independent consideration of the formal variants of antecedent influence, producing overlap among classes

of variables and categorization of unusual cases, by default, as "other variables" that have effects "similar to . . . deprivation or satiation" (Skinner, 1953, p. 158).

Aversive Stimuli

Another way in which antecedent conditions can influence behavior is through aversive stimulation. Skinner introduced the term *negative reinforcement* to describe response-contingent termination or avoidance of aversive stimulation. *Aversiveness* was a property defined by its effects on behavior rather than by its power to induce pain, discomfort, or annoyance; thus, a stimulus that strengthens behavior through its contingent withdrawal, postponement, or reduction is, by definition, aversive.

Although aversive stimuli share characteristics with discriminative stimuli in that their presence as antecedent conditions alters the probability of responding, aversive stimulation is not necessarily correlated with response-contingent reinforcement (as in the case of inescapable shock). Therefore, the evocative functions of aversive and discriminative stimuli seem more structurally than functionally similar. Skinner noted similarities between antecedent aversive stimulation and "a sudden increase in deprivation" (Skinner, 1953, p. 172) and acknowledged an apparent relationship between aversive stimulation and emotional responding (e.g., Skinner, 1953, pp. 172, 174, 176); however, the exact nature of this relationship is unclear (Skinner's argument that emotional responses generated by aversive stimulation may interfere with operant conditioning suggests that these were considered to be separate but correlated processes). Although antecedent aversive stimulation shares properties with discriminative stimuli, deprivation, and emotional responding, Skinner apparently viewed it a separate process, warranting independent analysis of its effects.

Skinner's analysis of antecedent events included a functional account of the discriminated operant; however, events such as satiation and deprivation, emotions, aversive stimulation, and other antecedent variables were described in terms of observed stimulus–response relations. Conspicuously absent was an account of the relationship between these antecedent conditions and the consequences that maintain operant behavior. Whereas the discriminative stimulus derives control over responding through a special historical relationship with behavioral consequences, Skinner's account of other antecedents suggests a different source of influence between some antecedent stimuli and behavior. Thus, although no internal contradictions exist in a Skinnerian account of antecedent influences, further theoretical extension is necessary.

KANTOR

J. R. Kantor's 1959 book, *Interbehavioral Psychology: A Sample of Scientific System Construction,* introduced a theoretical system that ostensibly accounted for complexities in human behavior beyond those explained by Skinner. In his analysis of the experimental analysis of behavior (TEAB), Kantor criticized limitations in its scope. He asserted that the customary methods of behavior analysis could not extend to complex human behavior and that "the needs of a general naturalistic psychology require such elaboration of the TEAB analytic procedure as to greatly multiply the number of factors searched for and described" (Kantor, 1970, p. 105). Wahler supported this view and suggested that although operant and respondent concepts had been "valuable guidelines," certain behavioral events "simply are not going to be 'understandable' within these concepts" (Wahler & Fox, 1981, p. 334).

Analysis of alternative approaches proposed by Kantor (1970) reveals a "structure-

bound" conceptual system in which it is inferred that, because certain elements comprising the behavioral field are formally distinguishable from discrete stimuli, the mechanisms by which they affect behavior must also be distinct. For example, he argued that the behavioral field was comprised of many setting events; antecedent (and concurrent) factors whose influence extended apart from those of simple, discrete stimulus events and included conditions of deprivation or satiation, age, hygienic condition, the presence or absence of important events or objects (e.g., other people, etc.), and previously or recently experienced behavioral interactions. However, as Skinner pointed out as early as 1935, defining stimuli and responses merely as parts of environment and behavior ignores the "natural lines of fracture along which behavior and environment break" (Skinner, 1935, p. 40). For Skinner, any environmental event or combination of events, regardless of temporal or physical extension, may meet the definition of a stimulus. He proposed that relevant features of the environment could be identified through progressive restrictions of behavioral preparations until maximum consistency is observed between independent and dependent variables. Skinner's argument was that more is gained by isolating relevant versus irrelevant variables and identifying classes of relations that may then be extended to complex cases than by presuming that complex cases operate outside of those classes.

Kantor similarly criticized behavior analysts for not probing deeply enough into the nature of stimuli, asserting that the traditional behavior-analytic definition of stimulus is an "object or condition that determines a response" (Kantor, 1970, p. 106). He argued that stimulus and response functions are not inherent but are mutually corresponsive "interbehavioral" functions. Few behavior analysts would disagree with those assertions; in fact, Skinner offered similar descriptions of the processes by which stimuli acquire behavioral functions in several writings (e.g., Skinner, 1931, 1935, 1945, 1953, 1969). One must remember that environmental and behavioral functions are not resident properties of responses or stimuli but are dynamic and mutually interactive; however, this also is compatible with traditional behavioral theory, which long has eschewed simplistic explanations of stimulus–response relations.

Claiming that "though anyone can claim semantic license to refer to every kind of behavior condition by the word 'reinforcement,' this is certainly not the advantage of behavioral analysis" (Kantor, 1970, p. 107), Kantor also criticized a putative emphasis on "rewards" to the exclusion of other events present during behavioral episodes. These were setting events, and enumerated among them were "the hygiene of the organism, its habituation or past behavioral history, what behavioral circumstances it has recently or just previously passed through, the presence or absence of confining objects, and numerous others. In human situations, of course, there are such circumstances as rivalry, compliance, and competition, as well as the unique needs and desires of the behaving individual" (Kantor, 1970, p. 107). Although Kantor identified a range of possible influences on behavior, the mechanisms of influence again were not clear. Setting events may exert stimulus control over behavior, or they may be motivating influences, or both; further, their effects are likely to be idiosyncratic. Thus, the benefits of classifying these influences according to formal features are unclear.

The concept of the behavioral field nevertheless may contribute to our understanding of antecedent events. Although Skinner's definition of the stimulus included no formal restrictions, much behavioral research has focused on simple and discrete stimulus events. The fact that temporally remote, ex-

tended, and compound events can also possess stimulus properties may have special relevance for applied research, in which stimulus properties typically are not established but are brought to the experimental situation. That is, in applied research the functional properties of many stimuli have been established prior to the experimental situation by idiosyncratic and often unknown histories. Whereas Kantor's account encourages an expanded search for relevant antecedent variables through recognition of the potential stimulus properties of temporally and spatially extended events, the most promising framework for interpreting these events remains in the purview of operant theory; it is not clear that additional concepts are necessary to describe the *fundamental* relationships between these variables and behavior.

Kantor charged the field of behavior analysis several times with providing merely a superficial explanation of the influences over behavior; however, the alternative system he proposed is also conceptually incomplete pending more exhaustive analysis of functional relationships. Thus, regardless of how one views or defines classes of antecedent events (using either Skinner's or Kantor's nomenclature), the functional properties of these events require further analysis.

MICHAEL

Although the term *establishing operation* (EO) was first introduced by Keller and Schoenfeld (1950), recent work by Michael has provided the clearest and most thorough articulation of this process (Michael, 1982, 1983, 1988, 1993a, 1993b). Defined as a variable that momentarily alters the reinforcing effectiveness of some other object or event (Keller & Schoenfeld, 1950), the establishing operation provides a framework for interpreting the effects of many variables whose functional properties were not fully described by either Skinner or Kantor.

The above definition imposes only one formal restriction on the EO: that of temporary effects. Thus, EOs are dynamic influences whose effects are motivational in nature. They do not derive their functional properties through prior pairings with reinforcer availability (as with discriminative stimuli); rather, their presence or absence mediates the effectiveness of stimuli as effective consequences and alters the momentary frequency of responses that have previously produced those consequences. These effects are, in turn, mediated by the presence of other establishing and discriminative conditions. Further, although the term *establishing operation* suggests directionality, EOs can either increase or decrease the potency of a given form of reinforcement.

Deprivation provides perhaps the most obvious illustration of an EO. For example, the effects of water deprivation are (a) to increase the reinforcing effectiveness of water and (b) to strengthen all conditioned and unconditioned responses associated with water consumption (Skinner, 1953). These are defining characteristics of an EO.

A less immediately obvious but equally appropriate example of an EO is aversive stimulation, which produces an increase in the probability of behavior that has been previously reinforced through the termination of such stimulation. Although some have suggested that aversive stimulation is a discriminative stimulus for escape responding (e.g., Carr, Newsom, & Binkoff, 1976; Touchette, MacDonald, & Langer, 1985), Michael pointed out two important differences that favor an EO interpretation. First, aversive stimulation is not necessarily correlated with the availability of response-contingent escape, which is a requirement for discriminative control. Michael aptly states the case:

> Being in pain is not systematically correlated with being able to remove pain, sad but true, except in the sense that if there were no pain there would be no pain to remove. In other words, the presence of pain is a necessary but not sufficient condition for its removal, just as food or water deprivation is necessary but not sufficient for food or water reinforcement. . . . Just because an organism is hungry doesn't mean that food is likely to be available, as would be pointed out by many currently hungry organisms. Similarly with painful stimulation: It is not differentially correlated with the availability of some way to reduce the pain. (Michael, 1988, p. 4)

A second difference between aversive stimulation and stimulus control is the mechanism that is responsible for low levels of responding (or nonresponding). Responding in the presence of a discriminative stimulus is due to the correlation between the stimulus and reinforcement; nonresponding in the absence of the stimulus is due to extinction. By contrast, nonresponding in the absence of aversive stimulation is not due to extinction; escape responses do not occur in the absence of aversive stimulation simply because there is no reason (i.e., motivation) to do so. Just as food presentation has no reinforcing function for the satiated organism, the absence of aversive stimulation as a consequence will not maintain responding in the absence of (at least a history of) antecedent aversive stimulation.

Emotional variables provide a third general example of EOs. As previously noted, Skinner viewed emotions as "a particular strength or weakness in one or more responses induced by any one of a class of operations" (Skinner, 1953, p. 166). Further, the operant concept of the emotion contained three defining characteristics: (a) induction via environmental stimulation, (b) the simultaneous occurrence of reflex responses, and (c) an alteration in the probability of a class of behaviors distinguished by a common consequence. It is the third feature of emotions that places them directly in the realm of EOs. Emotional stimuli do not derive their evocative functions via differential access to reinforcement, as do discriminative stimuli; rather, they fit nicely within the paradigm of EOs because they (a) momentarily alter the effectiveness of certain forms of reinforcement and (b) alter the frequency of conditioned and unconditioned responses associated with those reinforcers. The "felt" aspects of the emotional event are considered to be, as in Skinner's account, covariants with rather than causes of emotional behavior.

Skinner spoke of a number of other events whose effects are similar to those of deprivation but are difficult to classify within his theoretical system due to disparate formal characteristics. The effects of salt ingestion, blood loss, or perspiration on drinking, of aphrodisiacs on sexual behavior, of psychoactive drugs in general, and a host of other examples all were discussed in loosely motivational terms. Yet Skinner did not propose a common process underlying these similar effects. Because each of these variables alters the probability that operant behavior will occur independent of a special correlation with consequences, their influences seem amenable to an EO account.

The concept of the EO offers a parsimonious framework for classifying a broad range of motivational variables. The appeal of the EO is that it can assimilate the effects of deprivation, emotions, setting events, and related antecedent variables based on functional relations among environmental conditions and behavior. Its scope may be evaluated through conceptual review of existing literature as well as through empirical research.

The following is a review of selected research on behavior disorders, focusing on interpretation of antecedent operations. We have attempted to develop a set of general guidelines to distinguish discriminative from establishing operations and, given adequate procedural and historical information, to classify antecedent variables according to behavioral function. When it is necessary to infer information in order to classify variables, inference has been noted and interpretations are qualified. Classification of discriminative control requires the demonstration of control over behavior by antecedent events that are differentially correlated with consequences. That is, when behavior was altered as a function of the presence or absence of variables associated with different behavioral outcomes (as reported in the Subjects or Methods sections of reviewed studies), then those variables are classified as discriminative events.

Antecedent variables are classified as EOs if, given constant contingencies between behavior and consequences, behavior was altered by the presence or absence of antecedent variables. Thus, when antecedent conditions vary independent of the probability of reinforcement or punishment, behavioral effects are described in terms of EOs.

When it is not possible to specify sufficiently the conditions under which antecedent events influence behavior, alternative interpretations in terms of discriminative and establishing operations are explored, and the tentative nature of these accounts is noted. When future research might clarify unresolved issues, potential strategies are discussed.

It should be noted that the EO concept was not well articulated or widely understood when many of the studies we reviewed were conducted. Therefore, our interpretations have the advantage of a perspective informed by conceptual developments that may not have been available to the original investigators. In addition, the conceptual framework upon which our interpretations are based has not been universally adopted in our discipline, and so some of our accounts may be at odds with, or seem critical of, other explanations. Although our interpretations are sometimes inconsistent with those of the authors, the importance of these studies and their contributions to the applied literature are not diminished.

ASSESSMENT OF ANTECEDENTS

One approach to the assessment of antecedent variables that are associated with problem behaviors is to identify and catalogue the range of environmental conditions that are correlated with undesirable behaviors in the natural environment (e.g., Berkson & Davenport, 1962; Bijou, Peterson, & Ault, 1968; Davenport & Berkson, 1963; Wahler & Fox, 1981). Wahler argued that "conceptual and methodological expansion" was necessary to evaluate influences beyond the "relatively simple and temporally proximate conditions" typically studied by applied behavior analysts (Wahler & Fox, 1981, p. 328). Thus, he developed a methodology for assessing setting events, emphasizing dynamic interrelations among variables as well as an increased breadth and scope of analysis. Such methods, sometimes termed *ecological assessment,* attempt to form a comprehensive picture of environmental influences on problem behavior. For example, Wahler (1975) described an observational coding system that was used to identify environmental and behavioral covariations for 2 boys referred for treatment of behavior disorders. Using interval-based measures in the home and school settings, Wahler derived several "clusters" of intercorrelated behavior categories (e.g., a cluster for 1 child in the school setting included sustained schoolwork, self-stimulation, object

play, and noninteraction) that were considered to be indicative of possible response classes. However, within-session analyses of temporal relations between clusters and environmental events revealed no consistent antecedents or consequences for any cluster. Without empirical evidence of common maintaining variables, interpretation of correlated behavior categories as response classes is limited. Another interesting outcome of this study was that each child showed setting-specific behavior clusters; that is, clusters in the school settings were different from clusters in the home settings. Further, planned changes in behavior brought about by intervention in one of the settings were accompanied by additional unplanned changes in the second setting. For example, 1 child's increases in classroom schoolwork were associated with increased self-stimulation and decreased social interactions with adults in the home. Wahler's assertion that the operant model may inadequately describe the organization of behavior repertoires and environments (p. 28) suggests that theoretical extension may be required to account for such effects. Alternatively, these secondary changes may have been due to undocumented environmental or social changes that were associated with the treatments.

Another representative analysis of ecological conditions related to problem behavior described a program for the treatment of self-injurious behavior (SIB), including the use of data collected via "ecological interval recording." Using a variation of Wahler's recording system (Wahler, 1975; Wahler, House, & Stambaugh, 1976), Schroeder et al. (1982) scored the occurrence of 29 categories of behavior. Results indicated that variables such as the pace of staff-initiated interactions, presence of a disruptive client, time of day, staff-client ratios, presence of "self-protective devices," and presence of toys all appeared to affect rates of SIB and other maladaptive behaviors. Although these data may have general implications for the design of environments for persons with behavior disorders, several interpretive limitations exist. First, although some general relationships between broadly defined environmental variables and target behaviors are suggested, these findings may not be representative of the functional relationships affecting the behavior of any one individual. Also, because of the dynamic nature of the naturalistic context, it is difficult to isolate relevant variables. For example, Schroeder et al. found a correlation between time of day and maladaptive behavior; however, it is unlikely that this variable directly evoked or maintained problem behavior. Rather, some other correlated variables, such as the timing of medication regimes, activity or meal schedules, staffing shift changes, or other temporal changes, may have been relevant. Finally, this method does not permit analysis of the functional relationships involved, even when relevant conditions are identified. That is, although it may be the case that the presence of a disruptive client occasions increases in SIB among some individuals, it is not possible to determine the mechanisms that underlie this change. The disruptive client may represent an aversive stimulus, thus serving as an EO for escape behavior. Alternatively, the disruptive person may serve as a model for attention-maintained maladaptive behavior if staff members differentially attend to this behavior (the interaction between staff and the disruptive client being discriminative for the availability of attention for maladaptive behavior).

In another setting-event assessment, Repp, Singh, Karsh, and Deitz (1991) examined the effects of overt task demands (i.e., when a staff member worked directly with a student), covert task demands (i.e., when a student had been given a task demand but no staff member worked directly with the student), and no task demands

within six settings (leisure, prevocational, gym, academic, home living, and lunch) on the stereotypy of 12 individuals with developmental disabilities. Data were examined both within and across subjects. Group data showed little difference in stereotypy across settings but revealed higher correlations between stereotypy and demand conditions relative to no-demand conditions. Individual subjects' data showed idiosyncratic correlations between stereotypic behavior and environmental antecedents, with several subjects' data indicating relationships opposite to those reported for the group. Although the individual data provided information about the general conditions under which stereotypy was likely to occur in a given subject, identification of the mechanisms underlying stereotypy was not possible because these potentially important variables were not experimentally manipulated. For example, the observation that a subject's stereotypy increases as a function of demands may indicate that stereotypy is maintained by escape from demands (Iwata, Pace, Kalsher, Cowdery, & Cataldo, 1990), but may also suggest that the presence of demands is discriminative for attention contingent upon stereotypy (Vollmer, Iwata, Smith, & Rodgers, 1992), among other possibilities. The authors were appropriately cautious in concluding that "the functional relationship between maladaptive behaviour and environmental events may have to be assessed at a much greater molecular level than has been the case in the past to ensure appropriate and effective intervention" (p. 426); thus, they acknowledged that this observational method permits only an initial search for potentially relevant antecedent conditions and that greater focus and control are necessary to identify the functional relationships that form the basis of observed correlations between environmental events and occurrences of a given behavior.

Berkson and Mason (1963) examined the effects of molar antecedent variables more directly, placing their subjects in several settings (the dayroom and dining area of their residence, a hospital room, a barren room, and an outdoor playground) and measuring levels of stereotypy, self-manipulation, environment manipulation, and locomotion. They found that stereotypy and self-manipulation occurred at higher levels in a novel, restricted environment than in familiar contexts in which alternative activities, such as manipulation of the environment and locomotion, were possible. The authors interpreted these findings as suggesting that stereotypy and self-manipulation were "self-stimulation" that was reinforced by sensory consequences. However, the strength of this interpretation is limited to the extent that consequences for stereotypy and self-manipulation may have varied across experimental situations. A more definitive analysis might have been possible if consequences for all relevant behaviors (including environment manipulation and locomotion) had been held constant.

Kennedy and Itkonen (1993) performed setting-event analyses of the maladaptive behaviors of 2 female students with developmental disabilities. Awakening late was found to be correlated with increases in problem behavior later at school for 1 student; the use of a city street route versus a highway route on the way to school was associated with later problem behavior for the other student. Eliminating these setting events resulted in decreases in maladaptive behavior for both students; however, in each case the behavioral operations that were involved in these decreases remain unclear. Because no analysis of the reinforcement contingencies that maintained problem behaviors occurred, it is not possible to determine the discriminative or establishing functions of the setting events. Further, although getting up late or taking a given route to school may have been correlated with the occur-

rence of problem behaviors, it is quite possible that these events had no direct influence on those behaviors. Rather, they may have initiated a long and complex chain of environment–behavior interactions, potentially including both establishing and discriminative events that culminated in target responses, *and* some unknown type of reinforcement. Thus, the functional elements that were responsible for maintaining the students' problem behavior, as well as those that were responsible for subsequent behavior reduction, are unknown. And, as was the case with the Berkson and Mason (1963) study, the definition of setting variables does not permit specification of relevant versus irrelevant events. Kennedy and Itkonen suggested that

> future research should more stringently control for immediate antecedents and consequences that occur along with problem behavior to avoid possible confounding effects among events. Also, the need to ascertain directly the positively and/or negatively reinforcing consequences that maintain behavior and the relation of the setting event to the maintaining variable(s) is critical. (p. 327)

Another method for assessing the effects of ecological variables was developed by Touchette et al. (1985). These investigators devised a scatter plot for data collection and display that showed the temporal distribution of problem behaviors. Personnel in the subjects' home and training environments were instructed to make marks on a grid of consecutive half-hour intervals when subjects engaged in target behaviors. Time intervals were represented on the data sheet in horizontal rows, and consecutive days were represented in columns. After several days, patterns on the data sheet, when juxtaposed with a schedule of daily activities, revealed correlations between the occurrence of 2 subjects' maladaptive behaviors and certain daily activities. Although the authors interpreted these correlations as evidence of stimulus control by certain antecedent events over problem behavior, limitations on inferences about function based on correlation weaken this account. For example, 1 subject's scatter plot indicated that his self-hitting occurred more frequently in the presence of one attending aide than in the presence of a second aide. However, it was unclear whether this outcome was due to differential consequences or specific antecedent activities that were associated with each aide. Thus, the behavioral functions associated with different levels of problem behavior were unclear.

Several researchers have systematically controlled specific antecedents to analyze their effects on maladaptive behavior. The methodology described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) is an example of a procedure in which antecedent and consequent conditions were designed to simulate those that may evoke and maintain problem behavior in natural environments. By arranging conditions under which SIB produced either attention from therapists, escape from task demands, or no social consequences, and by comparing rates of SIB among these conditions (and a control condition), possible reinforcement functions of SIB could be assessed (i.e., social positive reinforcement, social negative reinforcement, and automatic reinforcement [either positive or negative], respectively). Although the primary purpose of this assessment is to identify maintaining or consequent variables, antecedent conditions are also designed to evoke behavior thus maintained. For example, in the attention condition, which assesses behavior maintained by social positive reinforcement, the therapist provides attention (e.g., statements of concern, mild reprimands) as a consequence for SIB. The condition also utilizes depri-

vation from attention to establish its reinforcing effects (i.e., the therapist ignores the subject unless SIB occurs) and the presence of a therapist as a discriminative stimulus for attention. In the demand condition, training trials are presented on a fixed-time schedule and are terminated contingent on SIB to assess whether SIB is maintained by social negative reinforcement. The training trials represent establishing stimuli for escape responses, which could not (by definition) occur in the absence of aversive stimulation. In the alone condition, which is designed to assess whether SIB is maintained by automatically produced stimulation, no social consequences for SIB are delivered. In addition, sessions are conducted in a deprived environment to simulate conditions that may establish self-stimulation as reinforcement (it is noteworthy that this condition will not identify the exact maintaining variable, because the automatically produced consequences of SIB are not controlled; thus, automatic reinforcement is inferred rather than analyzed). A play condition is also included in this assessment as a control. In this condition, toys are present and social interaction is delivered on a time-based schedule; these procedures should function as "abolishing operations" both for attention and automatic reinforcement, thus reducing motivation for SIB that is maintained by those variables. The establishing conditions for escape—task demands—are not presented in this condition. Thus, little or no SIB should be seen in this condition unless SIB is maintained by an idiosyncratic reinforcer or by some other process.

Antecedent analyses may be used to identify specific discriminative conditions after the variables that maintain problem behavior have been identified. Taylor, Sisson, McKelvey, and Trefelner (1993) used an assessment similar to that described by Iwata et al. (1982/1994) to assess the aggressive scratching of an adolescent girl with developmental disabilities. This assessment revealed that scratching was maintained by attention from adults; however, during a baseline phase conducted in her classroom in which the teacher was instructed to interact with other students and to attend to the subject only when scratching occurred, no scratching was observed. Casual observation indicated that the subject scratched only when the teacher interacted with other adults, and a baseline condition in which another adult was present was juxtaposed with the original baseline condition to assess this effect. The subject's scratching was shown to vary reliably as a function of the presence of another adult with the teacher, and this condition was the context for a differential-reinforcement-of-other-behavior treatment. The authors attributed the relationship between the presence of adults and scratching to discriminative control; although this is a reasonable interpretation, the conditions of this experiment did not permit a definitive conclusion. It is possible that the presence of other adults was not historically correlated with reinforcement for scratching, but that it somehow altered the reinforcing effectiveness of attention from the teacher. Thus, the primary contribution of this study was to show that manipulating antecedent conditions while maintaining a constant reinforcement contingency for maladaptive behavior can identify the specific context in which treatment should occur.

In some experimental analyses, there have been attempts to identify maintaining contingencies through manipulation of antecedent events exclusively. For example, Carr et al. (1976) investigated the effects of mands in the apparent absence of an escape contingency for their subject's SIB and found that the presentation of mands per se evoked high rates of SIB. That is, even though SIB had no programmed consequence (i.e., had no effect on ongoing task requirements), mands set the occasion for SIB. Comparison

conditions consisted of free-time activities and the presentation of simple declarative statements (tacts) to control for the general effects of therapist verbalizations; SIB almost never occurred in these conditions. The finding that SIB was maintained at high rates in the mand condition is somewhat surprising, given that it did not result in escape. The failure of this response to be extinguished was likely a result of rapid condition changes, with no more than four consecutive 10-min mand sessions in any phase of analysis.

In a later phase of the experiment the investigators conducted four mand sessions in which a "marker stimulus" was presented at the end of the session. In one condition, the therapist said "OK, let's go," a statement that had previously been correlated with session termination. In a second condition, the therapist said, "The sky is blue," a statement that had never previously occurred at the end of sessions. Observers continued to record data for 1 min following the marker stimulus. Results showed that SIB decreased to zero in the "OK, let's go" condition but continued to occur during the 1-min interval in the "The sky is blue" condition. This effect is consistent with that of the reflexive conditioned EO, in which a stimulus correlated with environmental changes (e.g., improvement or worsening) acquires motivational properties relative to that correlation (for a detailed description of conditioned EOs, see Michael, 1993a). The "OK, let's go" stimulus was correlated with improvement (session termination), so responses that may have interfered with such improvement (e.g., SIB) may have been suppressed. Alternatively, "OK, let's go" may simply have been discriminative for the absence of further aversive stimulation, and negatively reinforced behavior may thus have been decreased.

Durand and colleagues conducted a series of studies in which experimental analyses involved the manipulation of antecedent conditions exclusively (Carr & Durand, 1985; Durand & Carr, 1987, 1992; Durand & Crimmins, 1987, 1988). This assessment paradigm involves the systematic arrangement of establishing conditions associated with hypothesized functions of maladaptive behavior while no programmed consequences are provided for maladaptive behavior. In a representative example of this procedure (Durand & Carr, 1992), an assessment of challenging behavior was conducted across three conditions; sessions in each condition were 10 min in duration and were divided into 60 10-s intervals. In the baseline condition, easy tasks (identified previously as tasks that occasioned 100% correct responses) were presented, and prompts to complete these tasks were issued approximately every 30 s, or during 33% of intervals. A variable-ratio 3 schedule of social reinforcement for correct responses resulted in the occurrence of praise approximately every 30 s, or during 33% of intervals. Neutral comments were delivered in the remainder of intervals, resulting in the presentation of some form of attention from therapists in 100% of intervals during baseline. This was a control condition, in which attention-maintained behavior would not be expected to occur due to satiation (i.e., elimination of the EO for attention-maintained behavior), and behavior maintained by escape would not be expected to occur due to the absence of difficult tasks (i.e., the EO for escape).

The attention condition was designed to assess "changes in the participants' challenging behavior as a function of changing the distribution of verbal attention" (Durand & Carr, 1992, p. 780). Tasks and the total amount of attention delivered were identical to baseline. However, in this condition, the temporal distribution of attention was changed from 100% to 33% of intervals. Thus, the trainer presented a task demand, praise, and a neutral comment approximate-

ly every 30 s instead of every 10 s. The presumed establishing effect of the absence of social interaction during 66% of intervals was expected to evoke behavior maintained by contingent attention.

The demand condition assessed the effects of a more difficult task on challenging behavior. The distribution of attention was the same as in baseline (100% of intervals); however, tasks were selected for which the individual previously exhibited approximately 33% correct responses. To maintain task-consequent praise in 33% of intervals, a schedule of continuous reinforcement was in place. Accuracy percentages were monitored during sessions, and demands were changed as necessary to maintain correct responses in 33% of intervals. The increased level of difficulty in this condition was expected to establish the reinforcing effectiveness of escape and to evoke behavior thus maintained.

Results of this experiment showed low rates of challenging behavior in baseline and demand conditions and increases in challenging behavior during attention conditions for 16 subjects. The authors concluded that the maladaptive behavior of these subjects was maintained by attention from adults, and successful treatments based upon these findings provided further support for this interpretation. Other studies by this research group have implicated escape, the presentation of materials, and sensory reinforcement in the maintenance of challenging behavior (Carr & Durand, 1985; Durand & Carr, 1987; Durand & Crimmins, 1987, 1988).

Although Durand and colleagues report positive outcomes using this method of assessment, its reliance on subtle antecedent manipulations to differentiate functional classes of challenging behavior raises certain issues. For example, it is surprising that providing social interaction on a fixed-time (FT) 30-s schedule (compared to a 10-s schedule) represents sufficient deprivation to establish attention as a reinforcer for maladaptive behavior. Conditions that were designed to assess escape, tangible, and sensory functions appear to raise similar issues. In addition, providing antecedents that were presumed to evoke but not consequences that were presumed to maintain maladaptive behavior should result in extinction in all cases except that of a sensory function. Although some of the procedures seem to be inconsistent with reinforcement principles and the EO manipulations used to produce differentiation are subtle, Durand and colleagues have employed this methodology with positive results in a number of studies and have found it useful for prescribing effective treatment.

In a study designed to identify EOs for negatively reinforced behavior, the effects of various antecedent conditions were assessed in an arrangement in which SIB always produced escape (Smith, Iwata, Goh, & Shore, 1995). After first conducting experimental analyses showing their subjects' SIB to be maintained by escape, the investigators manipulated antecedent variables including task novelty, session duration, and rate of task trials. Subjects were able to escape task trials throughout all sessions, so the investigators attributed changes in patterns of SIB to EO effects. Outcomes suggested that each of these variables may have EO properties for escape behavior. Using a similar approach, O'Reilly (1995) showed that sleep deprivation increased the maladaptive escape behavior of 1 subject. Although sleep deprivation was not directly manipulated, an escape contingency for problem behavior was maintained throughout the analysis, suggesting an EO effect. The isolation of such variables by maintaining a consistent reinforcement contingency for problem behaviors may provide a general method for assessing EOs for behavior maintained by positive as well as by negative reinforcement.

We suggest that analysis of conditions (both antecedent and consequent) associated

with behavior disorders ideally should contain four elements: (a) conditions that establish the form of reinforcement suspected of maintaining the behavior, (b) conditions that are discriminative for reinforcement contingent upon the target behavior, (c) a contingency between the target behavior and reinforcement, and (d) control over (a), (b), and (c) by the experimenter. The ability of antecedent conditions, both establishing and discriminative, to reliably evoke behavior is inextricably linked with response-contingent reinforcement. Thus, it seems that each of these conditions (establishing, discriminative, and consequent) is necessary, and none is sufficient for an experimental analysis of operant behavior (although it may be argued that discrimination is irrelevant if no condition exists under which reinforcing consequences are not delivered contingent upon responding). Thus, analysis of antecedent variables requires (at least) specification of behavioral consequences, and vice versa. Further, scientific skepticism dictates that experimenters demonstrate functional relations by controlling the controlling variables, as in (d) above. That is, our certainty about functional relations is increased when we are able to manipulate relevant variables and observe orderly changes in behavior. Naturalistic observations of ecological conditions fail to meet criterion (d), and experimental analyses that manipulate only antecedents fail to meet criterion (c) immediately and criterion (b) eventually.

Naturalistic observation procedures may provide some initial insight into variables that may later be included in an experimental analysis. As more complex interrelationships among operant elements in behavior disorders are studied, naturalistic observations may help to identify potentially important variables (e.g., Mace & Lalli, 1991; Repp et al., 1991). Thus, as a screening tool and as a method to identify variables that otherwise may be neglected, ecological assessment can be useful. However, the level of control required to reveal the basic principles that underlie behavior disorders (both generally and case specifically) dictates the use of experimental analyses to identify relevant antecedent and consequent relations.

TREATMENT

Behavior Maintained by Positive Reinforcement

Very few studies have systematically manipulated only antecedent events to reduce problem behaviors maintained by social positive reinforcement. An early study in which establishing conditions were altered to reduce problem behavior was conducted by Ayllon and Michael (1958). For 4 psychiatric patients whose magazine hoarding had been targeted for reduction, a satiation intervention, consisting of flooding the psychiatric ward with magazines, was combined with extinction, in which social interaction relative to hoarding was withheld. This treatment resulted in decreases in hoarding for all subjects. Because no assessment of the variables that maintained hoarding was conducted (i.e., hoarding may have been maintained by viewing the magazines or by social reinforcement from ward staff), and because both components of treatment were introduced simultaneously, the relative effectiveness of each component is unclear. However, this experiment is commonly cited as the first published study in applied behavior analysis, and the use of an EO-based intervention shows a very early recognition of the potential importance of such events in modifying maladaptive behavior.

In a similar but more recent EO intervention, Vollmer, Iwata, Zarcone, Smith, and Mazaleski (1993) examined the role of satiation in reducing problem behavior maintained by attention. Following a functional analysis revealing that the SIB of 3 subjects was maintained by contingent attention, a

schedule of noncontingent reinforcement (NCR) was arranged in which attention was initially provided in 100% of 10-s intervals, and then was faded systematically to an FT 5-min schedule. The effects of NCR were attributed to a combination of extinction of SIB and elimination of the reinforcing effectiveness of attention. Extinction may have occurred because, as the schedule of NCR was gradually thinned, responses that occurred during interreinforcement intervals were not followed by attention. Hagopian, Fisher, and Legacy (1994) contrasted initial effects of lean (FT 5-min) versus dense (FT 10-s) NCR schedules and found that each reduced the maladaptive behavior of 3 of 4 subjects, but that dense schedules were more effective prior to fading, suggesting a combined EO and extinction effect. Results of a similar procedure used by Mace and Lalli (1991) to reduce bizarre vocalizations of an individual with mental retardation that were maintained by contingent disapproval, however, did not provide support for multiple treatment functions. Following conditions in which aberrant speech was reduced using extinction plus scheduled attention, the experimenters were able to maintain low rates of aberrant speech using a variable-time 90-s schedule of attention, although contingent social disapproval was reinstated. Results of these studies suggest that, although extinction *may* be necessary for initial NCR effects, it may not be critical for maintenance of a successful NCR intervention.

A component analysis of the NCR procedure, in which the contingency between maladaptive behavior and attention remains intact as the NCR schedule is thinned, would help to separate the relative effects of extinction and satiation. It is possible that the abolition of attention's effectiveness suppresses responding when attention is delivered on a rich schedule, but that extinction takes effect as scheduled attention is faded. In this case, the effectiveness of NCR without extinction would break down at some critical value of the reinforcement schedule, requiring that extinction be arranged for further fading of time-based reinforcement. In any event, the possibility that combining NCR with extinction may ameliorate the typical extinction burst that is associated with extinction alone makes this an attractive combination of antecedent and consequent strategies for behavior reduction.

A related treatment for behavior maintained by positive reinforcement (both socially mediated and automatically produced) is environmental enrichment (e.g., Berkson & Davenport, 1962; Berkson & Mason, 1963, 1965; Horner, 1980). This treatment involves noncontingent access to a range of potentially reinforcing items and activities that may compete effectively with maladaptive behavior. For example, Berkson and colleagues conducted a series of studies investigating variables such as the presence and nature of objects in the environment, social stimulation, and forced versus nonforced contact with objects and stimuli on the stereotypic and other behaviors of groups of subjects with profound developmental disabilities (Berkson & Davenport, 1962; Berkson & Mason, 1963, 1965). The results showed a variety of correlations, most notably that stereotypy was inversely correlated with object manipulation. Although analysis of the mechanisms underlying group differences was not possible, these findings set the occasion for the future development of the enriched environment approach to the treatment of stereotypic behavior.

It is possible that successes thus obtained are a function of reductions in the effectiveness of attention through an EO of some sort; however, due to the general nature of the intervention (i.e., a variety of stimuli are present), it is not possible to isolate the effective elements of treatment. An interesting point arises from the possibility that the availability of dissimilar forms of reinforce-

ment may reduce socially maintained problem behavior: If making alternative reinforcers available can reduce the effectiveness of the reinforcer that maintains problem behaviors (i.e., if alternative reinforcers are substitutable for the maintaining variable; Green & Freed, 1993), then it may be possible to construct effective treatments without identifying maintaining variables. Further, presentation of substitutable stimuli may have effects that endure temporarily following withdrawal of those stimuli (similar to satiation with the maintaining variable). This would have potentially powerful implications for treatment of automatically reinforced behavior, because the maintaining reinforcer is often unknown or inaccessible to manipulation. However, research on substitution functions *would* require analysis of the variables that maintain the behavior problem, as well as presentation of stimuli that are formally dissimilar from the maintaining variable, in order to distinguish substitutability from NCR. Manipulations of the availability and response requirements associated with each alternative would further illuminate substitutability relations.

Antecedent interventions designed specifically for maladaptive behavior maintained by nonsocial or automatic positive reinforcement typically involve a manipulation of putative establishing events to reduce the motivation to engage in the behavior. This is accomplished through the noncontingent provision of stimulation similar to that suspected of maintaining maladaptive behavior or by providing a generally enriched environment (e.g., Horner, 1980).

Favell, McGimsey, and Schell (1982) used an NCR approach to reduce three topographies of SIB in 6 subjects. The hand mouthing of 1 subject decreased when toys that could be mouthed were made available, the eye poking of 2 other subjects decreased when an alternative form of visual stimulation was presented, and the pica (ingestion of inedible objects) of 3 subjects decreased when alternative edible items were present. These outcomes may have been a function of satiation with respect to the reinforcers maintaining SIB, evidence for which was seen in differential effects of stimulation similar to that suspected to maintain SIB versus less similar forms of stimuli. In all cases, similar forms of self-stimulation were most effective in suppressing SIB. Also, because sensory extinction was not attempted, the confidence with which the results of this study can be attributed to EOs is increased (i.e., the absence of extinction in the Favell et al. study permits the isolation of NCR as the sole treatment variable).

Another possible example of the manipulation of an EO is the use of satiation techniques to reduce chronic vomiting or rumination. Rast, Johnston, and colleagues conducted a series of studies investigating the finding that consumption of large quantities of food can suppress rumination in some subjects (Johnston, Greene, Rawal, Vazin, & Winston, 1991; Rast, Johnston, & Drum, 1984; Rast, Johnston, Drum, & Conrin, 1981; Rast, Johnston, Ellinger-Allen, & Drum, 1985; Rast, Johnston, Lubin, & Ellinger-Allen, 1988). It was posited that the reductive effect of the satiation diet may be due to biochemical variables (i.e., nutritive effects), mechanical variables (i.e., volume of stomach contents and stomach distension), satiation of oropharyngeal and esophageal stimulation, or some combination of these variables. These researchers conducted parametric and component analyses of the potential behavioral and physiological mechanisms that might be responsible for this effect. Results of this series of studies suggest that each of the variables mentioned may contribute to the therapeutic effects of increased food consumption. Changes in caloric intake appear to have greater effects on ruminating than do changes in stomach distension or in oropharyngeal and esophageal

stimulation; however, increases in each of these variables were shown to produce moderate decreases in rumination. Of current interest is the possibility that oropharyngeal and esophageal stimulation were automatically reinforcing consequences that contributed to the maintenance of rumination and that the food-satiation procedure constitutes NCR, reducing the reinforcing effectiveness of these stimuli. Rast et al. (1988) showed that providing premeal oropharyngeal stimulation through gum chewing produced moderate reductions in rumination without changes in caloric intake or stomach distension. Their analysis provides support for an automatic reinforcement component to rumination and suggests that EOs may account for part of the therapeutic effects of the satiation diet.

Few attempts to isolate discriminative effects in behavior disorders that are maintained by positive reinforcement have been made. This paucity of empirical research is probably due to the relationship between discriminative stimuli and behavioral consequences. Discrimination occurs only as a function of the correlation between antecedent stimuli and the availability of certain consequences contingent upon behavior. Thus, stimulus control treatments to control maladaptive behavior necessarily involve either manipulation of that correlation to alter the discriminative relation or elimination of the effective discriminative stimulus from the environment. The effectiveness of these procedures depends primarily on consequences rather than on antecedents of behavior; in the first case, responding in the presence of the stimulus is extinguished, and in the second case, extinction must be applied when the stimulus is absent. Thus, because stimulus control over behavior is developed as a function of differential reinforcement, it is impossible to completely separate discriminative from consequent effects.

Azrin and Powell (1968) arranged a novel stimulus control intervention in which clearly discriminable periods of extinction were juxtaposed with reinforcer availability to reduce cigarette smoking. These researchers provided each subject with a cigarette container that automatically locked for a prespecified period after removal of a cigarette. Each container was fitted with a timer, a clock dial face, a ratchet-type clicker, and a narrow rod that could be projected 0.25 in. from the top of the container. During extinction (i.e., when the container was locked) the clock dial face showed how many minutes remained until the container could be opened. At the moment following an interval of extinction, the clicker sounded for 0.5 s and the narrow rod projected from the case. Smoking was reduced by slowly increasing the extinction intervals. Although discriminative control was systematically arranged in this study, its importance to the success of the intervention is unclear. That is, gradually increasing periods of extinction alone may produce similar results. In fact, making the conditions of this study so clearly discriminable may have increased the number of cigarettes smoked by establishing strong stimulus control over reaching for a cigarette at the end of extinction intervals. The authors noted that the number of cigarettes smoked was primarily a function of their availability and that latencies to removal of cigarettes from containers following extinction intervals were short. Perhaps arranging a schedule of reinforcement in which components are not differentially associated with exteroceptive stimuli (i.e., a mixed rather than a multiple schedule) would have produced longer latencies to cigarette withdrawal and, thus, fewer cigarettes smoked. However, the general strategy of fading reinforcement of problem behavior using differential reinforcement of diminishing rates schedules presents an approach to treatment that may minimize the negative

side effects that are associated with extinction, especially when combined with reinforcement for alternative behavior or omission of problem behavior (it should be noted that the use of fading or extinction as the sole strategy for reducing behavior would be proscribed in cases in which the behavior is maintained by life-sustaining reinforcers such as food or water).

Another study showed that treatment effects for cigarette butt pica could be maintained by pairing an arbitrary stimulus with treatment conditions and then presenting the stimulus in nontreatment contexts (Piazza, Hanley, & Fisher, 1996). Following a response-interruption treatment for the cigarette butt pica of an individual with mental retardation, a stimulus control assessment was conducted in which presentation of a purple card was associated with treatment conditions. After the participant received training with the card, the card continued to exercise stimulus control over pica even when treatment contingencies were not in place and in nontreatment environments. This study is significant in showing that stimulus control procedures can be used to maintain and generalize treatment effects under conditions in which it is not possible to implement actual treatment contingencies. No follow-up data were presented, so the durability of such procedures is unclear. Further research will be necessary to determine the conditions under which such effects can be maintained for long periods of time.

Behavior Maintained by Negative Reinforcement

Negatively reinforced problem behaviors present a unique opportunity for a high level of control over antecedent events; the researcher typically presents the stimuli that occasion escape responses. Several methods have been developed for the manipulation of antecedents to reduce problem behaviors maintained by escape. Perhaps the most obvious and direct method of reducing escape behavior involves elimination of aversive events from the environment—an effective, if sometimes impractical, strategy. Although no studies have investigated this effect per se, it can be seen in a range of studies in which no-demand conditions are contrasted with conditions containing demands during assessment (e.g., Carr et al., 1976; Iwata et al., 1982/1994).

A similar strategy is noncontingent escape (NCE), in which aversive stimuli are systematically introduced into the environment but are withdrawn on a time-based schedule (Vollmer, Marcus, & Ringdahl, 1995). By initially providing noncontingent escape almost immediately following presentation of task demands and subsequently increasing the duration of demands, subjects were able to tolerate up to 10 min of continuous instruction without exhibiting maladaptive escape behavior. During treatment phases of the study, maladaptive behavior did not produce escape, so, as with NCR, the relative effects of EOs versus extinction remain unclear.

A related approach for reducing behavior maintained by social negative reinforcement is the elimination and then systematic reintroduction of aversive stimulation into the environment. This approach is distinguished from NCE in that presentation rather than termination of aversive stimulation is determined according to a time-based schedule. Pace, Iwata, Cowdery, Andree, and McIntyre (1993) showed that low rates of escape behavior (in this case, SIB) could be maintained when escape extinction was combined with a gradual fading in of the frequency of demand presentations. A subsequent study by Zarcone, Iwata, Vollmer, et al. (1993) showed that instructional fading could enhance the effects of extinction by reducing the bursts of responding associated with extinction in the absence of fading. Results of

another component analysis of this treatment in which instructional fading was implemented without extinction (Zarcone, Iwata, Smith, Mazaleski, & Lerman, 1994) showed that initial suppression of SIB was not maintained as the frequency of task demands was increased. Extinction was required to complete the fading procedure for each of 3 subjects. These results suggest a shift in the functional aspects of treatment, from an initial abolition of escape as a reinforcing consequence to extinction of the escape response as increases in demand rates produced increases in self-injurious escape behavior (presumably due to the reestablishment of the reinforcing effectiveness of escape). However, a recent case study reported that demand fading alone was effective in reducing escape-maintained obscene verbalizations in a psychiatric patient. Thus, under certain conditions, fading may have durable escape-abolishing effects (Pace, Ivancic, & Jefferson, 1994).

It may be possible to use fading along dimensions other than demand frequency. For example, Weeks and Gaylord-Ross (1981) used errorless learning procedures (Touchette & Howard, 1984) to fade along the dimension of task difficulty. Eventually, stimuli that had evoked incorrect responses and maladaptive behavior came to evoke correct responses and no inappropriate behavior. Because the authors did not explicitly state the contingency for maladaptive behavior, it may be assumed that no change in procedures occurred as a consequence of target behaviors (i.e., extinction was in effect for these responses). Thus, the relative importance of extinction versus EO effects is unknown.

In a similar study, Cameron, Luiselli, McGrath, and Carlton (1992) showed that the noncompliant behavior of their subject (defined as falling to the ground, throwing his walker and eyeglasses, body thrashing), associated with a request to exit a van in front of his school, could be reduced by reinforcing approximations to the target response (walking from the van into the school without noncompliance) using a backward chaining procedure. After establishing the presentation of a ball as a conditioned reinforcer by pairing it with preferred activities (gym activities and music), walking to the gym from the classroom, then from outside the building, and finally from the van and through the building were shaped using the ball to reinforce initial responses in the chain (the chain always ended in reinforcement with gym activities). As in the Weeks and Gaylord-Ross (1981) study, the subject ultimately was required to comply (i.e., to enter the building from the van) throughout the study; thus, extinction of escape-maintained noncompliance may have contributed to treatment (presuming that noncompliance was maintained by escape, which was not clearly shown). However, in an interesting stimulus control analysis of this procedure, it was shown that when stimuli correlated with reinforcing gym activities (i.e., participating staff and the ball) were not present, noncompliance increased over treatment levels. That is, decrements in compliance were observed when participating staff met the subject at his van without the ball and when nonparticipating staff met the subject at his van with or without the ball. This stimulus control over correct responding suggests that positive reinforcement for correct responses might have altered the reinforcing effectiveness of escape (i.e., contact with positive reinforcers in the school diminished the aversiveness of that setting); when discriminative stimuli for compliance were absent, responses that were presumably maintained by escape increased.

A component analysis of the motivational and extinction effects of the errorless learning and backward chaining procedures would be especially interesting because it is possible that these procedures could produce

direct changes in EOs. That is, if the effect of errorless learning is to establish in the subject's repertoire correct responses to tasks that previously evoked incorrect responses, then the escape-establishing function of those task demands may be directly altered. Put another way, tasks that can be completed successfully may not be aversive, and if a difficult task can be transformed into an easy task using errorless training, the reinforcing effects of escape may be diminished to a point where escape behavior is not evoked. Similarly, pairing compliance with requests with reinforcement by requiring only the performance of terminal components of a task (as in backward chaining) may alter the escape-establishing function of the task. These effects may contrast with those of fading along the dimension of frequency, which may not fundamentally alter the EO function of demands; however, successful demonstrations of demand fading without extinction (e.g., Pace et al., 1994) suggest that mere exposure to a task in small, incremental steps might have durable effects with some individuals.

In a similar approach, Cameron, Ainsleigh, and Bird (1992) modified an aspect of a task that had been shown to evoke aggression and noncompliance in their subject. These behaviors reliably occurred when the subject was handed a bar of soap and was prompted to wash himself. In probe sessions, the trainer presented the subject with a liquid rather than a solid form of soap, and maladaptive responding was immediately eliminated. The authors termed this a "stimulus control analysis" of the subject's aggression and noncompliance; however, their explanation of the evocative effects of bar soap was that "the requirement of holding onto a wet bar of soap increased the level of difficulty of the bathing routine and set the occasion for behaviors that would allow [the subject] to successfully escape from the demand" (p. 337). This account suggests that their procedure was an assessment of establishing rather than discriminative operations. Despite this interpretive limitation, the study shows a simple method for reducing escape-maintained maladaptive behavior by making a minor modification in the nature of the task demand. Further, by utilizing a probe design to assess the effects of their procedure, they were able to limit the possibility that escape extinction (compliance with the bathing routine was required throughout the study) was responsible for differences in maladaptive responding. Throughout treatment, liquid soap probes were interspersed among sessions in which bar soap was presented; bar soap sessions continued to evoke maladaptive behavior whereas liquid soap sessions did not. This study differed from those previously described in that no return to the conditions that originally evoked problem behavior was attempted or necessary. This procedure demonstrated a pragmatic approach in which the goals of training could be achieved and maladaptive behavior could be eliminated merely by modifying a formal property of the task.

Dunlap, Kern-Dunlap, Clarke, and Robbins (1991) implemented a molar antecedent intervention called curricular revision to reduce the motivation for disruptive behavior and inappropriate vocalizations in an adolescent girl with developmental disabilities. This intervention included (a) a decrease in the duration of fine-motor activities, (b) interspersing fine- with gross-motor activities, (c) arranging activity content so that it was "interesting . . . and [led] to a concrete and preferred outcome" (p. 392), and (d) permitting the subject to choose activities from a menu of options when possible. Significant reductions in maladaptive behaviors and increases in appropriate responding were shown. However, neither the elements of the intervention package responsible for the treatment effect nor the mech-

anisms of change can be identified, because all were simultaneously implemented. Further, although the consequences for maladaptive behaviors during baseline were task termination and seclusion time-out, the contingencies for maladaptive behavior during treatment were not described. Unless the contingencies of baseline remained in place during treatment, the possible role of extinction in producing treatment effects must be considered.

Other methods of reducing the motivation to escape have also been investigated, including embedding demands in pleasant stories (Carr et al., 1976) or in the context of easy tasks (Horner, Day, Sprague, O'Brien, & Heathfield, 1991). Carr et al. interpreted the effectiveness of these procedures in terms of discriminative operations, suggesting that demands exerted stimulus control over their subject's SIB and that pleasant stories were discriminative for behavior that was incompatible with SIB. The drawbacks of a stimulus control account of antecedent aversive stimulation have been stated earlier and will not be repeated here. The effects of embedded requests may be better explained as resulting from an EO because the presentation of pleasant stories was not discriminative for escape; the correlation between SIB and task termination was unchanged by this manipulation, and that correlation was zero in this example because no contingencies were programmed for SIB. A definitive determination of motivational versus discriminative control would require examination of the effects of embedded demands while reinforcement for SIB (escape) remained in place.

In an inventive antecedent manipulation, Mace and Belfiore (1990) used high-probability demand sequences to establish compliance in treating stereotypy maintained by escape. After first presenting a series of requests that were highly likely to evoke compliance and unlikely to evoke stereotypy, they presented demands that were previously associated with stereotypy and a low likelihood of compliance. The results of this study showed increases in compliance accompanied by decreases in stereotypy. The authors interpreted these findings in terms of behavioral momentum (Nevin, Mandell, & Atak, 1983), in which behavioral persistence is a function of the product of response rate and reinforcement rate. By increasing both response and reinforcement rates through the presentation of high-probability sequences, compliance with low-probability demands would be predicted due to the persistence of the response class of compliance. Several possible mechanisms were suggested to explain reductions in stereotypy, including topographical or functional incompatibility between compliance and stereotypy and an inverse relation between concurrent operants. Each of these accounts suggests a change in the relative reinforcing efficacy of escape; stereotypy is reduced because the presence of alternative reinforcers, performance of other responses, or both alter the extent to which aversive stimulation evokes escape responses, rather than because of differential availability of escape for those responses. However, as in several previous examples, escape was not contingent on the target response during treatment, raising the possibility that extinction was at least partially responsible for reductions in stereotypy.

In a subsequent component analysis, the effects of high-probability sequences were replicated when escape was not contingent upon SIB; however, the procedures were ineffective when SIB produced escape (Zarcone, Iwata, Hughes, & Vollmer, 1993). These results suggest that escape extinction may be necessary for the success of high-probability sequences, at least when they are applied as treatment for escape behavior. In fact, these investigators reported that demands that were initially associated with

high probabilities of compliance and low probabilities of SIB came to evoke SIB and lower rates of compliance when the high-probability sequence was presented and SIB continued to produce escape. This result resembles that of the reflexive conditioned EO (Michael, 1993a). The high-probability sequence reliably preceded the presentation of a low-probability demand and was thus correlated with "worsening" of conditions. Eventually, the high-probability sequence began to evoke escape responding, as would be predicted by the model of the reflexive conditioned EO. This was the opposite of the intended effect; the expected outcome of the relationship between high-probability sequences and low-probability demands was to reduce or eliminate the escape-establishing function of low-probability demands.

A discriminative stimulus for negative reinforcement is correlated with the availability of an effective escape response in the presence of aversive stimulation. Thus, as with positively reinforced behavior, the reduction of negatively reinforced behavior using discriminative control is necessarily a matter of consequences. That is, treatments based on stimulus control involve an alteration of the correlation between the discriminative stimulus and escape (requiring extinction of responses that occur in the presence of the stimulus), the removal of that stimulus from the environment (requiring extinction of responses occurring in the absence of the stimulus), or transfer of stimulus control (requiring differential reinforcement across two or more stimulus conditions). We know of no studies reporting antecedent treatments for escape behavior that may be properly interpreted as specific manipulations of discriminative operations. Further, the pursuit of such treatments may be contraindicated because they involve (by definition) the maintenance or establishment of a condition in which maladaptive responding maintained by negative reinforcement is correlated with escape.

Antecedent interventions designed to reduce maladaptive behavior that is maintained by automatic negative reinforcement are conspicuously absent in applied research. Automatic negative reinforcement involves the nonsocially mediated termination or avoidance of aversive stimulation contingent upon a given response. This typically involves either physical withdrawal from the source of stimulation (as in pulling one's hand away from a fire) or behavior that directly attenuates private aversive stimulation (as in scratching at itchy skin). The second example often involves contact between afflicted and nonafflicted body parts, which, when excessive, may result in tissue damage. Thus, most maladaptive behavior maintained in this way would be characterized as self-injurious. That is, behavior disorders that arise from automatic negative reinforcement will, by definition, be self-directed, and their classification as undesirable will most likely be based on detrimental effects to the behaver.

The most straightforward antecedent intervention for SIB thus maintained is to treat the condition associated with pain or discomfort. Examples of this approach would be the application of topical creams on rashes and infected areas to reduce scratching, administration of analgesics to reduce head hitting maintained by attenuation of headaches, dental intervention to reduce jaw hitting maintained by attenuation of toothaches, and treatment of allergy conditions that may motivate self-scratching. Although each of these procedures is commonplace in the provision of services to persons with developmental disabilities, none is documented in the applied literature on behavior disorders. The effects of such procedures can be explained as the abolition of escape from aversive stimulation as a reinforcing event by providing noncontingent

reinforcement. This approach is directly analogous to the reduction of social escape behavior by eliminating aversive demands from the environment. It is unclear how discriminative control could be used to decrease maladaptive behavior maintained by automatic negative reinforcement.

Special Cases

In certain cases, antecedent interventions do not correspond directly to specific maintaining variables. That is, the effects of manipulating antecedent variables may not always depend upon a known relationship with consequences for problem behavior. One possible example of this is the enriched environment approach, in which noncontingently available reinforcers may substitute for the reinforcement that maintains problem behavior. Thus, knowledge of the specific reinforcer that maintains problem behavior may not be necessary for the success of this treatment. However, the enriched environment approach may be best suited to the treatment of positively reinforced behavior. Based upon current research, it is unclear whether substitutability occurs across types of reinforcement contingencies (i.e., whether a positive reinforcer is substitutable for a negative reinforcer). Thus, because studies on environmental enrichment are typically conducted in nondemand contexts, and because the relevance of this approach to negatively reinforced behavior is not obvious, the effects of enriching the environment were discussed in the context of behavior maintained by social and automatic positive reinforcement.

Several studies have investigated the effects of antecedent exercise in the treatment of behavior disorders (Allison, Basile, & MacDonald, 1991; Bachman & Fuqua, 1983; Bachman & Sluyter, 1988; Baumeister & MacLean, 1984; Kern, Koegel, & Dunlap, 1984; Kern, Koegel, Dyer, Blew, & Fenton, 1982; Powers, Thibadeau, & Rose, 1992). These interventions typically involve participation by subjects in aerobic exercise routines (e.g., jogging or dance) and have resulted in subsequent decreases in maladaptive behaviors such as self-injury (Baumeister & MacLean), aggression (Allison et al.), and stereotypy (Kern et al.).

Research has shown a positive correlation between exercise intensity and its effectiveness as intervention (Bachman & Fuqua, 1983; Baumeister & MacLean, 1984); however, a study reporting a physiological measure of exertion (pulse rate) showed no correlation between heart rate during exercise and subsequent maladaptive behavior (Allison et al., 1991). It is possible that this outcome was a function of their subject's relatively high heart rate throughout treatment (rates during exercise never fell below 59% of maximum, even during less intensive exercise), suggesting a threshold of intensity above which effects are asymptotic. Indeed, a subsequent study (Levinson & Reid, 1993) showed a relationship between heart rate just after exercise and effects of antecedent exercise when the low-intensity exercise generated increases in heart rate between 30% to 45% over resting rates. The use of physiologic measures of exertion is a promising method for research on antecedent exercise, because it may permit more definitive parametric analyses of the effects of different levels of exertion as well as controlled assessments of the effects of variables such as the type of activity (i.e., by controlling for level of exertion, it may be determined whether the type of movement involved in antecedent exercise has a differential effect on subsequent behavior).

These preliminary data on antecedent exercise suggest an EO account of its effects. Because no manipulation of the availability of reinforcement occurs, the effects of antecedent exercise seem to be most consistent with a change in the reinforcing efficacy of the consequences that maintain maladaptive

behavior. However, several issues remain unresolved. For example, what specific components of antecedent exercise are responsible for its effectiveness? As suggested above, analyses of the effects of exertion and different types of exercise may reveal important clues about the mechanisms that underlie this effect. If exertion is found to be the most important variable in reducing maladaptive behavior, then a general "fatigue" effect may be implicated. However, both empirical data and anecdotal evidence suggest that this may be an untenable account. Fatigue would be expected to produce a general suppression of behavior; however, several studies have reported increases in appropriate responding as a result of antecedent exercise (Kern et al., 1982), and others have noted the absence of drowsiness or other symptoms of fatigue in their subjects (Baumeister & MacLean, 1984; Kern et al., 1982; Tarnowski & Drabman, 1985). These outcomes are inconsistent with a fatigue account of antecedent exercise.

Analyses of the effects of various forms of exercise (controlling for exertion) might reveal relationships between the movements of exercise and levels of maladaptive behavior and, thus, may suggest particular interpretations about the effects of antecedent exercise. For example, if the movements involved in a particularly effective form of exercise are similar to those of the maladaptive behavior itself (e.g., highly repetitive aerobic exercises and stereotypic rocking), then satiation of the reinforcer that maintained the maladaptive behavior may be suspected. Levinson and Reid (1993) showed data suggesting that motor stereotypies may be differentially sensitive to antecedent exercise relative to vocal/oral or other forms of stereotypy. These effects were inconsistent, however, and the authors recommended further research to examine the possibility of functional relationships between exercise movements and topographical characteristics of stereotypy.

Another important direction for investigations of the effects of antecedent exercise is the integration of functional analysis methodology into this research. Analysis of the variables that maintain maladaptive behavior would provide a stronger basis for interpreting the functional properties of antecedent exercise and might provide important prescriptive information. For example, if antecedent exercise is especially effective for behavior maintained independently of social consequences, then functional analysis results could be important for determining when it should be used as treatment. Such an outcome would be consistent with a satiation account of the effects of antecedent exercise, especially if the topographies of exercise and maladaptive behaviors were similar.

The specificity of the effects of antecedent exercise (i.e., its suppressive effects seem to be specific to maladaptive behaviors) is puzzling; the class of behaviors reduced by these procedures is characterized only by social unacceptability and includes a wide range of behavioral topographies that are presumably maintained in idiosyncratic ways. It is unclear why the effects of antecedent exercise generalize across these behaviors, yet are also specific to them. The results of functional analyses of problem behaviors treated by antecedent exercise might clarify the basis for these effects if the functional properties of maladaptive behaviors are found to be differentially correlated with treatment effectiveness.

A special case in which the consequences for problem behavior may be irrelevant to the effectiveness of antecedent control is the use of restraint. The literature on the treatment of severe behavior disorders is replete with examples of the use of restraint or protective devices to control problem behaviors (Favell, McGimsey, & Jones, 1978; Favell, McGimsey, Jones, & Cannon, 1981; Foxx & Dufrense, 1984; Isley, Kartsonis, Mc-

Curley, Eager Weisz, & Roberts, 1991; Pace, Iwata, Edwards, & McCosh, 1986; Paul & Romanczyk, 1973; Rojahn, Mulick, McCoy, & Schroeder, 1978; Silverman, Watanabe, Marshall, & Baer, 1984). Clearly, the effectiveness of procedures that render maladaptive responding impossible is independent of the contingencies that maintain problem behavior. Responding is automatically eliminated. Restraint thus represents a special case of stimulus control in which the reinforcer previously contingent upon maladaptive responding is unavailable only because it is no longer possible to emit the previously reinforced response. When restraint is applied, no response will be reinforced because no reinforceable response can occur; the decrease in responding is a result of neither a change in consequences nor a change in the reinforcing function of those consequences. Thus, the effects of restraint are properly interpreted as resulting from a discriminative relationship between restraint and the absence of a response–reinforcement contingency.

Although restraint is unquestionably effective in reducing maladaptive behaviors, serious side effects, including the development of a preference for restraint (i.e., self-restraint; Favell et al., 1978) and reductions in social interactions and appropriate behaviors (Rojahn, Schroeder, & Mulick, 1980) may result from its use. The development of methods to investigate and reduce these side effects has produced data showing some interesting relationships between restraint and maladaptive behaviors. For example, several researchers have shown that it is possible to modify the form of restraint while maintaining control over it. Foxx and Dufrense (1984) were able to fade the size of held objects and the form of protective devices while controlling the self-injury of a subject, even though self-injury was possible when the restraints were in their final form. Similarly, Pace et al. (1986) faded rigid arm tubes to wrist bands and faded the air pressure in air splints while maintaining control over the SIB of their subjects. These examples, in which control is transferred from a stimulus that physically prevents responding to a stimulus that does not, present an interesting interpretive dilemma. Although it is tempting to interpret these results in terms of discriminative control, reinforcement is available contingent upon maladaptive behavior when symbolic restraint is used. Typically, when an antecedent event alters behavior but is unrelated to the availability of reinforcement contingent upon that behavior, its effects are interpreted in terms of EOs. However, because it likely that the effectiveness of symbolic restraint is a direct function of its historic relationship with functional restraint, symbolic restraint may represent a generalization of stimulus control based upon the gradual and systematic transformation of the stimulus (Touchette, 1968). Thus, the ultimate success of treatments that employ symbolic control may depend upon their integration with other treatments to reduce the likelihood of relapse due to recontact with the contingencies that originally maintained problem behavior.

Other research on restraint has shown that restraint may itself become a positive reinforcer and that some subjects will actively engage in self-restraint (Favell et al., 1981). Investigators have noted that self-restraint typically results in decreases in maladaptive behavior (usually SIB), and that self-restraint often seems "designed to prevent" maladaptive responding (Silverman et al., 1984, p. 545). Smith, Iwata, Vollmer, and Pace (1992) conducted an analysis of the variables that maintain self-restraint and found evidence that idiosyncratic contingencies may be operative. That is, for different individuals, self-restraint may be maintained by reducing SIB, by variables similar to those that maintain SIB, or by contingencies unrelated to those that maintain SIB. Thus,

conditions associated with SIB may establish the reinforcing effectiveness of self-restraint (as when self-restraint is maintained by reductions in SIB), or self-restraint may displace SIB in a reinforcer substitutability relation, as in the latter two cases.

Another way in which stimulus control over problem behavior may be important, independent of maintaining consequences, occurs when antecedent stimuli are differentially paired with punishment. Results of a study by Corte, Wolf, and Locke (1971) indicated that contingent electrical stimulation was effective in reducing their subjects' SIB. However, reductions in SIB came under discriminative control of stimuli associated with the delivery of shock. For example, the reductive effects of shock were specific to both the settings in which sessions took place and the therapists who delivered shocks. Only when generalization was actively programmed, by increasing the number of settings and therapists associated with shock (i.e., by making the conditions under which shock was contingent on SIB less predictable), was the specificity of effects reduced.

In another study, SIB was brought under discriminative control of a stimulus that could be constantly present in the subjects' environment. Linscheid, Iwata, Ricketts, Williams, and Griffin (1990) showed that wearing a device that had previously delivered electrical stimulation contingent upon SIB was discriminative for low rates of SIB. Specifically, following experience with the punishment contingency, merely placing the inactive device on the subject produced decreases in the SIB of 3 of 5 subjects. However, in all but 1 of these subjects, the decrease was temporary, with SIB returning to previous levels within several sessions. That is, when the device was no longer differentially correlated with the delivery of shock contingent upon SIB, the behavior reemerged, consistent with the abolition of discriminative control. It is possible that systematic fading procedures may produce a more durable generalization effect. Alternatively, a device that could deliver contingent aversive stimulation, but whose presence is undetectable (i.e., very small devices), might facilitate generalization by virtue of low correlations with any particular environmental conditions.

SOME DIRECTIONS FOR FUTURE RESEARCH

Much remains to be investigated about the influence of antecedent events on problem behaviors. Although antecedents are often manipulated (or at least controlled) in the assessment and treatment of behavior disorders, few studies have done so in a manner that permits the systematic identification of antecedent classes, and fewer still have attempted to relate the effects of antecedents to basic principles of behavior. A primary goal of research on antecedent variables in behavior disorders should be the development of research methods that permit experimentally sound analyses of antecedent effects and that produce a conceptually coherent understanding of these effects.

Although it is tempting to leap forward into analyses of complex relationships among antecedent, response, and consequence variables, an overview of the current state of the applied literature suggests that the field has not yet reached the point at which such analyses are productive. Research that shows correlations among broadly defined classes of variables brings a measure of scope to the search for environmental determinants of behavior. However, greater control is required for the demonstration of functional relations, and careful arrangements are necessary to reveal the mechanisms of behavior change. Even proponents of the setting-events approach to applied behavior analysis suggest the need for greater

precision in the analysis and control of antecedent events (e.g., Kennedy & Itkonen, 1993). Whenever broad classes of antecedent variables are defined in terms of formal properties (e.g., setting events), the likelihood of producing effects based upon changes in the class increases, even as the likelihood of correctly identifying relevant versus irrelevant variables decreases. Thus, setting-event analyses may cloud more issues than they clarify.

How, then, might applied behavior analysts proceed to disentangle the complex antecedent relations that are involved in the production of maladaptive behavior? To deny the influence of temporally distant or extended events or to discount the effects of interrelationships among prior environmental and behavioral events would be naive; indeed, the greatest contribution of the setting-events literature is to prompt consideration and investigation of such variables. However, analyses of these events must proceed using sound scientific practice. A suggested approach to the examination of contextual variables is to build context by first examining the effects of isolated antecedent variables and then studying the effects of various combinations and arrangements on resultant behavior.

Functional analysis of antecedents first requires identification of the contingency that maintains problem behavior. Then, while systematically controlling relevant consequences, the effects of antecedent events may be investigated. Following demonstrations of functional relationships between isolated antecedent events and behavior, antecedents could be combined in various ways to determine the effects of complex stimuli. This approach requires tedious and eventually complex experimentation, but the relationships thus identified would provide both functional and operational definitions of context and would allow component analyses of the elements comprising context.

Some specific areas for future research can be identified. Little research exists on discriminative control of problem behavior maintained by positive reinforcement. Bringing difficult behavior under discriminative control and then systematically restricting the occurrence of the S^D (Azrin & Powell, 1968) may reduce the negative side effects of extinction; however, the effects of discrimination per se in this treatment remain unclear pending a component analysis. EOs that are associated with positively reinforced behavior disorders present a wide range of research opportunities. Studies could investigate deprivation effects on behavior disorders maintained by attention by varying periods of isolation prior to sessions in which attention is contingent upon maladaptive behavior. Conversely, the effects of satiation on maladaptive behavior could be shown by arranging a time-based schedule of attention (e.g., NCR) while maintaining a contingency between maladaptive behavior and attention. Similarly, effects of deprivation from stimuli similar to those suspected of maintaining automatically reinforced behavior problems (e.g., the effects of food deprivation on pica) might increase the confidence of interpretations about these contingencies. Also, as was suggested previously, the possibility that substitutable reinforcers may alter the effectiveness of the form of reinforcement that maintains problem behavior suggests a potential program of research. Topics such as the identification of reinforcers that are likely to serve as successful substitutes and the conditions under which reinforcer substitution is more or less probable could be examined (e.g., can reinforcer substitutability be enhanced by using varied substitutes, by imposing deprivation from substitutes, or by imposing satiation with respect to the substituted reinforcer?).

Many possibilities exist for extending research on antecedent events in negatively reinforced behavior. As with positively rein-

forced behavior, analyses of discriminative events in negative reinforcement are rare. One possible approach to integrating stimulus control into the treatment of escape behavior might be to perform a manipulation similar to that described by Azrin and Powell (1968) to treat positively reinforced behavior. That is, by bringing escape behavior under stimulus control, and then restricting the S^D, it may be possible to limit the negative side effects of escape extinction.

The influence of EOs on escape behavior currently represents the most developed topic on antecedent effects in behavior disorders, yet much remains to be learned. Component analyses of aspects of the demand context that are associated with problem behavior might identify common dimensions of aversiveness that may then facilitate the development of generally effective treatments (Smith et al., 1995). Also, continued research into the extrademand conditions (context variables) that influence the reinforcing effects of escape will improve the ability of trainers to educate their students with a minimum of problem behavior. Similarly, further investigations of procedures that alter features of tasks to make them less aversive, such as errorless learning (Weeks & Gaylord-Ross, 1981) and backward chaining (Cameron et al., 1992), may also lead to the improvement of training techniques.

The analysis and treatment of escape behavior maintained by automatic reinforcement is an area in which almost no research data exist. As with all automatically reinforced behavior, the identification of maintaining variables is difficult, and it may be necessary to base preliminary interpretations on indirect evidence. However, one promising area of investigation is the use of medical treatment in a noncontingent reinforcement approach to reduce the reinforcing effectiveness of maladaptive escape behavior. If simple and straightforward treatments, such as topical creams and solutions for dermatological disorders and analgesic medication for headache and other pain, produce decreases in self-injury, then a negative reinforcement account of this problem behavior is tenable. A series of studies linking specific treatments to specific topographies of SIB (and, perhaps, the preexistence of specific medical conditions) could provide a rationale for basing treatment upon the form of SIB when automatic negative reinforcement is suspected.

Special cases of antecedent control also provide research opportunities. Careful studies that relate the effects of environmental enrichment to various functions of maladaptive behavior could produce information about the conditions under which reinforcer substitution is likely to occur. For example, the effects of environmental enrichment have not been investigated in cases of negatively reinforced behavior. Studies on this topic may reveal whether positive reinforcers may be substitutable for negative reinforcers.

Further investigation might also be productive in the use of restraint to reduce maladaptive behavior. The conditions under which restraint may be faded, and the conditions that promote continued symbolic control by faded forms of restraint over problem behavior, remain to be clarified. Future research might investigate how treatment components may combine to improve the likelihood of successful treatment using restraint fading.

Future research might also provide information about the relationship between SIB and self-restraint. As was previously suggested, self-restraint maintained by contingencies similar to those that maintain problem behavior or by independent contingencies may reduce maladaptive behavior through reinforcer substitutability. This possibility might be further investigated by manipulating the cost of engaging in one of these responses while monitoring changes in the other response. Also, continued refinement of a technology for functional analysis of the

variables that maintain self-restraint may be important for the above analyses.

Another potentially important area of future research involves the enhancement of punishment effects using stimulus control procedures. Punishment is typically seen as the alternative of last resort in the treatment of behavior disorders, and it seems prudent to investigate ways in which its effects can be enhanced to limit the necessity of its continued use. Evidence exists that pairing response-contingent punishment with antecedent stimuli may establish a discriminative function of those stimuli, at least temporarily. Identifying the conditions under which this stimulus function can be maintained may result in an increase in the effectiveness of punishment contingencies and reduce the total amount of aversive stimulation necessary to produce and maintain significant decreases in problem behaviors.

The topic of antecedent events in behavior disorders offers a wide range of potentially important research directions. One of the major contributions of developing an array of antecedent-based treatments is to provide alternatives to the use of aversive consequences for problem behavior. If the EOs that establish maladaptive behavior as reinforcing can be controlled, or if the conditions under which maladaptive behavior is likely to be reinforced can be limited, then it may be possible to avoid using aversive consequences or producing negative side effects attendant to extinction-based treatments. Careful study of the antecedent variables that affect maladaptive behavior may not only result in an expansion of treatment alternatives but also may contribute to a fundamental understanding of the mechanisms of antecedent control. By first identifying and controlling functional relations among isolated antecedents and subsequent behavioral events, it may be possible to build experimental models of setting events and behavioral fields. These models would have a distinct advantage over current research in that the functional properties of the elements that comprise these constructs already would be known. Potential special relations among these variables, such as synergism (enhanced effects of variables as a function of their combination) or antagonism (reduced effects of variables as a function of their combination), could be analyzed systematically. Thus, it is clear that much work remains to be conducted, and although the existence of difficult and complex human behavior disorders establishes the reinforcing effects of elaborate explanatory schemes, there is no substitute for a solid base of data as stimulus control over effective interpretation.

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