JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1996, **29,** 557–563 NUMBER 4 (WINTER 1996)

IN PURSUIT OF GENERAL BEHAVIORAL RELATIONS

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Efforts to develop behavioral technologies from advances in basic research assume that results from studies with nonhuman subjects can, in some instances, be applied to human behavior. The behavioral principles likely to be most useful for application are those that represent robust general behavioral relations. Basic and applied research on behavioral momentum suggests that there is a general behavioral relation between the persistence of behavior and the rate of reinforcement obtained in a given situation. Understanding the factors that affect behavioral persistence may have important implications for applied behavior analysts that justify studies aimed at establishing the generality and limits of the functional relation between reinforcement rate and behavioral persistence. Strategies for establishing the generality of behavioral relations are reviewed, followed by a brief summary of the evidence for the generality of behavioral momentum.

DESCRIPTORS: behavioral momentum, high-probability treatment, resistance to change, general behavioral relations

Nevin's essay in this issue of *JABA* occasions the consideration of some important issues at the heart of renewed efforts to establish connections between basic and applied behavior analysis (Mace, 1994; Mace & Wacker, 1994). These efforts assume that results of laboratory studies with nonhuman subjects can, in some instances, tell us something about the behavioral processes that maintain, or can be used to alter, human behavior outside the laboratory. For this assumption to hold true, there must be general behavioral (i.e., behavioral-environmental) relations involved in the behavior of organisms that are common to many vertebrate species. Further, the operant chamber, equipped with simple manipulanda and discriminative stimuli arranged in relation to primary reinforcers and punishers, must be a viable experimental setting to discover these general behavioral relations.

Skinner's search for orderly behavioral-environmental relations appears to have been guided by these assumptions. In the concluding section of *The Behavior of Organisms* (1938), Skinner writes,

> The reader will have noticed that almost no extension to human behavior is made or suggested. This does not mean that [the reader] is expected to be interested in the behavior of the rat for its own sake. The importance of a science of behavior derives largely from the possibility of an eventual extension to human affairs.
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> Whether or not extrapolation is justified cannot at present time be decided. It is possible that there are properties of human behavior that will require a different kind of treatment. But this can be ascertained only by closing in upon the problem in an orderly way and by following the customary procedures of an experimental science. (pp. 441–442)

Early connections between basic research and application seem to have followed Skinner's prescription: Begin first with a controlled experimental demonstration and then

I appreciate the constructive comments from Benjamin Mauro, Patrick Progar, and Timothy Vollmer on earlier drafts of this manuscript.

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systematically determine the generality of the behavioral relation through numerous and varied experimental replications, followed by a progression of conservative extensions to application.

One alternative to building technologies around general behavioral relations discovered in the laboratory is for applied behavior analysis to function as a self-contained enterprise (Baer, 1981). Baer describes this enterprise as "a new discipline, almost as easily divorced from behavior analysis as behaviorism was from physiology and mentalism" (1981, p. 90). Baer sees at least four important reasons for pursuing this path: (a) Our social problems are enormous, and the need to address them is immediate; (b) the most simple and robust behavioral principles have already been validated and found to be very useful foundations for behavioral technologies (e.g., positive reinforcement); (c) real-world applications of the latest basic research findings have a lower likelihood of success than does reformulation of well-validated principles into new and improved interventions; and (d) applied behavior analysis has made unquestionable progress in solving social problems following this model.

There is little question of the magnitude of our problems and the history of success that we have experienced in building interventions around the most robust behavioral principles. My main point of contention with Baer is that I believe our collection of useful behavioral principles is incomplete and that we should continue to expand this collection of broadly useful behavioral principles to address some fundamental questions that remain unanswered. One fundamental question in Nevin's work on behavioral momentum is, "What makes behavior persistent?" If there are clear and relatively simple answers to this question, applied behavior analysts may learn how to make desirable behavior more persistent when it is challenged and, conversely, how to weaken the persistence of undesirable behavior. For this prospect to be realized, however, there must be a manageable set of general behavioral relations involved in the persistence of behavior. In my view, the importance of Nevin's basic question supports our pursuit of the generality of behavioral momentum.

Establishing the Generality of a Behavioral Relation

How do we know when an experimentally derived behavioral relation is a general principle or law that, as Keller and Schoenfeld (1950) put it, "hold[s] true for the white rat as well as the college student, for the dog in the laboratory harness as well as the patient on the psychoanalyst's couch" (p. vii)? How do we know, for example, that the behavioral process Skinner (1938) termed *reinforcement,* describing the relation between contingent food and a rat's increased lever pressing, is the same reinforcement used to describe a seventh grader's improved academic performance resulting from her teacher's praise of accurate answers (Kirby & Shields, 1972)? And is there correspondence in behavioral process between Ferster's (1958) time-out from positive reinforcement, the response-suppressing effect that removal of a discriminative stimulus (S+) has for pigeons and chimpanzees, and Foxx and Shapiro's (1978) time-out ribbon, in which requiring a child to remove a ribbon contingent upon unacceptable behavior results in minimal access to social and material reinforcers and a corresponding reduction in unacceptable behavior?

One consideration in judging whether a behavioral relation demonstrated in the laboratory applies to a particular human situation is the degree of correspondence between the two sets of procedures. In general, the greater the degree of procedural overlap, the more reasonable it is to infer that a common behavioral process is involved in the two situations. Although the degree of procedural congruence is an important criterion for making this judgment, we should recognize that there will always be substantial differences, both in form and complexity, between events in the operant chamber and those encountered or arranged for humans in everyday life. As a result, there will ordinarily be room to question whether early attempts at application are invoking the same behavioral process that has been isolated in the laboratory.

Biomedical sciences face a similar situation when attempting to translate basic biological research findings into clinical medical treatments (Mace, 1991). In AIDS research, for example, there are often enormous differences between in vitro laboratory conditions and HIV disease within the noise of a complex biological system. Yet when the virologist discovers an experimental agent's antiviral effects in cells isolated from their host, there is hope that the mechanism observed in the laboratory can be eventually imported into new antiviral drug therapies for AIDS patients. The Food and Drug Administration, in concert with the National Institutes of Health, fosters this progression from basic research to clinical treatments through the structure of phased clinical trials. Phased clinical trials define a progression of systematic replications and extensions of research that both drive advances in clinical medicine and establish the generality of biologic mechanisms first detected in the laboratory.

Like the biomedical sciences, behavior analysis relies on systematic replication as an important means of establishing whether a behavioral relation that has been specified in the laboratory is limited to a given set of procedures, or whether the particular procedures in effect are one exemplar of a general and robust behavioral relation (Sidman, 1960). Prediction and control of behavior are key elements of systematic replication. In one sense, prediction of behavior follows from repeated measurement under comparatively constant conditions. However, experimentally demonstrated functional relations also permit prediction of future behavioral relations when procedures are replicated with variation. The general strategy to be followed is to first express the relationship between an experiment's independent and dependent variables as a general behavioral relation. The next step is to design systematic replication studies whose procedures embody the general behavioral relation in question and predict a general pattern of results that would be consistent with this behavioral relation.

Establishing the Generality of Behavioral Momentum

In devising the high-probability (high-*p*) treatment for noncompliance (Hock & Mace, 1986; Mace et al., 1988), our consideration of Nevin, Mandell, and Atak's (1983) analysis of behavioral momentum gave less emphasis to the particular baseline and momentum test procedures employed in their experiments than to the general behavioral relation (i.e., the persistence of behavior was a positive function of rate of reinforcement). If this general behavioral relation were robust, we reasoned that providing a high rate of reinforcement for a high rate of compliance would increase the persistence of compliant behavior when compliance was challenged by a low-probability (low-*p*) instruction. Our results (Mace et al., 1988), along with those of numerous replications of the high-*p* treatment (e.g., Davis, Brady, Hamilton, McEvoy, & Williams, 1994; Davis, Brady, Williams, Hamilton, 1992; Ducharme & Worling, 1994; Harchik & Putzier, 1990; Horner, Day, Sprague, O'Brien, & Heathfield, 1991; Houlihan, Jacobson, & Brandon, 1994; Kennedy, Itkonen, & Lindquist, 1995; Mace & Belfiore, 1990; Rortvedt & Miltenberger, 1994; Sanchez-Fort, Brady, & Davis, 1996; Singer, Singer, &

Horner, 1987; Zarcone, Iwata, Hughes, & Vollmer, 1993; Zarcone, Iwata, Mazaleski, & Smith, 1994), have been generally consistent with this behavioral relation.

However, after further consideration of our thesis that the high-*p* treatment invokes the same behavioral relation described by Nevin et al. (1983) (consideration compelled by a set of nine insightful and educational *JABA* reviews of our 1988 manuscript!), my collaborators and I concluded that our inference was premature. There were simply too many procedural differences between Nevin's multiple-schedule work with pigeons and our high-*p* treatment of noncompliance with humans. In other words, we had not yet followed Skinner's (1938) prescription to close in on the problem following the customary procedures of an experimental science. In the years following the review of our paper, my colleagues and I have spent a large portion of our time attempting to narrow some of the sizable gaps between Nevin et al. (1983) and Mace et al. (1988). Several basic researchers, including Nevin, have likewise examined the bounds of generality for behavioral momentum. As a result of this work, we now have a greater understanding of the general functional relation between reinforcement and the persistence of behavior.

Species generality. Resistance to change has been shown to be a positive function of rate of reinforcement with a variety of species, including pigeons (e.g., Nevin, Tota, Torquato, & Shull, 1990), rats (e.g., Cohen, Riley, & Weigle, 1993; Mauro & Mace, 1996), and monkeys (Hughes & Branch, 1991). Two studies have also replicated Nevin's principal findings with humans using procedures that closely parallel those used with pigeons. Using a multiple variable-interval (VI) VI schedule and a multiple VI/VI variable-time (VT) schedule, Mace et al. (1990) reinforced dinnerware sorting with 2 adults with mental retardation, and Cohen (1996) reinforced keyboard typing with undergraduate college students.

Procedure generality. The functional relationship between reinforcement and resistance to change has held across various reinforcement parameters including different types of multiple schedules of reinforcement (two and three components, fixed and variable schedules, and interval and ratio schedules; e.g., Cohen et al., 1993; Hughes & Branch, 1991), different reinforcer amounts (Harper & McLean, 1992), and different reinforcer types (points and food, Cohen, 1996; Mace et al., 1990). Successful replications have also been reported using several different response disrupters as momentum tests, including extinction (Nevin et al., 1983, 1990), prefeeding (Cohen et al., 1993), intertrial food (Nevin et al., 1983), cocaine (Hughes & Branch, 1991), distraction (Mace et al., 1990), and, in one correlational study, basketball adversities (Mace, Lalli, Shea, & Nevin, 1992).

*Variations of the high-*p *procedure.* A number of authors have examined different variations of the high-*p* treatment for noncompliance. Short interprompt intervals have been shown to be more effective than longer intervals, presumably because the shorter intervals increase the rate of reinforcement (Houlihan et al., 1994; Mace et al., 1988). Similarly, the effectiveness of the treatment appears to increase as the number of high-*p* instructions increases from two to three and then four high-*p* instructions (Eckert, Boyajian, & Mace, 1995). We have also found that the effectiveness of the procedure can be enhanced by using higher quality reinforcers for high-*p* compliance (Mace, Mauro, Boyajian, & Eckert, in press), a finding that is predicted by the relationship between choice and resistance to change (see Nevin, 1992). Finally, we have developed a rat model of noncompliance and the high-*p* treatment. Compliance is defined as the completion of a signaled fixed-ratio (FR) 15 task, and noncompliance represents the decrement in performance induced by another variable such as delayed reinforcement. In an unpublished pilot study (Mace & Mauro, 1996), we alternated FR 15 tasks in a two-component multiple schedule. In one of the two components, each FR 15 task was preceded by a rapid sequence of three signaled FR 1 schedules simulating the high-*p* treatment. After baseline stability was achieved over several sessions, a prefeeding momentum test resulted in more persistent responding in the FR 15 tasks in the component with the high-*p* treatment. Although some of these studies are as yet unpublished and should be cautiously interpreted, the collective results are consistent with a behavioral momentum interpretation.

Concluding Comments

The effort to build behavioral technologies through coordinated basic and applied research, and to understand treatment effects in terms of the behavioral processes they invoke, represents a different course for applied behavior analysis (cf. Baer, 1981). Whether it yields more effective technologies or a better understanding of our technologies is surely an empirical question that will not be resolved any time soon. The success of this effort, though, will depend in part upon an orderly pursuit of general behavioral relations that are truly useful for behavioral technologies. Not all, or even most, basic research findings will be candidates for application. We should set our sights on those principles that appear to be broadly applicable to human affairs and then establish their generality to humans and suitability for application in a systematic fashion.

Although Nevin's work on behavioral momentum addresses some issues of particular importance to basic researchers, it also speaks to one of the biggest concerns of applied behavior analysis: What makes behavior persistent? Nevin et al. (1983) was an impetus for our development of the high-*p* treatment (Mace et al., 1988). In retrospect, we were taking a huge leap in our interpretation of the high-*p* treatment as an instance of behavioral momentum. Were Nevin's findings limited to pigeons using his particular multiple-schedule procedure, or did his results represent an instance of a general and robust functional relation between reinforcement and persistence that was reflected in the high-*p* procedure? Although the question remains unanswered, most evidence available now supports the latter view. If momentum does represent a general behavioral relation, the most important applications of behavioral momentum have yet to occur. Needed are studies expressly aimed at strengthening the persistence of desirable behavior and weakening the persistence of undesirable responses. If successful, these studies, more so than the high-*p* treatment, will point to the value of coordinated basic and applied research.

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Received July 20, 1996
Final acceptance July 22, 1996
Action Editor, David P. Wacker