BASIC RESEARCH NEEDED FOR STIMULATING THE DEVELOPMENT OF BEHAVIORAL TECHNOLOGIES

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The costs of disconnection between the basic and applied sectors of behavior analysis are reviewed, and some solutions to these problems are proposed. Central to these solutions are collaborations between basic and applied behavioral scientists in programmatic research that addresses the behavioral basis and solution of human behavior problems. This kind of collaboration parallels the deliberate interactions between basic and applied researchers that have proven to be so profitable in other scientific fields, such as medicine. Basic research questions of particular relevance to the development of behavioral technologies are posed in the following areas: response allocation, resistance to change, countercontrol, formation and differentiation/discrimination of stimulus and response classes, analysis of low-rate behavior, and rule-governed behavior. Three interrelated strategies to build connections between the basic and applied analysis of behavior are identified: (a) the development of nonhuman animal models of human behavior problems using operations that parallel plausible human circumstances, (b) replication of the modeled relations with human subjects in the operant laboratory, and (c) tests of the generality of the model with actual human problems in natural settings.

Key words: basic-applied continuum, integrating basic and applied research, matching theory, behavioral momentum, stimulus equivalence, countercontrol, low-rate behavior, discrimination, differentiation, technology development

In recent years, behavior analysts have devoted much discussion to the proper relationship between basic and applied research. Such discussion is often a good thing; it can generate the full spectrum of viewpoints, prompt justification of each position, and eventually move a discipline toward consensus and coordinated action. However, there are many indications that we have not yet reached that point. In many respects, our basic and applied sectors appear to be polarized, and there is substantial disagreement within each sector about how best to proceed with basic research (see the Fall 1991 issue of *The Behavior Analyst*) and technology development (see the Fall 1991 issue of the *Journal of Applied Behavior Analysis*). Despite more than a decade of position papers encouraging greater interaction (e.g., Deitz, 1978; Epling & Pierce, 1986; Hake, 1982; Hayes, Rincover, & Solnick, 1980; McDowell, 1982, 1988; Michael, 1980; Myerson & Hale, 1984; Pierce & Epling, 1980; Suomi, 1982), our basic and applied sectors remain, to a large extent, disconnected, with neither reflecting significant knowledge of contemporary developments in the other sector or showing responsiveness to and influence on the other's agenda (Poling, Picker, Grossett, Hall-Johnson, & Holbrook, 1981).

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The goal of the present paper is not to trace the roots of this disconnection, but rather to suggest specific courses of action that can foster connection between our basic and applied sectors. If the connection is good for the discipline, the health of both sectors should improve and the fruits of cooperation will be many. The principal thesis of this paper, then, is that the disconnection between our basic and applied sectors poses a serious impediment to the advancement of our scientific discipline and perhaps to its ultimate acceptance by the surrounding culture. More important, a deliberate course of action is needed to determine whether the types of basic-applied connection that are evident in many other natural sciences can benefit behavior analysis. The present essay begins with a brief summary of the case for a strong connection between basic and applied research, and then offers specific suggestions for basic research that, if successful, could provide applied researchers with important tools to design more effective technologies.

The Need for Connection

Modern civilizations have come to accept, and even depend on, the technological advances that are derived directly from the discoveries of basic science. It is a winning formula that has garnered enormous public and private support for space exploration, for multibillion dollar physics laboratories, and for extensive biomedical research. These particular basic research enterprises have flourished, while support for other natural sciences (such as astronomy and archaeology) has diminished. An obvious difference between the flourishing sciences and those less well supported is that the former are connected directly with the development of new materials, new products, and effective medical therapies, whereas the latter have yielded limited tangible returns on investment into basic research.[1]

The profitable connections so clearly evident between physics and engineering and between biology and clinical medicine are generally absent in behavior analysis. Of course, some have argued that separate spheres of interest and activity are desirable and to be expected in our field (e.g., Baer, 1981; Palmer & Donahoe, 1991). Applied behavior analysts with this view contend that the experimental analysis of behavior has already discovered the most potent and useful behavior principles for the solution of human problems (i.e., positive and negative reinforcement, punishment, stimulus control, and extinction). Accordingly, applied researchers have a full agenda packaging these principles into new and improved preparations suited to the vast spectrum of human problems that are encountered by practitioners and, thus, have very little need to apply the latest basic findings (Baer, 1981). On the other hand, some basic researchers have argued that research with nonhumans provides the only (or at least principal) vehicle for the discovery of basic behavioral mechanisms without the obscuring contamination of genetic variation, learning histories, and verbal repertoires that are evident in human subjects (Dinsmoor, 1983, 1991; Palmer & Donahoe, 1991). By this view, the function of human operant research and real-world applications is to confirm the generality of these basic mechanisms. However, replication failures (e.g., Weiner, 1983) are generally seen as an indication that humans are less suitable subjects for basic research and, thus, may reveal little of what is important about behavior. An alternative, integrationist, view is that replication failures may be indicative of the relative significance of the behavioral relation discovered (cf. Baer, 1978).

Deleterious effects of disconnection for applied behavior analysis. Many behavior analysts have lamented the technical drift of applied behavior analysis (Hayes, 1991; Hayes et al., 1980), its preoccupation with behavioral operation over behavioral process (Johnston, 1991a), its emphasis on experimental demonstration over the analysis of behavior (Pierce & Epling, 1980), and its increasing insulation from its experimental roots (Michael, 1980; Poling et al., 1981). A common concern underlying these papers is that the scope of human problems faced by our culture is too complex to be addressed by iterative applications of the law of effect alone. To be sure, the simple and robust behavior principles embodied in most behavioral interventions have yielded some impressive practical applications. Nevertheless, if other natural sciences are valid models, the future of developments in behavioral technology without ongoing infusion of findings from basic science seems to be in question.

From a strictly applied perspective, if behavioral technologies based on the law of effect were effective for all problems in all cases, there would be little need for additional knowledge of fundamental behavioral mechanisms with generality to human behavior in social environments. But our interventions are far from uniformly effective. Although there is much we can do to increase adoption of already-effective technologies (e.g., improvement of the user-friendliness of educational minisystems and the development of nonexploitative performance-based pay systems in business), many social problems remain beyond our capacity to prevent or remediate with existing technologies. Moreover, in many applied areas, when we are unable to achieve our aims with reinforcement and stimulus control of alternative behavior alone, our only alternative is the use of a sequence of increasingly

[1] The wisdom of this policy of resource allocation can surely be contested. Increasingly, public policymakers in the last decade have differentially funded basic research projects that have clear potential to spawn technologies with obvious political or economic value. The point here is not that all basic research should adopt this focus. On the contrary, if a significant portion of basic research is aimed at questions of applied significance, support for unconstrained basic research may also improve because the technological benefits of basic research have been established.

conspicuous, intrusive, and controversial default procedures (Iwata, 1988). Yet, reliance on default technologies has placed applied behavior analysis on the defensive (Johnston, 1991b) and has led to external regulation of treatment options in the field of mental retardation (Sherman, 1991). This has resulted in impaired effectiveness of applied behavior analysis as a whole, irrespective of the validity of the principles upon which default technologies are based.

The field's dependence on default technologies will diminish as more is learned about the conditions necessary and sufficient for reinforcement operations to increase the rate of alternative, socially desirable human behavior. Of course, a sufficiently comprehensive answer to the question of necessary and sufficient conditions covers several substantive areas that have been long under investigation by basic researchers, including the determinants of response allocation and resistance to change and the formation and discrimination/differentiation of stimulus and response classes. Other topics receiving much less attention from basic researchers, but that have clear potential to enhance reinforcement-based treatments, are the specification of conditions that produce or ameliorate countercontrol and those that promote the formation of adaptive rule-governed behavior and weaken the control of faulty rules. However, without experimental training and ongoing exposure to the basic research literature, these developments in basic behavior-analytic research remain inaccessible to most applied behavior analysts, and their potential to stimulate behavioral technologies remains unknown.

Deleterious effects of disconnection for the experimental analysis of behavior. Applied behavior analysis is the natural consumer of basic research. Indeed, the connection between the discovery of behavior–environment relations and their application to human affairs, first on a conceptual and theoretical level (Skinner, 1948, 1953) and later on an empirical level (e.g., Ayllon & Michael, 1959; Azrin & Lindsley, 1956), gave rise to operant psychology's prominence outside of academia. However, the waning of the producer-consumer relationship in the 1960s that became all but nonexistent in the early 1970s (Epling & Pierce, 1986) was one important factor that insulated the experimental analysis of behavior from applied psychology and the broader culture that would support it.

This insulation from applied concerns has had three major consequences that, I believe, have hurt the field. First, the basic research agenda has become dominated by the study of features of behavior that, to a great extent, are irrelevant to human problems (e.g., Cullen, 1981). Second, insulation reduces opportunities to be influenced by the applied agenda, which is often synonymous with society's agenda. Third, a pragmatic consequence of disconnection is a suppressed job market for graduates of basic research programs.

Occupation with defining the lawfulness of behavior has limited the relevance to human behavior of basic research. Stated another way, "the laboratory behavior that is occasioned by questions about whether a particular law is correct or true is likely to be different from that occasioned by questions about whether particular variables affect behavior in particular contexts" (Catania, 1981, pp. 49–50). But these "particular variables [that] affect behavior in particular contexts" are not only those most germane to human problems but are also the ones most likely to have a robust influence on behavior generally (Baer, 1978; Epling & Pierce, 1986; Hake, 1982).

Research on the matching law provides a good illustration of how the features of behavior dominating the basic research agenda are those generally less relevant to human applications. Davison and McCarthy's (1988) comprehensive review of matching law research organizes studies into seven major categories: early research on strict and generalized matching, effects of reinforcer parameters (rate, amount, duration, quality, and delay), various concurrent schedule combinations, procedural variations and combinations, matching in multiple schedules, matching in concurrent-chains schedules, and matching models of signal detection. As their review indicates, the overwhelming majority of matching experiments have focused on the effects of various schedule combinations on response allocation, where rate of reinforcement under various schedule types (concurrent, multiple, concurrent chains) is the primary focus. However, rate of reinforcement is only one of three or four classes of independent variables that can affect the choices organisms make among concurrent alternatives (Fuqua, 1984; McDowell, 1989). On both logical and empirical grounds, rate of reinforcement is perhaps less influential than reinforcer quality, response effort, or reinforcer latency (Neef, Mace, Shea, & Shade, 1992) in natural human environments. Unfortunately for applied behavior analysis, these latter variables have received considerably less attention in the basic research literature.

Epling and Pierce (1986), Mace (1991b), and Moxley (1989), among others, have argued that science and technology have developed historically with reciprocal influence on each other's agenda, rather than in a hierarchical, unidirectional manner. The most pressing human problems can be maintained by especially challenging mechanisms or require knowledge of new mechanisms to resolve (e.g., fusion-derived energy, AIDS vaccines and therapies, heat-resistant materials for reentry of space vehicles, and behavioral solutions to crime, poverty, educational decline, economic productivity, and AIDS prevention). Experimental behavior analysts have, in the main, addressed the behavioral aspects of serious social problems at the theoretical level (e.g., Layng & Andronis, 1984; Marcattilio & Nevin, 1986), rather than by focusing their most formidable social engineering weapon—experimentation—on the problem. Success in such endeavors, predicated on collaboration between basic and applied researchers, is likely to enhance the standing of both sectors in the culture at large.

A final pragmatic consequence of disconnection is diminished employment opportunities in basic behavior-analytic research. Although employment in the basic sciences has suffered generally following the Reagan revolution and contraction of the college-age population, graduates of basic behavior-analytic research programs seem to be especially hard hit. Whereas chemists, geneticists, geologists, biologists, and, to a lesser extent, physicists have ample employment opportunities in the private sector or with projects located at large research universities, many graduates of basic research programs are forced to consider applied positions to remain in the field of psychology. A potential benefit of fruitful basic–applied collaboration may be the creation of a new demand for experimental behavior analysts in organizations having primarily applied missions. Indeed, major medical centers and pharmaceutical companies, for example, consider the employment of basic researchers to be essential to their overall mission.

To summarize, the basic and applied sectors of our field have evolved toward greater separation during the past 30 years; this separation, to some extent, has been to the detriment of both areas. Behavioral technologies have been founded on only the rudimentary principles of behavior. Further, because applied behavior analysts have little connection to the basic literature, basic findings with potential to improve behavioral technologies are unlikely to be recognized and stimulate new technologies. Basic research, on the other hand, has been generally insulated from the applied agenda and has given greater emphasis to the specification and testing of behavioral laws without due consideration to their relevance to human affairs. As a result, opportunities to collaborate on the solution of important social problems and to demonstrate the tangible value of basic behavioral research to the culture have been missed.

A program of collaborative basic–applied research, emulating the models of other natural sciences, may considerably narrow the gap between sectors and strengthen both. Specific lines of research are needed that progress systematically from basic laboratory studies with nonhumans, to replications with humans in the operant laboratory, and finally to the testing of interventions based on the basic findings in natural settings (Epling & Pierce, 1983, 1986; Hake, 1982; Mace, 1991b). The remainder of this essay attempts to initiate such a systematic process by suggesting particular types of basic research that could stimulate the development of behavioral technologies.

BASIC RESEARCH QUESTIONS OF PARTICULAR RELEVANCE TO APPLIED BEHAVIOR ANALYSIS

Applied researchers and practitioners have long known that arranging a particular consequence for a response does not always produce a consistent effect on that response. Such intervention failures can occur despite meticulous adherence to a well-designed protocol (i.e., one that consistently supplies a known reinforcer or punisher contingent on occurrences of a target activity). This inconsistent effectiveness of behavioral interventions has contributed to an erosion of support for behavioral interventions in fields such as education and mental health and has provided a climate conducive to the emergence of alternative formulations and therapies such as those based on cognitivist concepts. Where cognitivist therapies have not emerged, the mixed effectiveness of behavioral interventions has led to categorical and hierarchical models of treatment selection. That is, interventions are categorized by their operation (e.g., contingent praise, token economies, timeout, response cost, overcorrection, etc.) and ordered hierarchically on the basis of the "intrusiveness" of the intervention. The "least" intrusive intervention is typically tried first and, if ineffective, is abandoned in favor of the next intervention in the hierarchy. This process iterates until a desired outcome is attained. However, an alternative approach to the selection of treatment procedures would be possible if applied behavior analysts could identify the conditions necessary for the particular response–reinforcer and stimulus–reinforcer relations to be effective in particular applied contexts. The following section is devoted to identification of some general and specific areas of basic research that could potentially give direction to the design of problem-solving technologies.

Response Allocation

Potential applications of the matching law (Herrnstein, 1961, 1970) and matching theory have been discussed by several behavior analysts (Davey, 1988; Mace & Shea, 1990; McDowell, 1982, 1988, 1989; Myerson & Hale, 1984; Pierce & Epling, 1983; Rachlin, 1989). Matching theory is attractive to applied researchers because it provides a theoretical framework and experimental paradigm that show promise for accommodating the multiple response alternatives that are available to humans in natural situations. Within this framework, the effectiveness of any single response–reinforcer contingency is viewed as dependent on the relative value of concurrently available contingencies. Moreover, these relative values are dynamic, rather than static, and are likely to vary with the waxing and waning of deprivation and satiation as well as the changing reinforcement parameters for each available alternative. Although the model has intuitive appeal, direct application of the matching law to human behavior in natural settings is limited by important differences between laboratory preparations and the circumstances humans encounter in natural settings (Fuqua, 1984).

Asymmetrical free-operant choices. The free-operant choice paradigm arranges reinforcement for two or more concurrently available responses, typically according to interval or ratio schedules. The objective in this paradigm is to determine how the schedules control allocation of time or responses among the response alternatives. As indicated above, the vast majority of research on concurrent schedules has involved symmetrical choices (Davison & McCarthy, 1988) between alternatives that differ only in the rate of reinforcement each alternative produces, while the reinforcers, response manipulanda, and delays to reinforcement are held constant. Under symmetrical choice conditions, the matching law provides a good description of human choice behavior in laboratory settings (Pierce & Epling, 1983). In addition, a handful of applied studies have found socially relevant human behavior subject to concurrent variable-interval (VI) VI schedules (Conger & Killeen, 1974; Martens & Houk, 1989; Martens, Lochner, & Kelly, 1992; Neef et al., 1992; Neef, Mace, & Shade, 1993) and to concurrent variable-ratio (VR) VR schedules (Mace, McCurdy, & Quigley, 1990) to be allocated in proportions predicted by the matching law (Herrnstein, 1970; Herrnstein & Loveland, 1975).

In contrast, most choices in applied settings are asymmetrical (Fuqua, 1984; McDowell, 1989); hence, more basic research is needed to determine how different response and reinforcement parameters interact to affect choice. A good starting point would be the examination of three variables that are operative in applied settings and that have potential to produce a bias or preference for one alternative independent of the schedule of reinforcement correlated with the response alternative: reinforcer quality, response effort, and reinforcer immediacy.

It is rare in applied settings for response alternatives to yield qualitatively identical reinforcers. Reading a magazine produces different outcomes than reading a novel; both of these differ from the consequences of engaging in conversation, gazing out a window, or solving a crossword puzzle. All things being equal (i.e., deprivation, response effort, and rate, quantity, and immediacy of reinforcement), an individual is likely to have different preferences for available reinforcers that could be ordered hierarchically as different reinforcer qualities. These examples also differ with respect to the response requirements that constitute a reinforceable cycle of behavior. Performing a crossword puzzle can be intellectually effortful, whereas gazing out a window is comparatively effortless. Although ranking reinforcers by quality must be done empirically by measuring choice ratios, ranking alternatives in applied settings according to response effort can be at least partially accomplished through logical analysis. Factors to consider include the time to complete a response cycle, the number of identifiable steps required for reinforcement (e.g., long vs. short division problems), task complexity, and the physical demands of the task. For some individuals, under some circumstances, response effort will not influence preference, and choice will be affected primarily by reinforcer quality, rate, or immediacy. For others, however, response effort may govern preference irrespective of the reinforcement parameters associated with available alternatives (e.g., reading a magazine vs. a novel). Finally, choices differ with respect to the immediacy with which reinforcement is delivered following completion of the schedule requirement. For example, reinforcement is immediate following reading, conversing, and gazing, whereas feedback on the accuracy of one's solution to a crossword puzzle may be delayed until the next edition of the newspaper. Similarly, delayed reinforcement is typically inherent to activities as diverse as academic work, preventive health care, capital investment, vacation planning, letter writing, and the like.

In most applied situations, these three variables—reinforcer quality, immediacy of reinforcement, and response effort—will combine with rate of reinforcement to affect the choices humans make in free-operant and discrete-trial choice situations. Because many behavioral interventions can be viewed as arranging conditions to encourage the choice of adaptive alternatives while concurrently discouraging less adaptive choices, basic knowledge about how these variables influence choice may permit the design of more effective interventions. Answers to the following questions may have the most immediate relevance to the applied sector: Within each variable, what magnitude of difference is typically required to produce substantial or exclusive preference? Which of these variables influence choice most? What are the interactive effects of, for example, reinforcer rate and reinforcer quality on choice? Although research on these questions has been rare, Davison (1988) provided a prototype for such work by examining the interactive effects of reinforcer rate and reinforcer duration in concurrent schedules.

Discrete-trial models of choice behavior: Self-control paradigm. In the discrete-trial self-control paradigm, subjects are typically provided access to a single choice between a response producing immediate short-duration access to a reinforcer and a response producing delayed longer duration access to a reinforcer; no other sources of reinforcement are arranged. Choosing the smaller, more immediate reinforcer is said to be impulsive, whereas choosing the larger, more delayed reinforcer is considered to be self-control (Green & Snyderman, 1980; Rachlin & Green, 1972). The behavioral choice model of self-control, which was developed in relation to these arrangements, has perhaps the greatest applicability to applied work, among the products of the contemporary basic research literature. Many human problems can be conceptualized as problems of self-control, as illustrated by the child who does poorly in school because he consistently chooses the immediate rewards of play over the delayed rewards of completing homework assignments, by the CEO whose manufacturing firm suffers financially because she chooses short-term profits over long-term investments, and by the agoraphobic who elects the immediate comfort of staying at home instead of enduring the adverse physiological reactions that accompany excursions into the community. This conceptual framework has provided the basis for studies with obvious practical implications, demonstrating, for example, that initially impulsive subjects can be trained to "delay gratification" via commitment strategies (Rachlin & Green, 1972) and via fading procedures that gradually build tolerance of delays to reinforcement (Logue, Rodriguez, Peña-Correal, & Mauro, 1984; Mazur & Logue, 1978).

Although much of the basic research on self-control has implications for applied matters, additional studies are needed to improve the model's capacity to predict the conditions under which self-control is likely and to suggest methods of training self-control in even the most impulsive individuals. Humans have histories of temporally distal and proximal reinforcement that are likely to influence an individual's sensitivity to delayed reinforcement in discrete-trial choice situations. To the extent that these histories can be accurately identified and arranged for humans, answers to the following research questions should be useful for the design of behavioral interventions: Does history of impulsive choices predict the probability of successful self-control training or the duration of training that will be necessary to produce change? How does availability of alternative reinforcement (contingent and noncontingent) affect sensitivity to delayed reinforcement? Can alternative reinforcement be used to enhance self-control training? Does concurrent punishment of impulsivity enhance self-control training? Can a higher quality reinforcer be paired with delayed reinforcement to produce a bias for this response that can override a tendency toward impulsivity?

Transition phases and procedural contingencies. In the basic research literature, choice is typically studied under steady-state conditions. With both nonhuman animals and humans, achieving steady response rates generally requires numerous exposures to the schedules. In addition, procedural contingencies are often incorporated into experiments to encourage response patterns that conform to those predicted by the matching law. One common procedural contingency is the changeover delay (COD). The COD contingency imposes a penalty for switching from one schedule to another. Usually, a brief interval (1 to 5 s) without reinforcement is imposed contingent on switching between schedules. The contingency discourages frequent schedule switches and tends to encourage more sustained responding on a schedule once a switch is made.

Studying choice under conditions of steady-state responding and with the COD contingency may significantly limit the generalizability of matching research to natural human situations. The reinforcement and response parameters of most natural situations change before the conditions could result in steady response rates. Thus, humans can be said to be perpetually in transitions between sets of concurrent schedules. How humans respond in these transition phases could be important information for designing behavioral interventions, especially if the conditions that promote and interfere with rapid discrimination of relevant features of the schedule can be isolated. Similarly, if the function of the COD is to bring and maintain subjects in contact with relevant features of the schedules, functional facsimiles may need to be discovered for human situations. Perhaps this could be achieved through systematic study and use of verbal instructions.

Resistance to Change

Behavior reinforced in the presence of a distinct stimulus has a tendency to persist when the response–reinforcer relation is challenged by a separate variable such as extinction, noncontingent reinforcement, or distraction (Nevin, 1974, 1979; Nevin, Mandell, & Atak, 1983; Nevin, Smith, & Roberts, 1987; Nevin, Tota, Torquato, & Shull, 1990). Because this property of behavior has been verified for humans (Mace, Lalli, et al., 1990) as well as for various nonhuman species, it appears to have important implications for applied work. Interventions aimed at reducing undesirable behavior must compete effectively with the target behavior's resistance to change. Thus, the optimal design for an intervention is one that weakens the response–reinforcer relation as quickly as possible. On the other hand, when the goal of treatment is to maintain a desirable activity at a relatively high rate under conditions that may oppose its occurrence, knowledge of how to strengthen the target behavior's resistance to change should be incorporated into the intervention plan.

To date, basic research on the determinants of resistance to change has concentrated on temporally local variables. For example, Nevin and his colleagues have shown that resistance to change is a positive function of the rate of reinforcement in the presence of a discriminative stimulus (i.e., a stimulus–reinforcer relation) and is independent of baseline response rates, which are dependent on response–reinforcer contingencies (Nevin et al., 1990). Nevin has consistently found that, when challenged by extinction or noncontingent reinforcement, baseline response rates decrease comparatively less in the presence of the stimulus condition correlated with higher rates of reinforcement. In a study illustrating one advantage of greater connection between the basic and applied sectors, applied researchers used Nevin's findings as the basis for a novel intervention for the treatment of noncompliance (Mace et al., 1988). By first reinforcing compliance with a sequence of requests that were likely to be obeyed, compliance persisted when subjects were asked to perform activities they normally avoided.

Another finding with potential applied significance in the Nevin et al. (1990) and Mace, Lalli, et al. (1990) studies was the observation that alternative reinforcement produced increased resistance to change in the target response. Both studies showed that adding either noncontingent reinforcement or contingent reinforcement for a concurrent alternative response to baseline VI reinforcement of the target behavior resulted in more persistent behavior during extinction or distraction. If, for example, the target response was designated as undesirable, an inadvertent side effect of alternative reinforcement may be to strengthen the undesirable behavior's resistance to extinction. Because enriching the environment with noncontingent reinforcement and arranging high-rate reinforcement for appropriate alternative behavior are standard practices in applied work, additional research seems warranted to delineate when this effect is likely to occur. For example, does alternative reinforcement increase resistance to change when qualitatively different reinforcers are supplied for the target and alternative responses? Should extinction or punishment of the target response precede reinforcement of an alternative response to avoid increased resistance to change?

Experience with treating behavior disorders in both children and adults suggests that there may be additional sources of control of resistance to change yet to be discovered. It is common for problem behavior to persist for several weeks or even months, despite the discontinuation of its evident sources of reinforcement. Such persistence is also more likely in older children and adults than it is in young children or for behavior problems that have only recently emerged. Similarly, individuals who have had multiple care providers (e.g., staff members, foster homes, etc.), or who have been exposed to numerous behavioral interventions in the past, also tend to have behavior problems that persist in the face of well-designed treatments. The suspicion is that temporally distant factors also influence an individual's behavior during extinction.

One temporally distant variable that may contribute to resistance to change is the history of the target response with varied schedules of reinforcement. It is plausible that environmental responses to a long-standing behavior problem will vary considerably over the course of the disorder. For example, suppose that a psychiatric patient's psychotic speech is maintained by the attentive responses of family members (e.g., indulgence, redirection, rebukes, etc.). Such reactions may follow various VR and VI schedules in the home as family members become more or less responsive to bizarre comments over time. In public settings, on the other hand, rapid consequences to psychotic speech may follow FR or fixed-interval (FI) schedules as relatives attempt to quell disturbances quickly and to avoid embarrassment. To the extent that frequent schedule changes impede discrimination of response–reinforcer contingencies (e.g., Hearst, Koresko, & Poppen, 1964), such experiences may increase resistance to change during behavioral treatments.

A second remote variable with potential to affect resistance to change, especially to extinction, is experience with extinction schedules that are aborted before responding is reduced to zero. In working with parents to resolve their children's behavior problems, we have found that providing parents with verbal descriptions of how their reactions to problem behavior may serve to maintain that behavior does not necessarily guarantee that parents will consistently withhold such reactions. A common pattern is for parents to embark on an extinction schedule only to "give in" before the process is complete and then return to some intermittent schedule of reinforcement. It is quite likely that one or more experiences with aborted extinction schedules may enhance a target behavior's resistance to extinction when the intervention is implemented with consistency.

Experimental analysis of the role of historical factors in resistance to change may be best accomplished with nonhuman subjects (when nonverbal variables are in question) whose reinforcement histories can be controlled and programmed. The research questions having implications for applied work include: Do varied schedules of reinforcement and aborted extinction schedules increase a target response's resistance to change, and is this effect independent of overall rate of reinforcement? Should a target response be reduced to zero via extinction or punishment prior to introducing alternative reinforcement, to avoid inadvertent increases in resistance to change? Does the resistance-strengthening effect of alternative reinforcement hold when the response topographies and/or the qualitative aspects of the reinforcer differ markedly for the target and alternative responses? Can verbal descriptions of response–reinforcer contingencies lessen resistance to extinction?

Countercontrol

When one organism controls the delivery of aversive consequences or restricts the positive reinforcement available to another organism (e.g., opposing the latter's preference for free choice over forced choice, Catania & Sagvolden, 1980), repertoires may emerge in the latter individual that may counter the controlling influence of the former. This phenomenon is known as *countercontrol.* Although the term has broad usage in the behavioral community and is often referred to in conceptual writings (e.g., Skinner, 1948, 1953, 1972), I have found little experimental work aimed expressly at countercontrol that would guide the design of behavioral interventions.

It may be useful to distinguish countercontrol conceptually and operationally from escape, avoidance, and behavior elicited by aversive events, although these types of behavior may co-occur with or even be part of countercontrol. In a countercontrol paradigm, a response is available to Organism A (the controller) that is capable of imposing an aversive consequence to Organism B (the controlled). The aversive stimulation may occur contingent on Organism B's behavior in the form of a punishment operation, or can be independent of Organism B's behavior according to a fixed- or variable-time schedule. A further characteristic feature is Organism B's awareness (as defined by an available verbal repertoire) that the source of the aversive stimulation is Organism A's behavior. Finally, a response is available to Organism B that reciprocates aversive stimulation to Organism A. The principal objects of study in a countercontrol experiment are the interactions between A and B that control each organism's delivery of aversive consequences. We can see, then, that countercontrol involves an interaction between organisms that might be defined and recognized without appeal to characteristics of escape and avoidance paradigms. Like escape and avoidance, countercontrol is likely to be operant in nature and distinct from reflexive aggression elicited by aversive stimulation (Hutchinson, 1977), but it may be premature to appeal to those processes when it has not been verified that they are operative.

Countercontrol in humans can take many forms. It can be active or passive, and it can have as its object the behavior of a specific individual or be as general as opposition to the practices of a segment of society that appears to be responsible for the adversities befalling the controlled. Active countercontrol refers to actions on the part of the controlled that inflict adversity on the actual or perceived controller. For instance, a student who is ridiculed by her teacher before her classmates may puncture the teacher's automobile tires later that day. At the level of international relations, some political analysts have contended that terrorism is a (countercontrol) reaction to inescapable domination by more powerful nations (e.g., the bombing of a civilian airliner over Scotland in 1988 appears to have been a retaliatory response to the 1986 United States air assault on Libya). By contrast, passive countercontrol involves resisting the control of another individual by noncompliance with demands or by otherwise withholding positive reinforcers of importance to the controller. Employers faced with product deadlines will recognize passive countercontrol in their employees as the paradoxical decline in work rate in response to the employer's nagging reminders to meet the deadline. Similarly, politicians have noted the futility of raising taxes beyond a certain threshold because of the inverse relationship between tax rate and taxpayer compliance.

Although conceptual analyses of human countercontrol are possible, much remains to be known about the basic processes involved before substantive progress in applied analyses is probable. Because countercontrol is constitutionally a product of interactions between organisms, advances in this area may provide direction for the experimental analysis of other forms of social interaction yet to be studied at the basic level by behavior analysts (e.g., teacher–learner, buyer–seller, employer–employee). This may require a systems analysis, simultaneously accommodating the repertoires and consequences (including availability of alternatives) that are operative for each participant.

A first step in basic countercontrol research will be to devise an experimental paradigm for studying the phenomenon and to ascertain whether it involves distinctive processes operating at the systems level or whether it is best characterized as a special case of a well-known process, such as negative reinforcement, that can be sufficiently understood at the level of the individual (cf. Iwata, 1987, illustrating how basic research on negative reinforcement can stimulate applied research and technology). For example, does the countercontrol response affect the probability of the controller's delivery of aversive stimulation such that it is maintained, at least in part, by negative reinforcement? Once learned via negative reinforcement, do organisms discriminate the conditions under which countercontrol will be reinforced (as with other operants), or is countercontrol a probable reaction to all forms of socially mediated aversive stimulation? Alternatively, if countercontrol repertoires can be maintained without influencing the behavior of the controller, is reciprocity of socially mediated aversive stimulation a primary or secondary positive reinforcer? Preliminary investigations of countercontrol might also address the degree to which learning is involved in all cases (i.e., are the countercontrolling responses distinct from the automatic reactions to aversive stimulation). Basic researchers on human operant behavior may wish to extend their investigations of verbally mediated operant behavior to countercontrol to address questions such as: What role does verbal mediation play in maintaining acts of countercontrol that are disproportional to and/or temporally distant from the occasioning aversive stimulation? Is countercontrol occasioned by warning stimuli (e.g., verbal predictions of pending aversive consequences) consistent with other forms of avoidance behavior? Finally, applied researchers will be interested in studies that suggest potential interventions for minimizing countercontrol in situations in which aversive consequences are unavoidable or their elimination is undesirable. For example, does alternative reinforcement decrease the probability of countercontrol? Does punishment of the countercontrol response suppress or increase the likelihood of countercontrol? Does control via restricting choice alternatives result in less countercontrol than occurs with punishment?

Formation and Differentiation/Discrimination of Stimulus and Response Classes

Control of human behavior in natural settings by discriminative stimuli, as opposed to explicit arrangement of reinforcement contingencies, may be a practical necessity in many circumstances, because the maintaining consequences for a particular behavior pattern are difficult to identify at any given moment or because these consequences are not subject to direct manipulation (Premack, 1965; Touchette, MacDonald, & Langer, 1985). Effective behavior management via stimulus control then depends on the behavior analyst's knowledge of how stimulus classes are formed, strengthened, and weakened in natural environments. A related applied concern is the formation and differentiation of response classes, for much of applied behavior analysis centers around promoting new repertoires and behavioral diversity and, conversely, increasing the specificity of response-class members to conform to social convention or to perform specialized tasks. However, induction and differentiation have rarely been the explicit focus of basic research; as a result, these behavioral relations have not expressly guided the development of behavioral technologies. These operant processes could have more relevance to applied matters if basic research were aimed at simulating circumstances surrounding human behavior problems and their solutions.

Generalization and discrimination. The effects of contingent reinforcement in the presence of a distinct stimulus can extend beyond the stimulus–response–reinforcer relations embodied in the contingency. When the effects of reinforcement spread to stimuli that are uncorrelated with reinforcement, *generalization* is said to occur. In turn, repeated experience with the reinforcement contingency typically results in a contraction of generalization gradient, or *discrimination,* as the effects of reinforcement concentrate around stimuli most similar to the discriminative stimulus (Rilling, 1977).

Generalization is a mixed blessing for applied behavior analysts. Its occurrence is welcomed when training of a target response or response chain cannot be done under all stimulus conditions that are expected to occasion the desired behavior. Occurrence of the target behavior under stimulus conditions that bear similarity to the trained discriminative stimuli, but are nonetheless uncorrelated with the reinforcement contingency, provides the opportunity for the natural consequences of the target behavior to reinforce the response and, consequently, for the stimulus class to be expanded. For example, a child taught to read standard cursive writing may quickly learn to read the idiosyncratic handwriting of his or her peers when it means deciphering the content of secret notes passed across the lunchroom. On the other hand, generalization is unwelcome when a target response is useful or acceptable only under a restricted range of stimulus conditions. Adolescence is fraught with unwanted generalization as youths experiment with sexuality, employment, alcohol, and the like, only to encounter the contingencies for which context is critical to the acceptance (and reinforcement) of many types of social behavior.

Basic research on generalization and discrimination provides only limited direction to applied behavior analysts charged with promoting generalization and/or discrimination in many applied settings. We do know that to promote generalization, stimulus conditions in the training setting should overlap as much as possible with the generalization setting (Stokes & Baer, 1977). Conversely, discrimination training within and across stimulus dimensions can strengthen stimulus control and minimize unwanted generalization (Etzel, LeBlanc, Schilmoeller, & Stella, 1981). Although these guidelines have led to the development of useful techniques of generalization and discrimination training, they are insufficient for many situations. For example, training settings and generalization settings often differ unavoidably along several dimensions. Practical considerations require the use of simulations to train people to be assertive, to follow safety rules, to respond to emergencies effectively, or to manage their child's behavior problems in the home. Thus, applied behavior analysts are interested in knowing how simulated training can be improved to increase the likelihood that skills will generalize to real-life situations (i.e., multiple interdimensional generalization). For these situations, the expectation is that the trained skill will be reinforced as it proves to be useful. But how can generalization be maintained when the probability of positive or negative reinforcement is extremely low? For example, how do we teach people to answer questions truthfully, to report all taxable income, to abstain from littering, and to respect unattended private property in the absence of explicit sanctions or social approval? Is it necessary to establish these behaviors as rule-governed responses that are resistant to extinction? If so, how is this best accomplished?

Induction and differentiation. Reinforcement may also affect response topographies that are not directly subject to the reinforcement contingency. *Induction* occurs when reinforcement effects spread to response topographies outside the reinforced class. That is, probabilities of response topographies that are not subject to a given reinforcement contingency may increase (positive induction) or decrease (negative induction) as a result of a corresponding increase or decrease in reinforcement for another response (Schwartz & Gamzu, 1977). However, with repeated exposure to the reinforcement contingency, the effects of reinforcement typically concentrate around the reinforced topography, and *differentiation* is observed.

Induction can also be both desirable and undesirable in applied work. It is advantageous during the acquisition phase of skill training to the extent that induction of new response topographies increases the likelihood that responses necessary for the performance of the skill will occur and be reinforced. For example, induction appears to play an important role in language development in normal (Ross, 1981) and retarded (Lovaas, 1977) populations. Contingent parental attention or access to items manded is typically followed by an increase in vocalizations in general, permitting progressively precise articulations to be selected by their consequences (Skinner, 1957, 1981). By contrast, induction is unwanted when the emergent response topographies have untoward social consequences. This is commonly seen when aberrant responses are induced by extinction. For instance, a father may no longer accede to his 5 year old's tantrums and may find that the tantrums intensify and mutate to forms that include aggression and property destruction. To the extent that these more destructive behavior patterns result in renewed attention, induction may fuel the development of serious behavior problems.

Once again, applied behavior analysis may be aided by basic research that identifies operations that alternately promote and discourage induction. Teaching language and social interaction to autistic and/or severely retarded individuals can be especially difficult because of the perseverative quality of their behavior. That is, the effects of reinforcement do not spread readily to other responses that may be useful to their language or other repertoires of social skills. Some recent proposals by Neuringer (1992) may provide direction for research in this regard. Neuringer (1986, 1992) argues that reinforcement not only increases the probability of behavior but also can strengthen behavioral variability. Further, if reinforcement is applied differentially to variable performance, a variable response pattern becomes the reinforceable unit. The questions then arise: Does differential reinforcement of variable performance enhance induction? If so, is expansion of the response class more likely even when responses previously showed a stereotyped quality? Concerning the inhibition of induction during extinction, applied researchers may want to know whether and how alternative reinforcement and punishment can be used to minimize the trauma that discontinuation of reinforcement can often produce.

Equivalence classes. Sidman's stimulus equivalence paradigm (Sidman, 1971; Sidman & Tailby, 1982) provides a means of studying and describing the types of untrained stimulus–stimulus relations that are established as a result of differential reinforcement. Stimulus equivalence is said to occur when three types of conditional relations among stimuli are observed. If selection of Stimulus A has been reinforced when presented with a matching-to-sample task, a subject demonstrates *reflexivity* by equating Stimulus A with itself via a matching response without explicit training (i.e., A → A). *Symmetry* is observed when a subject is trained to match sample Stimulus A with comparison Stimulus B and later selects comparison Stimulus A when presented with sample Stimulus B (i.e., if A → B, then B → A). Finally, after learning the conditional relations selection of Stimulus B is occasioned by Stimulus A and selection of Stimulus C is occasioned by Stimulus B, *transitivity* is demonstrated by selecting Stimulus C when occasioned by Stimulus A (i.e., if A → B and B → C, then A → C).

Although some of the potential applications of stimulus equivalence and its associated methodology were recognized years ago (Sidman, 1971), to date most stimulus equivalence research has centered around examining its generality across species (e.g., Cohen, Looney, Brady, & Aucella, 1976; Hayes, 1989; McIntire, Cleary, & Thompson, 1987; Sidman et al., 1982), across age groups in humans (e.g., Lazar, Davis-Lang, & Sanchez, 1984; Stromer & Osborne, 1982), and across handicapping conditions (e.g., Devany, Hayes, & Nelson, 1986; McIlvane & Stoddard, 1985; Sidman, Wilson-Morris, & Kirk, 1986), determining the complexity limits of equivalence relations (e.g., Sidman, Kirk, & Willson-Morris, 1985; R. Saunders, Wachter, & Spradlin, 1988), and identifying the necessary and sufficient conditions for equivalence to occur (e.g., Harrison & Green, 1990; Lazar & Kotlarchyk, 1986; K. Saunders, 1989; R. Saunders, Saunders, Kirby, & Spradlin, 1988).

Crowley, Green, and Braunling-McMorrow (1992) reported the first direct application of stimulus equivalence methods in a strictly applied intervention. Their brain-injured adult subjects had difficulty associating the faces, spoken names, and written names (nameplates located on office doors) of the counselors at a rehabilitation center. In keeping with the equivalence paradigm, subjects were trained to match faces with spoken names and then to match spoken names with written names. Transitivity tests for the equivalence relation of matching faces to written names was positive for 3 of the 4 subjects. Importantly, these equivalence relations generalized to naturalistic situations at the rehabilitation center and were maintained for up to 3 months without further training. This study not only illustrates the applied relevance of stimulus equivalence procedures but also lends support to the general thesis that basic research emanating from human concerns can lead directly to the development of useful technologies.

Equivalence relations may have even broader application to human affairs. For example, elderly persons have become targets of dishonest and illegal sales practices. The perpetrators of these crimes typically win the confidence of an elderly individual through a series of legitimate transactions that prove to be profitable or otherwise acceptable to the buyer. When the illegitimate transaction is proposed, the buyer may not recognize it as such and will fall victim to the confidence game. One way to arm the elderly with a defense against these crimes is to conduct workshops that are aimed at teaching recognition of illegitimate transactions before it is too late. To be successful, the workshop must accomplish two goals. First, the participants will be able to discriminate between the exemplars of legitimate and illegitimate sales proposals presented in the workshop. The second and more important goal is that the participants will recognize novel or untrained examples of legitimate and illegitimate proposals. This latter skill is crucial, because these criminals are continually varying their approach.

Accurate discrimination of novel sales approaches can be seen as the identification of the kind of stimulus–stimulus relations that bear similarity to transitivity. However, the discrimination is more complex than those contained in most studies of stimulus equivalence, because each stimulus set is a compound of several stimuli, and novel comparison stimulus compounds do not overlap completely with trained stimulus compounds. Suppose that workshop participants were trained to equate Stimulus Compound ABCDEF with Stimulus Compound MNOPQR and then to match this second compound with Stimulus Compound UVWXYZ. In addition, participants were taught that each single stimulus in the compound represented a threatening situation. Will participants then be able to recognize the following examples as problematic: DEFGHI, PQRUVW, and CGMHYI? Because many human problems can be viewed as failures to match behavior with the circumstance, extending stimulus equivalence research to include complex stimulus compounds, especially those consisting of social situations, may stimulate behavioral technologies that have not been heretofore considered.

Analysis of Low-Rate Behavior

Many of the most serious and costly human behavior problems are those that occur rarely within the life of an individual. These include suicide, murder, assault, waging war, vandalism, "psychotic" episodes, desertion, rape, child abuse, and running away from home, to name a few. There are several reasons why these problems are extremely difficult to prevent or solve. First, our field lacks an adequate conceptual framework for understanding extremely low-rate behavior according to reinforcement theory. Because these actions may occur only once in a lifetime, they are unlikely to be shaped directly by contingencies. If they are rule-governed responses, we know little about the experiences that lead to rule formation of this type and the conditions that activate it. Second, our main tool for learning about behavior—direct observation—is of limited value when the dependent variable rarely occurs. The low rate of the response precludes systematic measurement of the behavior under controlled and varied conditions. Third, these limitations prevent accurate prediction of the occurrence of serious low-rate behavior problems. Hence, new dependent variables are needed that can predict occurrences of low-rate behavior that occur with sufficient frequency to permit direct observation and experimentation.

Analysis of low-rate behavior is more apt to be successful if done under laboratory conditions. Although high-rate human behavior lends itself to experimental analysis outside the laboratory (e.g., Iwata, Dorsey, Slifer, Bauman, & Richman, 1982), the extreme variability of natural human environments is sure to obscure the discovery of reliable predictors of low-rate behavior. The first, and perhaps most formidable, problem facing basic researchers will be to design an appropriate paradigm for studying low-rate behavior. Some preliminary considerations include the following: Can low-rate behavior be studied with a single organism interacting with response manipulanda, or does the nature of some low-rate activities necessitate study of interactions between organisms (e.g., analogues to child abuse)? To what extent will the operant function of low-rate behavior affect the design of the paradigm (e.g., positive vs. negative reinforcement)? To what degree is the topography of the low-rate response relevant to the analysis of the behavior? For example, desertion may be an escape response that is adequately represented by a bar press; however, rape produces a range of consequences that are not easily simulated by laboratory arrangements. Finally, what will be the basis for selecting predictor responses of low-rate target behavior?

The answer to this last question may depend largely on which operant processes an investigator believes are involved in the occurrence of low-rate behavior. One possible view is that the response is an anomalous outlier in an otherwise orderly and predictable repertoire. That is, the behavior is a rare mutation whose controlling conditions are unlikely to be replicated, such that, for descriptive purposes, the response appears to be random. Although this account is plausible, it provides little direction for research and, consequently, dim hope for prediction and control of the problem. Another view is that an extreme low-rate response occurs toward the end of a chained schedule whose terminal link varies with each trial. Consider an adolescent looking for the various social reinforcers that group membership can provide. The youth may move from one social group to another until he or she finds acceptance (terminal link); however, if the search leads to involvement in a group engaged in criminal activity, acceptance may be contingent on performing extreme acts (e.g., assault, robbery, murder). A third account of low-rate behavior is that it is a member of a response class comprised of elements with comparatively higher probabilities of occurrence. These response-class members may be hierarchically related on the basis of their relative response probabilities. Further, responses with a lower probability of occurrence may be emitted only when reinforcement for higher probability responses is inadequate. For example, a new parent may try numerous interventions to quell his or her infant's crying, beginning with feeding, then diapering, then rocking, followed by burping, and so on. These interventions may meet with success on most occasions; however, when they do not, response-class members with a lower probability of occurrence may emerge. To the extent that these responses include abusive topographies (e.g., yelling, spanking), the conditions may be in place for the occurrence of serious forms of child abuse.

Although the obstacles to basic study of low-rate behavior are numerous, a successful experimental analysis could prove to be especially valuable for the development of needed behavioral technologies. Basic researchers who choose to study low-rate behavior will clearly be responding to a question of applied importance and, as such, will be positioned to demonstrate the value of collaborative basic–applied research (Mace, 1991b).

Rule-Governed Behavior

Human capacity for verbal description of behavior and its relation to environmental events presumably has made human behavior susceptible to control by these verbal stimuli. This susceptibility permits the development of a distinct class of responses known as *rule-governed behavior.* Unlike behavior that is controlled directly by its operation on the environment (i.e., contingency-shaped behavior), rule-governed behavior is also controlled by antecedent verbal stimuli known collectively as instructions or rules (Skinner, 1957, 1969). When behavior conforming to the specifications of the rule is reinforced by social consequences, as opposed to the consequences produced by the action specified in the rule, the response class of rule following is formed (Catania, 1986; Zettle & Hayes, 1982). Cerutti (1989) has outlined how these relatively complex relations can develop from the more basic processes of instructional control and control by strictly consequent events. For example, we can separate conceptually, if not experimentally, the social consequences for complying with a parent's instruction to complete a homework assignment from the effects that assignment completion has on the student's grade. In this case, homework completion is rule governed to the extent that grades or direct consequences of studying have little effect on doing homework.

Experimental analysis of rule-governed behavior. Reported failures to replicate schedule performances characteristic of nonhuman subjects with verbal humans gave rise to systematic investigations of the verbal histories that are likely to confound experimental studies with humans (Vaughan, 1989). One of these efforts at reconciling discrepant nonhuman–human findings is the experimental analysis of rule-governed behavior. Much of this research has centered around establishing the extent to which experimenter instructions affect sensitivity to reinforcement contingencies and identifying the conditions under which instructional control and contingency control are relatively dominant (Catania, Shimoff, & Matthews, 1989; Vaughan, 1989).

Numerous studies have now shown that when response patterns are established by experimenter instructions, the pattern of responding is typically insensitive to subsequent changes in experimental contingencies (Galizio, 1979; Kaufman, Baron, & Kopp, 1966; Matthews, Shimoff, Catania, & Sagvolden, 1977; Shimoff, Catania, & Matthews, 1981). For example, Shimoff et al. (1981) provided written instructions to one group of college students indicating that low-rate responses on a telegraph key would occasionally turn on a light signaling that button presses could earn points exchangeable for money according to random-interval or random-ratio schedules. For the second group of students, low-rate key presses were shaped by contingencies without a verbal description of the contingency. Although both procedures produced low-rate key presses, when the low-rate contingency was discontinued, response rates increased only for those students who were exposed to the shaping procedure; students presented with the written description of the contingency continued to key press at low rates. Shimoff et al. concluded that this insensitivity to changes in environmental contingencies is a defining feature of rule-governed behavior that distinguishes it as a separate functional class from contingency-shaped behavior, independent of topographical similarities between the two classes.

A second principal focus in the experimental analysis of rule-governed behavior has been to identify the circumstances that lead to control by verbal stimuli rather than to control by experimental contingencies. Several conclusions can be drawn from these studies. First, verbal instructions differ along several dimensions, such as explicit versus implicit, complete versus incomplete, and paradoxical instructions versus those consistent with contingencies. These different forms of instruction appear to result in distinct classes of rule-governed behavior that vary in their sensitivity to contingencies (e.g., Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986). Second, control by contingencies can lead to the formation of rules that describe the conditional relations experienced (Shimoff, Matthews, & Catania, 1986). When this occurs, the nature of the response can change, and prior sensitivity of the behavior to altered consequences can diminish. Third, when rule formation is contingency shaped, performance rules are more effective than contingency rules in producing insensitivity to environmental contingencies (Catania et al., 1989). Further, when rule-governed performance appears in the form of schedule-sensitive behavior, performance may fail to become schedule sensitive despite contact with contingencies (Hayes, Brownstein, Haas, & Greenway, 1986). Finally, sensitivity to contingencies is enhanced when responding is variable, regardless of whether the variable performance follows nonspecific description of performance patterns (Joyce & Chase, 1990) or whether variable responding is explicitly trained (LeFrancois, Chase, & Joyce, 1988).

Thus, research on rule-governed behavior has progressed rapidly in the past decade or so and has, perhaps, the greatest immediate applied relevance of any area of basic behavioral science. No doubt this can be traced to the predominant use of human subjects and a focus on a class of behavior that permeates most human activity. Nonetheless, additional problem-focused basic research may accelerate the inclusion of rule-governed relations in applied work.

Applications of rule-governed behavior and areas for further research. Hayes, Kohlenberg, and Melancon (1989) aptly summarized four types of problems in rule control that humans typically encounter. The first, *self-rule formation,* concerns the verbal formulations an individual generates as a result of direct contact with contingencies. Problems arise when the person either fails to generate beneficial rules or when the rules formulated are faulty. Such problems in rule formation suggest that basic researchers begin by identifying subjects who respond atypically to experience with experimental contingencies. These are the outliers or exceptions to the rule that require further manipulations to achieve accurate rule formation. Once this subpopulation is identified, the following questions seem relevant. What characterizes these individuals as inaccurate rule formers? What experimental arrangements are necessary to produce accurate rule formation in this population? Once established, to what extent does accurate rule formation generalize to novel circumstances? Finally, to what contingencies is newly established rule formation especially vulnerable, and what can be done to minimize this risk?

Problems in *rule control by the group* occur when the rules established and enforced by the group are dysfunctional for the individual. This problem is exemplified in families who warn members "Don't trust anyone," "Look out for yourself above all else," "You'll never be able to do that," "It's all right to cheat; everyone else does," and so on. Enforcement of rules established by the group through contingencies of reinforcement or punishment poses formidable obstacles to the weakening of faulty rules. Here, the focus of basic research should be on discovering operations that are capable of countering enforcement contingencies.

A third concern is the *failure to follow rules* when it is beneficial to do so. A rule may be accurately formulated and understood but still fail to exert control over relevant behavior when the circumstances call for it. Insufficient rule following is likely to occur for two reasons. First, rule following in general may have an inadequate history of reinforcement. These repertoires are often referred to as impulsive or character disordered (Hayes et al., 1989) and can be said to reflect insufficient contact with the usual contingencies of socialization. For basic researchers, the problem will be to identify the subpopulation of individuals who accurately form but fail to follow rules and then delineate the histories needed to establish a strong repertoire of rule following. A second reason for insufficient rule following is similar to the group enforcement problem mentioned above. Competing contingencies for behavior that contradicts the rule may override those embodied in the rule. Findings from basic studies on countering enforcement of dysfunctional group rules should apply here as well.

Finally, some persons are subject to *excessive rule following*. The problem is not just whether the rule is faulty or not; it is the absence of discrimination of conditions under which the rule applies. Thus, there are times to be suspicious and times to trust, times to disclose information and times to retain it, times to be conservative and times to be flexible, times to diet and times to eat, and so on. Such excessive rule following reflects an insulation from environmental contingencies that is deleterious for the individual. Much of behavior-analytic psychotherapy focuses on weakening the tendency to follow rules to a fault (see Hayes et al., 1989; Kohlenberg & Tsai, 1987; Zettle & Hayes, 1982). However, the psychotherapeutic techniques rely on overriding the unknown contingencies that maintain excesses by establishing stimulus control of new rules or teaching repertoires that it is hoped will come into contact with natural and effective contingencies. Basic researchers could assist this effort by first identifying this subpopulation of excessive rule followers and then by isolating the relations that maintain the behavior.

BUILDING CONNECTIONS BETWEEN THE BASIC AND APPLIED ANALYSIS OF BEHAVIOR

The principal thesis of this essay has been that greater connection between our basic and applied sectors will benefit both sectors and strengthen the science of behavior in general. But connection will require deliberate action on the part of basic and applied researchers alike; neither is likely to accomplish the connections alone. This final section is devoted to a discussion of three specific strategies that may foster this connection and lead to tangible evidence of its value.

Animal Models of Human Behavior Problems

Using nonhuman subjects to simulate the constituent processes involved in human disease is a widely accepted practice in biomedical research. Animal models have approximated diseases as diverse as carcinogen-induced cancers, Alzheimers disease, cocaine addiction, hormonally mediated obesity, diet-induced heart disease, and the life cycle of the human immunodeficiency virus (HIV). Although clinical treatments do emerge that are independent of advances in basic biomedical research (e.g., aspirin's beneficial effects on heart disease), it is generally held that clinical treatments with greater specificity and effect will follow from an adequate understanding of the underlying disease process.

Despite obvious differences between simulation of disease processes and behavioral processes, explicit animal models have been used by behavioral researchers with promising results (Epling & Pierce, 1986; Pierce & Epling, 1987). For example, learned helplessness provides an experimental account and analogue to depression—a clinical condition affecting millions of humans (Overmeir & Seligman, 1967; Seligman & Maier, 1967; Seligman, Maier, & Solomon, 1969). The concept of learned helplessness arose from the observation that dogs with a history of inescapable shock failed to make escape responses when such responses were subsequently available to them. In addition, the dogs showed an affect and listlessness consistent with human depression. The basic strategy in this type of animal model, then, is to program a specific and plausible behavioral history with the hope of observing response patterns consistent with human behavior problems or propensities. Two other successful analogues of human behavior are Herrnstein's (1970) choice paradigm and the delay-to-reinforcement model of impulsivity and self-control (Rachlin & Green, 1972). These analogues differ somewhat from learned helplessness; rather than program specific behavioral histories, these models examine how current experimental arrangements affect choice among concurrently available alternatives. Their appeal stems from the ubiquitous nature of choice in natural human environments and the notion that much of what we term "good" and "bad" about human behavior can be conceptualized as matters of self-control and impulsivity, construed as relations between short-term and long-term consequences. Although notable examples of animal modeling exist in behavior analysis, there remains considerable potential for its widespread application.

Behavioral animal modeling of human problems of the kind proposed in this paper involves at least four distinguishable steps. First, a human behavior problem that is resistant to resolution with existing behavioral technologies is identified (e.g., behavior resistant to treatment by combined extinction, alternative reinforcement, and punishment). Second, a range of plausible reinforcement and/or punishment histories that could account for the problematic response pattern is reviewed. Competing accounts are discounted, retained, or prioritized on the basis of their consistency with the literature and their testability. Third, specific hypotheses are then tested, and the data are analyzed with an eye toward large, reproducible effects across multiple subjects. The importance here is that robust results of sizable magnitude are those most likely to generalize to humans in natural situations. A final step in the modeling process is to test the effectiveness of one or more independent variables in disrupting the target response patterns simulated by the model. Of course, these independent variables are those with potential relevance to the design of interventions for the human equivalent of the response pattern. The success of the model is ultimately measured by the degree to which the behavior pattern of interest is simulated and is shown to have a function distinct from other response patterns.

Replication via Human Operant Research

Basic behavioral research with nonhuman subjects contributes to a science of human behavior when the essential functional relationships are reproducible with people. Although the generality of functional relationships can be inferred from interpretation of natural human activity or from practical application of the concept in question, scientific confidence in the generality of research with nonhumans can only be derived from human operant research. As others have observed (Baron & Perone, 1982; Baron, Perone, & Galizio, 1991; Hake, 1982), this phase of the continuum of basic-to-applied research has often been omitted, and, consequently, the generality of much basic behavioral research to human behavior remains unknown.

Replicating nonhuman research with human subjects entails translating the preparations present in the experimental chamber into preparations suitable for human operant research. In general, the degree of inference necessary and the risk of failure to replicate findings are minimized by using parallel preparations to the greatest extent possible. Thus, early attempts at replication with humans may employ simple response manipulanda (e.g., button presses, video screen touches), single or simple compound signaling stimuli (e.g., colored lights, tones), and potent generalized reinforcers (e.g., money) or primary punishers (e.g., electric shock). (A matching experiment by Bradshaw, Szabadi, & Bevan, 1976, illustrates this strategy by use of button-pressing tasks maintained by monetary reinforcement on concurrent VI VI schedules.) Subsequent replications may deviate from strict translation of chamber preparations in order to establish the generality of the functional relationship across response topographies, signaling stimuli, and reinforcers/punishers. (Mace, Lalli, et al., 1990, illustrated this by replicating Nevin's behavioral momentum work with retarded adults sorting plastic dinnerware for popcorn or coffee according to multiple VI VI schedules in baseline and, then, when subjects were distracted by a video during the test for momentum.)

Although successful replications with human subjects are noteworthy (Pierce & Epling, 1983), the latency to replicate and the pace of replication studies with humans could be improved. I believe this improvement would follow naturally from deliberate collaborations between basic and applied researchers. Thus, collaboration on the development of animal models would lead naturally to replication of the model with humans with varying degrees of experimental control.

Effective Technologies: The Acid Test

The process of animal modeling and human replication culminates with the development and testing of technologies that will remedy human behavior problems. Here again, the goal is to translate the preparations that have been shown to weaken or strengthen the target behavior in basic research into viable interventions for humans in applied settings. An example of the process may be more useful than generic description.

My applied colleagues and I have collaborated with J. A. Nevin during the past 5 years in an effort to establish the generality of the concepts of behavioral momentum to human behavior and their usefulness for behavioral interventions. Recall that Nevin's principal finding was that behavior's resistance to change is a positive function of the rate of reinforcement in the presence of a discriminative stimulus (Nevin et al., 1990). Further, because resistance to change was strengthened by alternative reinforcement (delivered contingently or noncontingently), Nevin showed momentum to be a function of stimulus–reinforcer relations, whereas response rate was a function of response–reinforcer relations. After replicating this basic finding with adult human subjects in procedures similar to those used by Nevin (Mace, Lalli, et al., 1990), we examined the implications of Nevin's findings for applied work.

Alternative reinforcement is the mainstay of behavioral intervention. Arrange high-rate reinforcement for desirable behavior and, consistent with matching theory, the rate of desirable behavior will increase while occurrences of undesirable behavior will decrease. Although this finding is robust, Nevin's work suggests that alternative reinforcement may inadvertently increase the undesirable behavior's resistance to change, resulting in low-rate but persistent behavior. We subsequently tested the validity of this hypothesis with children who were hospitalized for treatment of their severe behavior disorders (Mace, 1991a). After identifying the maintaining contingencies for aggression (attention) and food stealing (access to food), 2 children were each exposed to two phases of extinction. One extinction phase was preceded by alternative reinforcement at the rate of 150% of baseline reinforcement, and the other extinction phase was preceded by baseline reinforcement only. Consistent with Nevin's findings with pigeons and our findings with retarded adults, resistance to extinction for both children was substantially greater when preceded by alternative reinforcement.

Conclusion

I am suggesting that some, not all, basic and applied researchers begin working together in deliberately coordinated ways. Some basic researchers should turn their attention toward the analysis of basic behavioral processes that support important human problems. To be responsive to the applied agenda will mean working collaboratively with applied researchers to identify appropriate areas of inquiry and to test the validity of nonhuman models with humans under experimental and nonexperimental conditions. I am suggesting further that the self-interest of some basic researchers extends beyond systematic replications for extending and elaborating behavioral principles to an interest in seeing their basic research lead to more effective behavioral technologies, especially with humans. This is the evidence that the public will respond to when decisions are made about allocation of funds for research, faculty positions, and retention or expansion of graduate programs, and space in introductory psychology textbooks. These ideas are hardly new. That they have served other sciences well behooves us to give them more than idle acknowledgment and to actively examine their suitability for behavior analysis.

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