**THE COLLATERAL EFFECTS OF BEHAVIORAL INTERVENTIONS:
APPLIED IMPLICATIONS FROM JEAB, JANUARY 1993**

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Our assignment was to review the January 1993 issue of the *Journal of the Experimental Analysis of Behavior (JEAB)* and identify papers or topics that might be of particular interest to individuals who work primarily on applied problems. As we reviewed the papers, it became clear that all of them touched on topics of general interest and contained provocative implications for applied issues. Indeed, we were tempted to discuss them all, but we worried that doing so would result in a product too diffuse to be effective. In the end, we resolved to focus on a single theme that emerged from considering several papers as a group: Behavioral interventions produce collateral effects, but predicting those effects in applied work will be complicated because of verbal and instructional influences and because of interactions among reinforcer types.

The most straightforward way to alter the frequency of some response is to alter the frequency of reinforcement or punishment for that response. But one can accomplish the same thing indirectly by altering the reinforcement or punishment for other responses in the situation. Such effects are familiar and intuitively known. For example, if one increases the frequency of going to the playground by adding reinforcement for playground activities, one may also find that the frequency of practicing the piano or doing homework decreases. Conversely, if the reinforcement for playground activities is

reduced, or if such activities are punished or restricted, other activities—possibly including homework—will increase in frequency. In other words, the reinforcement or punishment of one response can have an inverse effect on the frequencies of other responses.

Although these general trends may be familiar, important questions remain. For example, do all the “other” responses change in frequency, or only some of them? If the frequencies of all the other responses change, do they do so equally? Or do they change differentially, perhaps in relation to their baseline levels? If only some of the other responses change in frequency, is there some way to predict which ones will change?

As a concrete example, suppose that our goal is to increase the frequency of homework. We might try to accomplish this goal by decreasing the frequency of playground activity, perhaps by introducing some type of punishment (e.g., response cost), by reducing the reinforcement available from the playground activities, or by restricting access to the playground. It would be helpful to have some principled basis for predicting, at least roughly, which of the many possible other activities will increase in frequency and by how much. Would the increase be spread evenly over all the other responses? If so, the frequency of any one other response, such as doing homework, might not increase enough to be of practical interest. Alternatively, the increased frequency might be concentrated in only a few other responses, so that the increase for these few might be sufficient to achieve a practical effect.

One possibility is that responses that produce a

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similar (or substitutable) type of reinforcement to the reduced response increase the most in frequency. Suppose that some of the reinforcements for play-ground activities arise from social contact. If so, we might see an increase mainly in the frequency of other responses that produce social contact. Such activities might include going to the shopping mall or to the local hang-out. That result would, of course, be counterproductive to the goal of increasing the frequency of homework.

A large amount of basic research has been conducted that addresses these types of questions, and several principles have received solid empirical support. Appropriately, most of the research has been conducted with simplified preparations. For example, most of the work has been conducted with nonhuman animals as subjects, thus eliminating the effects of complex histories involving verbal behavior and instruction following. For many of the studies, the different response alternatives have been similar (e.g., two or more pecking keys or levers) so that the effects of different response forces, response durations, and intrinsic response preferences are minimized. Many of the studies also arranged for each of the various responses to produce the same type of reinforcer (e.g., food) so that the complicating effects of one type of reinforcement on the motivation for other types of reinforcement are largely eliminated.

These kinds of simplifications are essential if researchers are to isolate the effects of particular operations and establish general principles involving those operations. It is a fair question to ask, however, whether the relationships revealed with the simplified preparations are sufficient to predict the outcomes in circumstances more complicated than those arranged in the laboratory but that are found in everyday settings. The data from several studies reported in the January 1993 *JEAB* suggest that they may not be.

In Horne and Lowe's study, normal adult humans obtained points, convertible to money, by pressing response keys. Two keys were available, each correlated with a different variable-interval schedule to control the rate of reinforcement for each response. Over blocks of sessions, the variable-

interval schedules, and thus the rates of reinforcement for each response, were varied. It was therefore possible to see how the frequency of each response varied with its own rate of reinforcement and with the other response's rate of reinforcement.

Horne and Lowe were particularly interested in finding out whether these relationships were consistent with the matching law and its derivatives, which are a set of equations that express formally the relation between response frequencies and the rates of reinforcement from various sources. In particular, one of these equations (Herrnstein's hyperbola) succinctly expresses the fact that the frequency of a response is positively related to the rate of its own reinforcement and inversely related to the rate of reinforcement from other sources. These equations have provided a good fit to the data from many different experiments with nonhuman animals and from some experiments with humans. Potential applications to clinical phenomena have been discussed in several papers (e.g., Fuqua, 1984; McDowell, 1982; Myerson & Hale, 1984), and several empirical investigations of such applications have been reported recently (e.g., Mace, McCurdy, & Quigley, 1990; Neef, Mace, Shea, & Shade, 1992).

The important result from Horne and Lowe's study is that the matching law and its derivatives did not fit the data very well. Moreover, the deviations were not random but instead were correlated with aspects of the subjects' verbal descriptions of the task. This correlation was determined in the following way. The key-pressing performance of each subject was assigned, on the basis of quantitative criteria, to one of five categories: indifference, undermatching, approximate matching, overmatching, and exclusive preference. Independently, the experimenters derived a verbal "performance rule" for each subject from answers to a series of questions about the task and about his or her performance. Each performance rule was then assigned to one of the five performance categories. The intriguing result was that the verbal performance rule and the actual key-pressing performance fell in the same category for 29 of 30 subjects (see their Table 2, p. 35). Thus, a subject's response pattern

(matching, overmatching, undermatching, etc.) was better predicted by his or her verbal rule than by the actual schedules of reinforcement.

This and other similar findings raise a troubling set of issues for applied work. Applied researchers have traditionally attempted to understand why a particular behavior occurs by conducting a functional analysis, which involves some direct observation and recording of the antecedent stimuli, establishing operations, and consequences that are reliably associated with the response of interest. On occasion, this descriptive analysis is supplemented by experimental manipulations of the suspected controlling variable(s) in an effort to validate the descriptive analysis. If, however, the performance of interest is better predicted by the subject's verbal performance rule than by the independent variables (e.g., the schedules), why not simply ask clients why they are engaging in a particular behavior? And if one's goal is to change a client's behavior, why not simply change the client's rule—say, through instruction?

The problem with adopting this strategy too quickly is that the links between circumstances (current and past) and the production of verbal rules are very complexly determined, as are the links between those rules and other performance (e.g., Bernstein & Michael, 1990; Catania, Matthews, & Shimoff, 1982; Galizio, 1979; Hackenberg & AxteLL, 1993; Hayes, 1986, 1989; Schlinger, 1993; Wanchisen, Tatham, & HineLine, 1992). That is, the descriptions or rules that a client generates may or may not be accurate. And the client may or may not follow any particular rule (whether other-generated or self-generated), depending on a large number of variables in the past and current environments. Further, the often covert nature of self-rules poses a rather severe methodological challenge.

One aspect of Horne and Lowe's data illustrates some of these complexities. In their descriptions of the schedules, many of the subjects were fairly accurate in saying which variable-interval schedule produced the highest rate of reinforcement, which produced the next highest rate, and so forth. Nevertheless, the descriptions of the performance rules—

that is, the descriptions of the strategies for distributing responses between the concurrent alternatives—were highly variable among subjects. Indeed, only 7 of the 30 subjects described a strategy that would have maximized overall earnings (which in this case was matching). Apparently, the subjects were good at describing some fairly simple features of the schedules (e.g., the rank ordering of the individual variable-interval schedules), but they were not so good at describing more complex features deriving from the concurrent relationships. One wonders, then, about the degree to which humans accurately describe reinforcement contingencies based on exposure to experimental preparations or to "natural" environments in which the contingencies might be more complex and more variable over time.

What would happen if humans were trained to describe reinforcement contingencies accurately? Would they then derive appropriate performance rules and behave accordingly? Would such training enhance the treatment efficacy of common behavioral interventions by ensuring that performance rules are congruent with the operative contingencies? That effect would be beneficial. But such discrimination training might also facilitate the detection of changes in reinforcement contingencies across settings and over time. Whether the acquisition of such a contingency-tacting repertoire would interfere with the (stimulus) generalization of behavioral effects across treatment conditions and deter response maintenance efforts seems worthy of investigation.

The relation between the contingencies and a subject's description of those contingencies and the relation between description and performance have additional implications for applied work. For example, it would be useful to know when verbal reports are likely to help in conducting a functional analysis and when they are likely to mislead (e.g., when the "reasons" for a behavior are potentially embarrassing or illegal). It might be worthwhile for applied researchers to collect data on subject-derived performance rules to determine the conditions affecting the degree to which observed performance is congruent either with such rules or with

the reinforcement contingencies. Behavioral interventions may sometimes fail to produce expected effects because subjects have derived performance rules that counteract the expected effects of the contingencies. It might prove useful for applied researchers to pursue the analysis of what might be called "treatment failures" to determine the extent to which such verbal processes have contributed to unexpected effects of interventions.

In short, Horne and Lowe argued that self-instructions were evoked by the current task, and those instructions, in turn, influenced the frequency and distribution of key-pressing behavior in much the same way that instructions by another person might influence such behavior. The self-instructional repertoires presumably developed from extensive and idiosyncratic histories involving verbal behavior and instruction following.

It would be a mistake to conclude from these data that the matching law and its derivatives do not apply to the behavior of normal adult humans. The path of a falling leaf is not well described by the equations that define the law of gravity. Indeed, on a very windy day someone who tries to predict the path of the leaf simply on the basis of the law of gravity will be badly off the mark. Yet few would argue from this fact that the law of gravity does not apply to the falling leaf. Instead, the usual interpretation is that additional variables, such as friction and wind forces, must be taken into account for an adequate description.

The analogous interpretation of Horne and Lowe's data is that predictions of adult humans' behavior based solely on the matching law and its derivatives may be off the mark—sometimes badly off. With verbal humans, complex verbally related repertoires are available to be evoked by aspects of our tasks. These repertoires, in turn, are a potential source of stimuli that can function in all the various ways that stimuli can function to influence other behavior. Furthermore, the typical experimental preparation in which the matching law has been so thoroughly studied differs along many dimensions from naturalistic or therapy settings involving humans (e.g., the types of reinforcers and the behavioral units of analysis). The matching law and

its derivatives quite properly do not express these additional complexities. As a result, there may be some limitations on extrapolations of the matching law in its current quantitative form to applied behavioral problems (Fuqua, 1984).

For effective prediction and control, then, the additional complexities will need to be taken into account. It may be necessary, for example, to assess verbal and instruction-following repertoires, including their functional relations with independent variables and other behavior. Such assessment imposes enormous methodological challenges. There is, however, a growing body of research on these kinds of issues and relationships. (Of some relevance is the paper by Critchfield & Perone, 1993, which describes a novel procedure for assessing and establishing control over reporting behavior by stimuli that are normally private.)

The paper by Crosbie provides a useful review of earlier work by Dunham (e.g., 1971) on the effects of punishing or restricting one response on the frequencies of other responses. Much of Dunham's work was conducted with gerbils in an experimental chamber that afforded the opportunity for several different activities, such as drinking, sand digging, wheel running, nest building, and eating. Presumably these different activities were maintained by different types of reinforcement. Dunham's basic procedure was to punish or restrict access to one of these activities and then see which other activities changed in frequency and by how much. Crosbie's paper summarizes the main findings from these studies and the principles that Dunham derived to predict the pattern of change in the other activities.

The goal of Crosbie's research was to determine whether Dunham's principles could be used to predict the pattern of change in the behavior of adult humans. The different activities in Crosbie's study were pressing buttons at different locations on a computer screen. Each of these different activities was reinforced by points, convertible to money. A different variable-interval schedule was correlated with each activity. The basic procedure was then to punish (through response-contingent point loss) or restrict access to one of the activities. As a result

of these operations, the frequencies of the other activities increased, but not in a way that was consistent either with Dunham's principles or with the matching law and its derivatives. There was some evidence in support of a momentum effect (Nevin, Mandell, & Atak, 1983). That is, the frequencies of activities increased in inverse relation to their baseline frequencies.

It is not clear why Dunham's principles and the matching law failed in this case. Verbal influences are again a possibility. Also, in relation to Dunham's principles, it may be significant that each of the humans' activities produced the same type of reinforcement. It is notable that most of the research on the matching law has used reinforcers of the same type for all responses, whereas in Dunham's research, the activities were maintained by different types of reinforcers. In any case, the issue deserves further study.

The papers by Horne and Lowe and by Crosbie were concerned with reciprocal effects, such as the reduction in the frequency of a response due to increasing the rate of reinforcement from other sources. The paper by Reid, Bacha, and Morán reminds us that the presentation of "other" reinforcers can also have facilitating effects. The paradigmatic case is schedule-induced polydipsia. If a food-deprived rat is given small bits of food intermittently, it will drink a large amount of water immediately after eating each pellet despite the fact that drinking has no bearing on the delivery of the pellet. The amount of water consumed is often far in excess of the amount needed to maintain fluid balance. Thus, the intermittent delivery of an inducing reinforcer (food) increases the frequency of other behavior, namely, behavior relevant to a different type of reinforcer (drinking water). Analogous effects have been observed with inducing reinforcers other than food and induced behavior other than drinking. These phenomena have been termed *adjunctive* or *schedule-induced* behavior.

Different interpretations have been offered about the nature of the inducing event. Some interpret the delivery of the inducing reinforcer as an arousing or activating event that enhances the disposition to engage in any of a wide range of activities that the

environment might support (Killeen, 1975). Such an interpretation is consistent with Skinner's (1953, chap. 10 and p. 180) conception of emotional dispositions. A child who has just opened a couple of birthday presents may suddenly race around the room, pick up toys and then drop them, engage in fragmented conversation, and generally act in ways that we speak of as excited or wild. More restrained versions of the same effect may be seen when an adult has just received a commendation or prize.

Others note that right after the delivery of a reinforcer, the probability of the next reinforcer is usually low. Thus the delivery of reinforcement signals a period of nonreinforcement. Perhaps this signaled period of nonreinforcement is what induces adjunctive behavior (Staddon, 1977).

Still others (e.g., Falk, 1977, 1981, 1986) have suggested that adjunctive behavior is induced by a reinforcement schedule that is neither very rich nor very lean. A mediocre schedule of reinforcement generates some disposition to leave and some disposition to stay and work, with these two conflicting dispositions in approximate balance. This condition of conflict may be what favors the occurrence of adjunctive behavior.

Whatever the inducing event is, it is clear that what gets induced is not merely a particular behavioral topography (like drinking) but rather a motivational state—a change in the ability of some event to function as a reinforcer and a change in the disposition to respond in ways that have produced that event in the past (Falk, 1966). After consuming a bit of food, there is a short period of time during which access to water or access to a running wheel can be a potent reinforcer for operant behavior. For example, during this brief period a rat will press a lever at a high rate if lever pressing has in the past produced water or access to a running wheel. The rat, in other words, is made momentarily thirsty or momentarily motivated to run. The inducing event thus functions as an establishing operation (or a motivational operation) (Malott, Whaley, & Malott, 1993, chap. 10; Michael, 1982; Staddon, 1977).

Often we think of establishing operations in terms

of some type of deprivation that tends to have a long-lasting effect. Food deprivation is representative. There may be classes of establishing operations, however, that are much more fleeting in their effects and that may be responsible for some transient changes in behavioral frequencies. The phenomenon of schedule-induced behavior might provide one model of such effects. The emotional excitement referred to above might be interpretable in these terms. Other examples, suggested by Falk, include certain rituals and drug self-administration (e.g., drinking or smoking at a business lunch).

In the study by Reid et al., food-deprived rats were given food pellets periodically in an apparatus that contained a water bottle, a running wheel, and a block of wood to gnaw. Each of these objects was located in a different section of the chamber, and, in some conditions, access to the object was contingent on pressing a lever in the appropriate section. The typical pattern following delivery of a food pellet was for the rat to eat, then go to one of the sections, press the appropriate lever, obtain access to one of the objects, and then engage in whatever adjunctive behavior the object supported (i.e., run, drink, or gnaw). These results replicated previous findings and indicated that the inducing event indeed functioned as an establishing operation.

The primary purpose of the study was to determine whether each food pellet induced an orderly sequence of different motivational states or just one. The fine-grained data analyses suggested that only one was induced but that the type might differ from pellet to pellet. Regardless of the particular answer, however, the data provide a clear reminder that the delivery of one type of reinforcer can induce behavior that bears no obvious relationship to that type of reinforcer, perhaps by modulating emotional or motivational dispositions.

Taken together, this collection of studies from *JEAB* reminds us that any manipulation of reinforcement contingencies or response opportunities has the potential to alter the frequencies of concurrently available responses. To the extent that such effects occur generally, all applied behavioral interventions might be said to have side effects (see

also Balsam & Bondy, 1983). In many situations, these side effects are desirable (as for example when a decrement in self-stimulatory behavior permits other more adaptive behaviors to occur and be strengthened by contrived or naturalistic contingencies), but in other situations desirable concurrent behaviors may be decreased (e.g., a student who shifts study time away from an academic course because of the programming of more effective behavioral contingencies in a PSI course) or undesirable behavior may be increased (e.g., implementing a token economy that restricts free access to reinforcers may increase the probability of stealing or other means of attaining the now-restricted reinforcers). Achieving a better understanding of the various collateral effects of our operations may allow applied behavior analysts to predict, document, and prepare for these behavioral side effects and document the conditions under which certain interventions might be contraindicated (e.g., a token economy might be contraindicated when alternative sources of back-up reinforcers are readily available).

In many ways, applied behavior analysts are analogous to practitioners of modern medicine (physicians), but the science underlying behavioral practice is much younger and less developed than that underlying the practice of modern medicine. One difference is that physicians have an indispensable resource—the *Physician's Desk Reference (PDR)*—that contains detailed information on drugs, including discussions of indications, contraindications, and side effects. Would applied behavior analysts and their clients benefit from something analogous to the *PDR* that would shed light on the side effects and contraindications of our behavioral interventions?

Predicting the nature of these collateral effects in everyday and applied settings will be difficult, however, because of the multiple factors and processes involved. With adult humans, it may be necessary to take into account the role of verbal and instruction-following repertoires. And the effects of one type of reinforcer on the motivation for other types of reinforcers—effects that may be relatively fleeting—may prove to be important.

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