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Introduction: The Control of Behavior by Consequent Drug Injections*

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THE view that a drug can function as a reinforcer to maintain behavior was explicitly formulated many years ago, but only in recent years has this view been given substance by experimental results. The degree of control that can now be achieved with drug injections as controlling events is a good way of gauging progress in this field. In the earliest experiments the behavior under study served merely to detect that drugs could function as reinforcers, whereas today the performances that can be engendered by consequent drug injections closely approximate performances engendered by a variety of other consequent events.

In bringing general concepts to worthwhile fullfillment, technical innovations, both devices and procedures, are usually necessary. Fortunately, there have been ingenious experimenters among those working with drug injections as controlling consequent events, and there has always been a ready willingness to share technical laboratory experiences. Information about types of jackets, harnesses and other restraint devices to protect the external part of catheters, the characteristics of different catheter materials, the relative advantages of different surgical techniques and so on has been commonly shared. But progress does not come just from improved technical devices. Progress in studying behavior also depends on the discovery of effective procedures and combinations of optimal parameter values, that is, on good schedule conditions. To give one example, Kelleher (5) notes differences in performances under unlimited and under limited access to drug injections. Even in simple situations there are scores of features and many possible combinations of parameter values that may affect the degree of control that can be achieved. Therefore the attainment of optimal schedule conditions is likely to come only after systematic experimentation.

The degree to which behavior in experimental situations can be well controlled by drug injections has steadily increased over the last decade. The significance of this progress and the reasons for it deserve comment. The increased control comes not from finding drugs that are inherently effective as consequent events, but in using them better. As with any environmental event, drug injections maintain behavior only under certain conditions; the more we know about the conditions, the better the control over behavior. Without changing the consequent event, the control over behavior changes depending on such factors as how the event is scheduled, on various parameter values in the situation, and the individual's antecedent behavior. What determines behavior then is not so much the nature of the consequences as the conditions of their use. Better control comes about through better arrangement of the relevant conditions.

One value of achieving powerful control over the behavior of experimental subjects is the effect it has on the behavior of the scientific community. For example, in his

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early experiments, Skinner (8) observed a fixed-interval scallop as a local deviation from linearity, but at that time the finding attracted little notice. It was not until these schedule-controlled patterns of responding could be easily produced in any individual, under stimulus control, that the enormous potential of schedules began to be widely appreciated. The situation is similar with respect to experiments with drug injections as consequent events. To show that drug can function as a reinforcer is of theroretical interest to a select group of people, but the capability of making drug injections maintain strong behavior for extended periods of time commands attention generally and urges the application of experimental findings to problems of human drug abuse.

This progressive achievement of greater and greater control over behavior with drug injections is the cumulative contribution of many investigators. Many of the participants in this symposium have taken part in this development and undoubtedly identify with it. There is, however, a corollary to this success. Because it is now possible to achieve better experimental control over behavior with drugs as consequent events, experiments that fall short of this mark make less and less useful behavioral contributions. One of the positive values of this symposium will be to indicate what the current state of the art is.

A great many experiments with drug injections have had as their purpose to show that the injection of a certain drug would function as a reinforcer or to compare different drugs as reinforcers. But simply showing that a drug can function as a reinforcer is only a first step toward using it to control behavior. In determining the conditions of suitability for events to maintain behavior it is necessary to conduct systematic behavioral experiments. As the following papers indicate (3, 5), such experiments are being conducted and it is now possible to engender stable schedule-controlled behavior with consequent drug injections.

Determining the special conditions under which unlike events control behavior similarly provides a functional basis for further comparisons between the events. Again, such conditions have been determined, and it is possible to engender similar behaviors with such different consequent events as food presentations and drug injections (2). One value of being able to produce the same behavior with different consequent events is that it brings into question tacit assumptions that apply to only one instance. Because views about reinforcement are often overlayed with extra, misleading meaning, there is heuristic value in excluding irrelevant considerations. Comparing drug injections with other events as reinforcers highlights the nature of reinforcement. For example, for most individuals observing a pigeon producing food by pecking a plastic key, the inevitable, compelling forces in the situation simply do not stand out. It is not thought-provoking to see a hungry pigeon peck and eat. The essential nature of reinforcement is better seen in less natural situations that appear to go more against the grain of ordinary conceptions. Many people understand that drug use is not rational and that compulsive drug use is not simply because the user wants to do it. For this reason, drug injections as consequent events dramatically emphasize the essence of reinforcement. Rather than teaching that drug injections act like food presentations, it would be better to emphasize that food presentations act like drug injections. A related point is that among those people who have the least understanding that drug use exemplifies behavior that is caught up and developed by its consequences is the addict himself. Addicts are likely to explain their behavior mentalistically in terms of personal needs and wants. Direct personal experience may not be a good path to scientific understanding.

A large part of determining the optimal

conditions for an event to control behavior is learning how to schedule it suitably. A primary reason why unlike events can function similarly in controlling behavior is because the schedules whereby events are presented are critically important. In order for different events to function similarly, it is essential that the events be scheduled in functionally equivalent ways. The capability of producing comparable schedule-controlled patterns of responding with different consequences gives a meaningful way of comparing consequences with respect to both similarities and differences.

It appears that the direction of research with consequent drug injections will parallel that of behavioral pharmacology generally. The capability of producing comparable schedule-controlled patterns of responding with different events emphasized the importance of ongoing behavior in determining the effects of drugs on behavior. Under the conditions of comparable ongoing behavior, other determinants of the behavioral effects of drugs are now being studied (1, 6, 7). Similarly, in studying drugs given by injection as consequent events, the capability of engendering standard types of schedule performances will make it possible to evaluate the specific features of consequent drug injections.

Stimulus events that function as reinforcers all have other behavioral effects. In part, determining the conditions of suitability for using consequent events to control behavior usually involves eliminating or minimizing these other effects. For example, food presentations that are "reinforcing" can also be "satiating," and thus lead to a decrease in subsequent behavior. As noted by Kelleher (5) and Goldberg (3) in the following papers, drug injections used as consequent events can have generalized pharmacological effects on all subsequent behavior. These generalized effects of drug injections can be minimized by the use of time-out periods after each injection or by the use of second-order scheduling procedures in which the drug injection is the last event in each daily session. Goldberg (3) also notes that drug injections, as well as neutral stimuli that have been associated with certain drug injections, can function as eliciting stimuli for behavioral and physiological responses.

The occurrence of physiological responses evoked by environmental stimuli seems to play little role in much of the operant behavior that is studied in laboratory settings. Nevertheless, physiological changes are involved in much ongoing behavior. For example, a dog will salivate copiously as it responds under a schedule of food presentation. In ordinary life, physiological changes are clearly associated with sexual activities and also with eating. Yet in the culture the expression of physiological changes accompanying ongoing behavior is often suppressed, and in laboratory situations such changes are often ignored.

In studying some drugs as consequent events, especially narcotic analgesics and antagonists, Pavlovian and operant conditioning appear to operate jointly. After narcotic antagonists or during opiate withdrawal many physiological changes occur while individuals and animals are engaged in ongoing behavior. The way such conditioned physiological changes could play a role in maintaining continued drug-taking in the human addict has been analyzed by Wikler (10). The following paper by Goldberg (3) shows that physiological changes seem also to play a role both in the maintenance and disruption of drug-controlled behavior in laboratory settings.

McKearney (7) has shown recently that fixed-interval performances maintained by food presentation are suppressed by doses of narcotic analgesics and antagonists that enhance fixed-interval performances maintained by shock presentations. These drugs, especially the antagonists, produce vomiting and excessive salivation conditioned to environmental stimuli. Could it be that conditioned and direct effects of this sort are selectively disruptive to food maintained behavior? The work on condi-

tioned aversions to poisons and other substances suggests this may be the case. Thousands of drug injections have been made into experimental subjects without producing lasting conditioned effects, yet injections of certain substances leading to gastrointestinal disturbances can result in very strong conditioned food aversions. Something that produces nausea may not affect all behavior equally—perhaps behavior controlled by food will be differently affected.

Very little is known about how various responses differ with respect to their succeptibility to Pavlovian conditioning or about the extent to which concurrent physiological changes affect other ongoing behavior. Drugs vary in the extent to which they produce physiological changes and in the ease with which environmental stimuli are conditioned to them. Morphine and morphine antagonists are examples of drugs that produce pronounced conditioned physiological changes whereas barbiturates seem to produce few at behaviorally active doses. It should therefore be possible to experimentally evaluate the contribution of physiological changes, both conditioned and direct, to behavior controlled by different drugs.

The main topic of this symposium is schedule-controlled drug-taking. It is appropriate to conclude this introduction by emphasizing the importance of schedules in developing and controlling behavior. Earlier I spoke about technical advancements in the uses of drug injections as controlling events. To some extent it has happened in the experimental analysis of behavior generally that technical advances in controlling behavior have been taken up by people who continue to do traditional experiments but with fancier equipment. What will this technical capability in the use of drug injections as controlling events be used for?

It has been generally agreed at this symposium that drug dependence is, in essence, operant behavior reinforced by drug administration. Certainly the best way to show this is by shaping up strong operant behavior with drug injections. To show that an event can be a reinforcer is only the beginning in realizing its potential for developing behavior. Behavior is shaped by sequential, temporal contingencies resulting from scheduling events in relation to behavior. The potential for engendering behavior with drug-injections is only now beginning to be realized. Kelleher (5) and Goldberg (3) both describe the powerful control resulting from second-order schedules; as yet there seems to be literally no limit to the amount of behavior that can be produced by these higher-order scheduling contingencies used under optimal conditions (4). The associated stimuli seem to be especially critical with these schedules and is another promising field for research.

Many years ago Professor Wikler analyzed complex sequences of behavior that are shaped in the natural environment by scheduled heroin use (9). At that time, there did not exist the technical laboratory capability to produce comparable complex behavior experimentally. We now have this capability and we should use it to better understand the range and the variety of behavior that drug use can engender.

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