Notes and Comment

Controls and schedule-induced behavior

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The selection of appropriate controls to establish a phenomenon is often as much art as science. A control is initially selected on the basis of a particular alternative explanation of the data. Since there are few rules for developing alternative explanations, controls are limited to those explanations entertained by a particular experimenter. As in the case of styles in art, the experimenter's training, medium of expression, theoretical orientation, and exposure to the "public" through reviews, reading habits, and friendships will all contribute to the controls employed. Furthermore, as a control becomes popular, its use may become tenuously related to its original justification. In the extreme, a control procedure may serve primarily as a badge that identifies the experimenter as a member of the particular fraternity of scientists producing work that the current "public" will buy. Thus, one decade's critical control may become another decade's historical relic.

Given the lack of abstract criteria for good controls, several related steps are required to settle on an appropriate procedure. One must first attain agreement on the nature of the experimental phenomenon and its likely causation, then determine what alternative causal elements are potentially important, and finally choose how the effects of these alternative causal elements should be measured. As a result of this complexity, there may be a number of competing procedures in evaluating new and complex phenomena, each associated with a particular group of researchers. Such is certainly the case for the phenomenon of schedule-induced behavior, as Roper's (1981) recent article amply documents. Roper (1981) points out several measures and at least five controls that have been used to establish the presence of schedule-induced behavior.

Though Roper's (1981) consideration of the various measures and controls for schedule-induced behavior is interesting and important, he did not provide a comprehensive definition of schedule-induced behavior or a general framework for evaluating alternative control procedures. Given the content of his article, it is clear that Roper's focus is on postreward

responding. However, he identified as schedule-induced any behavior that is increased in frequency by an intermittent schedule. As Roper mentions in a footnote, such a definition does not clearly distinguish among autoshaped, schedule-reinforced, adventitiously reinforced, interim (postreward), and facultative behaviors (e.g., Staddon, 1977). Nor are the alternative control procedures designed to distinguish among these potential effects.

Additional criteria for schedule-induced behavior might include alteration of sequences and temporal patterns of behavior that occur as the result of intermittent reward. For example, one could identify classical adjunctive behavior (Falk, 1971) as behavior that increased in frequency and more regularly and closely followed reward under intermittent delivery. One might even imagine cases in which changes in temporal pattern or sequence alone might be sufficient to identify a behavior as schedule-induced. Such a definition demands clarification of whether changes in temporal patterns or sequences are primary actions of the reward or indirect (competitive) effects based on the action of reward on other behaviors or changes in its availability. Thus, a more complete definition and understanding of schedule-induced behavior will depend on careful consideration of the structure of behavior before and after intermittent reward (e.g., Staddon, 1977; Timberlake, Wahl, & King, 1982).

The second problem with Roper's (1981) approach was that it lacked a general framework to organize the evaluation of the alternative control procedures related to changes in frequency of behavior. His objections were made on the basis of face-valid arguments raised separately for each control; thus, a type of objection that was raised in one instance might be omitted in another. In my opinion, a general framework for evaluating control procedures should focus on two important classes of variable that determine the expression of behavior: (1) the cues instigating the aspect of responding of interest, and (2) the opportunity for expression of that aspect of responding. I will refer to these as the instigation and opportunity dimensions of control. Except for the variables presumed to be critical to an experimental effect, the instigation and opportunity dimensions must be identical between the experimental and control conditions.

An analysis of the control groups listed by Roper reveals that most of them do not equate either the instigation or opportunity dimensions of responding between the control condition and the experimental condition. Home-cage baselines clearly fail to equate

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instigation or opportunity dimensions between the experimental and control conditions. Different stimuli are present in each condition and different responses compete for expression over a different slice of time. Similarly, free-reinforcer and FR-1 baselines fail to equate the type and/or amount of instigation and opportunity between experimental and control conditions. An FR-1 baseline does not equate either frequency of reward (instigation) or time of availability of the response (opportunity) during baseline and experimental conditions.

Most importantly, the extinction baseline control recommended by Roper is clearly flawed because the opportunity for expression of an allegedly schedule-induced behavior is clearly greater under extinction than under an intermittent schedule of reward. For example, wheel running under an intermittent schedule of food reward must compete for expression with eating, whereas under extinction it need not. In extinction, there is greater opportunity for expression because wheel running has only to compete with "background" responses. Thus, the level of wheel running under an intermittent schedule need not exceed its extinction level in order to be considered schedule-induced; it need only show relatively more successful competition for expression with background responding under the schedule than under the baseline. The relative success of competition can be assessed either by subtracting out the eating time under the schedule and comparing the proportion of wheel running to total other time with that in the extinction condition or by using the massed-reinforcer condition. (For a similar problem in evaluating reinforcement effects against a single operant baseline in the case of high-operant-level responses, see Timberlake, 1979.)

By the instigation and opportunity criteria, the best control for evaluating increased frequency of responding is the massed-reinforcer baseline in which the number of rewards and the total session time are the same as in the intermittent schedule case. Thus, the opportunity for expression is the same and the level of instigation is the same except for the intermittency of the reward. Even this baseline may be somewhat problematic in cases in which the instigation of an allegedly schedule-induced behavior fluctuates and the unexpressed amount of instigation does not cumulate.

For example, it may be that the instigation for wheel running is maximal when the animal is first exposed to the wheel in a particular session and then rapidly dissipates independently of its level of expression. When food is presented intermittently, there is opportunity to engage in quite a bit of

early wheel running. However, when food is made available all at once, eating may compete successfully with wheel running until later in the session. At this point, the instigation of wheel running may be lower and, thus, its expression inappropriately less than that occurring under the schedule. To assess such fluctuations in instigation, it may be necessary to examine carefully the course of behavior across a session in extinction and to manipulate the point of availability of the wheel. In this case, Roper's extinction control might serve some use, although in revealing the typical within-session pattern of responding rather than in showing the appropriate amount of responding.

In short, Roper's (1981) important effort to parcel out the appropriate measures and control procedures for evaluating schedule-induced behavior was not entirely satisfying because: (1) it failed to distinguish among different types of behavior influenced by intermittent reward and, thus, did not consider the complete set of appropriate controls; (2) it neglected criteria other than increases in frequency of responding in identifying schedule-induced effects; (3) it did not provide a general framework for evaluating alternative controls; and (4) the recommended extinction control is flawed. An appropriate control procedure must equate the experimental and control conditions in terms of the instigation of behavior and its opportunity for expression. Development of an appropriate control must include agreement on the nature and proposed causation of a phenomenon, determination of likely alternative causation, and agreement on how the effects of alternative causal variables are to be measured or negated. Careful development of such a control should clarify the conditions of its use and the limitations of its application.

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