On the discriminative function of the reinforcing stimulus¹

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An examination of steady-state DRL behavior showed that a reinforced response was more likely to occur after a reinforced than after an unreinforced response. This finding was interpreted in support of the hypothesis that the reinforcing stimulus in a DRL schedule may exhibit discriminative properties. Additional support for the hypothesis was found in the rapid extinction and reconditioning reported after DRL conditioning.

In the experiments discussed below, a response was reinforced only when it followed the preceding response by some minimum interresponse time (IRT). This procedure, called a DRL schedule of reinforcement, produces behavior which is characterized by IRT distributions showing a peak at or near the criterion IRT.

Wilson & Keller (1953) observed that the behaviors which occupy each IRT often become stereotyped. The behaviors, which have been described as a behavioral chain, or as a sequence of responses, may be thought of as a behavioral unit (R_1). When the duration of R_1 is at least as long as the criterion IRT, the response (R_2) which terminates R_1 , produces the reinforcing stimulus (S^R). For example, in a 15-sec DRL schedule, the extent to which R_2 (the specified response) depends on the occurrence of R_1 may be represented by the paradigm

$$R_1 \cdot R_2 \rightarrow S^R \quad (1)$$

where the duration of $R_1 \geq 15$ sec. In the free-operant situation, the $R_1 \cdot R_2$ sequence is repetitive. Our suggestion in the present paper is that the reinforcing stimulus, at least under some conditions, may acquire a discriminative function in initiating the next $R_1 \cdot R_2$ sequence.

Characteristics of Steady-State DRL Behavior. It is possible to demonstrate the discriminative function of the reinforcing stimulus by showing that behavior following a reinforced response is different from behavior following an unreinforced response. For example, the cumulative records of steady-state DRL behavior characteristically show sequences of reinforced responses separated by series of unreinforced responses (e.g., Farmer & Schoenfeld, 1964). The records indicate that a response was reinforced more often when it followed a reinforced rather than an unreinforced response.

A closer examination of the sequential dependencies evident in the records of DRL behavior was made possible by data obtained in a graduate laboratory at Columbia University. Seven naive rats were reinforced with water for bar pressing under a 15-sec DRL schedule. The apparatus and procedure were similar to that used by Carter & Bruno (1968). An examination of the conditional probabilities in Table 1 shows that after 20 h of conditioning an

Table 1
The Conditional Probability of a Reinforced Response Given that the Previous Response Was Reinforced, $P(R_n \rightarrow S^R | R_{n-1} \rightarrow S^R)$, and the Conditional Probability of a Reinforced Response Given that the Previous Response Was Not Reinforced, $P(R_n \rightarrow S^R | R_{n-1} \nrightarrow S^R)$, for Seven Rats on a 15-sec DRL Schedule

Rat	$P(R_n \rightarrow S^R R_{n-1} \rightarrow S^R)$	$P(R_n \rightarrow S^R R_{n-1} \nrightarrow S^R)$
1	0.73	0.33
2	0.55	0.35
3	0.53	0.30
4	0.65	0.34
5	0.84	0.27
6	0.64	0.32
7	0.71	0.28

Fig. 1. Relative frequency of interresponse times (IRTs) following reinforced responses (solid line) and unreinforced responses (broken line) for seven rats on a 15-sec DRL schedule. Numbers on the abscissa represent the lower bounds of 3-sec IRT categories.

animal was more likely to make a reinforced response if the previous response were reinforced (column 2) than if the previous response were unreinforced (column 3).

The conditional probabilities in Table 1 were derived from the IRT distributions presented in Fig. 1. For all animals, the mode of the distribution of IRTs following reinforced responses (solid line) occurred in the IRT category having the criterion IRT as its lower bound. However, the mode of the distribution of IRTs following unreinforced responses (broken line) occurred at least 3 sec before the DRL criterion. The differences between IRT distributions appeared to correspond to the fact that some animals performed sequences of behavior following unreinforced bar presses which were very different from the sequences which followed reinforced bar presses.

Extinction of DRL Behavior. The data described above showed that behavior following a reinforced response is different from behavior following an unreinforced response. We interpret this difference as evidence in support of the hypothesis that the reinforcing stimulus may serve as a discriminative stimulus for the repetition of the $R_1 \cdot R_2$ sequence.

One clear implication of the hypothesis is that rapid extinction of DRL behavior should occur: the extinction procedure is defined by the absence of the reinforcing stimulus whose discriminative function is assumed to control the initiation of the next $R_1 \cdot R_2$ sequence. Rapid extinction has been observed by Carter & Bruno (1968) as well as Ferraro, Schoenfeld, & Snapper (1965), but other investigators have found high resistance to

extinction following DRL conditioning (Wilson & Keller, 1953; Reynolds, 1964). There are many procedural differences between these experiments, but close examination of the differences failed to provide any simple indication of the variables which controlled high and low resistance to extinction.

A more revealing comparison among the experiments was made on the basis of the baseline behavior obtained immediately preceding extinction. For each experiment, the ratio of reinforced to total responses was computed. Carter & Bruno (1968) have suggested that the ratio provides a rough index of the discriminative properties of the reinforcing stimulus. The ratio may range from 0.0 when no responses are reinforced to 1.0 when every response is reinforced. When the value is greater than 0.5, the frequency of reinforced responses must be greater after reinforced than after unreinforced responses. In other words, in a relatively large sample of IRTs for which the ratio exceeds 0.5,

$$P(R_n \rightarrow SR | R_{n-1} \rightarrow SR) > P(R_n \rightarrow SR | R_{n-1} \rightarrow \text{no } SR). \quad (2)$$

The ratio of reinforced to total responses during the baseline session immediately preceding extinction was computed for each of the extinction studies cited above. Both experiments reporting low resistance to extinction also report baseline ratios greater than 0.5 (Carter & Bruno, 1968; Ferraro et al, 1965). In these experiments, inequality (2) held for all animals. Both studies reporting high resistance to extinction yielded baseline ratios which were low enough (less than 0.09) so that the likelihood of a reinforced response was probably not greater following a reinforced than following an unreinforced response (Wilson & Keller, 1953; Reynolds, 1964).

Reconditioning of DRL Behavior. The extinction experiments discussed above provide additional support for the hypothesis that the reinforcing stimulus may, under some conditions, also function as a discriminative stimulus. Another source of support is found in the data obtained during reconditioning of DRL behavior. In this procedure, a reinforced response reinstates the stimulus which presumably had acquired discriminative control over the occurrence of the $R_1 \cdot R_2$ sequence. To the extent that the reinforcing stimulus exerts discriminative control, the $R_1 \cdot R_2$ sequence should occur, and rapid reconditioning is predicted. This prediction is in agreement with the findings of Carter & Bruno (1968) and of Ferraro et al (1965).

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NOTE

1. Reprints are available from David E. Carter, 470 Schermerhorn Hall, Columbia University, New York, N. Y. 10027.