

Factors affecting the conditioned reinforcing strength of stimuli in differential reinforcement of other behavior and fixed-time schedules

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In an experiment that investigated the effects of a low-rate response requirement on the strength of conditioned reinforcing stimuli, pigeons' observing responses (treadle presses) produced stimuli associated with either a short (10-sec) or a long (30-sec) schedule component. Naive pigeons were exposed to a mixed schedule with two differential reinforcement of other behavior (DRO) components, which were later replaced by fixed-time (FT) components. Differential observing behavior was not maintained during the DRO procedure, but preference was demonstrated for the shortest FT component stimulus. Fantino's delay-reduction hypothesis was supported. However, the absence of differential observing under the DRO procedure suggests that either the low-rate response requirement or the lack of specific stimuli that unambiguously predict reinforcement delivery interfered with the establishment of the schedule stimuli as conditioned reinforcers.

The exact nature of the association between a conditioned and an unconditioned reinforcer is not yet fully understood. Fantino's theory, known as the "delay-reduction hypothesis" of conditioned reinforcement, has received consistent support (Fantino, 1969a, 1969b, 1977). According to this theory, a stimulus paired with a relatively short delay to reinforcement (e.g., 10 sec) will acquire greater conditioned reinforcing strength than a stimulus associated with a longer delay to reinforcement (e.g., 30 sec).

It has been suggested that another variable, namely, response requirements, could also affect the conditioned reinforcing strength of a stimulus. Duncan and Fantino (1972), for example, used the concurrent-chains paradigm to show that pigeons preferred a simple fixed-interval (FI) 30-sec schedule to a chain FI 15-sec FI 15-sec schedule. When Wallace (1973, Experiment 3A) replicated this study using fixed-time (FT) schedules, he concluded "no preference for either the FT or the Chain FT FT was demonstrated" (p. 71). This suggests the response requirements in the presence of a stimulus that signals a discriminable period of nonreinforcement (chained schedules) can reduce the conditioned reinforcing strength of such a stimulus. Moore and Fantino (1975) provided support for this argument by showing that pigeons preferred a periodic response-independent schedule over a periodic response-dependent schedule.

The present study proposes to attack a related

question. In periodic reinforcement schedules, in which responding is restricted (differential reinforcement of other behavior, DRO), might this requirement itself reduce the conditioned reinforcing strength of a stimulus that is paired with a relatively short delay of reinforcement? In a comparison condition, an identical periodic schedule, except for the absence of any response requirements (FT) in the components, was run. An observing paradigm was utilized to measure the conditioned reinforcing effectiveness of the component stimuli in both schedules. Any differences in observing response probability in the FT and DRO schedules would presumably be due to the role of the response requirement (DRO) or, conversely, its absence (FT).

METHOD

Subjects

Five experimentally naive adult Homer pigeons (B1, B2, B6, B7, B9), maintained at 80% (± 20 g) of their free-feeding weights, served as subjects.

Apparatus

A three-key pigeon chamber, measuring 40.6 x 40.6 x 40.6 cm, was used. The side keys were not used and remained dark. A minimum force of 7 g (.07 N) was required to operate the center key. A treadle, requiring an operating force of about 7 g (.07 N), was located at the bottom right corner of the front panel. An opening for the food hopper was also situated on the front panel of the chamber. The houselight for the chamber was located in the center of the chamber ceiling. White noise was continuously present in the experimental room to mask extraneous sounds. Experimental conditions were controlled and data were recorded by conventional relay and timing circuitry. A BRS/LVE photosensor unit (Ph-901/221-10) was used to initiate the reinforcement timer, which was set at 6 sec throughout the experiment.

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Procedure

Phase 1: DRO. DRO training. Following hopper training, each pigeon was exposed to a DRO schedule of reinforcement. A keypecking response to the white center key at any time during the session produced a 45-sec blackout (key light and the houselight dark), and the schedule timer was reset after the termination of each blackout. A treadle press had no scheduled consequence. The duration of the DRO schedule was gradually lengthened, in steps, from 2 sec to 30 sec. This center key darkened during food delivery.

Multiple schedule training. Following the acquisition of stable DRO 30-sec performance, each subject was exposed to a multiple (mult) DRO 10-sec DRO 30-sec schedule of reinforcement. The center key was illuminated with red light if the DRO 10-sec component was scheduled or with green light if the DRO 30-sec component was in effect. Schedule components alternated at random after reinforcement, with the restriction that no more than three of the same components occurred in succession. Key-pecks interrupted the component in effect and resulted in a 45-sec blackout, timed from the last keypeck. Upon termination of the blackout, the schedule component was reinitiated. Treadle presses were recorded but had no programmed consequence.

Sessions were terminated after 24 reinforcements and were conducted once a day, 6 or 7 days/week. All subjects were exposed to this schedule for at least 18 sessions.

Baseline observing procedure. Following multiple-schedule training, the red and green key colors were replaced with white light, thereby changing the schedule to a mixed DRO 10-sec DRO 30-sec schedule. As before, a peck to the center key resulted in a 45-sec blackout of both the key light and the houselight, followed by reinstatement of the white key. A treadle response, however, changed the center key from white to the stimulus color associated with the component in effect (white to green during DRO 30-sec; white to red during DRO 10 sec). The stimulus change (S_0) that followed the treadle (or observing) response (R_0) persisted until (1) the component ended and reinforcement was delivered, or (2) a keypeck occurred and a blackout period commenced. If a keypeck occurred after an observing response, the key color following blackout termination was white. Reinforcement was never delivered within 3 sec of an observing response. Food was delivered regardless of whether an observing response was made, provided no keypeck occurred to delay that delivery.

Manipulations in the observing procedure. Subjects were divided into two groups, which were given different sequences of the experimental conditions described below. In each condition, an observing response, or treadle press, produced a different result. Except for the no-consequence (NC) condition, which was terminated after the 12th session, conditions changed when a stability criterion was met by the subject after 18 sessions.

This stability criterion required that the subject's observing response probability (number of trials with at least one R_0 divided by total number of trials) for the immediately preceding two sessions did not vary more than 5% from the mean of the previous three sessions.

In addition to the baseline (B) condition, the three other observing conditions were as follows. (1) S^{10} only (S^{10})—Here, a treadle press resulted in a stimulus change (white to red) only if the DRO 10-sec component was in effect. An observing response during the DRO 30-sec component was recorded but had no scheduled consequence. (2) S^{30} only (S^{30})—In this case, a treadle press had an effect (white to green) only when the DRO 30-sec component was programmed. All other observing responses were recorded but had no scheduled effect. (3) NC—During this condition, all treadle presses were recorded, but they had no scheduled effect.

Phase 2: FT schedules. Upon completion of Phase 1, each subject was exposed to a procedure in which FT schedules were employed instead of the DRO schedules of Phase 1. Under FT

schedules, a subject received reinforcement after a fixed amount of time, regardless of the subject's behavior. The same apparatus was used in both phases.

Multiple-schedule training. Immediately upon completion of the last DRO NC observing condition of Phase 1, subjects were exposed to a mult FT 10-sec FT 30-sec schedule of reinforcement for 12 sessions. The only difference between this condition and the multiple-schedule training condition in Phase 1 was that, although keypecks were recorded, they had no scheduled consequence.

Manipulations in the observing procedure. The conditions were identical to those in Phase 1, with the exception that keypecks had no programmed consequence. Each subject in Phase 2 received the same sequence of conditions it received in Phase 1. Conditions changed after 18 sessions (provided there was no consistent trend in the probability of an observing response over 3 days), except for the NC and the M conditions, which were terminated after 12 sessions.

RESULTS

Each subject's treadle presses were recorded, and the probability of an observing response was calculated. The term "observing response" will be used for all treadle presses, although this response was not necessarily under the control of its consequences (e.g., during the mult and NC conditions in which a treadle press had no consequence).

Phase 1

Figure 1 shows the means and standard deviations of the probability of an observing response [$P(R_0)$] per session for the last 5 days of each condition for each bird in Phase 1. The data are shown in the sequential order of conditions to which each bird was exposed.

As can be seen in Figure 1 (top), there was no consistent preference for either the S^{10} or the S^{30} discriminative stimulus. Pigeons B1 and B2 demonstrated decreasing $P(R_0)$ s across observing conditions. Pigeons B6 and B7 showed higher $P(R_0)$ s in the NC condition than in the S^{10} and S^{30} conditions. This suggests that treadle pressing was not under good stimulus control by the S^{10} stimulus. In addition, the variability, as measured by the standard deviation, was large in each condition for all birds. Finally, the $P(R_0)$ s demonstrated by the birds in the observing conditions of this phase rarely were higher than the operant levels of treadle pressing obtained in the mult or NC conditions.

The proportion of total time spent in each of the two DRO components was calculated for each subject and each observing condition. Two of the five birds (B1 and B7) did spend a disproportionately large amount of time in the S^{10} component under the baseline and S^{10} conditions by pecking the center key and producing blackouts. However, the greater amount of exposure to the S^{10} condition, in contrast to the S^{30} condition, seemed to have little effect, since the $P(R_0)$ during these conditions was not systematically different from those obtained from the other three birds.

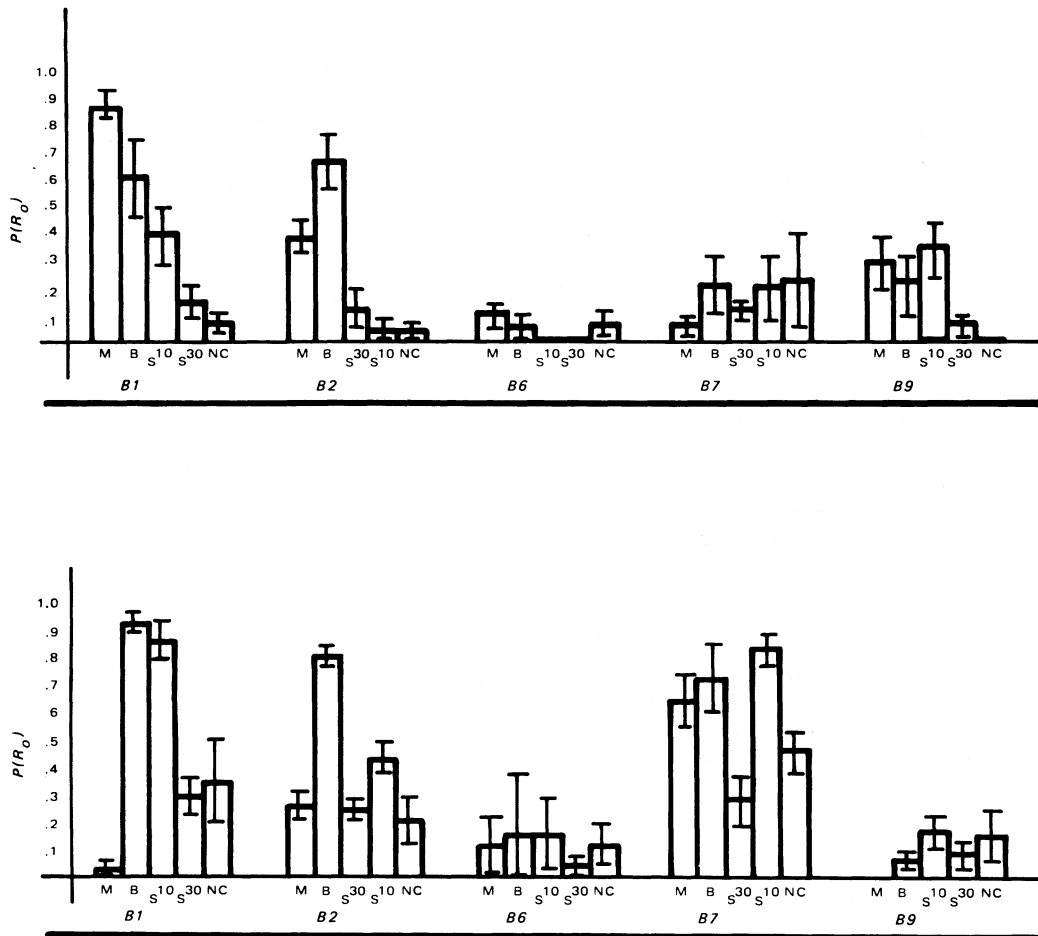


Figure 1. The means and standard deviations of the probability of an observing response [$P(R_0)$] for the last 5 days of each condition for each subject in Phase 1 (top: DRO) and Phase 2 (bottom: FT). Bars represent the means, and the standard deviations are represented by the vertical lines. Data are shown in the sequential order of conditions to which each bird was exposed.

Phase 2

Figure 1 (bottom) presents the means and standard deviations of the probability of an observing response [$P(R_0)$] per session for the last 5 days of each condition for each bird in Phase 2. Again, the data are presented in the sequential order of conditions to which each bird was exposed.

In this phase, in which the DRO components were changed to FT components, all five subjects demonstrated higher $P(R_0)$ s during the S^{10} condition than during the S^{30} or NC conditions. [Four of the five birds (B1, B6, B7, B9) produced $P(R_0)$ s during the last 5 days of the S^{30} condition that were lower than that of the NC condition; see Figure 1.]

The differences between the results of Phase 1 and Phase 2 are considerable. In Phase 2, in which the schedules were FT instead of DRO, the birds demonstrated a large and consistent preference for the S^{10} stimulus over the S^{30} stimulus. The $P(R_0)$ data of Phase 1 showed that these same birds were, for the most

part, indifferent toward the two stimuli. No consistent order (sequence of conditions) effects were observed in either phase of the experiment.

Table 1 presents the subjects' keypeck responses in each of the conditions. Although all of the birds keypecked occasionally during the DRO conditions, four of the five birds demonstrated good DRO performance, in that they made few keypeck responses. Pigeon B7 responded more than the others, but it produced far fewer keypecks during the DRO phase than during the FT phase, suggesting that there was adequate schedule control. All birds generally responded more during the FT phase.

DISCUSSION

Within the context of a schedule composed of two different interreinforcement intervals, the present study examined the effects of manipulating response requirement on observing behavior. It was found that under the FT schedules, subjects produced the S^{10} stimulus more often than the S^{30} stimulus,

Table 1
Trials With A Keypeck Response During All Stimuli
for Each Bird in Each Condition

Sub- ject	Condition									
	Phase 1 (DRO)					Phase 2 (FT)				
	M	B	S ^{1°}	S ^{3°}	NC	M	B	S ^{1°}	S ^{3°}	NC
B1	1	111	98	5	3	20	259	312	100	18
B2	39	34	23	17	7	63	197	72	65	18
B6	83	47	1	23	17	74	37	9	3	0
B7	14	138	134	179	67	191	411	425	453	271
B9	47	46	77	91	64	74	228	168	67	52

but this was not true under DRO schedules, in which the S^{1°} and S^{3°} stimuli were produced about equally.

A close examination of the DRO and FT schedules reveals a number of factors that might account for the differences in observing behavior under these schedules. First, had the birds responded consistently more often to the S^{1°} stimulus than to the S^{3°} stimulus in the DRO phase, the conditioned reinforcing strength of the S^{1°} stimulus might have been considerably reduced. Such was not the case; for three birds, more trials with a keypeck were recorded in the S^{3°} component. Accordingly, amount of responding could not account for the differences in observing between these two schedules.

A second factor to consider is difference in schedule requirements: a zero response rate requirement in the DRO schedule and the absence of any response requirement in the FT schedule. Fantino (1968) and Moore and Fantino (1975), using concurrent-chain schedules, have shown that a stimulus' conditioned reinforcement strength diminishes when it signals a period of non-reinforcement in which one or more responses are required. However, these studies involved response requirements that produced a higher than zero response rate. The DRO schedule, in contrast, required the absence of a response for food delivery during a stimulus that signaled reinforcement. Thus, it is difficult to implicate or rule out the DRO response requirement as the factor responsible for the lack of differential observing in this schedule.

A third factor that also seems relevant concerns the stimulus characteristics of the DRO schedule. Unlike the stimuli in the FT schedule, the S^{1°} and S^{3°} stimuli in the DRO schedules were not perfectly correlated with food. If either the red or green stimulus had been produced by a treadle press, a keypeck would produce a blackout, followed by the presentation of the white mixed-schedule stimulus. Thus, neither of these stimuli was 100% predictive of reinforcement, since all birds occasionally

keypecked in the presence of these stimuli. Kendall (1973) has shown that response rate produced by a stimulus varies as the probability of reinforcement is varied. Specifically, "the greater the probability of reinforcement. . . , the higher the response rate" (Kendall, 1973, p. 73). In a similar fashion, the DRO stimuli in the present study (S^{1°} and S^{3°}) may have become poor indicators of delay to reinforcement (unlike the FT stimuli) and, therefore, may have functioned similarly as weak conditioned reinforcers (or neutral stimuli).

By observing differentially to the S^{1°} and S^{3°} stimuli under the FT schedule, the birds provided data that support Fantino's delay-reduction hypothesis. Moreover, because these data result from an observing procedure, instead of the concurrent-chain schedule procedure typically used, the generality of Fantino's hypothesis is extended. The absence of differential responding to the S^{1°} and S^{3°} stimuli under the DRO schedule does not necessarily contradict Fantino's hypothesis. Either the zero-rate response requirement or the fact that the S^{1°} and S^{3°} stimuli were unreliable predictors of food in this schedule could have reduced the effectiveness of these stimuli as conditioned reinforcers.

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