IMPAIRMENT OF PERFORMANCE WHEN A DISCRIMINATIVE STIMULUS IS CORRELATED WITH A REINFORCEMENT CONTINGENCY

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Ratio-like behavior can be produced under temporally defined reinforcement schedules (Schoenfeld, Cumming, & Hearst, 1956; Hearst, 1958; Clark, 1959; Millenson, 1959; Schoenfeld & Cumming, 1960). Hearst (1958) describes such schedules as follows: "The terms t^D and t^A . . . are respectively . . . time periods during which (a) reinforcement may be given and (b) reinforcement is never given. The simplest cases arise where t^D and t^A are held constant and are alternated, and only the first response in t^D is reinforced."¹ Under this system, failure to respond during t^D results in missed reinforcements.²

When t^D exceeds a few seconds in a repeating t^D and t^A cycle of from 30 seconds to several minutes, pigeons develop fixed-interval performance (Hearst, 1958; Clark, 1959). Reduction of t^D to about 0.5 second results in missed reinforcements and ratio-like responding. Therefore, a single temporal parameter, the variation of t^D , yields qualitatively differing response patterns.

If a discriminable stimulus change is presented concomitant with a lengthy t^D , typical fixed-interval behavior is unlikely to occur.³ Instead, a stimulus discrimination, characterized by a very few t^A responses, will probably arise.⁴ Short t^D periods may also be paired with a discriminative stimulus (s^D). Preliminary studies (Weissman, 1958) show that reduction of the duration of periodically recurring s^D 's to something less than a second brings about rapid extinction in rats initially well trained on a discrimination. In contrast, animals which discriminate poorly respond with unusually rapid rates during s^A when s^D is similarly reduced.

The present experiment expands on these findings. Changes in the key-pecking behavior of pigeons are investigated when t^D is reduced in duration under

three conditions: (a) When t^D is accompanied by an s^D and the stimulus discrimination is well formed; (b) when t^D is unaccompanied by an s^D ; and (c) when t^D is accompanied by an s^D but the discrimination is poorly formed.

METHOD

Subjects

Five White Carneaux hen pigeons were the subjects. They were 2 years old when obtained, and were fed freely for 3 weeks. Thereafter, food reinforcements plus supplemental feeding maintained their body weights at about 80% of the final free-feeding levels.

Apparatus

A commercial Skinner box (Foringer & Co., Inc., Rockville, Md.) was used. Its important working parts were a Gerbrands pigeon key, which could be illuminated white or green, and a solenoid-operated reinforcement magazine. External circuitry automatically programmed stimulus conditions and recorded key pecks.

PROCEDURE

The birds were first trained by known procedures (Ferster, 1953) to peck at a green key for reinforcement (3 seconds' access to a mixture of grains). The experiment proper began after this initial training. Succeeding experimental sessions were all 1 hour and were conducted 5 days each week.

Other than reinforcements earned during sessions, the only food allowed to the pigeons was enough grain to bring their body weights to 80% of their free-feeding levels. This supplemental food was given immediately after each session.

Part I

During each session, the key was illuminated green every 90 seconds (the $s^D + s^A$ cycle length). A key peck while the key was green produced a reinforcement and changed the key color to white. Key pecks were not reinforced until the key was again green. (See footnote 3.) For 30 sessions, the green illumination (s^D) in each cycle lasted a maximum of 30 seconds. Thus, if the subject ever failed to peck the green key within 30 seconds of its onset, s^A (white) was reinstated and the bird missed a reinforcement. The maximum duration of s^D periods was then reduced to 3, 1, and 0.5 seconds. Birds were subjected to each s^D value except 0.5 second for 30 1-hour sessions; only two sessions were devoted to the 0.5-second value.

¹Schoenfeld, Cumming, and Hearst (1956) present a fuller exposition of the system.

²These temporally defined reinforcement schedules are virtually identical to "limited-hold" schedules (Ferster & Skinner, 1957).

³When no exteroceptive stimulus accompanies t^D , it is inconsequential, in practice, whether t^D is said to end immediately after a reinforcement or whether only the first response in t^D is said to be reinforced. This paper deals with t^D as if it ends either after a reinforcement or after its timed duration has expired. When s^D is added, it therefore terminates when a reinforcement is received.

⁴Dinsmoor (1951), Morse (1955), and Weissman (1958) have shown, however, that those relatively few s^A responses which are emitted during a regularly cycled stimulus discrimination are not randomly distributed in time. Possibly because of "spurious" reinforcement, they show a positive acceleration as s^D is approached.

Table 1

Part I: Number of Reinforcements and s^a Responses at Each s^D Value

Pigeon	s ^D Value (seconds) *							
	30		3		1		0.5**	
	S ^R 's	s ^a resp.	S ^R 's	s ^a resp.	S ^R 's	s ^a resp.	S ^R 's	s ^a resp.
A-1	40	1	27	2	0	0	0	0
A-2	40	7	38	3	26	6	0	0
A-3	40	0	38	1	31	10	0	0
A-4	40	0	39	0	0	0	0	0
A-6	40	3	37	1	8	1	0	0

*Medians of the last five sessions are given for each pigeon.

**Only two sessions were run at this value.

Table 2

Part II: Number of Reinforcements and t^a Responses at Each t^D Value

Pigeon	t ^D Value (seconds) *							
	30		3		1		0.5	
	S ^R 's	t ^a resp.	S ^R 's	t ^a resp.	S ^R 's	t ^a resp.	S ^R 's	t ^a resp.
A-1	39	3649	36	4138	27	4816	29	5572
A-2	40	2019	36	2553	33	3605	35	3555
A-3	39	3400	40	3790	35	5090	40	5271
A-4	40	1890	39	2053	15	3804	8	2797
A-6	39	2488	40	3029	35	3758	26	3414

Table 3

Part III: Number of Reinforcements and s^a Responses at Each s^D Value

Pigeon	s ^D Value (seconds) *					
	1		0.5		0.3	
	S ^R 's	s ^a resp.	S ^R 's	s ^a resp.	S ^R 's	s ^a resp.
A-1	19	582	0	0	0	0
A-2	22	2178	16	2912	0	0
A-3	4	908	6	2857	0	0
A-4	23	1562	15	1378	14	2343
A-6	37	843	35	1145	22	2030

Fig. 1. Cumulative-response curves of Pigeon A-4 corresponding to median days in Tables 1-3. Signal marks on the curves represent reinforcements.

Each session consisted of 40 identical $s^D + s^A$ cycles of 90 seconds.

Part II

After the 0.5-second s^D value in Part I, the $t^D + t^A$ paradigm of Schoenfeld, Cumming, and Hearst (1956) was reproduced; $t^D + t^A$ was set at 90 seconds. Because the green-key illumination was continuous through both t^D and t^A , stimulus discrimination was impossible; t^D was reduced in 10-session steps from 30 seconds to 3, 1, and 0.5 seconds.

Part III

After the 0.5-second t^D value in Part II, the discrimination procedure of Part I was reinstated. Maximum s^D durations were reduced in 10-session steps from 1 second to 0.5 and 0.3 second.

RESULTS

Table 1 summarizes the effect of reducing s^D from 30 to 0.5 seconds in a 90-second $s^D + s^A$ cycle. Median session totals of s^A responding and total reinforcements (s^R 's) are shown. At the 30-second s^D , the birds responded in every s^D period and missed no s^R 's. When s^D equaled 3 seconds, few s^R 's were missed. During exposure to an s^D of 1 second, responding of Pigeons A-1 and A-4 was extinguished. The other birds were missing substantial numbers of s^R 's. When s^D was re-

duced further to 0.5 second, all of the birds' responding was extinguished. The s^A responding did not change consistently except under extinction. At all s^D values, the s^A response totals signified s^A rates of far less than 1 response per minute.

Table 2 shows the effect of reducing the t^D in Part II. At 30- and 3-second t^D values, very few s^R 's were missed. At 1- and 0.5-second t^D values, progressively increasing numbers of s^R 's were usually missed, but more were obtained than at corresponding s^D values in Part I. The t^A response totals were high, and they usually increased as t^D was reduced. (For practical purposes, t^A totals are virtually identical with t^A responses per hour.)

Figure 1 presents cumulative curves for Pigeon A-4 from the median days recorded in Tables 1, 2, and 3. Curves from Parts I and II are substantially representative of those of all the pigeons. The reduction in t^D produced a ratio-like curve, although less clearly than Hearst (1958) and Clark (1959) reported. (These investigators ran individual t^D values until stability criteria were met.)

Table 3 presents results of Part III. When s^D equaled 1 second, the stimulus discrimination was much worse than in Part I. High s^A rates were common. Unlike the results of Part I, all the birds earned s^R 's at this s^D value. Reduction of s^D to 0.5 and 0.3 second eliminated first one and then three birds from responding. Nevertheless, the number of s^R 's received

contrasts strikingly with the universal extinction observed in Part I when s^D was equal to 0.5 second.

In Part III, the birds tended to respond with increased s^A rates when s^D was reduced until extinction arose. Pigeon A-4's cumulative records at 1.0- and 0.5-second s^D values (Fig. 1) reveal fixed-interval characteristics. Low rates followed earned and missed s^R 's. These increased to produce typical fixed-interval scallops. At the 0.3-second s^D value, ratio-like behavior appeared, evidenced by long breaks resembling straining, and high, steady response rates. However, some t^D and t^A cycles still resulted in fixed-interval scallops initiated by either received or missed s^R 's.

DISCUSSION

Results of Part II corroborate previous findings which relate behavioral changes to step-by-step reductions in t^D duration. When t^D was reduced to about 1 second in a 90-second $t^D + t^A$ cycle length, rapid ratio-like responding replaced the fixed-interval performance at longer t^D durations.

In Part I, t^D was also accompanied by a discriminative stimulus (s^D). Under this condition, prolonged exposure to s^D durations of over a few seconds resulted in very low s^A rates and consistent responding in s^D . Comparatively rapid extinction arose when s^D was reduced step by step to about 1 second in a 90-second $s^D + s^A$ cycle length.

A comparison of these results from Parts I and II indicates that situations can be devised in which a discriminative stimulus impairs appropriate performance as measured by the s^R 's. The subjects responded with quick reaction times in Part I when s^D equaled 3 seconds. However, reduction of s^D to 0.5 or 1.0 second produced a reaction-time requirement which could not be met. In Part II, the identical temporal procedure contained no s^D . High rates were differentiated out; by means of sustained high rates, subjects did respond and consistently obtain s^R 's in t^D periods as short as 0.5 second.

The degree of discriminative control exerted by s^D determines whether extinction will occur at low s^D values. In Part III, s^A responding was never fully extinguished, although some degree of stimulus discrimination had developed. As a result, high rates were differentiated out at low s^D values in Part III. These high rates qualitatively resembled fixed-interval behavior and also fixed-ratio behavior at a 0.3-second s^D duration. Temporal characteristics of s^D and level of discriminative training may therefore be manipulated to reconcile behavior under stimulus discriminations and certain "pure" reinforcement schedules.⁵ Previous attempts at such reconciliation have relied

upon principles of stimulus generalization (e.g., Frick, 1948; Cumming, 1955).

The present experiments exemplify fixation procedures in which extremely strong stimulus control causes maladaptive behavior to persist despite new and apparently simple reinforcement contingencies. They demonstrate that the low s^A response rates evoked by prolonged exposure to a discriminative procedure may lead to very inappropriate behavior.

SUMMARY

Pigeons were exposed to a series of temporally defined reinforcement schedules. Recurring 90-second cycles in each experimental session consisted of one period (t^D) in which the first key peck was reinforced, and another period (t^A) in which key pecks went unreinforced. The duration of t^D was reduced in three successive parts. In Part I, a discriminative stimulus (s^D) accompanied t^D , and the birds were given prolonged discrimination training at each t^D value; in Part II, t^D was not accompanied by s^D ; and in Part III, t^D was again accompanied by s^D , but little discriminative training was allowed.

In Part I, all responding had extinguished when the s^D value reached 0.5 second. In Part II, fixed-interval responding characterized high t^D values; low t^D values produced rapid ratio-like behavior. In Part III, the reduction of s^D resulted in high rates when s^D was 0.3 second despite the presentation of s^D .

Previous findings relating behavior to reductions in t^D duration are confirmed (Part II). The pairing of t^D with an s^D is shown to lead to inappropriate behavior and rapid extinction at low s^D durations if prolonged discriminative training is given at long s^D durations (Part I). Without prolonged discriminative training, the pairing of t^D with an s^D leads to rapid responding with qualitative characteristics of fixed-interval and ratio schedules at low s^D durations (Part III).

ACKNOWLEDGMENT

The technical assistance of Mrs. Elizabeth M. Sullivan is gratefully acknowledged.

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⁵Skinner (1938, p. 183) describes the experimental procedure used to produce a simple operant discrimination: "In the act of throwing switches to both the source of s^D and the magazine at once the fundamental condition of a discrimination of this sort is epitomized."

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Received March 8, 1961.