

Unconfounding time and number discrimination in a Mechner counting schedule

DONALD M. WILKIE, JANET B. WEBSTER, and LESLIE G. LEADER
University of British Columbia, Vancouver, British Columbia V6T 1W5, Canada

Food-deprived pigeons were trained on a modified Mechner counting schedule under which a peck at the center key produced grain reinforcement provided that this response was preceded by *n* or more consecutive pecks at the left key. Each peck at the left key produced either a fixed- or a variable-duration blackout. In the former, but not the latter, procedure, confounding of a fixed time period between the first and last responses on the left key and number of responses on the left key was possible. The results showed that the count of responses, independent of the duration of responding, may act as a controlling stimulus.

Animals' performance on fixed-ratio discrimination (e.g., Hobson, 1975; Pliskoff & Goldiamond, 1966; Rilling & McDiarmid, 1965) and related procedures (e.g., Buchman & Zeiler, 1975; Rilling, 1967; Dodd, Note 1) suggests that response number may act as a controlling stimulus.

Performance on so-called counting schedules also has been taken as evidence that response number may act as a controlling stimulus. Mechner and Guevrekian (1962), for example, required that rats press one lever (B) at least four consecutive times before a press on another lever (A) produced a water reinforcer. The fact that the modal number of presses made on Lever B between presses on Lever A was very close to four was taken as evidence of control of Lever A responses by the count of Lever B responses.

It is ambiguous, however, if such results are evidence of control by number of responses because (1) a sequence of a fixed number of responses is likely to be reasonably invariant in duration, and (2) responding may be controlled by duration of events (e.g., Reynolds & Catania, 1962; Zirix & Silberberg, 1978). Thus, the time between the first and last B responses rather than the number of B responses might be the controlling stimulus.

There is some evidence that number rather than duration controls responding in the Mechner schedule. Laties (1972) found that injections of haloperidol decreased pigeons' rate of pecking response Key B (and thus increased the time from first to last B response)

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without affecting accuracy of switching to respond on response Key A.

We attempted to provide further evidence on this issue. We modified the Mechner counting schedule so that each B response produced a blackout (both A and B keys turned off) that lasted for a variable amount of time. We reasoned that such a procedure would decrease the number of times responding on A would be reinforced if the pigeons' responding was controlled by the time between the first and last B responses rather than by the number of B responses.

METHOD

Subjects

Two adult Silver King pigeons were maintained at about 85% of their free-feeding weights by mixed grain obtained during and after experimental sessions. The birds had unlimited access to water and grit in their home cages. Both birds were experimentally naive.

Apparatus

One wall of a BRS/LVE Model PS-004 lightproof, sound-attenuating chamber contained three clear plastic pecking keys arranged in a row, a grain feeder, and three Industrial Electronics Engineers' Series 10 projectors. The projectors, which were mounted behind the keys, illuminated the keys during trials with a uniform field of green light. The feeder was located directly below the center key. The feeder, when operated, permitted timed access to mixed grain illuminated by a lamp. The chamber was dark except for the projector and feeder light. A fan ventilated the chamber and provided masking noise. Experimental conditions and data recording were implemented by the ACT language (Millenson, 1973) running on a Data General Nova 3/12 computer connected to the chamber via BRS/LVE Interact interface.

Procedure

The birds received experimental sessions at approximately the same time each day, 7 days/week, for the duration of the experiment.

The birds first were trained to eat mixed grain from the feeder during five sessions in each of which the hopper was raised and illuminated for 60 5-sec periods at variable intervals averaging 60 sec. In the next two sessions, the birds were trained, using the method of reinforcing successive approximations,

to peck the center key, which was illuminated with green light. Each keypeck produced 5-sec access to mixed grain. Each bird was allowed to obtain 45 reinforcers per session. The third stage of preliminary training lasted three sessions. Each session lasted until 45 reinforcers were obtained. In these sessions, the left-hand key was illuminated with green light. Two pecks on this key turned it off and caused the illumination of the center key with green light. A single peck on the center key produced 5-sec access to grain and turned off the center key light. At the end of the reinforcement period, the left key was again illuminated.

The first stage of the experiment proper consisted of 104 sessions. As a rule, each session lasted until 45 reinforcers were obtained. In these sessions both the center and left-hand key normally were illuminated with green light. Each peck at the illuminated left key produced a minimum 1.0-sec blackout in which both keys were turned off and pecks had no consequences. After 1.0 sec of blackout, the probability was p that the blackout would terminate and $1 - p$, or q , that it would continue. If the blackout did continue, it lasted for another .5 sec, after which the probability was again p that it would terminate. The probability of the blackout ending at the i th .5-sec interval was $p \times q^{i-1}$, where q^{i-1} was the probability of an i th interval occurring. The value of p was gradually changed over these sessions from 1/2 to 1/8. The value of p was 1/8 for the final 22 sessions. These sessions were designated as Condition 1. Every time the illuminated center key was pecked, both keys were turned off for 5.0 sec and pecks had no consequences. If the left-hand key had not been pecked or had been pecked only once since the last time the center key had been pecked, this 5-sec period was a blackout. If two or more consecutive left keypecks had intervened between center keypecks, the center keypeck produced food reinforcement. For Bird 2 reinforcement was 5.0-sec access to the hopper. For Bird 1 reinforcement was 5.0-sec access to the hopper for a random 50% of the time; for the other 50%, the hopper was raised for .5 sec, followed by 4.5 sec of blackout.

Condition 2 was the same as the first except that left keypecks produced blackouts that were always 1.0 sec (see Table 1 for details). Condition 3 was the same as Condition 1. Conditions 4 and 5 were the same as Conditions 2 and 3 except that the reinforcement period for Bird 1 was made identical to that of the other bird. In Condition 6 the required number of consecutive left keypecks was increased to three or more and blackout probability was 1/4. In Condition 7 the blackout was fixed at 1.0 sec.

RESULTS AND DISCUSSION

The last 60 (40 for the last two conditions) center keypecks from each session were analyzed.¹ The data of primary interest were the frequencies with which

Table 2
Frequency with which Different Numbers of Left Keypecks (0, 1, 2, etc.) Preceded Center Keypecks during Conditions 1-3 in which at Least Two Left Keypecks were Required

	Number of Left Keypecks											
	Bird 1					Bird 2						
	0	1	2	3	4	5	0	1	2	3	4	5
Day	Condition 1											
1	2	10	43	2	0	0	1	14	42	2	1	0
2	4	10	44	4	0	0	2	16	38	4	0	0
3	1	6	49	2	0	0	1	29	29	1	0	0
4	4	8	46	1	0	0	0	18	38	4	0	0
5	2	7	50	6	0	0	4	10	42	4	0	0
6	4	10	39	2	1	0	4	25	28	3	0	0
7	5	5	44	2	1	0	0	18	35	6	1	0
8	1	7	48	2	2	0	3	13	37	7	0	0
9	2	4	52	2	0	0	2	7	38	7	1	0
10	1	4	53	2	0	0	2	22	32	4	0	0
Total	26	71	468	25	4	0	19	172	359	42	3	0
Day	Condition 2											
1	0	8	47	3	2	0	1	16	34	8	1	0
2	0	4	53	3	0	0	0	15	34	9	1	0
3	0	2	56	2	0	0	1	15	34	9	1	0
4	0	4	54	2	0	0	0	17	39	4	0	0
5	1	12	45	2	0	0	1	24	35	0	0	0
6	0	2	57	1	0	0	0	22	34	4	0	0
7	1	4	54	1	0	0	1	14	35	10	0	0
8	0	0	57	3	0	0	0	26	31	3	0	0
9	0	5	54	1	0	0	2	28	28	2	0	0
10	1	7	52	0	0	0	1	20	35	4	0	0
Total	3	48	529	18	2	0	7	198	335	57	3	0
Day	Condition 3											
1	1	6	47	5	1	0	0	29	29	2	0	0
2	1	5	51	3	1	0	7	23	29	1	0	0
3	4	9	43	3	1	0	1	30	27	2	0	0
4	5	12	41	1	1	0	1	10	38	2	1	0
5	3	13	41	2	1	0	5	17	34	3	1	0
6	4	13	32	0	0	1	1	14	44	1	0	0
7	1	5	49	5	0	0	0	10	39	4	2	1
8	5	10	45	0	0	0	2	7	38	7	1	0
9	1	11	47	1	0	0	1	14	45	0	0	0
10	0	9	51	0	0	0	1	19	39	1	0	0
Total	25	93	447	20	4	1	19	181	362	23	5	1

different numbers of left keypecks preceded these center keypecks. Table 2 shows the frequency with which 0, 1, 2, 3, . . . left keypecks preceded a center keypeck during the first three two-peck requirement phases (Conditions 1-3). Two things are apparent in this table. First, both pigeons most frequently made two left keypecks before pecking the center key. Hence, most center keypecks were reinforced. Second, performance under the fixed and variable blackout conditions was essentially indistinguishable. This result suggests that it is the count of left keypecks rather than the time from first to second left keypecks that is critical in controlling center keypecks, since the latter stimulus was not constant in the variable blackout conditions. This conclusion can be verified by examining data from Conditions 4 and 5. Figure 1 shows the

Table 1
Summary of Procedure

Condition	Key-pecks	Blackout	Number of Sessions
1	2	variable (p = 1/8)	22
2	2	fixed (1 sec)	10
3	2	variable (p = 1/8)	10
4	2	fixed (1 sec)	5
5	2	variable (p = 1/8)	5
6	3	fixed (1 sec)	14
7	3	variable (p = 1/4)	10

Note—"Keypecks" refers to the minimum number of left keypecks required.

Table 3
Frequency with which Different Numbers of Left Keypecks (0, 1, 2, etc.) Preceded Center Keypecks during Conditions 6 (Fixed Blackout) and 7 (Variable Blackout) in which at Least Three Left Keypecks were Required

Condi- tion	Bird	Number of Left Keypecks							Time (Seconds) from First to Third Left Keypeck								
		0	1	2	3	4	5	>5	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10
6	1	1	5	31	64	14	4	1	27	33	4	0	0	0	0	0	0
	2	1	3	38	59	14	3	2	15	38	5	0	1	0	0	0	0
7	1	0	1	36	64	16	3	0	0	10	13	15	7	5	5	4	5
	2	0	3	44	66	7	0	0	0	9	10	13	14	5	7	2	6

Note—The time between the first and third of the sequence of three left keypecks preceding a center keypeck is also shown. Data are sums over the last three sessions of the conditions.

frequency with which different numbers of left keypecks preceded a center keypeck and the frequency of intervals (IRT) between two consecutive pecks on the left key preceding a center keypeck. As can be seen in the top panels, both birds most often made two left keypecks before pecking the center key during both fixed and variable blackout conditions. Indeed, the functions for the two conditions were essentially indistinguishable.

The bottom panels of Figure 1 show that the modal time between two left keypecks preceding a center keypeck was in the 1.0- to 2.0-sec class for both birds during the fixed blackout condition. Thus, a fixed amount of time from first to last left keypeck normally preceded a reinforced center keypeck. These data make it unclear if it is left-key response sequence duration or count that controls center-key responding. The variable blackout data, however, show that duration is unimportant. Even though the time between two left

keypecks varied considerably from 2 sec, both birds switched to the center key after two left keypecks with the same frequency.

Table 3 shows data, similar to that shown in Figure 1, from the three-peck requirement phases. These data replicate those from the two-peck requirement phases.

In conclusion, the results show that the number of responses in a sequence, independent of the duration of the sequence, may act as a controlling stimulus in a Mechner counting schedule.

REFERENCE NOTE

1. Dodd, P. W. D. *Stimulus properties of autoshaped responses*. Paper presented at the meeting of the Canadian Psychological Association, Ottawa, Ontario, 1978.

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NOTE

1. In a few sessions, fewer than 60 were available; in these cases, all were analyzed.

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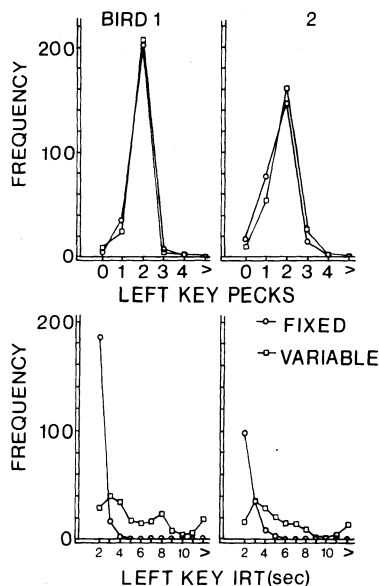


Figure 1. The top panels show the frequency with which the pigeons pecked the center key after different numbers of pecks on the left key. The bottom panels show the frequency of times between two left keypecks (IRT) that preceded a center keypeck. Values on the bottom panel abscissa are upper limits of IRT classes in seconds. The parameter in both top and bottom panels is blackout duration (fixed vs. variable). The data are sums across all five sessions of Conditions 4 and 5.