SECOND-ORDER SCHEDULES: BRIEF SHOCK AT THE COMPLETION OF EACH COMPONENT¹

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Pigeons worked on second-order schedules in which completion of fixed-interval component schedules was reinforced with food according to a variable-interval schedule of reinforcement. The completion of each fixed-interval component resulted in the presentation of a brief electric shock. In one condition (shock-paired), the completion of every fixed-interval component, including those that ended in food, resulted in the shock. In another condition (shock-nonpaired), completion resulted in shock except for those components that ended in food. Shock presentations resulted in a positively accelerated rate within fixed-interval components. This patterning within components was similar whether the shock was intermittently paired with food or not. Response rates tended to decrease as shock intensity increased. The characteristic fixed-interval response pattern within components did not occur when shock presentations were omitted at the end of each component (tandem schedule). When shocks were scheduled but food was no longer presented (extinction) response rates declined to a near-zero level. The performance under shock conditions is similar to that in other studies in which visual and auditory stimuli are presented at the completion of component schedules.

Kelleher (1966*b*, p. 476) defined a second-order schedule as a schedule "which treats a pattern of behavior engendered by a schedule contingency as a unitary response that is itself reinforced according to some schedule of reinforcement." If, for example, the completion of four fixed-interval schedules is required before food is presented, we may speak of the fixed interval as a component schedule that is reinforced according to a fixed-ratio schedule (FR 4). There are several ways in which stimuli have been arranged in second-order schedules. Under one arrangement, there is no change in exteroceptive stimuli from component to component; this type of second-order schedule has been called a tandem schedule (Ferster and Skinner, 1957). Under a second arrangement, the completion of each component results in the brief presentation of a stimulus, such as a 0.5-sec presentation of the feeder light (brief-stimulus schedule). Brief-stimulus schedules have been of two classes.

For one class, the brief stimulus is presented at the completion of each component including components in which the reinforcer is delivered. For the second type of brief-stimulus schedule, the stimulus is produced at the completion of each component except those components that terminate with reinforcement; accordingly, the stimulus is never paired with a reinforcer.

Under second-order schedules, brief-stimulus presentations at the completion of components have been shown to have marked effects on response rate and on the pattern of responding within components (Byrd and Marr, 1969; Davison, 1969; de Lorge, 1967, 1969, 1971; Ferster and Skinner, 1957; Findley and Brady, 1965; Kelleher, 1966*b*; Marr, 1969; Neuringer and Chung, 1967; Stubbs, 1969, 1971; Thomas and Stubbs, 1966, 1967; Zimmerman, 1960). The main, consistent finding is that brief-stimulus presentations engender patterns of performance within components similar to those produced when a reinforcer is presented. When, for example, fixed-interval components are used, the response pattern within components is characterized by positive acceleration. The effects of brief-stimulus presentations have been observed both when the brief stimulus has been intermittently paired with food (*e.g.*, Kelleher,

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1966*b*; Marr, 1969) and when it has not been paired (*e.g.*, Neuringer and Chung, 1967; Stubbs, 1971).

In all of the previous studies, a "neutral" stimulus such as a visual or auditory stimulus has been used for the brief-stimulus operation. In contrast, shock was used in the present study. Shock is an interesting stimulus because of its traditional role as an aversive stimulus (Azrin and Holz, 1966). When responses produce shocks, response rates are usually suppressed (see, however, Byrd, 1969; Kelleher and Morse, 1968; McKearney, 1969). The question in the present study was whether shock presentations would result in effects on performance similar to those when visual and auditory stimuli are presented at the completion of components of second-order schedules. Comparisons were made between conditions in which completion of all components, including those that also resulted in food, produced shock (shock-paired), conditions in which completion resulted in shock except when reinforcement occurred (shock-non-paired), and those in which completion resulted in no shock (tandem). Also under study were the effects of the omission of food (extinction) to assess whether the scheduled presentation of shocks alone would maintain responding.

METHOD

Subjects

Four adult White Carneaux pigeons were maintained at approximately 80% of their free-feeding weights throughout the experiment. The pigeons all had prior experimental histories. Two pigeons (219 and 224) had histories that included second-order schedules; no pigeon, however, had a prior history involving shock presentation.

Apparatus

A two-key chamber, similar in design to that described by Ferster and Skinner (1957) was used. Only the right key was used although the left key remained uncovered. A force of approximately 15 g (0.15N) was required for effective operations of the response key.

Electric shock (117 v 60 Hz) was delivered to each pigeon through stainless steel wires (18/8 stainless 0.06 cm) implanted after the method described by Azrin (1959). A harness arrange-

ment similar to Azrin's allowed the bird relatively free movement around the chamber. Shock was delivered by a circuit similar to one described by Ramsay, Knapp, and Zeiss (1970). An ammeter wired in series with the pigeon allowed for continual monitoring of the amount of current passing through each pigeon.

Sessions were controlled by relay circuitry; data were recorded on counters and a cumulative recorder. The scheduling and recording equipment was located in a room adjacent to the experimental chamber. White noise was present continually in the chamber to mask extraneous sounds.

Procedure

Each daily session lasted until 20 reinforcements had occurred. When long pauses occurred, sessions were terminated after 90 min if 20 reinforcements had not occurred. Five minutes before the start of each session in which shock was to be delivered, a given level of shock was delivered, measured directly across the pigeon, and calibrated. During the 5-min period, no lights were on in the chamber and responses had no scheduled consequences.

Performance was studied under second-order schedules in which a fixed-interval schedule was the component schedule maintained under a variable-interval schedule. The value of the fixed-interval schedule was 60 sec (FI 60-sec); the value of the variable-interval schedule was 240 sec (VI 240-sec). The intervals of the variable-interval schedule were arranged after the method described by Catania and Reynolds (1968, pp. 380-381). After Kelleher's (1966*b*) notation, the schedule may be characterized as VI 240-sec (FI 60-sec). Under this schedule, the pigeon completed a sequence of fixed-interval component schedules until an interval of the variable-interval schedule had elapsed; the completion of the next fixed interval produced food. Thus, food was presented only after a response that terminated a fixed-interval component. Although food presentations were scheduled on the average of one every 240 sec, the observed interreinforcement interval was greater than 240 sec. Typically, the pigeon was only part way through an FI component when an interval of the VI had elapsed; the FI requirement set a 60-sec lower limit on the interreinforcement interval. The response

key was transilluminated by green light. The reinforcer consisted of 5-sec access to grain during which the keylight was off and during which the feeder was illuminated by white light. A houselight was not used. Each effective response produced a feedback relay click.

The conditions after each FI 60-sec component was completed were varied (Table 1). In the first condition for all birds (tandem), the completion of each component resulted in no change in stimuli except when food was presented. In the shock-paired conditions, completion of each component resulted in a 0.5-sec presentation of shock; the keylight remained on during this period. When component completion resulted in food, the reinforced response produced the simultaneous onset of shock for 0.5 sec and the operation of the magazine for 5 sec. Accordingly, shock and food overlapped for 0.5 sec. This shock-paired condition may be characterized as a VI 240-sec (FI 60-sec:S^p), where S^p refers to the presentation of a stimulus intermittently paired with food. For the shock-nonpaired condition, completion of each component resulted in a 0.5-sec shock presentation except when food was presented; this condition was exactly the same as the shock-paired condition except that shock was never present during the magazine cycle (and, in fact, was always separated from

food presentation by a minimum of 60 sec). This condition may be characterized as VI 240-sec (FI 60-sec:Sⁿ) where Sⁿ refers to the presentation of a nonpaired stimulus.

Table 1 shows the various conditions in order of presentation. Each shock condition was continued arbitrarily, for 10 sessions (Shull and Pliskoff, 1967). The intensity of the shock was varied over conditions, and for two pigeons, 213 and 224, pairing and nonpairing operations were used. Shock was delivered at levels of 1, 2, and 4 mA.

As a final procedure, food presentations were discontinued (extinction) and responses simply produced shocks according to the FI 60-sec schedule. Here it is inappropriate to speak of the shock as S^p or Sⁿ because food was never presented. The final condition was in effect for 10 sessions.

RESULTS

Figures 1 and 2 show response rate as a function of fixed-interval quarters over the various experimental conditions. The data are medians of the last five sessions. The first four columns of Tables 2 and 3 also show the medians and the ranges for performance. The measures were obtained by calculating responses per second for each successive 15-sec

Table 1

The sequence of experimental conditions and the number of sessions in each condition.

<i>Pigeons</i>	<i>Schedule</i>	<i>Shock Level</i>	<i>Number of Sessions</i>
213 and 224	VI 240-sec (FI 60-sec)	—	20
	VI 240-sec (FI 60-sec:S ⁿ)	1 mA	10
	VI 240-sec (FI 60-sec:S ⁿ)	2 mA	10
	VI 240-sec (FI 60-sec:S ⁿ)	4 mA	10
	VI 240-sec (FI 60-sec:S ^p)	4 mA	10
	VI 240-sec (FI 60-sec:S ^p)	4 mA	10
	VI 240-sec (FI 60-sec:S ^p)	4 mA	10
	VI 240-sec (FI 60-sec:S ^p)	2 mA	10
	EXT (FI 60-sec → shock)	2 mA	10
154 and 219	VI 240-sec (FI 60-sec)	—	20
	VI 240-sec (FI 60-sec:S ^p)	1 mA	10
	VI 240-sec (FI 60-sec:S ^p)	2 mA	10
	VI 240-sec (FI 60-sec:S ^p)	4 mA	10
	VI 240-sec (FI 60-sec:S ^p)	2 mA	10
	VI 240-sec (FI 60-sec:S ^p)	1 mA	10
	VI 240-sec (FI 60-sec:S ^p)	2 mA*	10
	VI 240-sec (FI 60-sec:S ^p)	2 mA*	10
	EXT (FI 60-sec → shock)	2 mA	10

*These two conditions were identical; the condition was continued for 20 sessions but the data are presented as if two conditions were given.

period of the fixed-interval component. The responses following 60 sec did not enter into the calculations. Rates in the various quarters were used for calculations except for those in components that directly followed reinforcement; fixed-interval components following food were excluded because pauses typically followed each food presentation whether or not shocks were presented (Stubbs, 1971).

Figures 1 and 2 show that when shocks were presented, median response rates increased from first to fourth quarters in most conditions. This increase indicates a positively accelerated pattern of responding within components. The positively accelerated pattern was absent when shocks did not occur (tandem condition); under the tandem condition, there was a constant rate of responding across quarters. Figure 1 shows that fixed-interval patterning occurred whether or not shocks were intermittently paired with food. No systematic differences between results on the paired and

nonpaired procedures were observed: the variability between paired and nonpaired data was no greater than that between data for successive redeterminations of the same schedule conditions. Figures 1 and 2 show that acceleration across quarters generally occurred over the entire range of shock intensities unless complete suppression occurred. The main effect of increasing shock intensity was the lowering of response rates across all quarters. Pigeons 154 and 219 (Figure 2) showed almost complete suppression when a shock intensity of 4 mA was used. There was a slight tendency for the functions to steepen with increases in shock intensity (unless suppression occurred); Pigeons 213 and 224, for example, had steeper functions at 4 mA than at 2 mA, and Pigeon 219 generally had steeper functions at 2 mA

Fig. 1. Response rates in each quarter of fixed-interval components over the experimental conditions. The data represent medians of the last five sessions under each condition. The tandem condition is shown by squares, the nonpaired brief-stimulus conditions by circles, and the paired brief-stimulus conditions by triangles. Shock intensity is shown in the figure. The numbers, 1 to 8, show the order in which conditions were presented.

Fig. 2. Response rates in each quarter of fixed-interval components over the experimental conditions. The data represent medians of the last five sessions under each condition. The tandem condition is shown by squares and the paired-stimulus conditions by triangles. Shock intensity is shown in the figure. The numbers, 1 to 8, show the order in which conditions were presented.

than at 1 mA. However, these results did not always occur (see Pigeon 154).

There was a great deal of variability in the data. Some of this probably resulted from increases in patterning over conditions. Some variability, however, resulted from day-to-day fluctuation in overall response rates. Tables 2 and 3 show that variability was large throughout the course of the study and showed no tendency to decrease from session to session in the course of the study. Despite variability, positive acceleration was the main result. Examination of the ranges shows that acceleration occurred regardless of whether overall rates were high or low.

Response rates are not shown in Figures 1 and 2 for the condition under which food was

eliminated (extinction); under this condition, response rates dropped to a near-zero level within two or three sessions and remained at a negligible level for the remaining sessions.

Figures 3 and 4 show representative cumulative records for two pigeons. Figure 3, for Pigeon 224, includes a tandem record, two records when a 4-mA Sⁿ was scheduled, and a record when a 4-mA S^p was scheduled. Under the tandem schedule, response rate was generally constant; the main deviation from the constant rate was a pause following each food presentation. Under the brief-stimulus schedules, responding within components was generally positively accelerated. The brief-stimulus records show similar patterning whether shock was intermittently paired with food or not.

Table 2

Medians and ranges over the last five sessions of each experimental condition for response rates over fixed-interval quarters, total response rates, and reinforcements per hour.

Condition		Q ₁	Q ₂	Q ₃	Q ₄	Total Resp/sec	Reinf/hour
Pigeon 213	— 0 mA	1.22	1.20	1.17	1.17	0.67	11.9
		0.56-1.57	0.58-1.49	0.60-1.48	0.58-1.47	0.46-1.28	9.0-13.0
	S ⁿ 1 mA	0.96	1.29	1.29	1.32	1.13	14.8
		0.41-1.52	0.64-1.66	0.61-1.72	0.64-1.68	0.40-1.43	13.0-15.0
	S ⁿ 2 mA	1.21	1.20	1.16	1.21	1.06	12.6
		1.05-1.59	1.07-1.62	1.05-1.55	1.04-1.62	0.87-1.46	11.8-15.8
	S ⁿ 4 mA	0.56	0.84	1.11	1.20	0.77	13.7
		0.20-0.74	0.38-1.21	0.50-1.39	0.58-1.52	0.20-1.05	12.2-14.8
	S ^p 4 mA	0.16	0.36	0.34	0.49	0.41	6.1
		0.05-0.47	0.00-0.68	0.00-0.75	0.02-0.81	0.04-0.52	1.8-13.3
	S ⁿ 4 mA	0.08	0.15	0.16	0.17	0.04	7.20
		0.07-0.52	0.06-0.78	0.07-0.92	0.05-1.01	0.00-0.62	5.8-11.9
	S ^p 4 mA	0.19	0.42	0.44	0.49	0.08	7.9
		0.09-0.53	0.11-0.74	0.28-0.92	0.21-1.00	0.01-0.31	5.8- 9.7
	S ^p 2 mA	0.37	0.54	0.58	0.61	0.26	11.5
		0.24-0.98	0.31-1.15	0.35-1.26	0.35-1.28	0.13-0.96	8.6-14.8
EXT 2 mA		0.00	0.00	0.00	0.00	0.00	00.0
		0.00-0.00	0.00-0.00	0.00-0.01	0.00-0.02	0.00-0.00	00.0-00.0
Pigeon 224	— 0 mA	0.87	0.84	0.86	0.86	0.75	13.3
		0.64-0.94	0.64-0.94	0.61-0.95	0.64-0.92	0.61-0.88	13.0-16.2
	S ⁿ 1 mA	1.04	1.03	1.03	1.02	0.83	12.2
		0.78-1.12	0.86-1.22	0.96-1.17	0.96-1.20	0.71-1.07	10.1-19.8
	S ⁿ 2 mA	0.30	0.37	0.40	0.39	0.13	9.7
		0.01-0.48	0.01-0.68	0.00-0.70	0.00-0.76	0.01-0.55	7.6-12.2
	S ⁿ 4 mA	0.06	0.27	0.32	0.36	0.17	12.2
		0.03-0.13	0.10-0.64	0.16-0.78	0.17-0.83	0.05-0.56	9.7-12.6
	S ^p 4 mA	0.45	0.72	0.90	0.98	0.67	13.0
		0.13-0.82	0.29-1.03	0.49-1.11	0.64-1.12	0.32-0.83	12.2-14.4
	S ⁿ 4 mA	0.01	0.14	0.32	0.47	0.16	11.2
		0.00-0.13	0.06-0.35	0.09-0.64	0.22-0.72	0.03-0.38	7.6-13.0
	S ^p 4 mA	0.14	0.30	0.51	0.62	0.26	10.4
		0.04-0.22	0.17-0.50	0.28-0.71	0.30-1.10	0.08-0.38	8.6-12.2
	S ^p 2 mA	0.92	1.01	1.02	0.92	0.76	13.0
		0.36-1.06	0.47-1.08	0.65-1.11	0.68-1.11	0.33-0.95	11.5-14.8
EXT 2 mA		0.00	0.01	0.03	0.00	0.00	00.0
		0.00-0.01	0.00-0.06	0.00-0.07	0.00 0.06	0.00-0.01	00.0-00.0

Table 3

Medians and ranges over the last five sessions of each experimental condition for response rates over fixed-interval quarters, total response rates, and reinforcements per hour.

Condition		Q ₁	Q ₂	Q ₃	Q ₄	Total Resp/sec	Reinf/hour
Pigeon 154	— 0 mA	1.38	1.42	1.40	1.40	1.28	13.3
		1.04-1.51	1.09-1.52	1.05-1.52	1.02-1.49	1.04-1.36	12.6-14.0
	Sp 1 mA	1.24	1.45	1.44	1.40	1.18	12.6
		0.90-1.82	1.11-1.79	1.09-1.75	1.01-1.76	0.84-1.48	10.8-14.4
	Sp 2 mA	1.90	2.05	1.94	1.86	1.72	13.7
		1.55-2.04	1.65-2.23	1.59-2.13	1.58-2.05	1.42-1.86	13.3-14.7
	Sp 4 mA	0.00	0.00	0.00	0.01	0.00	4.3
		0.00-0.00	0.00-0.00	0.00-0.01	0.00-0.05	0.00-0.01	0.0- 5.4
	Sp 2 mA	0.42	0.79	0.90	0.96	0.50	11.2
		0.01-1.00	0.01-1.68	0.01-1.74	0.04-1.70	0.01-1.24	6.5-14.4
	Sp 1 mA	0.38	0.97	1.30	1.40	0.66	12.6
		0.25-0.56	0.60-1.18	0.70-1.58	0.90-1.62	0.38-1.09	11.2-13.3
	Sp 2 mA	0.25	0.49	0.33	0.28	0.10	9.4
		0.00-0.48	0.00-0.92	0.00-1.08	0.00-0.96	0.00-0.71	0.7-11.1
	Sp 2 mA	0.03	0.05	0.06	0.05	0.00	7.2
EXT 2 mA		0.00-0.26	0.00-0.30	0.00-0.28	0.00-0.24	0.00-0.13	7.0- 9.7
		0.00	0.00	0.00	0.00	0.00	00.0
		0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00	00.0-00.0
Pigeon 219	— 0 mA	1.05	1.08	1.07	1.04	0.94	14.4
		0.97-1.29	0.95-1.27	0.96-1.27	0.94-1.23	0.89-1.18	13.0-14.8
	Sp 1 mA	0.82	0.89	0.95	1.00	0.90	14.0
		0.47-1.04	0.56-1.17	0.66-1.18	0.60-1.18	0.44-1.02	13.0-15.0
	Sp 2 mA	1.05	1.12	1.14	1.16	1.07	13.0
		0.88-1.09	0.95-1.36	0.97-1.40	0.94-1.30	0.88-1.11	12.6-13.7
	Sp 4 mA	0.01	0.00	0.01	0.02	0.01	8.6
		0.00-0.06	0.00-0.05	0.00-0.08	0.00-0.05	0.00-0.02	2.9-10.4
	Sp 2 mA	0.57	1.01	1.16	1.18	0.97	13.0
		0.27-0.72	0.61-1.16	0.79-1.31	0.89-1.30	0.36-1.00	12.2-14.0
	Sp 1 mA	0.56	0.76	0.92	0.96	0.79	13.0
		0.39-0.63	0.69-0.95	0.77-1.20	0.84-1.34	0.52-0.83	12.6-15.4
	Sp 2 mA	0.16	0.54	0.85	1.12	0.13	7.6
		0.06-0.48	0.36-0.99	0.34-1.42	0.45-1.47	0.08-0.91	5.0-12.6
	Sp 2 mA	0.42	0.80	0.98	1.03	0.65	12.2
EXT 2 mA		0.29-0.45	0.55-0.88	0.81-1.08	0.92-1.11	0.44-0.72	11.9-13.3
		0.00	0.00	0.00	0.00	0.00	00.0
		0.00-0.06	0.00-0.15	0.00-0.02	0.00-0.15	0.00-0.00	00.0-00.0

The middle brief-stimulus record shows the highest rates of the three brief-stimulus records; correlated with the higher rate was a decrease in the pause following shock presentations. All three brief-stimulus records show occasional pauses. Pauses like that shown occurred to different degrees for all subjects. The degree of pausing varied from session to session, from a negligible amount to almost an entire session. When long pauses occurred, they were generally observed at the start of a session.

Figure 4, for Pigeon 154, shows a tandem record and four records under 2-mA conditions: one record taken from the second determination at 2 mA and three records taken from the third determination. The tandem

record, like that for Pigeon 224, is characterized by a relatively constant rate except following food presentations. The positively accelerated pattern within components occurred under the shock conditions but was not as noticeable as was the pattern for Pigeon 224 (Figure 3). The bottom three records show the large amount of session-to-session variability: in one record there are no noticeable pauses, in the next, extreme pauses, and in the next, occasional pauses, with responding being generally rapid throughout the session.

Figure 5 shows median overall response rates and reinforcement rates under the various experimental conditions. Response rates were calculated by dividing the total number of responses per session by total session time ex-

Fig. 3. Portions of cumulative records for Pigeon 224. The top record shows performance under the tandem condition. The middle two records show performance under the nonpaired-stimulus condition with shock intensity at 4 mA; both records were taken from the sixth condition (see Figure 1). The bottom record shows performance under the paired-stimulus condition with shock intensity at 4 mA. Each response stepped the pen once. For the brief-stimulus conditions, downward deflections of the response pen indicate shock presentations; for the tandem condition deflections indicate the completion of a fixed-interval component. The response pen reset at the completion of each reinforcement cycle. The event pen was down whenever a reinforcer was scheduled by the variable-interval. The recorder motor ran continuously except during reinforcement periods.

cluding reinforcement periods. (This measure is more than a composite of the quarter-rate measures because responses in all fixed intervals were included, as were responses and time beyond the first 60 sec of an interval, *e.g.*, long pauses.) Reinforcement rates were calculated by dividing the number of reinforcements per session by total session duration excluding reinforcement time. Total response rates tended to decrease as shock level in-

creased; the rates, however, were variable over redeterminations of the same condition. There was a tendency shown by three pigeons for response rates to be lower with successive redeterminations at a particular intensity. To some degree, the lowering of rates was correlated with an increased steepening of the quarter-rate functions (Figures 1 and 2). Tandem response rates were higher in almost every case than any rates under shock conditions. As

Fig. 4. Portions of cumulative records for Pigeon 154. The top record shows tandem performance. The remaining records show performance under the paired-stimulus condition with shock intensity at 2 mA. One record was taken from Condition 5 while the bottom three records were from successive sessions under Condition 7 (see Figure 2). Each response stepped the response pen once. Downward deflections of the response pen indicate shock presentations (and the completion of an FI) under brief stimulus conditions; deflections indicate completion of a component under the tandem. The response pen reset at the completion of each reinforcement. The event pen was down whenever a reinforcer was scheduled by the variable interval. The recorder motor ran continuously except during reinforcement cycles.

response rates decreased substantially, reinforcement rates also decreased; decrements in response rates, however, were not always correlated with decrements in reinforcement rates.

Pigeon 154, for example, showed differences in response rates over the two determinations at the 2-mA shock level, yet reinforcement rates remained constant. Thus, decrements in

Fig. 5. Median response rates and reinforcement rates over the experimental conditions. The tandem condition is shown in the bars with stripes. The paired-stimulus conditions are represented by open bars while nonpaired-stimulus conditions are represented by filled bars. At each intensity level, the bars are arranged in the order of their occurrence, with first occurrence on the left and last occurrence on the right.

response rates were not necessarily the effect of changes in reinforcement rates.

DISCUSSION

When brief shocks were scheduled at the end of fixed-interval components of second-order schedules, positively accelerated response patterns occurred within components. The effects of shock appear similar to the effects of other brief stimuli on second-order schedule performance. There was essentially no difference between conditions in which shock was intermittently paired with food and those in which it was not. The present results agree with the results of Stubbs (1971). Across a wide variety of second-order schedules, Stubbs found that paired and nonpaired brief stimuli produced similar effects on the response pattern within components. The present results demonstrate that pairing is not a necessary condition for patterning to result, at least under the present conditions. Some authors have reported a difference between the effects of paired and nonpaired brief stimuli (Byrd and Marr, 1969; de Lorge, 1967, 1969; 1971; Kelleher, 1966*b*; Marr 1969). However, in these studies generally one stimulus (*e.g.*, keylight) was the paired stimulus and a second stimulus (*e.g.*, tone) was the nonpaired stimulus. The results of Stubbs (1971) demonstrated that different stimuli may have different effects on patterning, and that the use of different stimuli for pairing and nonpairing operations might have produced the effects rather than pairing or nonpairing *per se*. In the present study, the same stimulus was used for pairing and nonpairing operations and produced similar effects on performance.

The present findings augment past studies in two respects. First, the use of shock extends the range of stimuli that have been shown to engender within-component patterning. Though shock has been viewed traditionally as an aversive stimulus, the present results show similarities between the use of shock and so-called "neutral" stimuli. Second, the present findings give added weight to the findings that nonpaired stimuli affect behavior to the same degree as paired stimuli (Stubbs, 1971). In this previous study, no difference was found between the effects of paired and nonpaired visual stimuli. The key normally was trans-illuminated by one color such as blue; the

nonpairing operation involved a change in key color from blue to white, plus the illumination of the houselight; during reinforcement the magazine was illuminated (by red light, for example) and the houselight was off. The brief stimulus was nonpaired because the white keylight and houselight were never present during reinforcement. However, the brief-stimulus operation might have involved a subtle pairing in that the blue light was off during both the brief-stimulus and reinforcement periods. In the present study, however, such a subtle pairing did not take place. The key stimulus remained on during brief-stimulus periods; and the stimulus dimensions were different for brief-stimulus and reinforcement operations.

One effect of shock was a general reduction in over-all response rate as shock intensity increased. This finding is similar to the general findings on shock intensity in the punishment literature (*cf.* Azrin and Holz, 1966). The present effects, however, differ from those of punishment studies in one respect. Response rates in the present study typically were highest at the end of each fixed-interval component, just before shock. Azrin (1956) delivered shocks according to a fixed-interval schedule while food was delivered according to an independent variable-interval schedule of reinforcement. He found that response rates decreased as the fixed-interval punishment schedule neared completion; response rates were lowest just before delivery of shocks. The difference in the schedule relation between shocks and food probably accounts for the different results in the two studies. In the present study, the scheduling of shocks and food were not independent. The completion of each component resulted in either shock or food or both. In Azrin's study, however, food and shocks were scheduled independently; thus, food might follow a shock presentation at any time. The manner in which both shock and food are scheduled undoubtedly is an important factor in producing different effects of shock (*cf.* Kelleher and Morse, 1968; Morse and Kelleher, 1966).

The lowering of response rates with increasing shock intensity probably was not due entirely to the suppressive effects of the shock. In other studies in which brief visual stimuli were used, rates have been found to be lower under brief-stimulus than under tandem con-

ditions (Byrd and Marr, 1969; Stubbs, 1971). When a brief stimulus is scheduled according to fixed-interval component schedules, positively accelerated rates develop within components, and the pattern results in pauses or lowered rates following brief-stimulus presentations. As a by-product of the lowered rates following this stimulus, overall rates tend to be lowered. However, punishment effects played at least a partial role in controlling behavior, as is evidenced by complete response suppression under some conditions.

It is possible that pauses following shocks in the present experiment were due to disruptive effects of shock. The results of other studies, however, argue against such an interpretation. In punishment studies, pauses like those observed here did not occur after shock presentation (Azrin and Holz, 1966).

Patterning within components could be interpreted as the result of the discriminative properties of shock. A relatively high rate of responding would have been maintained by the intermittent presentation of food (as under the tandem schedule). The occurrence of shock was always separated from reinforcement by a minimum of 60 sec; thus, shock presentations could have served as discriminative stimuli for periods of nonreinforcement. The pairing of shocks with periods of non-reinforcement could have resulted in pausing or the lowering of response rates following shock presentations (Ferster and Skinner, 1957). That response-produced shocks may have discriminative properties has been demonstrated by Holz and Azrin (1961), who employed a multiple schedule with shock as the only stimulus differentiating components. In one component, each response produced shock and responses intermittently produced food; in the other component, visual stimuli were the same but responses produced neither shock nor food. Response rates were higher in the shock component.

Under different procedures, schedules of shock presentation have resulted in patterns of responding similar to those observed in the present study. Under one type of procedure (Byrd, 1969; McKearney, 1968, 1969, 1970; Stretch, Orloff, and Gerber, 1970), subjects (monkeys or cats) were trained first on a free-operant or Sidman avoidance schedule. Then, a schedule of shock presentation, such as FI 10-min, was superimposed on the avoidance

schedule. Finally, the avoidance schedule was removed and responses simply produced shocks according to a fixed-interval schedule of electric-shock presentation. The results of these studies have been that the shock schedule maintains a pattern of responding like that observed when food is presented. Kelleher and Morse (1968) employed procedures in which responses concurrently produced food according to a variable-interval schedule and shocks according to a fixed-interval schedule. Kelleher and Morse found that response rate increased toward the end of the fixed-interval schedule despite the fact that food was concurrently scheduled throughout the interval. When the food was omitted, responding was maintained by the shock schedule alone. The present results differ from the results of these other studies in two respects. First, whereas responding was maintained in the other studies when the sole schedule contingency was an FI schedule of shock presentation, behavior was not maintained in the present study unless food was presented intermittently. Second, in Kelleher and Morse's study, the food and shock were scheduled independently. The independent scheduling suggests that patterning might result even when there is not a fixed relation between shock and food. The difference between the present results and the results of the other studies is probably related to different past histories of the subjects and scheduling differences.

A second possible reason for the difference is that the species were different: pigeons in the present study, monkeys and cats in the other studies. In the present study, there was a consistent relation between shock presentation and food presentation; in the others, shock and food were scheduled independently or food was never used. Possibly the scheduled relation between shocks and food in the present study was responsible for the elimination of behavior when food was no longer scheduled and only the shock schedule was in effect.

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