SCHEDULES OF RESPONSE-INDEPENDENT CONDITIONED REINFORCEMENT[1]

M. JACKSON MARR AND MICHAEL D. ZEILER

GEORGIA INSTITUTE OF TECHNOLOGY AND EMORY UNIVERSITY

Rates and patterns of responding of pigeons under response-independent and response-dependent schedules of brief-stimulus presentation were compared by superimposing 3-min brief-stimulus schedules on a 15-min fixed-interval schedule of food presentation. The brief-stimulus schedules were fixed time, fixed interval, variable time, and variable interval. When the brief stimulus was paired with food presentation, its effects depended upon the schedule and ongoing rates. Fixed- and variable-interval brief-stimulus schedules enhanced the low rates normally occurring early in the 15-min interval, whereas fixed- and variable-time schedules suppressed these rates. Although the overall rates later in the interval were not affected to any great extent, the fixed brief-stimulus schedules generated patterns of positively accelerated responding between stimulus presentations. These patterns appeared less frequently under the variable brief-stimulus schedules. Initially, when not paired with food delivery, presentations of the brief stimulus produced relatively little effect on either response rate or patterning. However, once the stimulus had accompanied food presentation, the original performance under the non-paired condition was not recovered. The effects were more like those occurring when the stimulus was paired with food.

All schedules of intermittent reinforcement share the ability to maintain numerous responses per reinforcer presentation. They differ, however, in how these responses are distributed in time. For example, if the reinforcer follows the first response occurring after a fixed period of time (a fixed-interval schedule), moderate and large parameter values typically result in a period without responding followed by positive acceleration to a high steady rate. These patterns emerge with an unconditioned reinforcer such as food (e.g., Dews, 1970; Ferster and Skinner, 1957) or with a conditioned reinforcer such as a brief stimulus that is occasionally paired with food (e.g., Byrd and Marr, 1969; deLorge, 1967; Kelleher, 1966; Marr, 1969; Stubbs, 1971). In contrast, if the time parameter is variable (a variable-interval schedule), responding occurs at a more constant rate (e.g., Catania and Reynolds, 1968; deLorge, 1971; Ferster and Skinner, 1957; Zimmerman, 1969). Distinctive patterns are salient and reliable characteristics of different types of reinforcement schedule.

Stable patterning occurs with schedules in which the reinforcer is dependent on a response. However, there is another class of schedules, i.e., schedules in which the reinforcer appears independent of responses. In such schedules, the reinforcer is presented either periodically (fixed-time schedules) or aperiodically (variable-time schedules) without reference to responding. Research concerned with studying possible distinctive effects of each type of response-independent schedule has encountered difficulties. One problem has been that of ascertaining just which response to observe. Skinner (1948) reported that any of a number of different responses might be the one that predominated, and he also found that the predominant response could change over time. Staddon and Simmelhag (1971) showed that the response is likely to be selected from among a restricted group of behaviors; however, that group does contain enough members to preclude predicting which particular one will emerge. As a consequence of this difficulty, it is more convenient to begin with a specified response maintained by a response-dependent schedule and then to switch to the time sched-

ule to observe its effects (Herrnstein, 1966). Using this procedure, it has been found that fixed-time schedules establish patterns like those of fixed-interval schedules (Appel and Hiss, 1962; Lattal, 1972; Zeiler, 1968), and variable-time schedules produce patterns like those of variable-interval schedules (Lattal, 1972; Zeiler, 1968). However, none of these experiments reported stable behavior, because the time schedules ultimately resulted in substantial rate reductions and even eventual cessation of the response.

Brief-stimulus schedules provide a potential solution to both problems. Under these schedules, brief-stimulus presentations are superimposed on a schedule of unconditioned reinforcement. Stubbs' (1971) observation that a brief stimulus presented according to a fixed-time schedule produced patterns of positive acceleration led to the present procedures.

Brief-stimulus and food deliveries were combined in a conjoint schedule (cf., Zimmerman, 1969). In a conjoint schedule, two or more independent schedules are in effect simultaneously; in the present case, one schedule was for food presentation and the other was for brief-stimulus presentation. A key peck was followed by food according to a fixed-interval (FI 15-min) schedule. The assumption was that the fixed-interval food schedule would guarantee that responding would be maintained. To ascertain response-independent reinforcing effects, the brief stimulus appeared alone, either at regular 3-min intervals (FT 3-min) or at intervals averaging 3-min (VT 3-min). A basis for comparing the effects of response-independent with response-dependent effects under this arrangement was provided by presenting the stimulus according to fixed- and variable-interval schedules (FI 3-min and VI 3-min). A fixed-interval food schedule was used because it results in a wide range of response rates in each interval. Such a schedule, therefore, enabled observations of how the schedules of brief-stimulus presentations interacted with ongoing rates to control performance.

Recent data have indicated that a brief stimulus can maintain responding similarly to an unconditioned reinforcer (e.g., food) even if it is never paired with food (e.g., Neuringer and Chung, 1967; Stubbs, 1971). Although these data are difficult to interpret

because of the large body of research showing that only a paired stimulus will have such effects (Byrd and Marr, 1969; deLorge, 1967; Kelleher, 1966; Marr, 1969; Thomas and Stubbs, 1967; Zimmerman, 1969), it was of interest to determine how both a paired and a nonpaired stimulus would function in the present context. The nonpaired conditions were studied first because of data suggesting that a history of pairing could produce at least partially irreversible effects (deLorge, 1967; Kelleher, 1966).

METHOD

Subjects

Two White Carneaux pigeons were maintained at 80% of their free-feeding weights. Both had extensive histories with fixed-interval schedules involving differential reinforcement with respect to three simultaneously presented stimuli differing in color (Zeiler, 1970).

Apparatus

The experimental chamber was a standard single-key unit (Ferster and Skinner, 1957). The 2-cm diameter response key (R. Gerbrands Co.), operated by a minimum force of 0.18 N, was transilluminated by either two green or two red 7-W lamps. A 5-cm square aperture centered 8 cm below the key provided occasional access to Purina Pigeon Checkers, the birds' standard diet. During the 4-sec feeder cycles, a 1.1-W white lamp illuminated the aperture. A G.E. 25T10/1F lamp in series with a 300-ohm resistor served as a houselight; it was lit except during feeder cycles and blackout periods, when both it and the keylights were darkened. White noise masked extraneous sounds.

Procedure

All conditions involved a fixed-interval (FI) schedule of food presentation: the first response occurring after 15 min resulted in food presentation after a 0.5-sec delay. The 15-min interval was timed from the end of the 1-min blackout that followed each food presentation. The nine basic conditions differed in whether the FI 15-min schedule was in effect alone or whether it was accompanied by a schedule of brief-stimulus presentations. Under all conditions the prevailing key color

was green, but under the brief-stimulus conditions, the color changed to red for 0.5-sec periods.

There were four different schedules involving the brief stimulus. (1) Fixed interval (FI 3-min): the first response occurring 3 min after the blackout produced the red stimulus. Each successive stimulus then began the FI 3-min period anew. (2) Variable interval (VI 3-min): the first response occurring after irregular periods averaging 3-min produced the 0.5-sec stimulus. (3) Fixed time (FT 3-min): the stimulus occurred every 3 min without reference to responses. (4) Variable time (VT 3-min): the stimulus occurred after irregular periods averaging 3 min without reference to responses. To preclude occasional pairings of the brief stimulus with food under the nonpaired conditions, the brief-stimulus schedules could not present a stimulus in the last 1.5 min of the 15-min fixed interval. The same restriction applied to the paired conditions, in order to keep the various conditions comparable in this respect.

Under any of the four brief-stimulus schedules, the 0.5-sec stimulus either could be paired or not paired with food presentation. Under the paired (S^p) conditions, the final response meeting the FI 15-min schedule requirement changed the key color from green to red during the 0.5-sec delay period before food was presented. Under the nonpaired (S^{np}) conditions, as well as when the FI 15-min food schedule was in effect alone, the key remained green during the delay period.

The different manipulations produced nine different schedules, one being the simple FI 15-min food schedule, and each of the other eight being a conjoint schedule involving the FI 15-min schedule in conjunction with a brief-stimulus schedule having either a paired or a nonpaired stimulus. The complete notation of the conjoint schedule indicates the events controlled by each component. For example, conjoint FI 15-min: food FT 3-min: S^p indicates that food was presented according to the FI 15-min schedule, while concurrently the brief stimulus was presented on an FT 3-min schedule and was paired with food presentation. To simplify the schedule descriptions, the convention used here will be to describe the schedule as FI 15-min when that schedule was in effect alone. The conjoint schedules will be designated simply by refer-

ence to the brief-stimulus schedule as FI 3-min:S^p, FI 3-min:S^{np}, FT 3-min:S^p, FT 3-min:S^{np}, VI 3-min:S^p, VI 3-min:S^{np}, VT 3-min: S^p, and VT 3-min:S^{np}.

A given schedule was maintained until cumulative records revealed that behavior had stabilized for both birds. The sessions were conducted five days per week and each session terminated after 15 food presentations.

Table 1

Sequence of Schedules

Condition	Sessions	Condition	Sessions
1. FI 15-min	1-38	15. FI 15-min	286-295
2. FT 3-min:S^{np}	39-60	16. VI 3-min:S^p	296-328
3. FI 15-min	61-77	17. FT 3-min:S^p	329-342
4. VT 3-min:S^{np}	78-101	18. FI 15-min	343-388
5. FI 15-min	102-106	19. FT 3-min:S^p	389-412
6. FI 3-min:S^{np}	107-131	20. FT 3-min:S^{np}	413-445
7. FI 15-min	132-145	21. FT 3-min:S^p	446-472
8. VI 3-min:S^{np}	146-170	22. FI 3-min:S^p	473-494
9. FI 15-min	171-180	23. VT 3-min:S^p	495-521
10. FT 3-min:S^p	181-205	24. VI 3-min:S^p	522-547
11. FI 15-min	206-215	25. VT 3-min:S^p	548-577
12. VT 3-min:S^p	216-241	26. VT 3-min:S^p	578-602
13. FI 15-min	242-251	27. VI 3-min:S^p	603-624
14. FI 3-min:S^p	252-285	28. FI 3-min:S^p	625-649

Table 1 shows the sequence of schedules and the sessions with each. The sequence consisted of three general types of transition. Conditions 1 to 16 were studied to determine how each of the conjoint schedules influenced behavior when they were imposed immediately after the FI 15-min schedule. The four nonpaired stimulus conditions were studied first, and then were followed by the four paired stimulus conditions. Conditions 18 to 21 were investigated to determine the effects of a paired and unpaired stimulus when studied with respect to the same schedule, after the birds had a history with pairing. Schedules 21 to 28, as well as Schedules 16 and 17, investigated transitions from one brief-stimulus schedule to another with the stimulus paired under all conditions. They, together with Schedules 9 to 16, indicated the ability of the conjoint schedules involving a paired stimulus to establish characteristic performances when starting from a variety of baselines.

RESULTS

Overall Response Rate

Table 2 shows the mean and standard deviation of the overall response rate per ses-

sion. These data were derived from the rates in the last five sessions of each exposure to the FI 15-min schedule (nine exposures, 45 sessions) and the paired-stimulus conjoint schedules (the FT 3-min:S^p data are based on five exposures, or 25 sessions, whereas the other paired-stimulus conditions are based on three exposures, or 15 sessions). The data for the nonpaired conditions are based on the final 15 sessions of each condition (only the first exposure to the FT 3-min:S^{np} schedules is included). All of the brief-stimulus schedules established fairly stable response rates, and similar performances were recovered on repeated exposures to each of the paired-stimulus conditions.

The least stable response rates occurred with the FI 15-min schedule for P-103. Beginning with the fourth exposure to that schedule, the rates decreased. The average rate over the last five sessions declined from 0.36 responses per second in the first exposure to 0.09 responses per second in the ninth. Bird P-102 also showed a rate decrease, although not of the same magnitude (0.83 in the first exposure to 0.53 in the fourth, remaining stable afterwards). The changing fixed-interval baseline made it difficult to compare overall rates in the brief-stimulus conditions with those under the FI 15-min schedule; however, the stability in the brief-stimulus conditions permitted comparison among those conditions.

Subject P-102 had nearly a two-fold higher overall rate than did P-103 under all of the conditions. Neither bird revealed systematic

rate differences under the four nonpaired-stimulus conditions and the simple fixed-interval schedule. However, both responded at lower rates under the two paired-stimulus time schedules than under any of the non-paired-stimulus schedules. For P-102, responding was also decreased under the two paired-stimulus interval schedules, although these conditions tended not to reduce rates for P-103. Perhaps this difference reveals a rate-dependent effect. The paired-stimulus interval schedules may decrease prevailing high rates while not affecting lower ones to any marked extent.

Patterns of Responding

Each paired-stimulus condition was preceded either by the FI 15-min schedule (Conditions 9 to 16) or by a different brief-stimulus schedule (Conditions 17 to 28). Inspection of cumulative records revealed no differences in patterning depending on the nature of the preceding schedule. They did reveal that particular paired brief-stimulus conditions influenced the patterns of responding. Figure 1 shows representative records for each paired-stimulus condition. All revealed at least some pauses after stimulus presentations, but there were distinctive schedule effects as well. Pausing followed by positively accelerated responding occurred consistently with the fixed-time and fixed-interval schedules; these patterns were most evident after the third and fourth stimulus presentations. Even when the two fixed schedules controlled very different absolute rates of responding, they maintained

Table 2

Overall Response Rates

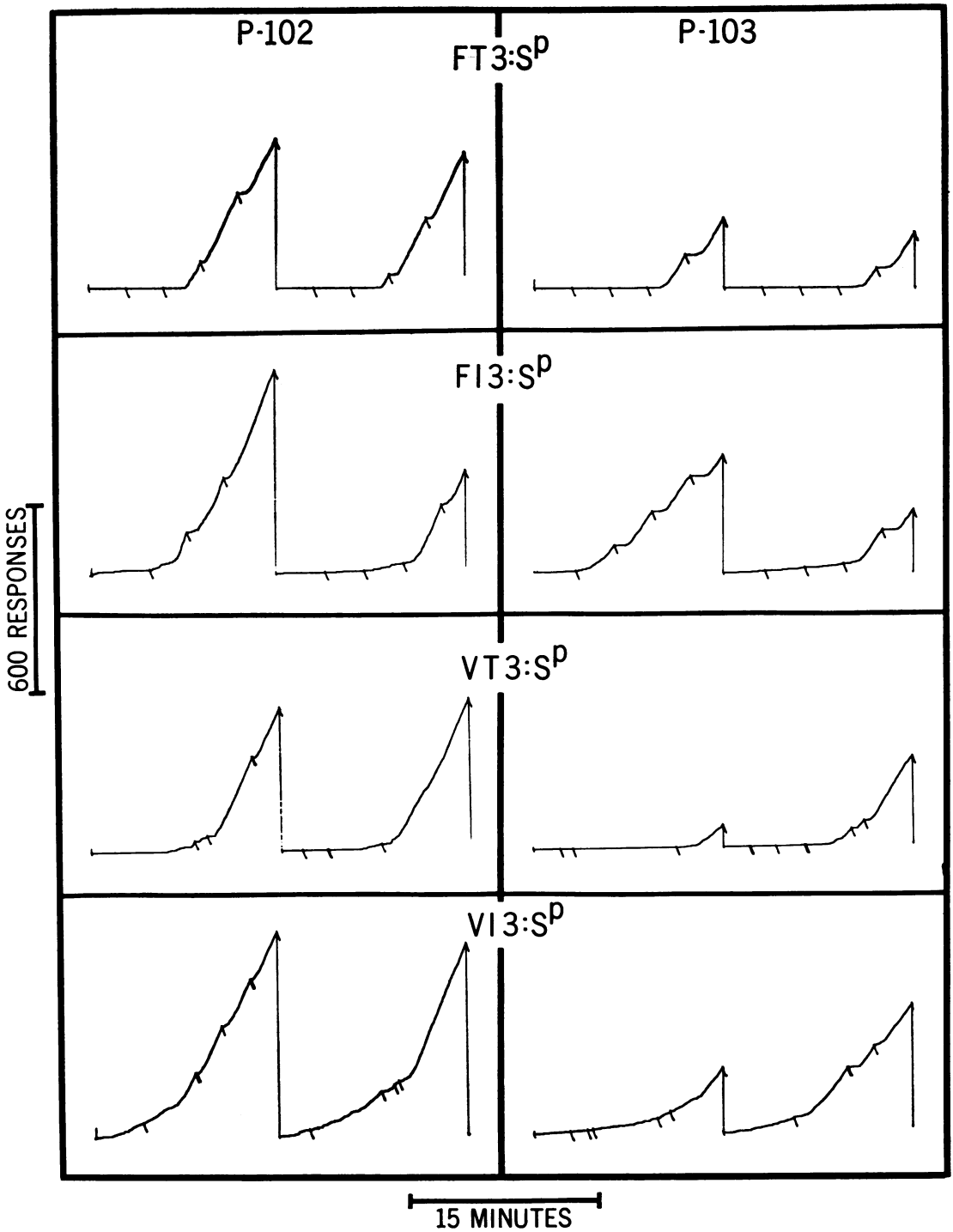|	Bird 102		Bird 103	
	Mean Rate (Resp/Sec)	Standard Deviation	Mean Rate (Resp/See)	Standard Deviation
FI 15-min	0.64	0.09	0.25	0.09
FT 3-min:S^{np}	0.67	0.06	0.26	0.04
VT 3-min:S^{np}	0.64	0.09	0.27	0.03
FI 3-min:S^{np}	0.65	0.07	0.26	0.03
VI 3-min:S^{np}	0.63	0.07	0.25	0.02
FT 3-min:S^p	0.42	0.07	0.18	0.02
VT 3-min:S^p	0.43	0.06	0.19	0.03
FI 3-min:S^p	0.41	0.07	0.27	0.03
VI 3-min:S^p	0.46	0.06	0.27	0.03

Fig. 1. Representative cumulative records showing the performance under the various paired brief-stimulus (S^P) schedules. The diagonal stroke of the response pen marked the occurrence of the brief stimulus. The pen reset after food presentation.

similar patterns. The two variable schedules also were similar to each other. Under the variable schedules, there were some intervals like those established by the fixed schedules, but often, pauses followed by positive acceleration did not prevail.

Under all of the brief-stimulus schedules, strong effects of the FI 15-min food presentation schedule were evident. Responding increased as the interval progressed. Rather than obliterating that pattern, the brief-stimulus schedules modulated responding within it. Thus, the fixed brief-stimulus schedules fractionated the overall FI 15-min performance into a series of smaller units, each having fixed-interval characteristics.

A quantitative analysis of rate changes within the 15-min interval appears in Figure 2. The format of the figure was derived from Dews' (1964) technique for showing rate-dependent effects of drugs. It has the particular advantage of showing relative effects in a way that permits the recovery of absolute response rates. The ordinate is scaled in terms of the ratio between the number of responses emitted in the conjoint schedules and the
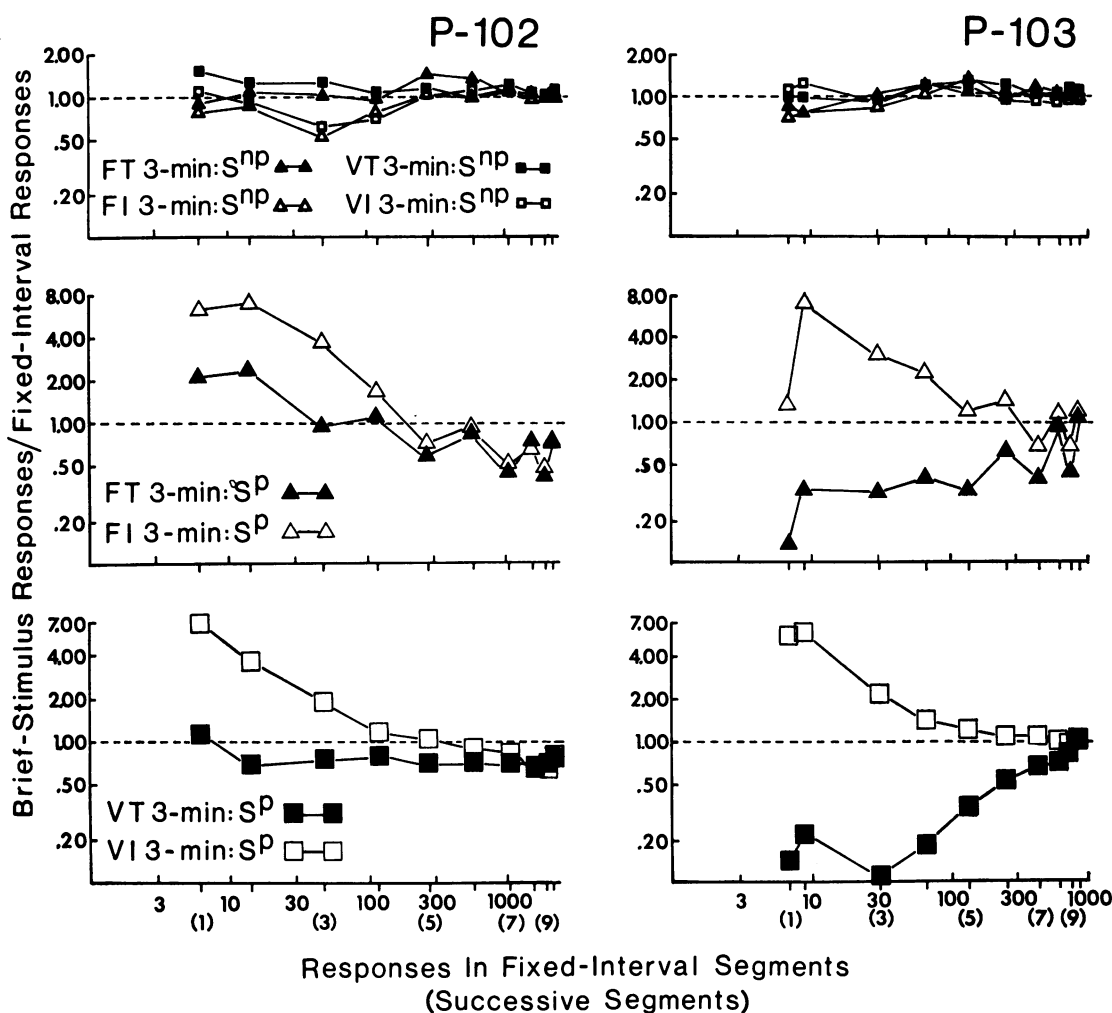

Fig. 2. A segment-by-segment comparison of the number of responses under the various conjoint schedules with that under the simple FI 15-min schedule. The 15-min interval has been divided into ten 1.5-min segments and the ratio of the number of responses per session in the brief-stimulus condition to that in the FI 15-min schedule has been plotted for each segment. Both the ordinate and abscissa are log scales. The odd-numbered segments are indicated by the figures in parentheses. The top graphs indicate all the nonpaired (S^{np}) brief-stimulus schedules; the middle and bottom graphs display the fixed and variable, paired brief-stimulus (S^p) schedules respectively. The data were obtained from the same sessions used in deriving Table 2. See text for details.

number emitted in the corresponding portion of the simple FI 15-min schedule. The abscissa shows the average number of responses emitted in each 1.5-min segment of the FI 15-min schedule. These data are based on the same sessions described in Table 2. The purpose was not necessarily to compare performance in the brief-stimulus schedules with that in the simple fixed-interval schedule, but rather to provide a common frame of reference for comparing the brief-stimulus schedules with each other. Since the average number of responses increased in each successive tenth of the FI 15-min schedule, the first point corresponds to the first 1.5-min segment, the next with the second, and so forth.

The rates in each tenth of the nonpaired-stimulus conditions did not differ from each other to any great extent. The paired-stimulus conditions did produce distinctive schedule effects. Relative to the time schedules, the interval schedules produced higher rates, the difference diminishing as the 15-min interval progressed. The variable schedules resulted in relatively uniform rate changes with the VI 3-min:S^p schedule showing higher rates than the VT 3-min:S^p schedule, especially early in the 15-min period. The fixed schedules produced markedly different effects. Rather than being monotonic, the function was irregular, with discontinuities appearing in alternating segments. Response rates were elevated in the sixth, eighth, and tenth segments relative to those in the fifth, seventh, and ninth segments. Under the fixed-time schedules, the odd-numbered segments always were those beginning the 3-min interval; rates were sufficiently high under the fixed-interval schedules for this to be the case with those as well. Thus, the rates were highest in the even-numbered segments that ended with the brief stimulus and lowest in the odd-numbered segments that began with the stimulus. This alternation in rate in successive segments further illustrated the patterning produced by the brief stimulus in each 3-min period. In the variable schedules, the relationship between the stimulus and successive segments was irregular, and the alternation did not develop.

An additional procedure was devised that made it possible to quantify between-stimulus patterning directly from the cumulative records of the last session under each exposure to the brief-stimulus conditions. It was not possible to measure precisely the time to any specific response. As an alternative, we determined where in each segment between stimulus presentations a straight edge aligned with the terminal slope (*i.e.*, the line best fitting the terminal rate) intersected a horizontal line drawn from the mark indicating the start of the segment. Segments with no responses were excluded, as were those shorter than 2-min. This distance was converted into seconds and averaged over the sessions, and an average was computed over the several exposures to each paired-stimulus schedule. These "intercept times" are shown for each brief-stimulus schedule in Figure 3 (only the first exposure to the FT 3-min:S^{np} schedule is shown). Although the magnitude of the difference was larger for P-103 than for P-102,
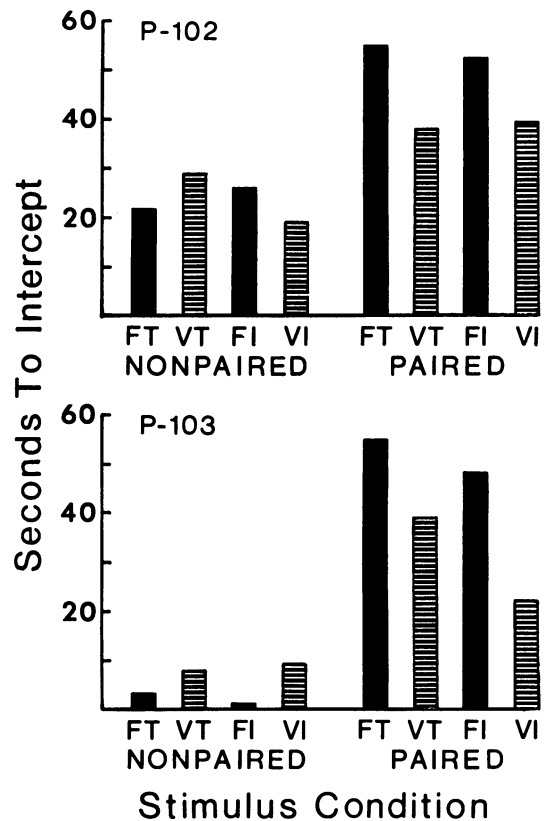

Fig. 3. A comparison of time to intercept point, *i.e.*, point of maximal slope, under the nonpaired and paired brief-stimulus conditions. The fixed-interval and fixed-time schedules are represented by the dark bars while the variable-interval and variable-time schedules are represented by the striped bars. See text for further details.

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the intercept times for both birds were less under the nonpaired than under the paired-stimulus conditions. In addition, under the paired-stimulus schedules, the mean intercept times were smaller under the two variable than under the two fixed conditions. Thus, these data confirmed that paired and nonpaired stimulus presentations produced different patterns, and that there were distinctive schedule effects with paired stimuli.

Paired and Nonpaired Stimuli

Figures 2 and 3 indicated that the nonpaired brief-stimulus conditions studied in Conditions 1 to 8 did not affect patterning comparably to the paired conditions. The middle record of Figure 4 shows performance under one of these schedules, the FT 3-min: S^{np} condition. Performance was much like that under the immediately preceding FI 15-
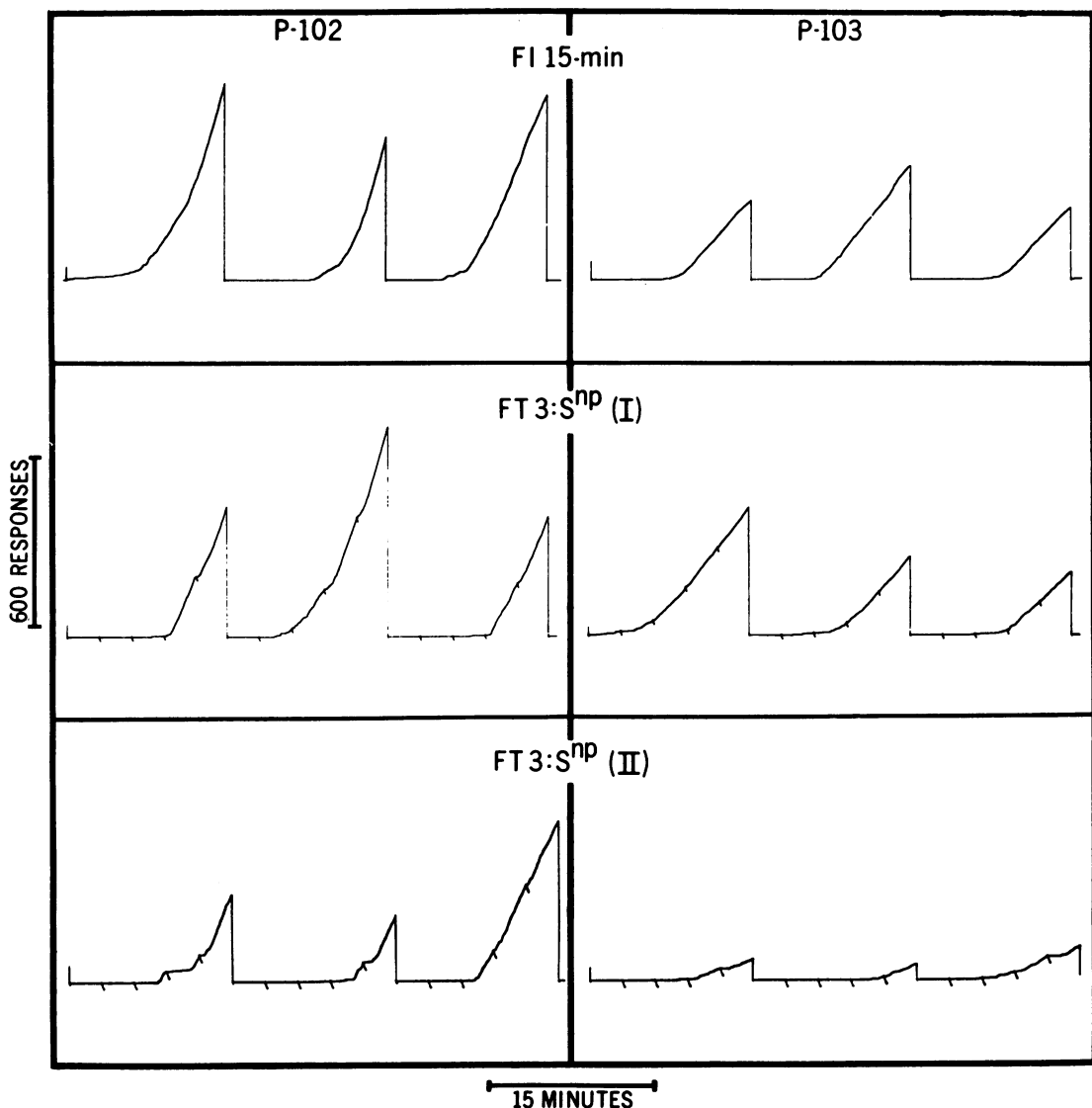

Fig. 4. Representative cumulative records comparing the performance under the FI 15-min schedule and the two nonpaired fixed-time (FT 3-min) brief-stimulus schedules. I shows performance before the stimulus had ever been paired with food presentation; II shows performance under the same schedule but after a history of pairing with food. Recording as in Figure 1.

min schedule (top record) with the pattern typically consisting of a pause at the onset of the interval followed by positive acceleration. The stimulus had somewhat larger effects for P-102 than for P-103; however, for neither were there patterns comparable to those occurring in the FT 3-min:S^p condition.

The FT 3-min:S^{np} schedule was studied again in Condition 20, this time to compare it directly with the FT 3-min:S^p schedule. As the lower records of Figure 4 show, the nonpaired stimulus now often produced within-interval patterning for P-102. The low rates for P-103 made patterning difficult to discern. However, intercept times did change in the same direction for both birds. The average intercept time was now 37.1 sec for P-102 and 40.0 sec for P-103. These times were shorter than those occurring with the FT 3-min:S^p schedule (55.3 sec for P-102, 55.1 sec for P-103), but were longer than they had been in the first exposure to the nonpaired condition (21.8 sec for P-102, 3.7 sec for P-103). These data indicated that once the stimulus had been paired with food, its effectiveness when later nonpaired was modified. However, even after the history of pairing, the nonpaired stimulus had more equivocal effects than did the paired stimulus. Another change between the two exposures to the nonpaired stimulus was that overall response rate decreased in the second (P-102: 0.67 responses per second to 0.51 responses per second; P-103: 0.26 responses per second to 0.13 responses per second).

DISCUSSION

The results confirm those of a number of previous studies in showing that presentation of a brief stimulus can substantially alter ongoing rates and patterns of responding. These results are in accord with the notion that the brief stimulus, by being paired with food presentation, had acquired reinforcing properties. The safest procedure for assessing acquired reinforcing ability is to compare the effects of the stimulus with those of a known reinforcer, such as food. One of the most important effects of a food reinforcer is that the pattern of responding changes depending upon the particular schedule. Since, as a result of pattern changes, overall response rate can either increase or decrease, rate *per se* may be

an inappropriate measure of reinforcing effects. For example, overall response rate usually decreases with the change from a variable-interval to a fixed-interval schedule, yet each establishes characteristic patterns. As Byrd and Marr (1969) showed, when presented according to a fixed-interval schedule a stimulus occasionally paired with food has effects different from one never paired. The pattern typical of fixed-interval food schedules occurred only with the paired stimulus; however, overall response rate was higher with the nonpaired stimulus. Rates increased because of the absence of the fixed-interval pattern (*i.e.*, there was no pause at the outset of the interval). Thus, conditioned reinforcing effects are most sensitively measured by how responses are distributed in time, rather than by overall rate.

The interval and time schedules of the present experiment both established characteristic patterns of responding between brief-stimulus presentations. The two fixed schedules produced consistent pausing followed by positive acceleration, whereas the two variable schedules sometimes produced this pattern and sometimes produced a more constant response rate. It may be that the rate under the variable schedules would have been more consistently linear had there not been a minimum of 1.5 min between the brief-stimulus and food presentation. The patterns were analogous to those maintained by response-independent and response-dependent unconditioned reinforcement (Lattal, 1972; Zeiler, 1968). Furthermore, although rates differed, the data show that the patterns maintained by response-independent conditioned reinforcement (*i.e.*, the time schedules) were like those produced by response-dependent conditioned reinforcement (*i.e.*, the interval schedules).

Both birds revealed similar patterns despite their persistent differences in response rate. Since the time and the interval schedules produced equivalent patterns, but could produce substantial differences in rates, the variable responsible for patterning would seem to be the temporal placement of the reinforcing event. The precise behavior occurring at the moment of reinforcement determined rate; the temporal location of reinforcement determined pattern. The independence of rate and patterns has been asserted elsewhere in the context of fixed-interval schedules (Dews,

1969) and response-independent schedules of food presentation (Zeiler, 1968).

A stimulus not paired with food presentation influenced performance differently from one paired intermittently. In the absence of a history of pairing, the stimulus had smaller effects whether presented according to interval or time schedules. Stubbs (1971) also did not find consistent strong effects of a nonpaired brief stimulus when it was presented according to a fixed-time schedule and was combined in a conjoint schedule with a fixed-interval schedule of food presentation. Differential effects of paired and nonpaired stimuli agree with the results of most experiments involving brief stimuli (Byrd and Marr, 1969; deLorge, 1967; Kelleher, 1966; Marr, 1969; Thomas and Stubbs, 1967; Zimmerman, 1969), although these differences may not always occur (e.g., Stubbs, 1971).

In the present study, once the stimulus had been paired, discontinuation of the pairing did not result in recovery of the original performance. Instead, the nonpaired stimulus had effects more like those of the paired stimulus, although the effects were less consistent and strong. After many sessions, the influence of the stimulus was lessened, but the performance had not returned to that of the initial nonpaired condition. Thus, once the stimulus had been associated with food presentation, effects persisted even in the absence of further pairing. This irreversibility of stimulus function confirms similar observations that have been made in experiments investigating response-dependent stimulus presentations (deLorge, 1967; Kelleher, 1966).

Given a reinforcing stimulus, it is possible to be specific about when response rate will increase or decrease. Whatever response occurs in close contiguity with the reinforcer will increase in frequency. If the response is key pecking, the rate of pecking will increase; if the response involves doing something other than key pecking, the rate of pecking will decrease. Note that this is an analysis of rate changes at particular points in time, rather than one of overall rates. The patterning observed in the present experiment indicated that the paired brief stimulus was a reinforcer, therefore local rate effects should fit this description. The effects of the paired brief stimulus depended jointly upon its schedule of presentation and the ongoing

rates when it appeared. Ongoing rate itself depended on the location of the point within the 15-min interval. The interval schedules enhanced the low rates characteristic of the early segments of the 15-min interval under the food schedule, whereas the time schedules tended to suppress the low rates still further. As the 15-min interval progressed, responding occurred at a substantial rate under all of the schedules, although it continued to be suppressed somewhat under the time schedules for P-103.

These effects can be traced to the temporal relation between responding and the brief stimuli. The interval schedules assured that the stimulus would immediately follow a key peck. The time schedules provided no such guarantee; however, the higher the prevailing rate when the stimulus was introduced, the more likely it would occur in close contiguity with a key peck. If subsequent rates depended on previous temporal relations between the response and the reinforcer, by immediately following a response with a reinforcing stimulus, the interval schedules increased the otherwise low rates in early segments. With the time schedules, however, the brief stimulus followed periods having little or no key pecking and consequently made pecking still less probable. Later in the 15-min interval, when the food schedule itself was engendering substantial rates, the differences between interval and time schedules would be attenuated. Additional support for this account derived from the characteristically larger suppression established by the time schedules in P-103 than in P-102. Once again, this indicates that there is a relation between the effects of a time schedule and ongoing rate, since P-103 also had substantially lower rates under the FI 15-min food schedule.

It has been suggested that brief stimuli operate similarly to food when the schedule requirements for each are identical (Neuringer and Chung, 1967). This consistency in schedule is generally employed in second-order schedules in which the relation between successive brief-stimulus presentations is the same as that between the final brief stimulus and food (ignoring the pairing operation). Neuringer and Chung (1967) and Stubbs (1971) both found that the effects of the brief stimulus were like those of food only with a second-order schedule and not with a

conjoint schedule in which the stimulus and food presentations were scheduled independently. The present conjoint schedules, however, show that such identicalness is not essential. Although the fixed schedules maintained constant 3-min components with the last ending with food and the earlier ones with the stimulus, the variable schedules did not preserve this consistency. The same was true when Zimmerman (1969) presented water according to fixed-interval schedules of either 3, 5, 6, or 10- min durations while presenting the stimulus according to either a VI 2-min or a VR 12 schedule. In both Zimmerman's and the present study, the stimuli established characteristic schedule performances, while the food reinforcement schedule established its own distinctive effects. These data indicate that the effectiveness of a conditioned reinforcer does not require that it and the unconditioned reinforcer appear according to the same schedule.

With response-independent food presentation, response rate usually declines to a low level (Herrnstein, 1966; Lachter, Cole, and Schoenfeld, 1971; Rescorla and Skucy, 1969; Zeiler, 1968). However, the present experiment showed that such a decline may not occur with conditioned reinforcement, if the behavior is being maintained by a superordinate schedule of response-dependent unconditioned reinforcement. Key pecking was maintained by the FI 15-min schedule of food presentation, while the FT 3-min and VT 3-min schedules of brief-stimulus presentation modulated the patterns and sometimes the overall response rates. The conjoint schedule seems to be particularly well-suited for studying maintained patterning under response-independent reinforcement, because responding continues indefinitely. Even if the schedules should reduce responding, as they did for P-103, pecking persisted at a sufficiently high level to permit long-term observations of stable patterning. These data complement others (Zimmerman, 1969) showing that conjoint schedules of conditioned and unconditioned reinforcement provide sensitive procedures for analyzing how conditioned reinforcement influences performance.

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