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SECOND-ORDER SCHEDULES: A COMPARISON OF CHAINED, BRIEF-STIMULUS, AND TANDEM PROCEDURES[1]

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Pigeons were exposed to seven types of two-component schedules, each component a 2-min fixed-interval schedule. Food presentation occurred at the completion of the second component under all conditions. The seven types of schedules were: (1) a chained schedule in which completion of the first component produced the discriminative stimulus associated with the second component; (2) a chained schedule to which was added the brief presentation of a food-paired stimulus at the completion of the first component; (3) a chained schedule to which was added the brief presentation of a stimulus not paired with food at the completion of the first component; (4) a multiple schedule in which food presentation occurred at the completion of both components; (5) a tandem schedule in which completion of the first component initiated the second component, with no changes in exteroceptive stimuli; (6) a food-paired brief-stimulus schedule in which the brief presentation of a food-paired stimulus was made at the completion of the first component and no other changes in stimuli occurred; and (7) a brief-stimulus schedule in which the brief presentation of a stimulus not paired with food was made at the completion of the first component and no other changes in stimuli occurred. Positively accelerated patterns of responding developed in the first component under three conditions: (1) the chained schedule with the added food-paired brief stimulus; (2) the multiple schedule; and (3) the food-paired brief-stimulus schedule. Response rates were low in the first component, with few instances of positively accelerated patterns, under two conditions: (1) the chained schedule; and (2) the chained schedule with the added nonpaired brief stimulus. The results suggest that a briefly presented food-paired stimulus may function as a more effective conditioned reinforcer than does the presentation of a discriminative stimulus.

Under second-order schedules, component schedule performance may be treated as a unitary response that is reinforced according to some schedule of unconditioned reinforcement (Kelleher, 1966*a*, *b*). Second-order schedules may be divided into at least two classes on the basis of the manner in which exteroceptive stimuli are arranged: chained schedules with sequences of discriminative stimuli, and brief-stimulus schedules with sequences of brief exteroceptive stimulus changes (Kelleher, 1966*a*, *b*; Marr, 1969). Under second-order chained schedules, each component schedule in a sequence is of the same form and each is associated with a different discriminative stimulus. For example, a 2-min fixed-interval schedule (FI 2-min) may be in effect in the presence of each of three different discriminative stimuli. Completion of the FI 2-min schedule in the presence of a red light may produce a green light, and completion of the FI 2-min schedule in the presence of the green light may produce a white light. Completion of the FI 2-min schedule in the presence of the white light produces unconditioned reinforcement. Patterns of responding within the individual FI 2-min components may be treated as unitary responses that are themselves reinforced according to a three-unit fixed-ratio schedule of unconditioned reinforcement, FR 3. Following the notation system introduced by Kelleher (1966*a*), the complete sequence may be described as *chain* FR 3 (FI 2-min).

Under second-order brief-stimulus schedules, completion of each component schedule in a sequence may produce a brief presentation (0.25 to 1.0 sec) of an exteroceptive stimulus, in the presence of which responses have no scheduled consequences. Two types of second-order brief-stimulus procedures have been

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employed. Under a paired-stimulus procedure, for example, completion of each of the first two FI 2-min components produces a brief exteroceptive stimulus change such as a flash of white light; completion of the third FI 2-min component produces the flash of white light either coincidental with or immediately followed by unconditioned reinforcement. In the most frequently used nonpaired-stimulus procedure, completion of each of the first two FI 2-min components similarly produces the brief flash of white light; completion of the third FI 2-min component produces unconditioned reinforcement directly, without presentation of the brief stimulus. The paired-stimulus sequence may be described as FR 3 (FI 2-min: S^p), and the nonpaired-stimulus sequence may be described as FR 3 (FI 2-min: S^n) (Stubbs, 1971).

Analyses of responding under these forms of second-order schedules have focused upon three major aspects of the procedures. First, many experiments have studied within-component performance as a function of the type of component schedule and/or the position of the components relative to presentation of unconditioned reinforcement. These experiments have individually studied either chained-schedule procedures (*e.g.,* Ferster and Skinner, 1957; Findley, 1962; Gollub, 1958; Marr, 1971) or brief-stimulus procedures (*e.g.,* Findley and Brady, 1965; Lee and Gollub, 1971; Thomas and Stubbs, 1966). Second, within the context of brief-stimulus schedules, several experiments have been primarily concerned with comparisons between paired and nonpaired brief-stimulus procedures (deLorge, 1967, 1969, 1971; Kelleher, 1966*b;* Stubbs, 1969, 1971; Stubbs and Cohen, 1972). Third, several experiments have made comparisons between chained-schedule procedures and brief-stimulus procedures (Byrd and Marr, 1969; Crossman, 1969; Thomas and Stubbs, 1967).

The results of these experiments suggest that performance within individual components of second-order schedules is controlled by interactions among at least these variables: (1) the form and parameter value of the component schedule; (2) the form and parameter value of the schedule according to which the components are associated with unconditioned reinforcement; and (3) the manner of presenting exteroceptive stimuli at the completion of components.

The present experiment studied the effects of paired and nonpaired brief stimuli when presented in standard forms of second-order brief stimulus schedules and when presented between successive discriminative stimuli in chained schedules.

METHOD

Subjects

Three experimentally naive male White Carneaux pigeons were maintained at 80% of their free-feeding body weights. Water and health grit were continuously available in the home cages.

Apparatus

Standard BRS-Foringer PH-002 experimental chambers were used. Only the right key was operative, the other being covered with a metal plate. The key required a minimum force of 25 g (0.25N) to operate the circuitry. Electromechanical scheduling equipment was located in an adjoining room. Data were recorded by cumulative recorders, electromechanical impulse counters, and elapsed-time meters. White noise was present at all times.

Procedure

Experimental sessions occurred six days per week, were 2 hr in duration, and were preceded and followed by timeouts of at least 10 min. During timeouts, the chambers were dark and responses had no scheduled consequences. After standard training procedures (Ferster and Skinner, 1957), the birds were exposed to seven experimental conditions, each of which had in common three features: (1) The basic second-order schedule employed was of the form FR 2 (FI 2-min). That is, the first response after 2 min in the first component produced the second component, and the first response after 2 min in the second component produced 3.5-sec access to mixed grain via elevation of the food tray. (2) During the feeder cycle the key was dark, the houselights were off, and the food aperture was illuminated with white light. (3) Following food delivery at the end of the second component, a 1-min timeout was in effect, *i.e.,* all lights were turned off.

The food-paired brief stimulus was a 0.25-sec presentation of the feeder cycle. That is,

the key was dark, the houselights were off, the food aperture was illuminated with white light, and the food tray was briefly activated. Observations of the birds via television monitors confirmed previous reports that the brief duration of the cycle precluded access to grain (Thomas, 1969; Zimmerman, 1963). The nonpaired brief stimulus was a 0.25-sec presentation of an audible tone and transillumination of the key with blue light.

The seven experimental conditions were as follows.

Chained schedule. In the first component, the key was transilluminated with a green light and circular pattern; the first response after 2 min (FI 2-min) produced the second component during which the key was transilluminated with a white light and triangular pattern. Completion of the FI 2-min schedule in the second component produced food delivery. This schedule may be abbreviated as *chain* FR 2 (FI 2-min).

Chained schedule with food-paired brief stimulus. As with the chained schedule, the key was transilluminated with a green light and circular pattern during the first component. Completion of the FI 2-min schedule terminated the green light and circle, and produced the 0.25-sec feeder cycle. Responses during the feeder cycle had no scheduled consequences. The key was transilluminated with the white light and triangular pattern after the feeder cycle terminated. Completion of the FI 2-min schedule in the second component produced food delivery. This schedule is abbreviated as *chain* FR 2 (FI 2-min: S^p).

Chained schedule with nonpaired brief stimulus. The conditions were the same as those described immediately above, with the exception that the 0.25-sec blue light and tone were presented at the end of the first component, in place of the 0.25-sec feeder cycle. This schedule may be abbreviated as *chain* FR 2 (FI 2-min: S^n).

Multiple schedule. The conditions were the same as those described for the chained schedule, except that the 3.5-sec feeder cycle was presented at the end of both components. The schedule may be abbreviated as *mult* FI 2-min FI 2-min.

Tandem schedule. The key was transilluminated with a yellow light and square pattern throughout both components. Completion of the first FI 2-min schedule initiated the timing of the second component with no changes in exteroceptive stimuli. Completion of the second FI 2-min schedule produced food delivery. This schedule may be abbreviated as *tand* FR 2 (FI 2-min).

Food-paired brief-stimulus schedule. The conditions were the same as with the tandem schedule in that the key was transilluminated with a yellow light and square pattern during both components. The 0.25-sec feeder cycle was presented at the end of the first component, and timing of the second component began with termination of the brief feeder cycle. This schedule may be abbreviated as FR 2 (FI 2-min: S^p).

Nonpaired brief-stimulus schedule. The conditions were the same as those described immediately above, except that the 0.25-sec blue light and tone were presented at the end of the first component, in place of the 0.25-sec feeder cycle. This schedule may be abbreviated as FR 2 (FI 2-min: S^n).

Birds D-2469 and M-7751 were exposed to all of the conditions described above, and Bird I-1168 was exposed to four of the conditions. The birds remained under each condition until responding appeared stable in both components. Response rates, quarter-life values, and cumulative records were examined in determining whether stability had been obtained. In most cases, the median response rates and ranges in the first component from the last five sessions had to be equivalent to those from the preceding five sessions before conditions were changed. The first two birds were exposed at least once to all conditions, and a maximum of three times to several of the conditions. Table 1 summarizes the orders of exposure and the number of sessions under each condition.

RESULTS

Figures 1 to 3 show representative cumulative records for the three birds. Portions of sessions for Bird D-2469 under each condition are shown in Figure 1. In record A, under *chain* FR 2 (FI 2-min), response rates were usually low in the first component; most frequently, a single response occurred after the end of the 2-min interval. Occasionally, positively accelerated patterns of responding occurred at low rates in the first component, such as at points *a* and *b*. In the second component,

Table 1

Summary of Procedure

Schedule	Bird D-2469		Bird M-7751		Bird I-1168	
	Order	Sessions	Order	Sessions	Order	Sessions
chain FR 2 (FI 2-min)	1	30	1	30	1	28
	3	15	3	21	3	19
	8	10	7	15		
chain FR 2 (FI 2-min: S^p)	2	76	2	84	2	88
	10	33	9	48		
chain FR 2 (FI 2-min: S^n)	9	11	8	18		
mult FI 2-min FI 2-min	7	13	13	18		
tand FR 2 (FI 2-min)	4	29	4	28	4	47
	6	36	6	20	6	80
	11	48	10	25		
FR 2 (FI 2-min: S^p)	5	29	5	65	5	43
			12	40		
FR 2 (FI 2-min: S^n)	12	26	11	16		

higher response rates and positively accelerated patterns of responding typified most sequences. Record B shows the effect of adding the food-paired brief stimulus at the end of the first component of the chained schedule, under *chain* FR 2 (FI 2-min: S^p). Response rates increased and positively accelerated patterns developed in the first component. Responding in the second component was similar to that shown in record A, with longer pauses at the beginning of the interval. Record C shows that adding the nonpaired brief stimulus at the end of the first component of the chained schedule, under *chain* FR 2 (FI 2-min: S^n), had little effect on rates and patterns of responding in either component. Response rates in the first component remained low, with occasional positively accelerated patterns, such as at point *c*. Record D shows performance under the *mult* FI 2-min FI 2-min schedule when the 3.5-sec feeder cycle was presented at the end of both components. Responding was positively accelerated and well maintained in both components, being generally comparable to that maintained under *chain* FR 2 (FI 2-min: S^p), as shown in record B.

Record E shows the patterns of responding typically controlled by the *tand* FR 2 (FI 2-min) schedule. Sometimes there was little responding in the first component, such as at *d*, and sometimes there was considerable responding in the first component, such as at *e*. When responding did occur at high rates in the first component, there were no systematic changes in rate when the second component began. Record F shows the effects of adding the food-paired brief stimulus at the end of the first component of the tandem schedule, under FR 2 (FI 2-min: S^p). Response rates increased in the first component and positively accelerated patterns of responding developed in both components. Record G shows that adding the nonpaired brief stimulus at the end of the first component of the tandem schedule, under FR 2 (FI 2-min: S^n), resulted in performance comparable to that obtained under the basic tandem schedule (record E).

Figure 2 shows similar performance under each schedule for Bird M-7751. Responding in the first component of the chained schedule was usually at a low rate (record A), increased and was positively accelerated when the food-paired brief stimulus was presented at the end of the first component (record B), and remained at a low rate when the nonpaired brief stimulus was presented at the end of the first component (record C). Responding in the second component of the chained schedule accelerated to high terminal rates under all conditions, with longer initial pauses under *chain* FR 2 (FI 2-min: S^p). Under the multiple schedule (record D), responding was well maintained and positively accelerated in both components. Performance under *tand* FR 2 (FI 2-min), in record E, was comparable to that maintained with Bird D-2469, as were the effects of adding both the food-paired stimulus (record F) and the nonpaired stimulus (record G) at the end of the first component.

Figure 3 shows similar effects of adding the food-paired brief stimulus to both the chained and tandem schedules with Bird I-1168. Re-

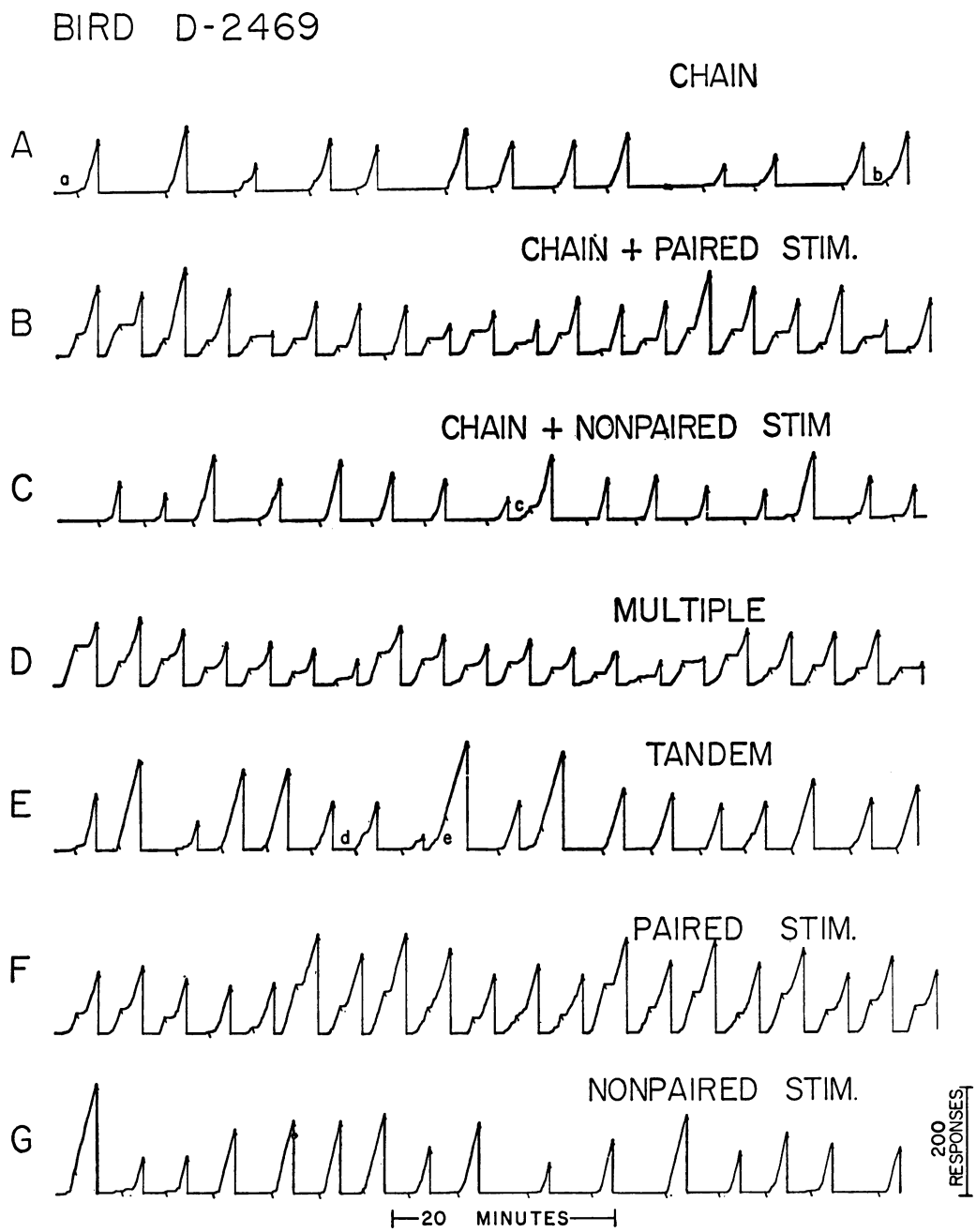

Fig. 1. Representative cumulative records for Bird D-2469 under a variety of second-order schedules of the general form FR 2 (FI 2-min). In all record segments the first diagonal hatch mark indicates completion of the first component. The second diagonal hatch mark and reset of the response pen to baseline indicates grain delivery at the end of the second component. The recorder was inoperative during the 1-min timeouts following grain delivery at the end of the second component. In record A, the second-order schedule was *chain* FR 2 (FI 2-min). In record B, the schedule was *chain* FR 2 (FI 2-min: S^p). In record C, the schedule was *chain* FR 2 (FI 2-min: S^n). In record D, the schedule was *mult* FI 2-min, FI 2-min. In record E, the schedule was FR 2 (FI 2-min). In record F, the schedule was FR 2 (FI 2-min: S^p). In record G, the schedule was FR 2 (FI 2-min: S^n).

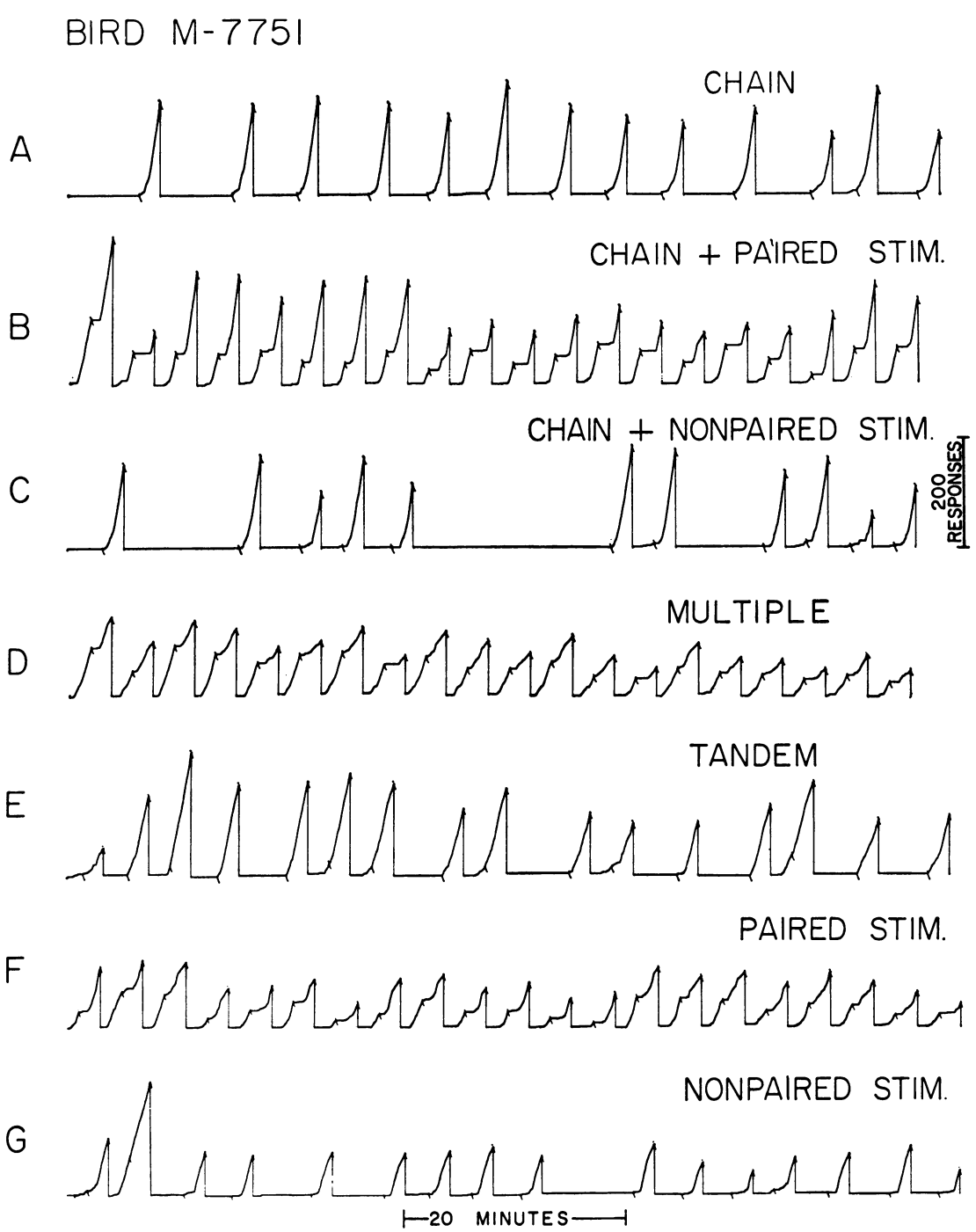

Fig. 2. Representative cumulative records for Bird M-7751 under a variety of second-order schedules of the general form FR 2 (FI 2-min). Recording specifications are the same as in Figure 1.

sponse rates were low in the first component of the chained schedule (record A), and increased markedly and were positively accelerated when the food-paired brief stimulus was presented at the end of the first component (record B). Responding in the second component of the chained schedule was at a high positively accelerated rate under both conditions. Re-

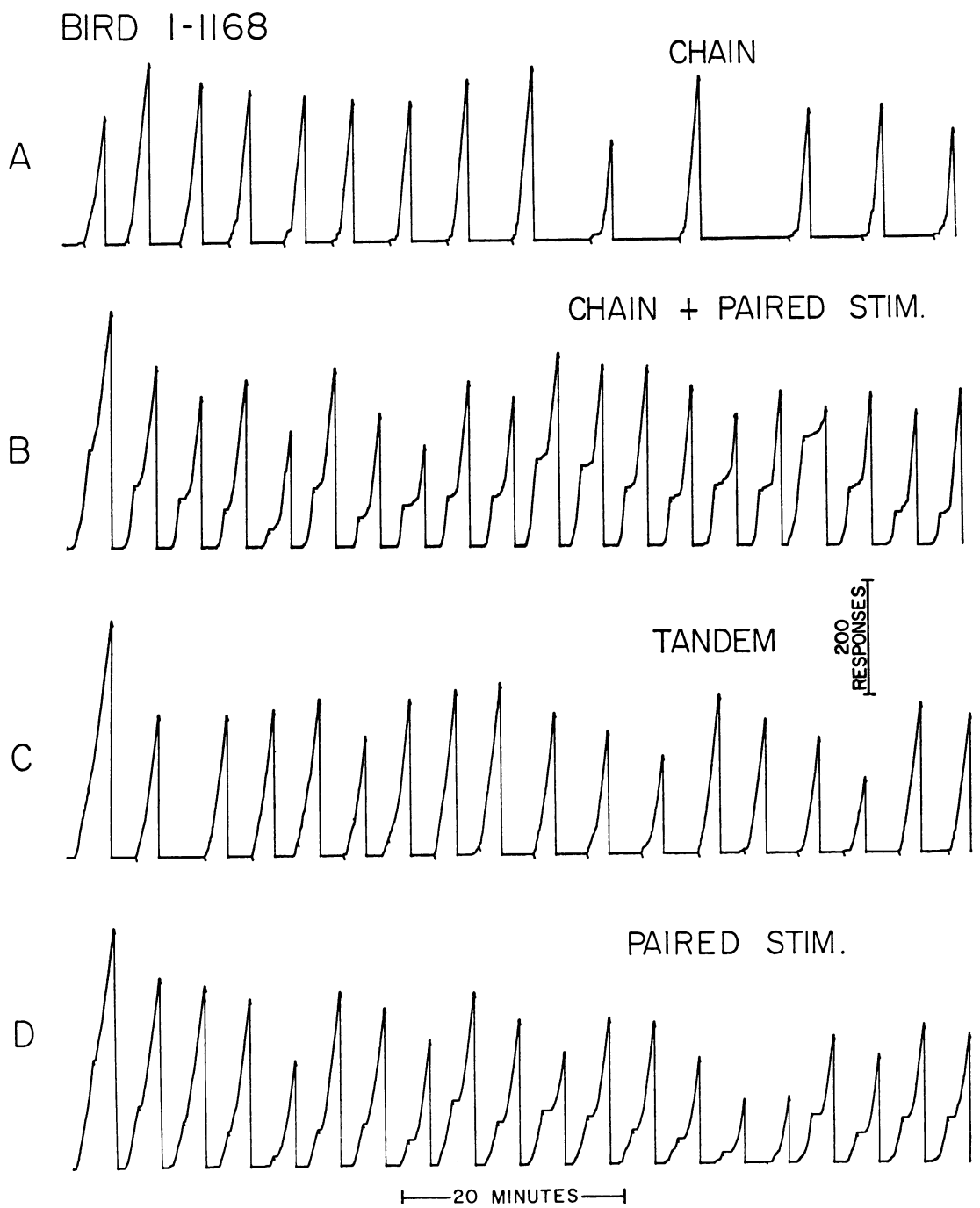

Fig. 3. Representative cumulative records for Bird I-1168 under a variety of second-order schedules of the general form FR 2 (FI 2-min). Recording specifications are the same as in Figure 1.

sponding under the tandem schedule was at a higher overall rate than with the first two birds, but was otherwise similar (record C). Adding the food-paired brief stimulus at the end of the first component of the tandem schedule resulted in high response rates and positively accelerated patterns in both components (record D).

Figures 4, 5, and 6 summarize the results in showing median values of overall response

rates and response rates during both components for the last five sessions under each condition. The lower portions of the figures show that response rates during the first component increased for all birds when the food-paired brief stimulus was added to both the chained schedule (Figures 4A, 4D, 5A, 5C, 6A) and to the tandem schedule (Figures 4B, 5B, 5D, 6B). Response rates during the first component were unchanged with Birds D-2469 and M-7751 when the nonpaired brief stimulus was added to both the chained schedule (Figures 4D, 5C) and to the tandem schedule (Figures 4E, 5D).

The effects of introducing either the food-paired brief stimulus or the nonpaired brief stimulus on response rates during the second component were less systematic. The middle portions of the figures illustrate these results. Introducing the food-paired brief stimulus to the chained schedule had no effects on response rates during the second component in four cases (Figures 4A, 4D, 5A, 6A), while there was a decrease in those response rates during the second exposure with Bird M-7751 (Figure 5C). Introducing the food-paired brief stimulus to the tandem schedule resulted in decreased response rates during the second component in three cases (Figures 4B, 5B, 5D), and no systematic change in the fourth case (Figure 6B). Introducing the nonpaired brief stimulus to the chained schedule had no effects on response rates during the second component (Figures 4D, 5C). When added to the tandem schedule, the nonpaired brief stimulus had no effects on response rates during the second component with Bird D-2469 (Figure 4E), while there was a decrease in those response rates with Bird M-7751 (Figure 5D).

The upper portions of the figures illustrate the effects on overall response rates. When added to the chained schedule, the food-paired brief stimulus increased overall response rates in all cases (Figures 4A, 4D, 5A, 5C, 6A). When the food-paired brief stimulus was added to the tandem schedule, overall response rates increased for Bird D-2469 (Figure 4B), and were unchanged for Birds M-7751 (Figures 5B, 5D) and I-1168 (Figure 6B). Adding the nonpaired brief stimulus to the chained schedule produced no changes in overall response rates with Bird D-2469 (Figure 4D) and M-7751 (Figure 5C). Adding the nonpaired brief stimulus to the tandem schedule produced no changes in overall response rates with Bird D-2469 (Figure 4E) while there was a small decrease in overall response rates with Bird M-7751 (Figure 5D).

DISCUSSION

Rates and patterns of responding throughout each type of second-order schedule were dependent upon the stimulus event that was presented when the first component was completed. The results were clearest with respect to performance during the first component. Consistent patterns of positively accelerated responding at moderate-to-high rates occurred during the first component under three conditions: (1) when the food-paired brief stimulus was presented at completion of the first component; (2) when both the food-paired brief stimulus and a discriminative stimulus were presented at completion of the first component; and (3) when food was presented at completion of both the first and second components. Response rates were low during the first component, with occasional patterns of positively accelerated responding, under two conditions: (1) when a discriminative stimulus was presented at completion of the first component; and (2) when both the nonpaired brief stimulus and a discriminative stimulus were presented at completion of the first component. Responding accelerated positively throughout the two components, with no systematic changes in rates and patterns of responding after the first component was completed, under two conditions: (1) when there were no changes in exteroceptive stimuli throughout the two components; and (2) when the nonpaired brief stimulus was presented at completion of the first component. Response rates during the first component increased and remained above those maintained under the baseline chained and tandem schedules after the food-paired brief stimulus was introduced, while after the nonpaired brief stimulus was introduced they increased for two to 10 sessions and then returned to baseline levels.

The effects of the food-paired brief stimulus on performance during the second component were dependent upon the conditions under which it was introduced. Positively accelerated patterns of responding typified performance during the second component under the

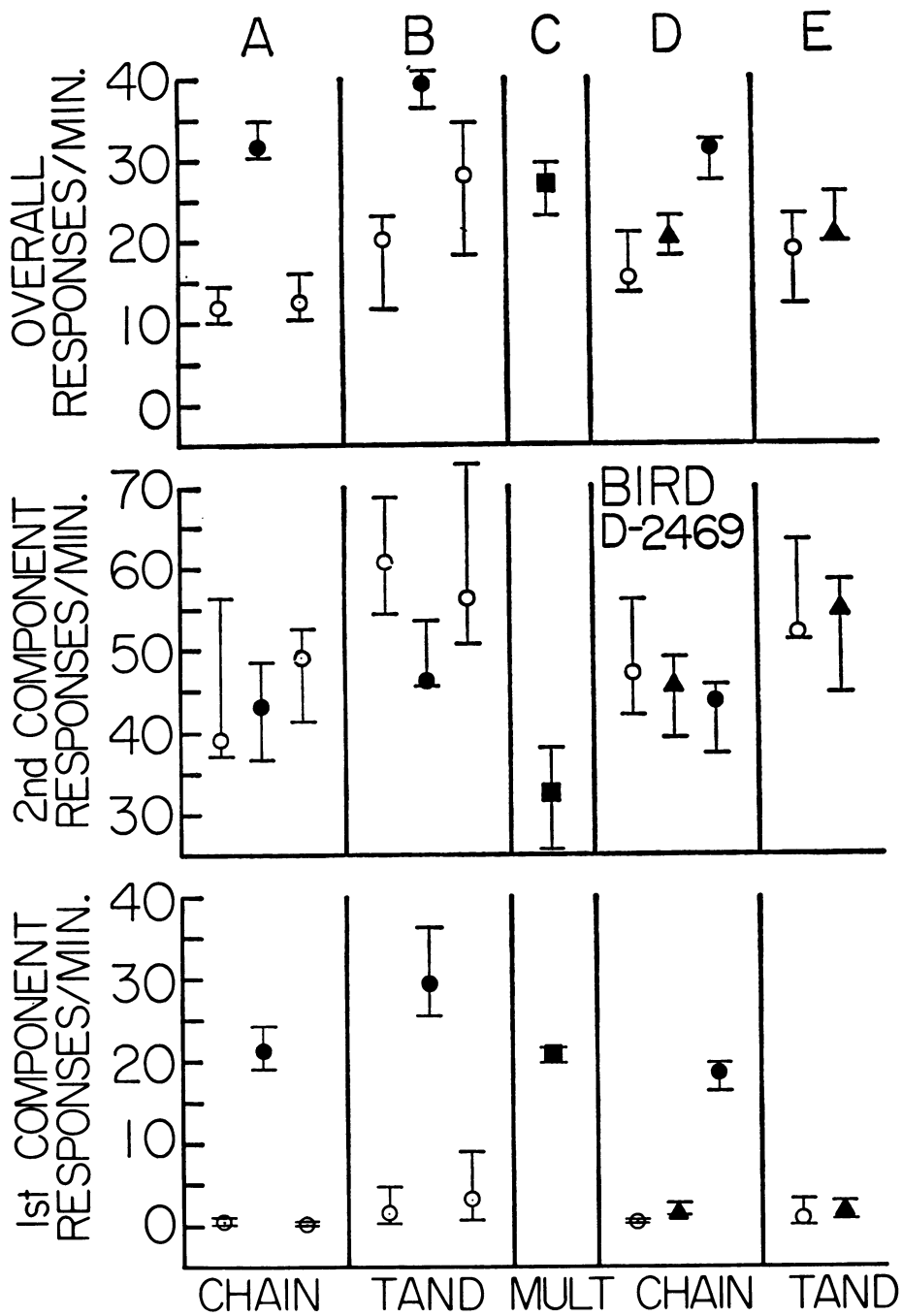

Fig. 4. Summary of the results for Bird D-2469. Shown are overall response rates (upper portion), response rates during the second component (middle portion), and response rates during the first component (lower portion). The symbols indicate the medians and the vertical lines indicate the ranges for the last five sessions under each condition. Unfilled circles indicate the basic chained or tandem schedules, as labelled. Filled circles indicate the addition of the food-paired brief stimulus at the completion of the first component of either the chained or tandem schedule. Filled squares indicate presentation of food at the completion of both components. Filled triangles indicate the addition of the nonpaired brief stimulus at the completion of the first component of either the chained or tandem schedule.

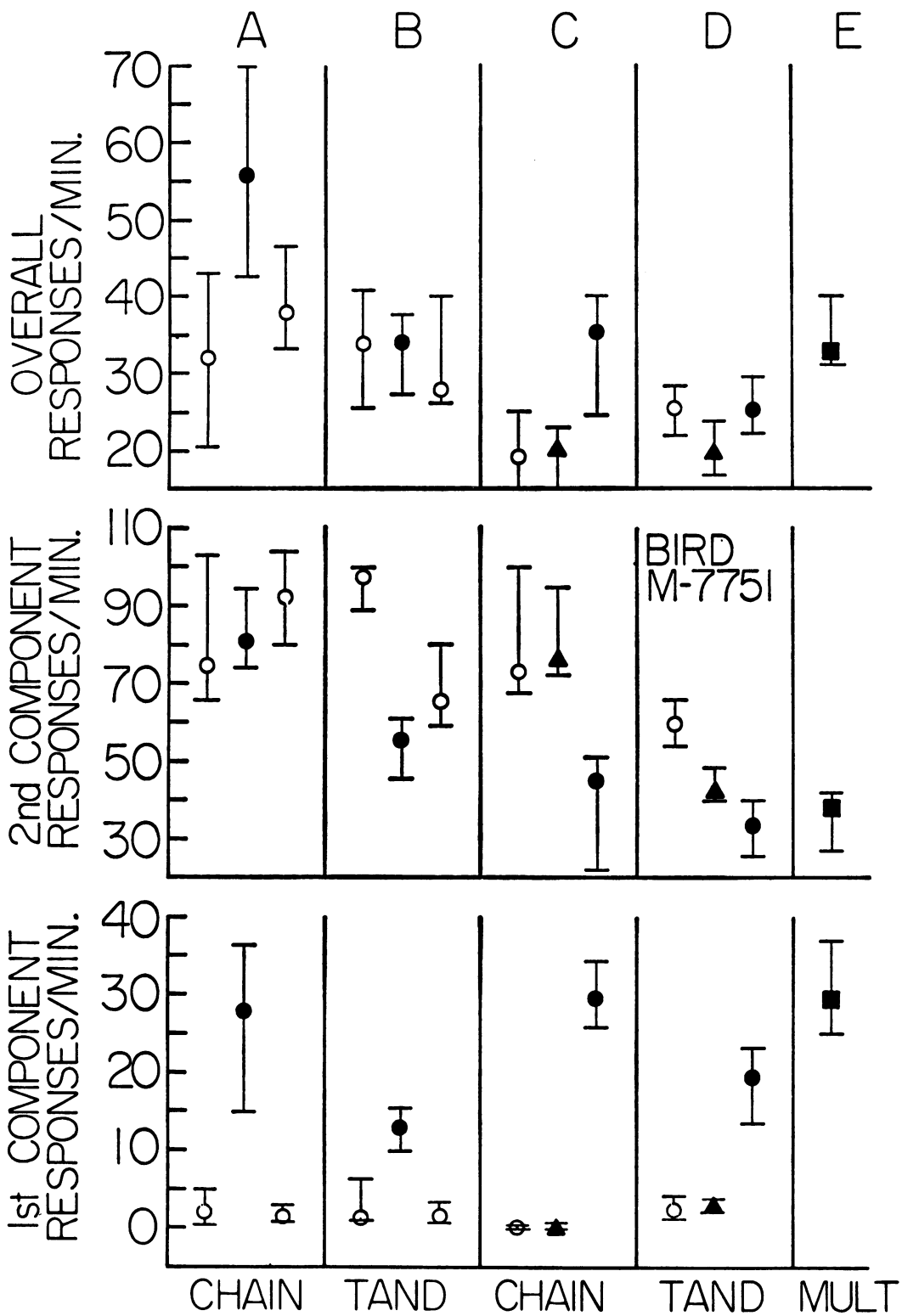

Fig. 5. Summary of the results for Bird M-7751. Symbol designations are the same as in Figure 4.

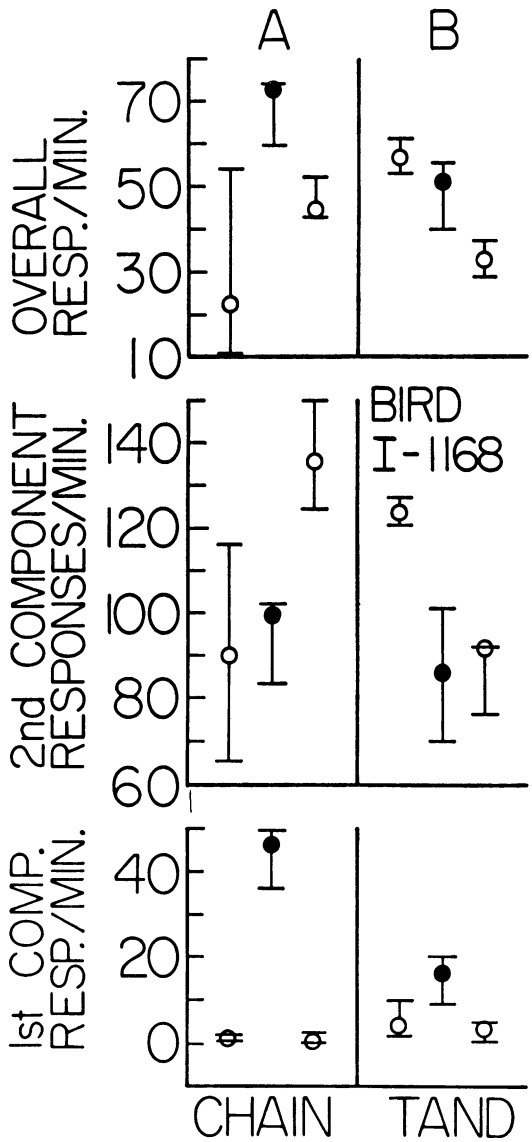

Fig. 6. Summary of the results for Bird I-1168. Symbol designations are the same as in Figure 4.

chained schedule, and introducing the food-paired brief stimulus under these conditions had no effects on second-component performance in four of five cases. Responding was positively accelerated throughout the two components under the tandem schedule, and introducing the food-paired brief stimulus under these conditions developed positively accelerated patterns of responding during the second component, with a decrease in response rates in three of four cases. Introducing the nonpaired brief stimulus to the chained schedule had no effects on second-component performance with either bird. Introducing the nonpaired brief stimulus to the tandem schedule resulted in no changes in patterns of responding during the second component with either bird, in no changes in response rates with one bird, and in an apparent decrease in response rates with the second bird.

The effects of both the food-paired and nonpaired brief stimuli on overall response rates essentially reflect a summation of the effects that occurred during the individual components. Adding the food-paired brief stimulus to the chained schedule increased overall response rates in all cases, while there were no changes in overall response rates in three of four cases after the food-paired brief stimulus was introduced to the tandem schedule. Introducing the nonpaired brief stimulus had no effect on overall response rates in three of four cases.

The present results are in general agreement with those of previous experiments with similar forms of second-order schedules. The patterns of responding obtained under the basic chained and tandem schedules are comparable to those reported by Gollub (1958) under chained and tandem FR 2 (FI 2-min) schedules. The general patterns of responding obtained within FI 2-min components under both the food-paired and nonpaired brief-stimulus schedules are similarly comparable to those obtained by Kelleher (1966*a*, *b*) and deLorge (1967). Interpolating both the food-paired brief stimulus and the nonpaired brief stimulus between the successive discriminative stimuli of the chained schedule affected the rates and patterns of responding within individual FI 2-min components in a manner similar to that obtained by Byrd and Marr (1969). In that experiment, FI 2-min components were associated with food on a 12-unit variable-ratio schedule, and both food-paired and nonpaired brief stimuli were added to both chained and tandem schedules. Positively accelerated patterns of responding within individual components were only consistently maintained when the food-paired brief stimulus was presented at completion of the components. Overall response rates throughout the sequence of components were affected differently in the two studies. Overall response rates decreased in the Byrd and Marr (1969) experiment when the food-paired brief stimulus was

added to the chained schedule, while they increased in the present study. These differences in results may be due to the use of different schedules according to which the FI 2-min components terminated in food delivery.

Many previous experimenters have interpreted results similar to the present findings in terms of differences in the conditioned reinforcing effectiveness of discriminative stimuli, food-paired brief stimuli, and nonpaired brief stimuli. In general, the discussions have centered around these suggestions: (1) food-paired brief stimuli control rates and patterns of responding appropriate to the component schedules because their direct and intermittent association with food establishes and maintains the stimuli as conditioned reinforcers; (2) nonpaired brief stimuli do not control rates and patterns of responding appropriate to the component schedules because they are never directly paired with food and hence do not become established as conditioned reinforcers; and (3) discriminative stimuli may or may not control rates and patterns of responding appropriate to their schedules of presentation, their effectiveness as conditioned reinforcers being determined by a wide range of factors including frequency of food reinforcement in their presence, position in the chain, *etc.* (Byrd and Marr, 1969; Crossman, 1969; deLorge, 1967, 1969, 1971; Ferster and Skinner, 1957; Findley and Brady, 1965; Gollub, 1958; Kelleher, 1966*a, b;* Kelleher and Gollub, 1962; Lee and Gollub, 1971; Marr, 1969; Stubbs, 1969; Thomas and Stubbs, 1966, 1967). However, results have recently been reported that suggest restrictions on the conditioned reinforcement interpretations of many of these previous results as well as of those from the present experiment (Stubbs, 1971; Stubbs and Cohen, 1972).

The major issue raised by the experiments of Stubbs (1971) and Stubbs and Cohen (1972) concerns the selection of exteroceptive stimuli used in second-order schedules. In many previous experiments comparing the effects of food-paired brief stimuli with those of nonpaired brief stimuli, physically different stimuli were employed in the two procedures. The results supported conditioned reinforcement interpretations. That is, rates and temporal patterns of responding within components were similar to those obtained with comparable schedules of food reinforcement with the food-paired stimulus, and were not similar to those obtained with comparable schedules of food reinforcement with the nonpaired stimulus. Both the procedures and the present results are comparable to those previous experiments (Byrd and Marr, 1969; deLorge, 1967, 1969; Kelleher, 1966*b;* Marr, 1969; Stubbs, 1969). In sharp contrast, Stubbs (1971) and Stubbs and Cohen (1972) sampled a variety of exteroceptive stimuli across a wide range of second-order brief-stimulus schedules. Under each condition, the same physical stimulus was employed in both food-paired and nonpaired procedures. No differences in rates and temporal patterns of responding were found in comparing the effects of food-paired brief stimuli with those of nonpaired brief stimuli. Under all conditions, the rates and patterns of responding within components were similar to those ordinarily obtained with comparable schedules of food reinforcement. From the results of these experiments, the authors came to three major conclusions. First, pairing a brief stimulus with food is not a necessary condition for the brief stimulus to affect performance under second-order schedules. Second, some stimuli (*e.g.,* keylight plus houselight) are more effective than other stimuli (*e.g.,* blackout) in controlling performance within second-order schedules. Third, comparisons between food-paired and nonpaired brief-stimulus procedures are confounded when different stimuli are used in the two procedures.

Given the restrictions on interpretations imposed by these considerations, it is difficult to make firm conclusions regarding the role of the pairing operation in the present experiment. Perhaps the stimulus used as the food-paired brief stimulus (offset of houselights and keylight, illumination and activation of the food tray) was more salient than both the stimulus used as the nonpaired brief stimulus (blue keylight and tone) and the stimulus used as the discriminative stimulus associated with the second component of the chained schedule (white keylight with triangular pattern). The differences between the rates and patterns of responding controlled in the first component by the food-paired brief stimulus and those controlled by either the nonpaired brief stimulus or the discriminative stimulus may have been due to these differences in saliency among the stimuli employed.

Other considerations suggest, however, that these apparent differences in stimulus saliency may not have been the only factors responsible for the differences in performance. First, it should be noted that the presence of differences among the stimuli does not mean that the nonpaired brief stimulus and the discriminative stimulus were not attended to by the birds. Introducing the brief blue keylight and tone frequently resulted in effects that were comparable to those chronically maintained by the food-paired brief stimulus; these effects, however, dissipated within two to 10 sessions. That the white key with a triangular pattern functioned as a discriminative stimulus is evidenced by the patterns of responding controlled in its presence as compared with those controlled by the tandem schedule. And second, the stimuli used as both the nonpaired brief stimulus and as the discriminative stimulus associated with the second component are comparable to those that have been previously found to be effective as food-paired brief stimuli in second-order schedules (deLorge, 1967; Kelleher, 1966*a*, *b*).

In conclusion, the differences in rates and patterns of responding controlled by the three exteroceptive stimuli could have been due to several factors. Interpretation of the results in terms of conditioned reinforcement suggests that the food-paired brief stimulus was a more effective conditioned reinforcer than was the discriminative stimulus associated with the second component of the chained schedule. These differences in conditioned reinforcement effectiveness may be due to the different frequencies of food reinforcement associated with the two stimuli (see Kelleher, 1966*a*, for a thorough discussion of this point). In addition, these results also suggest that the nonpaired brief stimulus was "neutral" because of its lack of direct pairing with food. However, the issues raised by Stubbs (1971) and Stubbs and Cohen (1972) should be considered in interpreting these results. Further experiments comparing the three procedures should control for these confounding stimulus variables.

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