

*CHARACTERISTICS AND RESPONSE-DISPLACEMENT
EFFECTS OF SHOCK-GENERATED RESPONDING
DURING NEGATIVE REINFORCEMENT PROCEDURES:
PRE-SHOCK RESPONDING AND POST-SHOCK
AGGRESSIVE RESPONDING¹*

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Bar-pressing (Experiment I) or key-pressing (Experiments II and III) responses of monkeys were reinforced according to a fixed-interval schedule of negative reinforcement: the first response after a fixed interval of time terminated regularly spaced shocks for a fixed time designated as the reinforcement period. During extinction, shocks continued during the reinforcement period. That there were two types of responding generated by shock alone was indicated by (1) the level of responding maintained during extinction relative to conditions without shock, (2) the stability of two between-shock response patterns across reinforcement and extinction conditions, and (3) the development of these two between-shock patterns without a history of reinforcement. Subjects developed either a pre-shock or a post-shock response pattern when only the bar was available. However, when both a bite tube, an operandum requiring an aggressive topography, and a recessed key, an operandum that did not require an aggressive topography, were provided, the post-shock pattern was observed in tube biting and the pre-shock pattern was observed in key pressing. Removal of the bite tube produced post-shock key responding similar to that observed when only the bar was available. The displacement of post-shock, aggression-motivated responding confirmed the confounding effect of shock-generated responding in negative reinforcement procedures, and suggests that the use of concurrent response alternatives would reduce such confounding.

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- Experiment I. Analysis of pre- and post-shock responding during a negative reinforcement procedure with only one operandum.
- Experiment II. Analysis of pre- and post-shock responding during a negative reinforcement procedure when there is an additional operandum for aggressive responding.
- Experiment III. Response-displacement effects: the effects of removing the operandum for aggressive responding upon the rate and pattern of responding on the other operandum.

Research in the area of aversive control has shown that behavior can be increased by electric shock when that behavior does not ap-

pear to reduce the shock. For example, when a target object is available, aggressive responding has been observed to follow immediately after electric shock (see reviews by Ulrich, Hutchinson, and Azrin, 1965; Azrin, 1967). There is also the recent finding that shocks delivered at regular time intervals can generate a pattern of increasing response rates between shocks. These pre-shock patterns of non-aggressive responding have been observed (1) when responding produced shock according to a fixed-interval schedule (Kelleher, Riddle, and Cook, 1963; Kelleher and Morse, 1968; Byrd, 1969; Morse, Mead, and Kelleher, 1967; McKearney, 1968, 1969; Stretch, Orloff, and Dalrymple, 1968; Powell and Peck, 1969) and (2) when regularly spaced shocks were delivered independent of responding (Hutchinson, Renfrew, and Young, 1971; Powell and Peck, 1969).

Although neither pre-shock nor post-shock patterns of responding appear to result from negative reinforcement in the form of shock reduction, it is possible that both may occur during negative reinforcement procedures that involve shock. The present research attempted

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(1) to determine if these types of responding occurred during a negative reinforcement procedure and, if so, (2) to determine the characteristics and effects of these types of responding during a negative reinforcement procedure. Shocks were delivered at regular intervals independent of responding for a minimum, fixed period of time. These shocks could not be modified. In this way, the procedure provided conditions under which both pre- and post-shock responding have been observed. Reinforcement in the form of shock reduction was provided according to a fixed-interval schedule of negative reinforcement: the first response after a minimum, fixed period of time terminated the regularly spaced shocks for a fixed period designated as the reinforcement period. Since the procedure provided for reinforcement as well as response-independent shocks, it was possible to study responding controlled by the reinforcement contingency and responding generated by the shock alone by systematically manipulating the availability of reinforcement.

EXPERIMENT I. ANALYSIS OF PRE- AND POST-SHOCK RESPONDING DURING A NEGATIVE REINFORCEMENT PROCEDURE WITH ONLY ONE OPERANDUM.

METHOD

Subjects and Apparatus

Seven experimentally naive squirrel monkeys were individually seated in a restraining chair equipped with tail-electrodes (Hake and Azrin, 1963). A horizontal plate that extended to the walls of the chamber served as the waistlock and also prevented the monkey from reaching its tail. Electric shocks were delivered to the tail, which was immobilized by a tail-stock, through two brass electrodes that rested on a shaved portion of the tail. To ensure a low resistance electrical contact, the shaved portion of the tail was massaged with electrode paste (EKG-Sol). A 160-v ac, 60-Hz, 75-msec shock was delivered through a 10k-ohm series resistor resulting in a current level of approximately 10 mA with the subject in the circuit. Since over the range of shock intensities used in this series of experiments, current levels changed in nearly direct proportion to volt-

age changes, the shock levels are specified as voltages at the secondary coil of the transformer.

The monkeys were free from the waist up. The work space above the horizontal waistlock was 8 by 12 by 10 in. (20 by 30 by 25 cm) high. The response bar was located on the front wall, 2.25 in. (6 cm) above the waistlock and about 4.75 in. (12.5 cm) from the monkey. The response bar was 1 in. (2.5 cm) wide and protruded 0.75 in. (2 cm) from the wall. A downward force of 5 g (0.049N) defined a response and produced an audible click. The stimuli used to signal the experimental conditions were: (1) a 1-in. (2.5-cm) diameter stimulus light that could be illuminated with either red or white light was located above the response bar, and (2) a 100-Hz tone that raised the ambient noise level from 70 to 90 dB. Two 7.5-w overhead lights were on continuously.

Procedure

Reinforcement condition. Shocks occurred every 30 sec in the presence of the fixed-interval (FI) stimulus, white illumination of the stimulus light. The first bar response after 3 min was followed by reinforcement, the absence of shocks for a 3-min period, and the reinforcement-period stimulus, the 100-Hz tone and red illumination of the stimulus light. The 3-min reinforcement period was followed by the next FI.

Extinction condition. During the extinction condition, shocks occurred every 30 sec during the FI stimulus and continued to occur at the same rate during the reinforcement-period stimulus. As in the reinforcement condition, the first bar response after 3 min during the FI stimulus was followed by the 3-min reinforcement-period stimulus.

Experimental design. The design was the traditional ABA with A representing the reinforcement condition and B representing the extinction condition. Five subjects were tested in the ABA order and two were tested in the BAB order. There were typically about 30 sessions under each condition: the exact number is given in Figure 2. Sessions were conducted each weekday and lasted 2 hr.

RESULTS AND DISCUSSION

Figure 1 shows that the FI schedule of negative reinforcement resulted in the pattern of

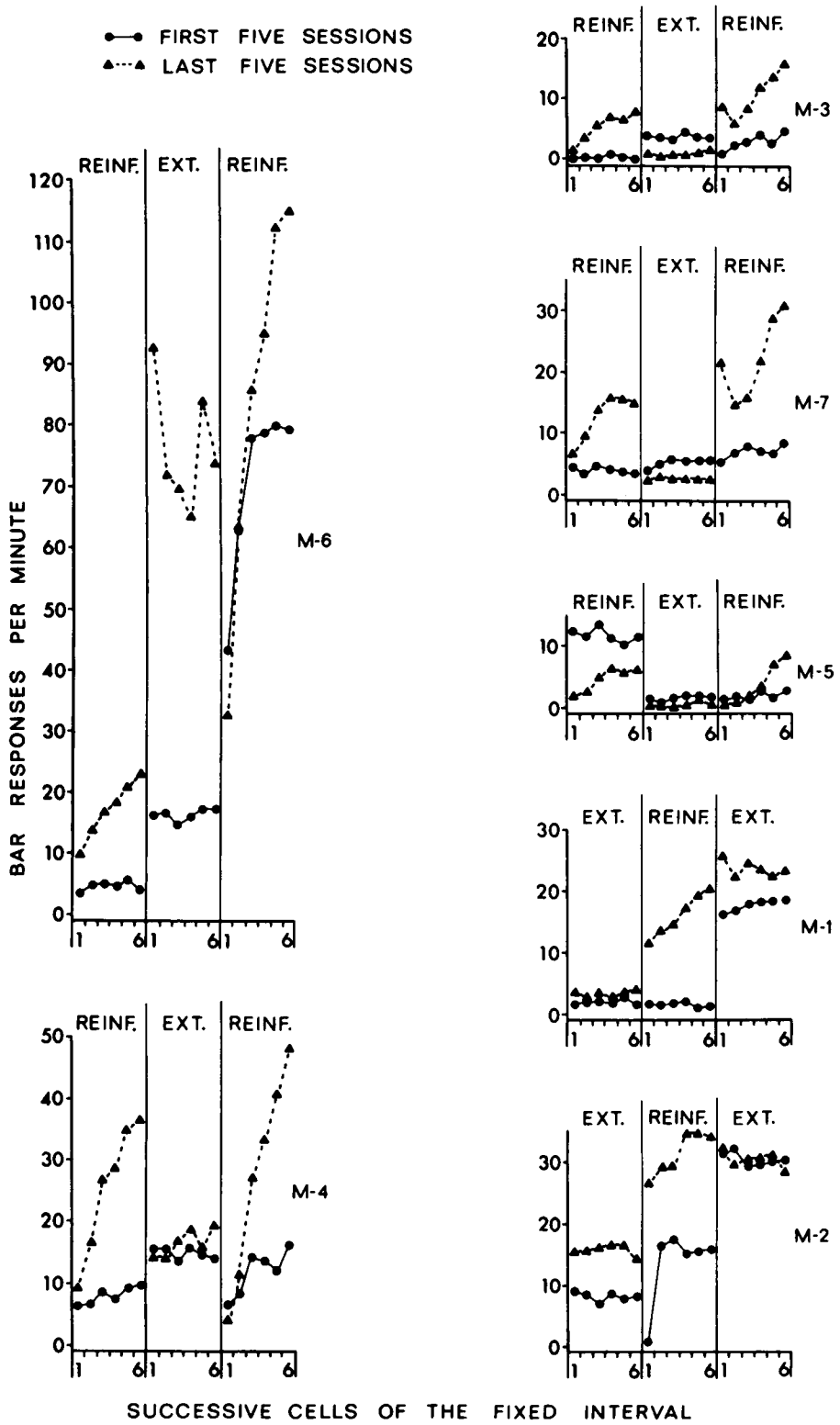


Fig. 1. Rate of bar responding during successive cells of the fixed-interval across reinforcement and extinction conditions.

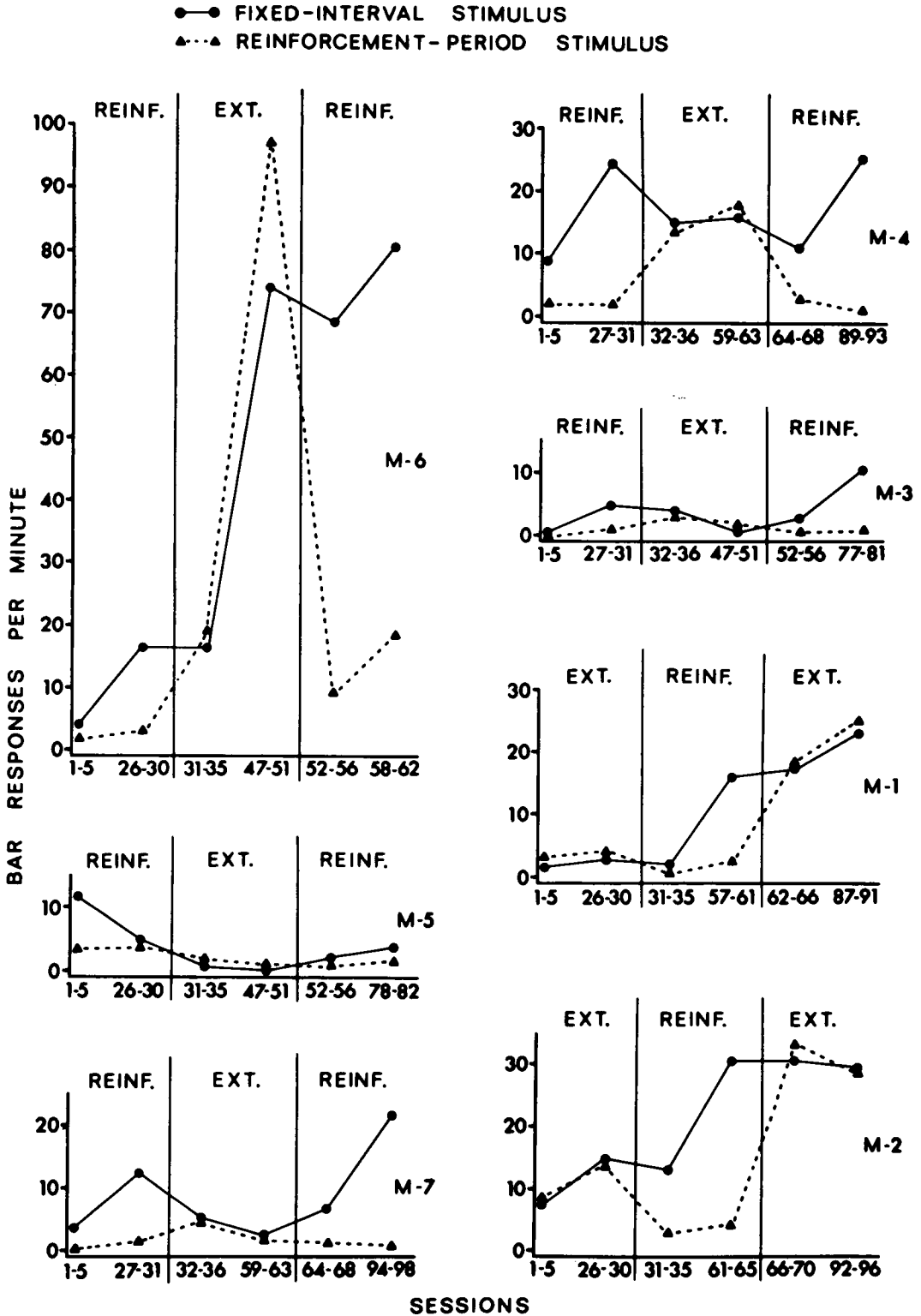


Fig. 2. Mean rate of bar responses during the fixed-interval stimulus and the reinforcement-period stimulus across reinforcement and extinction conditions.

responding characteristic of the FI schedule of positive reinforcement: response rate increased across the successive cells of the FI under the reinforcement condition. As is the case under a FI schedule of positive reinforcement, the pattern of increasing response rate across the FI became more pronounced with continued exposure, *i.e.*, from the first (circles) to the last five sessions (triangles) under the reinforcement condition. Evidence that the pattern of increasing response rate was due to negative reinforcement is provided by the relatively constant rate of responding across the FI under the extinction condition.

The FI pattern of responding was a more consistent indicator of reinforcement than average response rate. Although response rate was generally higher during the reinforcement condition, considerable responding occurred during extinction. This can be seen more clearly in Figure 2, which shows the average response rate during both the FI stimulus and the reinforcement-period stimulus across reinforcement and extinction conditions. That responding was generally higher during the reinforcement condition can be seen by comparing the stable response rates (last five sessions) during the FI stimulus under the reinforcement and extinction conditions. On 11 of the 14 changes from reinforcement to extinction and *vice versa*, the stable response rate in the new condition was in a direction consistent with a reinforcement interpretation. Similarly, during 11 of the 12 exposures to the reinforcement condition, responding increased from the transitional (first five sessions) to the stable sessions.

On the other hand, the extinction results indicate that considerable responding was generated by shock alone independent of reinforcement. First, consider the responding during the reinforcement-period stimulus. Responding there under the reinforcement condition provides a baseline for evaluating the generative effects of shock alone because such responding was never reinforced and no shocks were delivered during that stimulus. Little responding occurred there during the reinforcement condition, and much of what did occur resulted from a continuation of the terminal FI response rate. There was typically more responding during the reinforcement-period stimulus under the extinction condition where shock was presented during that stim-

ulus: 12 of the 14 times that the presence and absence of shock was manipulated, stable response rates during the reinforcement-period stimulus changed in a direction consistent with an interpretation of shock-generated responding. Now consider the stable responding during the FI stimulus in extinction. Reinforcement history would be expected to have little or no effect upon this responding because 15 to 25 sessions had elapsed since responding had been reinforced. Yet, responding remained during the FI stimulus in the stable extinction sessions for all subjects at a level equal to that generated by shock alone during the reinforcement-period stimulus. Further evidence of shock-generated responding that is independent of reinforcement is shown by the development and continuation of responding by M-1 and M-2 that were initially exposed to the extinction condition. Since reinforcement history cannot account for the development and continuation of responding during extinction, and since shock occurrence is the only other variable operating during extinction, it may be concluded that responding during the FI stimulus and the reinforcement-period stimulus was generated by shock alone during extinction.

If shock alone generated responding during extinction, it follows that shock also generated some of the responding during the FI stimulus under the reinforcement condition. Additional evidence that part of the FI responding was generated by shock alone is shown in Figure 3, which reveals consistent patterns of responding between shocks across both reinforcement and extinction conditions. The rate of responding was generally lower during extinction, but the same patterns remained. There were two distinct patterns: a pattern of predominantly decreasing response rate, or post-shock pattern, emerged for four of the subjects (M-6, 7, 2, 1), while a pattern of predominantly increasing response rate, or pre-shock pattern, emerged for three subjects (M-4, 3, 5). Another consistent feature of the pre-shock pattern was a decrement in response rate in the cell just before shock. That the pattern of responding between shocks remained consistent for a given subject independent of the presence or absence of negative reinforcement definitely indicates that these patterns of responding were generated by shock alone.

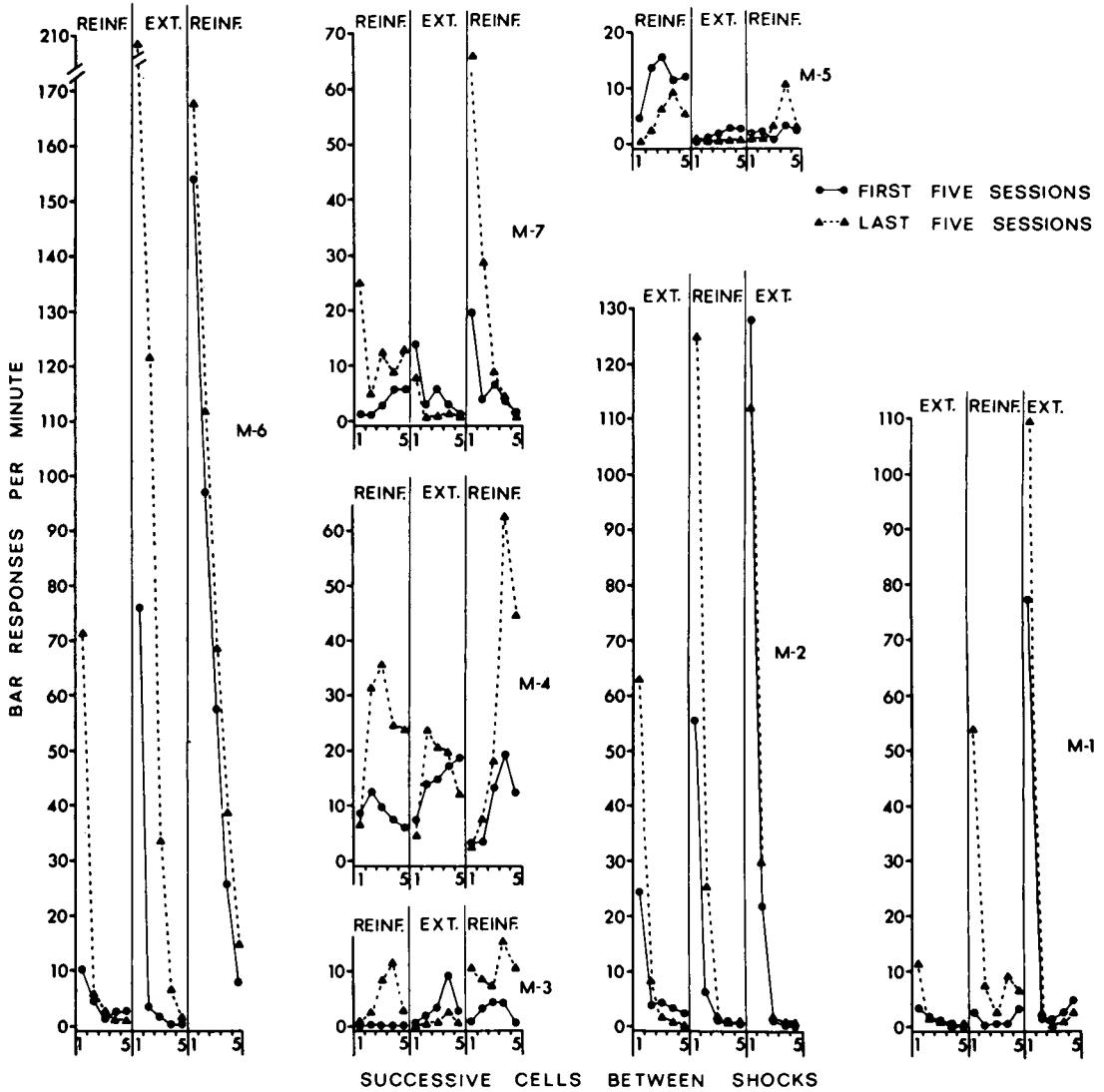


Fig. 3. Rate of bar responses during successive cells between shocks across reinforcement and extinction conditions.

Examination of the response bar frequently revealed evidence of bar biting. Subsequent observations of the responding confirmed that some of the recorded bar responses were bar-biting rather than bar-pressing responses.

EXPERIMENT II. ANALYSIS OF PRE- AND POST-SHOCK RESPONDING DURING A NEGATIVE REINFORCEMENT PROCEDURE WHEN THERE IS AN ADDITIONAL OPERANDUM FOR AGGRESSIVE RESPONDING.

In Experiment I, two patterns of responding generated by shock alone emerged when a

single operandum was available. Previous research suggests that these patterns are associated with different response topographies, but because they occurred on a single operandum no clear differentiation of the response topographies could be made. The post-shock response pattern has been associated with aggressive responses such as biting (*e.g.*, Azrin, Hutchinson, and Hake, 1963, 1967; Hutchinson, Azrin, and Hake, 1966; Hutchinson, Azrin, and Renfrew, 1968), while the pre-shock response pattern has been associated with non-aggressive responses, such as chain pulling and lever pressing (Hutchinson *et al.*, 1971).

Experiment II attempted to define further the characteristics and effects of responding generated by shock alone during negative reinforcement procedures by providing two operanda: one required an aggressive response topography and the other could be activated by a non-aggressive response topography. If pre- and post-shock response patterns are indicative of non-aggressive and aggressive response categories respectively, and if post-shock aggressive responding did occur on the operandum provided for it, pre-shock responding could then be observed on the other operandum, and in this way differentiate the response patterns characteristic of aggressive and non-aggressive responding. Further, if the pre- and post-shock patterns were generated by shock alone, both should be evident during extinction as well as the reinforcement condition. Experiment II tested these possibilities through the addition of a bite tube, an operandum requiring an aggressive response topography (Hutchinson *et al.*, 1966), and the substitution of a pigeon key for the response bar. The pigeon key was sufficiently recessed to prevent biting.

Subjects and Apparatus

Five experimentally naive squirrel monkeys served.

There were three changes in the experimental chamber. First, the response bar was replaced by a 0.75 in. (1.9-cm) diameter Gerbrands pigeon key that was centered on the front wall about 7 in. (17 cm) up from the horizontal waistlock and recessed 0.4 in. (1.0 cm) into the front wall. About 5 g (0.049N) of force operated the key and produced a relay click. Since the key could be illuminated with either red or white light, it was used in conjunction with the 100-Hz tone to signal the FI and reinforcement periods. The second change was the addition of a bite tube (Hutchinson *et al.*, 1966), a 5 in. (12.7 cm) long and a 0.5-in. (1.5-cm) diameter rubber hose located 0.4 in. (1 cm) below the key, but 1.5 in. (4 cm) out from the front wall. The bite tube was connected to a pneumatic switch calibrated to record pressures over 2-mm Hg. This pressure has been shown to record biting responses reliably in squirrel monkeys while other contacts have not produced readings of this magnitude (Hutchinson *et al.*, 1966). The third change was the addition of a hinged neck yoke that

insured proximity of the monkey's head to the bite tube (see Hutchinson *et al.*, 1966) but restricted head movement such that it was impossible for the monkey's head to reach the key, which was recessed into the front wall 2 in. (5 cm) beyond the bite tube. Given the occurrence of biting, the neck yoke insured that biting would be directed toward the tube rather than the key or some part of the chamber where it was not recorded. Both the key and the tube were placed at eye level because the position of the neck yoke restricted head movement and thus restricted the visual range.

Procedure

The fixed-interval schedule of reinforcement in this experiment was essentially the same as that used in Experiment I. Shocks occurred every 30 sec (M-11, 12) or 60 sec (M-8, 9, 10) in the presence of the fixed-interval stimulus, the key illuminated by white light. The first key push after 6 min was followed by reinforcement, the absence of shocks for a 6-min period, and the reinforcement-period stimulus, the key illuminated with red light plus the 100-Hz tone. During the extinction condition, the regularly spaced shocks occurred during the FI stimulus and continued to occur at the same rate during the reinforcement-period stimulus. The bite tube was always available, and biting could occur at any time. However, to insure that bites were never immediately followed by the reinforcement-period stimulus, a changeover delay, which was either 2.5, 5, or 10 sec for different subjects, was imposed between bite responses and key responses that could be followed by the reinforcement-period stimulus. For a given subject, the shock level was 200 or 300 v.

The experimental design was essentially the same as in Experiment I: the reinforcement condition (A) alternated with the extinction condition (B) in either an ABA (M-8, 9, 11, 12) or BAB (M-10) order. There were approximately 30 sessions under each condition except the initial one. During the initial condition, whether A or B, there were changes in the duration of the changeover delay and the shock intensity that necessitated the subjects being run for more than 30 sessions in order to have 30 sessions under constant conditions. For this reason, data are shown for only the last five sessions under the initial condition.

Sessions were conducted weekdays and lasted either 1 hr (M-11, 12) or 2 hr (M-8, 9, 10).

Before the initial experimental condition, there were 15 sessions without shock. The procedure was the same as in the initial experimental condition, and the data were recorded as if shock were being presented. This was done to determine if there were any definitive patterns of key responding or tube biting before shock was actually introduced.

RESULTS AND DISCUSSION

No-shock condition. Most of the subjects made few key-pressing and biting responses during the 15 sessions without shock. Only two of the five subjects (M-8 and 9) averaged more than one biting response per session. During the stable sessions without shock, M-8 averaged 4.2 bites per minute as contrasted to averages of 14.0 and 15.6 bites per minute, respectively, for the stable reinforcement and extinction sessions. The other subject (M-9) averaged 1.0 bites per minute as contrasted to 2.1 and 3.4 bites per minute, respectively, for the stable reinforcement and extinction sessions. No consistent pattern of biting was evident during the sessions without shock with respect to either the temporal intervals at which shocks were later delivered or the FI.

Only one of the five subjects made more than one key response in any session without shock. This subject (M-9) averaged 3.7 key responses per minute during the stable sessions without shock compared to averages of 6.4 and 1.9 responses per minute, respectively, during the stable reinforcement and extinction sessions. This subject did average more key responses without shock than during extinction, but there was no consistent pattern of key responding with respect to where shocks were later delivered. There was, however, some indication of FI schedule control: the rates of key responding increased from 2.5 to 3.0 responses per minute during the first two 1-min cells of the 6-min FI to a rate of 4.5 responses per minute in the last two cells. This schedule control through stimulus change is slight as compared to that seen under the reinforcement condition (Figure 4) when response rates increased from 0.0 to 0.5 responses per minute in the first two cells to rates of 18.0 to 22.0 responses per minute in the last cell.

Reinforcement and extinction conditions. The effects of reinforcement upon the rate

and pattern of key and bite responses across the FI are shown in Figures 4 and 5. Reinforcement for the key response did affect the key responding but not the biting. First examine the reinforced key responding shown in Figure 4. Reinforcement resulted in the characteristic fixed-interval pattern of responding: response rate increased across the successive cells of the fixed-interval, and this pattern became more pronounced from the transitional to the stable sessions under the reinforcement condition. Consistent with a reinforcement interpretation, the pattern of increasing response rate was less evident (M-8, 9) or absent (M-10, 11, 12) during the stable sessions under the extinction condition. As was the case in Experiment I, the pattern of responding was a better indicator of negative reinforcement than overall response rate, which was reduced during extinction for only three (M-8, 9, 11) of the five subjects.

That reinforcement for the key response had no effect upon biting can be seen in the consistent rate and pattern of biting across reinforcement and extinction conditions (Figure 5). There were about the same number of bites in each cell across the fixed-interval, and these numbers remained about the same regardless of the presence or absence of reinforcement for the key response.

Figures 6 and 7 show the pattern of the biting and key responding between the shocks. There was a predominantly post-shock pattern of biting, a predominantly pre-shock pattern of key pushing, and neither pattern was affected by the presence or absence of reinforcement for the key response. First, examine Figure 6, which shows the pattern of biting between shocks. It can be seen that four of the five monkeys had a predominantly post-shock pattern of biting that was not affected by the presence or absence of reinforcement. The fifth monkey (M-10) rarely bit the tube. It can also be seen that three of the subjects (M-11, 12, and for M-8 during the stable sessions in the second reinforcement condition) had a secondary pattern of responding suggestive of temporal respondent conditioning: the post-shock responding was followed first by a period of little or no biting and then an increase in biting as the time for the next shock approached.

Figure 7 shows that none of the subjects had a predominantly post-shock pattern of key responding as was the case for some of the sub-

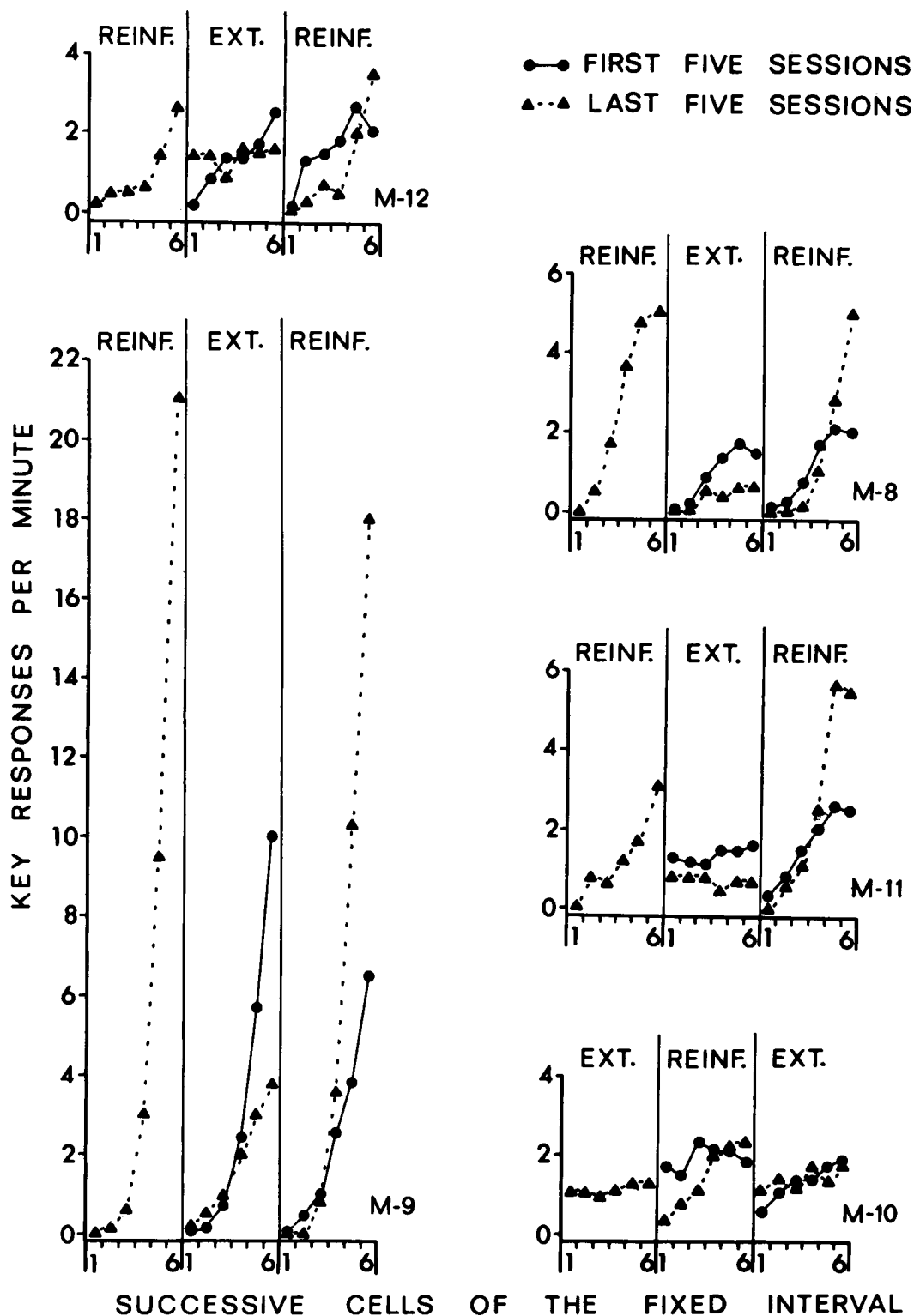


Fig. 4. Rate of key responses during successive cells of the fixed-interval across reinforcement and extinction conditions.

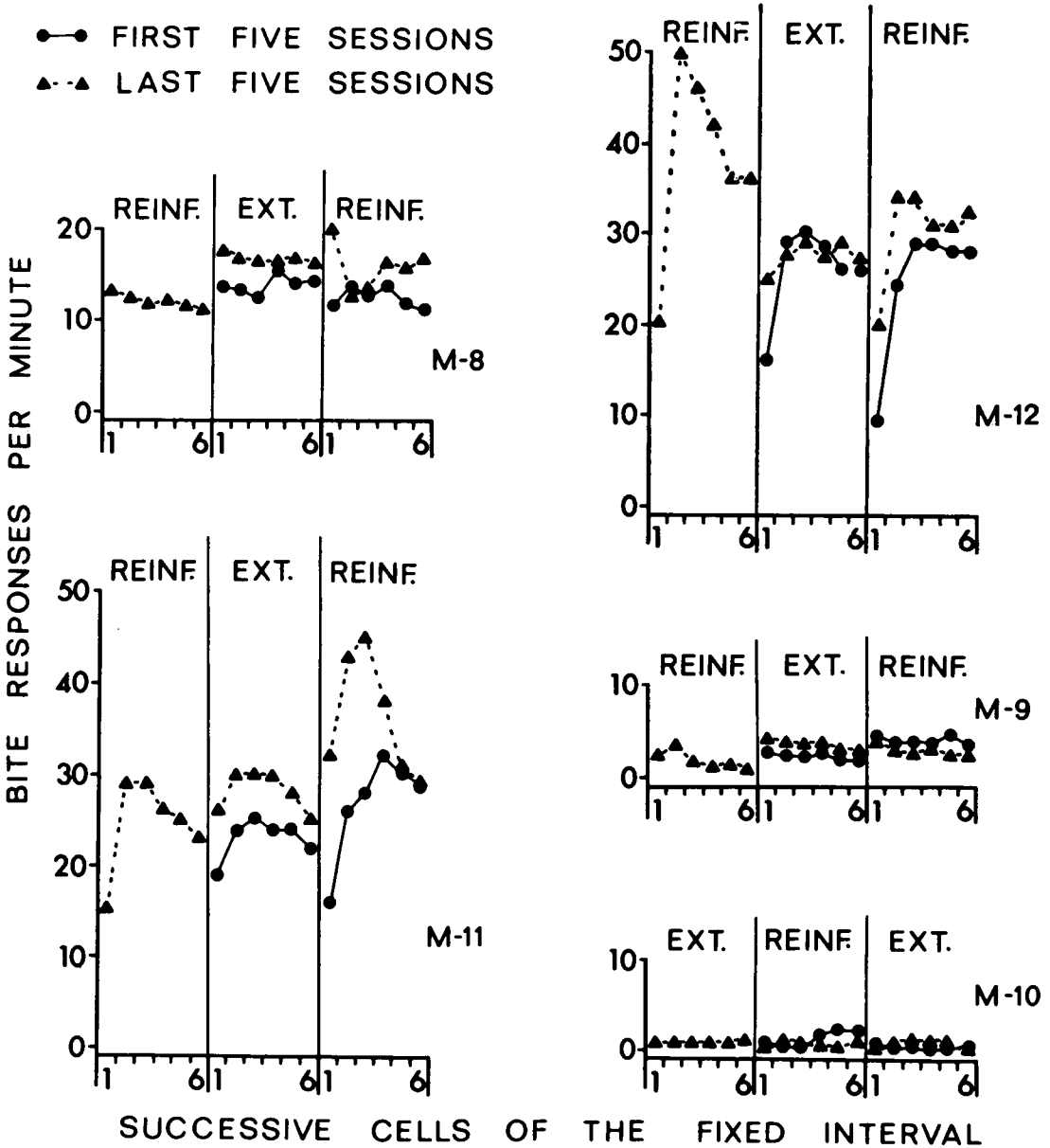


Fig. 5. Rate of bite responses during successive cells of the fixed-interval across reinforcement and extinction conditions.

subjects in Experiment I, where only one operandum was provided. Rather, the highest rate of key responding generally occurred during the cells preceding shock (M-10, 11, 12) or during the cells intermediate between two shocks (M-8, 9). As with the biting, the pattern of responding was essentially unaffected by the presence or absence of reinforcement. In addition, the results for M-10, the subject initially exposed to the extinction condition, further

indicate that the pre-shock pattern is not dependent upon a history of reinforcement. A secondary pattern of key responding was also observed: the gradually increasing rate of key responding between shocks was occasionally seen to decrease in the cell preceding shock.

The pattern of key responding for M-10, in addition to showing an increase in response rate before shock, showed a second smaller peak in response rate after shock. In that

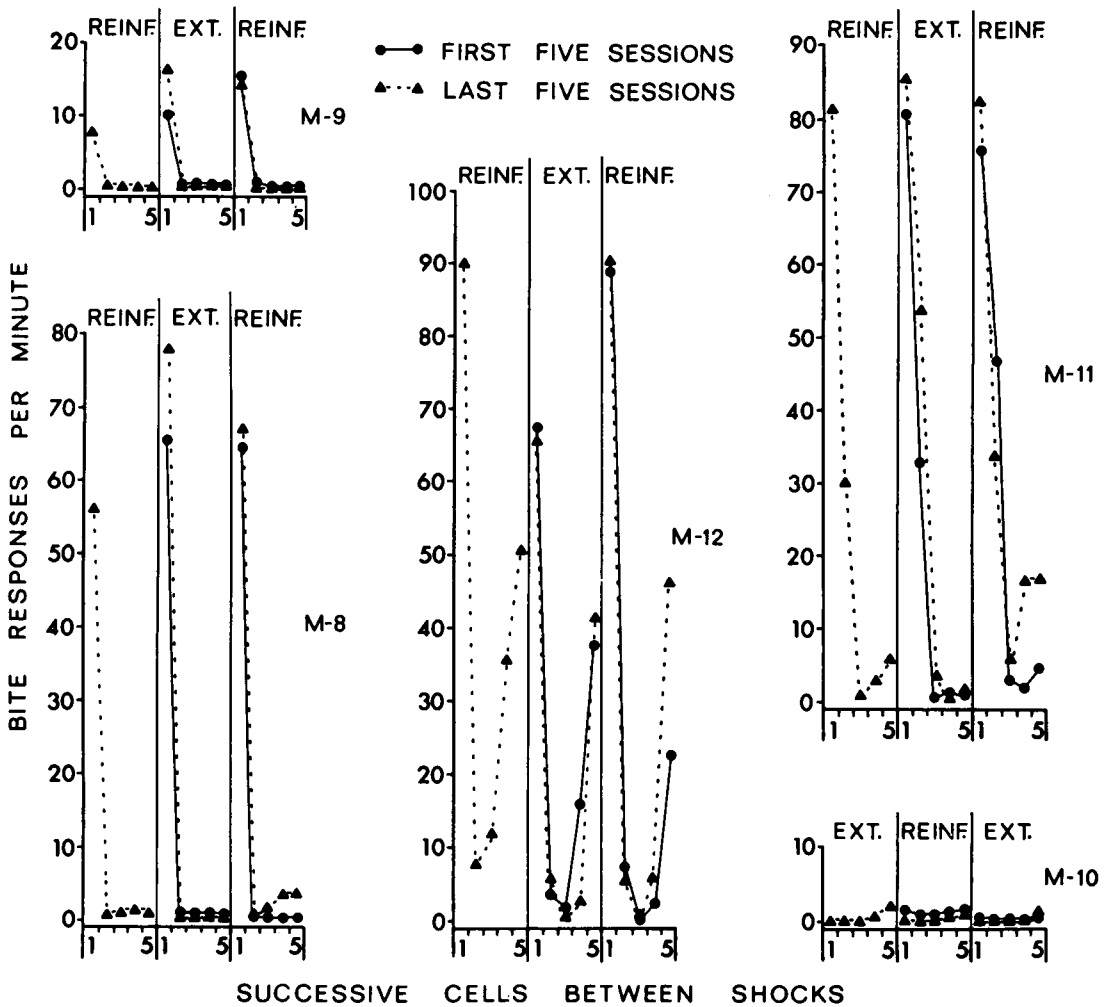


Fig. 6. Rate of bite responses during successive cells between shocks across reinforcement and extinction conditions.

bites seldom occurred for this subject (Figures 5 and 6), it is possible that the post-shock elevation of key responses was under the control of variables similar to those controlling post-shock bar responding in Experiment I.

EXPERIMENT III. RESPONSE-DISPLACEMENT EFFECTS: THE EFFECTS OF REMOVING THE OPERANDUM FOR AGGRESSIVE RESPONDING UPON THE RATE AND PATTERN OF RESPONDING ON THE OTHER OPERANDUM.

In Experiment II, as in previous experiments that have provided electric shock and an operandum requiring an aggressive response,

aggressive responding resulted and the pattern of that responding was predominantly post-shock (see reviews by Ulrich *et al.*, 1965; Azrin, 1967). And, as in previous experiments, which have also provided an operandum that did not require an aggressive response, the key responding that developed in Experiment II was predominantly pre-shock (Hutchinson *et al.*, 1971). The regular occurrence of shocks was sufficient to generate these two types of behaviors, and they could be differentiated by (1) response topography and (2) pattern of occurrence with respect to shock.

In Experiment I, a differentiation of patterns of responding with respect to shock was possible, but because all responding occurred

●—● FIRST FIVE SESSIONS
 ▲---▲ LAST FIVE SESSIONS

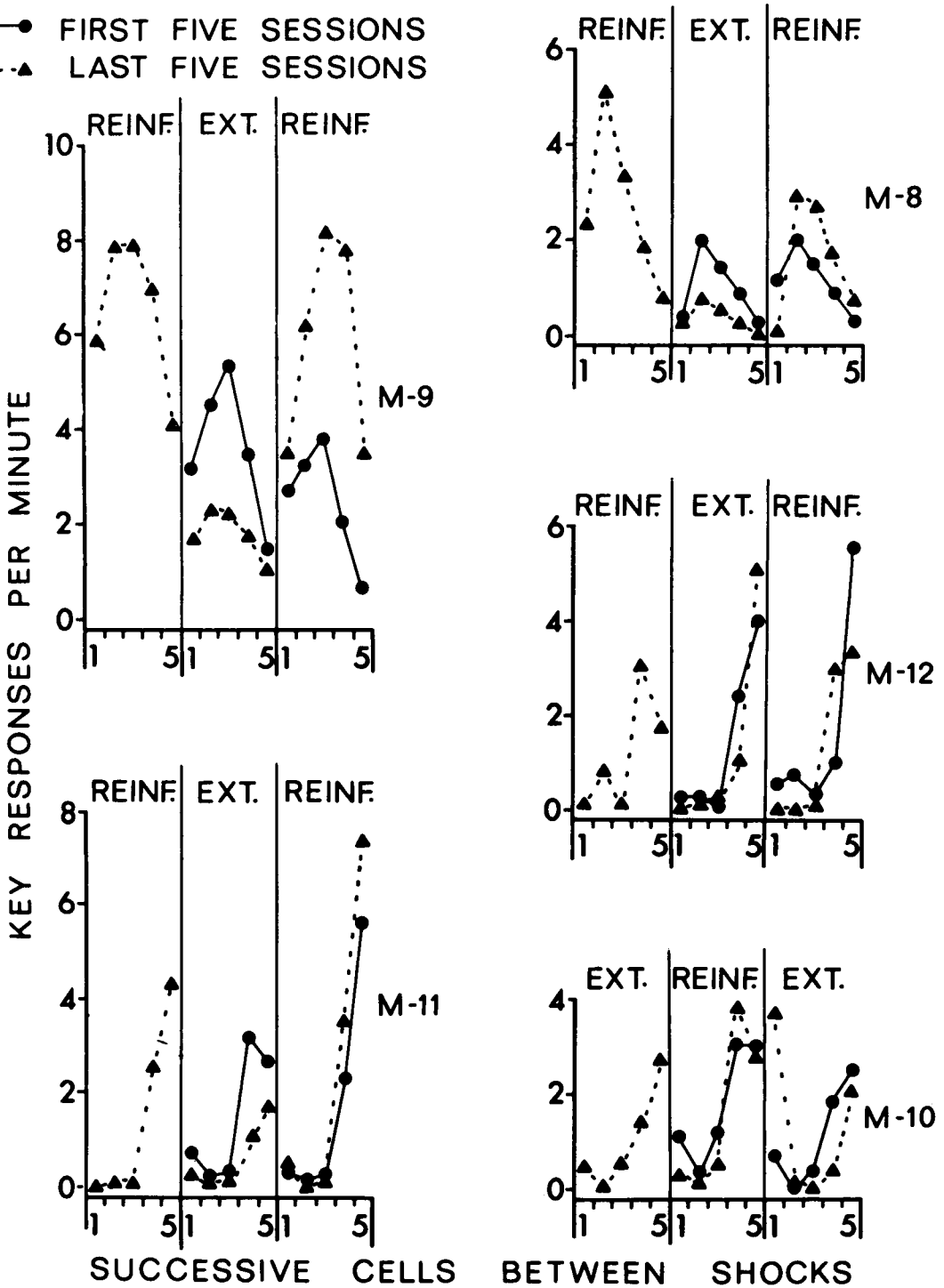


Fig. 7. Rate of key responses during successive cells between shocks across reinforcement and extinction conditions.

on one operandum, the specific characteristics of either type of responding could not be defined. By providing the bite tube in Experiment II, the aggressive character of post-shock responding was established, and pre-shock responding was more consistently evident than in Experiment I because biting was the preferred response following shock. Further, it is probable that if the bite tube had not been available in Experiment II, post-shock key responding would have developed similar to the post-shock bar responding in Experiment I. This possibility could be evaluated by the systematic manipulation of the presence and absence of the bite tube. Removal of the bite tube would be expected to result in the development of post- as well as pre-shock patterns of key responding similar to those observed in Experiment I bar responding. Reintroduction of the bite tube should result in post-shock responding on the bite tube and a more consistent pre-shock pattern of key responding. Such results would indicate that the post-shock key responding and post-shock biting were generated by the same conditions and which operandum the subjects responded on would be governed by availability. Since biting would be the preferred response following shock if the bite tube were available, post-shock key responding that developed with the tube removed could be designated as aggression-motivated responding displaced to an operandum that does not require an aggressive response.

Systematic manipulation of the presence and absence of the bite tube would also allow evaluation of whether or not the availability of an operandum requiring an aggressive topography affects the rate as well as the pattern of responding on an operandum that does not require an aggressive response topography.

METHOD

Subjects and Apparatus

Six squirrel monkeys served: two (M-3, 5) of the seven that had previously served in Experiment I and four (M-9, 10, 11, 12) of the five that had served in Experiment II. The other monkeys were not used because during the time lapse between experiments they had been used in other experiments or had deceased.

Two chambers each equipped with a bite tube and a response key were used. The monkeys that had served in Experiment II continued in the chamber used in that experi-

ment, while the two monkeys that had served in Experiment I were tested in another chamber that did not have a neck yoke. The only other difference was that in the new chamber without the neck yoke, the recessed response key was located about 2 in. (5 cm) below the bite tube rather than above it.

Procedure

All sessions were conducted under the reinforcement condition. The fixed-interval schedule of negative reinforcement in this experiment was identical to that used in previous experiments in which these subjects had served. Shocks occurred every 30 sec (M-3, 5, 11, 12) or 60 sec (M-9, 10) in the presence of the white fixed-interval stimulus. The first key press after 3 min (M-3, 5) or 6 min (M-9, 10, 11, 12) was followed by the reinforcement period, the absence of shocks for a time period equal to the minimum duration of the FI stimulus. As in the previous experiments, the reinforcement period was accompanied by red illumination of the response key plus a 100-Hz tone. For a given subject, the shock intensity was 160, 200, or 300 v, and the changeover delay between bites and a key response followed by reinforcement was 2.5, 5, or 10 sec.

The four subjects (M-9, 10, 11, 12) that had participated in Experiment II had already had about 90 sessions with the bite tube and the key. The two subjects (M-3, 5) that had not been in Experiment II were also given about 70 sessions under the reinforcement condition before the start of Experiment III. These sessions were preceded by 12 sessions without shock.

The experiment proper followed an ABA design with A representing sessions with the bite tube present and B representing sessions with the bite tube absent. There were about 30 sessions under each condition except for Subjects M-3 and M-11, which were unable to complete the experiment. The experiment ended for M-11 after nine sessions of the B condition and for M-3 after five sessions of the last A condition. Sessions were run weekdays and lasted for 1 hr (M-3, 5, 11, 12) or 2 hr (M-9, 10).

RESULTS AND DISCUSSION

As was the case with most of the subjects in Experiment II, the two subjects (M-3, 5) that were initially tested without shock aver-

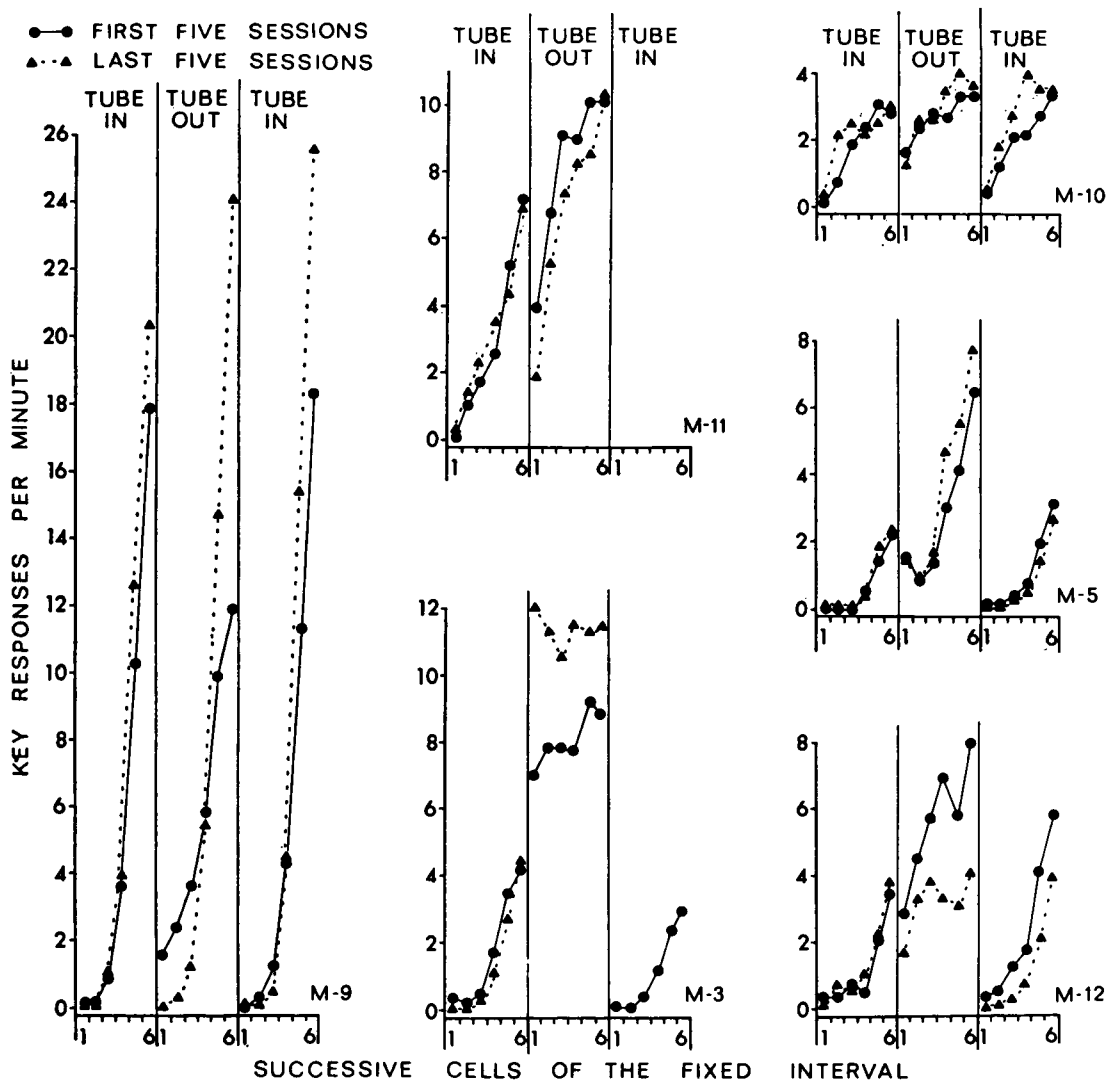


Fig. 8. Rate of key responses during successive cells of the fixed-interval across conditions in which the bite tube was either present or absent.

aged fewer than one key press and biting response per session during the stable sessions without shock. After shock was introduced, however, the patterns of responding seen in previous experiments developed, and these are shown along with those of the other subjects in the subsequent figures.

Figure 8 shows the effects of the availability of the bite tube upon the rate and pattern of key responding across the fixed interval. With the tube available (panels 1 and 3), all subjects showed the characteristic FI pattern of increasing response rate across the successive cells of the FI. With the bite tube removed,

however, response rates were substantially higher for four subjects (M-3, 5, 11, 12), slightly higher for a fifth (M-10), but about the same for the sixth (M-9). This can be seen more clearly in Table 1, which shows the average number of responses per minute for each subject under each condition. Removal of the bite tube also affected the FI pattern of two subjects: the fixed-interval pattern of increasing response rate was less evident (M-12) or absent (M-3) without the bite tube.

Figure 9 shows that the pattern of key responding between shocks with the bite tube available (panels 1 and 3) was similar to that

Table 1

Average number of key-pressing responses per minute during the FI stimulus across conditions in which the bite tube was either present or absent.

Subject	Bite Tube Present		Bite Tube Absent		Bite Tube Present	
	First Five Sessions	Last Five Sessions	First Five Sessions	Last Five Sessions	First Five Sessions	Last Five Sessions
M-3	2.0	1.6	8.0	11.1	1.3	
M-5	1.0	1.0	2.7	4.0	1.3	1.1
M-9	5.8	6.7	6.0	7.9	6.3	7.9
M-10	1.7	2.1	2.5	2.7	2.3	2.4
M-11	2.9	3.2	7.7	6.6		
M-12	1.3	1.5	5.4	3.2	2.3	1.3

obtained in the previous experiment. None of the subjects had a predominantly post-shock pattern of key responding, as was the case for some subjects in Experiment I where only one operandum was available. Rather, as in Experiment II, the highest rate of key responding occurred during the cell preceding shock (M-10, 11, 12) or during cells intermediate between two shocks (second cell, M-3; third cell, M-5; fourth cell, M-9). For one subject (M-10), the pattern of responding showed two peaks in response rate between shocks: in addition to the increase in response rate before shock, there was a second lower peak after shock (see also Figure 7 of Experiment II). The secondary pattern of key responding between shocks, a gradually increasing rate of response that decreased abruptly in the cells immediately preceding shock, was seen in the pattern of three of the subjects (M-3, 5, 9).

Removing the bite tube (Figure 9, panel 2) resulted in an increase in the rate of responding in the cell immediately after shock for all subjects except M-10, the subject that seldom bit (Figures 5 and 6 of Experiment II and Figures 10 and 11) and had already developed post-shock key responding with the tube present (also see Figure 7 of Experiment II). Removal of the bite tube also affected the pattern of responding between shocks for four subjects (M-3, 5, 11, 12). These subjects developed a post-shock peak in responding in addition to (M-5, 11, 12) or replacing (M-3) the pre-shock peak in responding. For M-3 and M-5, the post-shock response rates were higher than the pre-shock rates, resulting in a predominantly post-shock pattern. The fact that the removal of the bite tube, the operandum that had been preferred following shock, resulted in the development of post-shock key

responding suggests that part of the responding on the key was aggression-motivated responding displaced to the key. These patterns of key responding with the bite tube absent are similar to the patterns of bar responding in Experiment I, where there was also only one response manipulandum available.

For M-9 and M-10, the subjects that showed little change in the overall rate of key responding when the tube was removed, there was also no change in the pattern of key responding between shocks when the tube was removed. A possible reason that there was little or no change in key responding upon removal of the bite tube for M-9 and M-10 is seen in Figure 10, which shows the rate of biting for successive cells between shocks. Subjects M-9 and M-10 did not bite as much as the other subjects. It will be recalled that M-9, although showing a pre-shock pattern of key responding, had the highest rate of post-shock key responding with the tube present, and for M-10 the rate of key responding between shocks had two peaks, one before shock and one after shock. These results suggest that for M-9 and M-10, post-shock, aggression-motivated responding was displaced to the key even before the tube was removed.

Figure 10 also shows that the pattern of biting between shocks was similar to that seen in the previous experiment. Five of the six subjects showed post-shock biting, with two subjects (M-11, 12) also showing the secondary pattern resembling temporal respondent conditioning. Only M-10, the subject that bit the tube rarely, did not develop the characteristic post-shock pattern of biting.

That the biting was not controlled by the reinforcement for key responding is shown in Figure 11 by the absence of an increasing rate

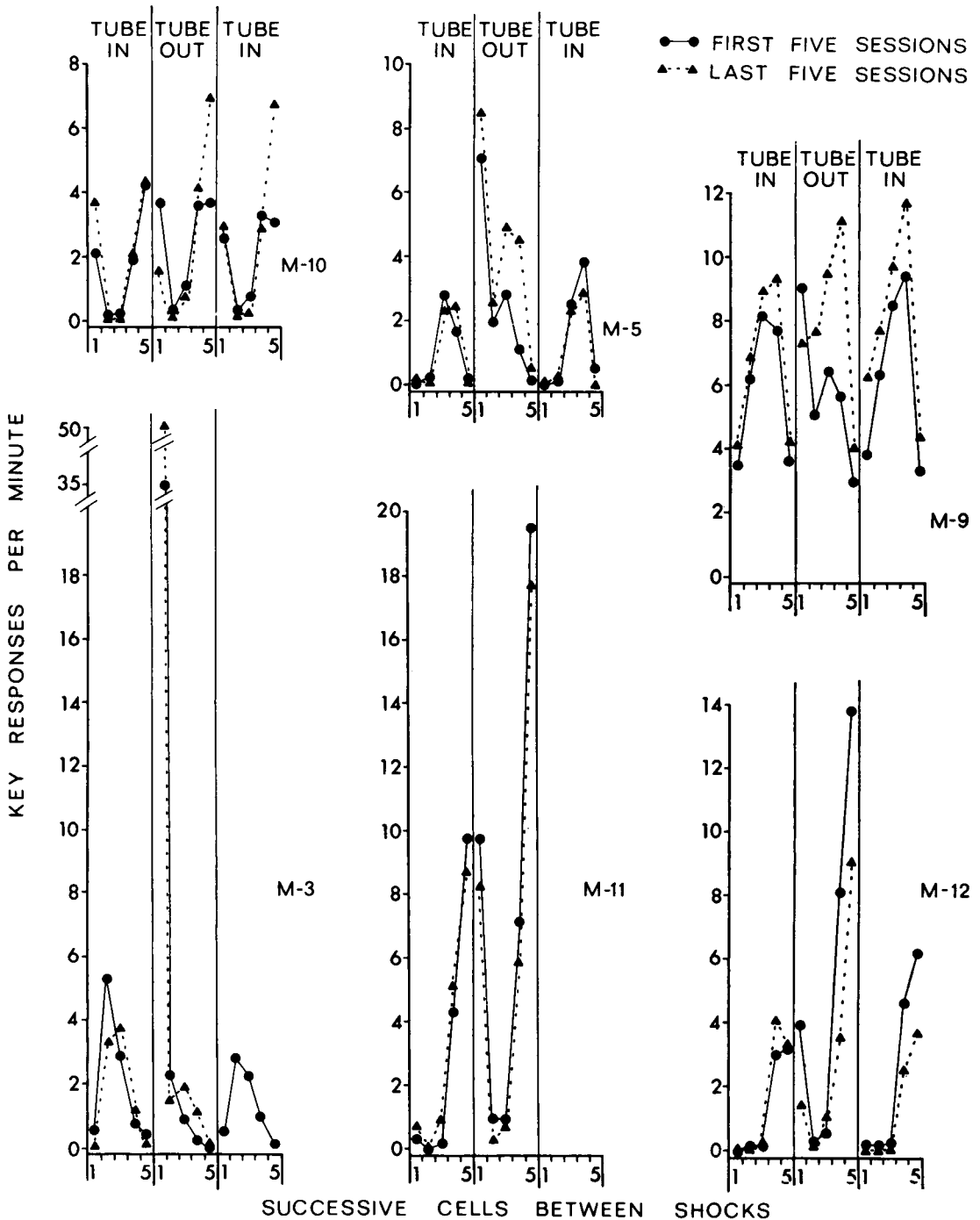


Fig. 9. Rate of key responses during successive cells between shocks across conditions in which the bite tube was either present or absent.

of biting across successive cells of the fixed interval. Rather, the rate of biting across the fixed interval either remained about the same or decreased slightly.

GENERAL DISCUSSION

These experiments showed that shock alone can generate responding during a negative re-

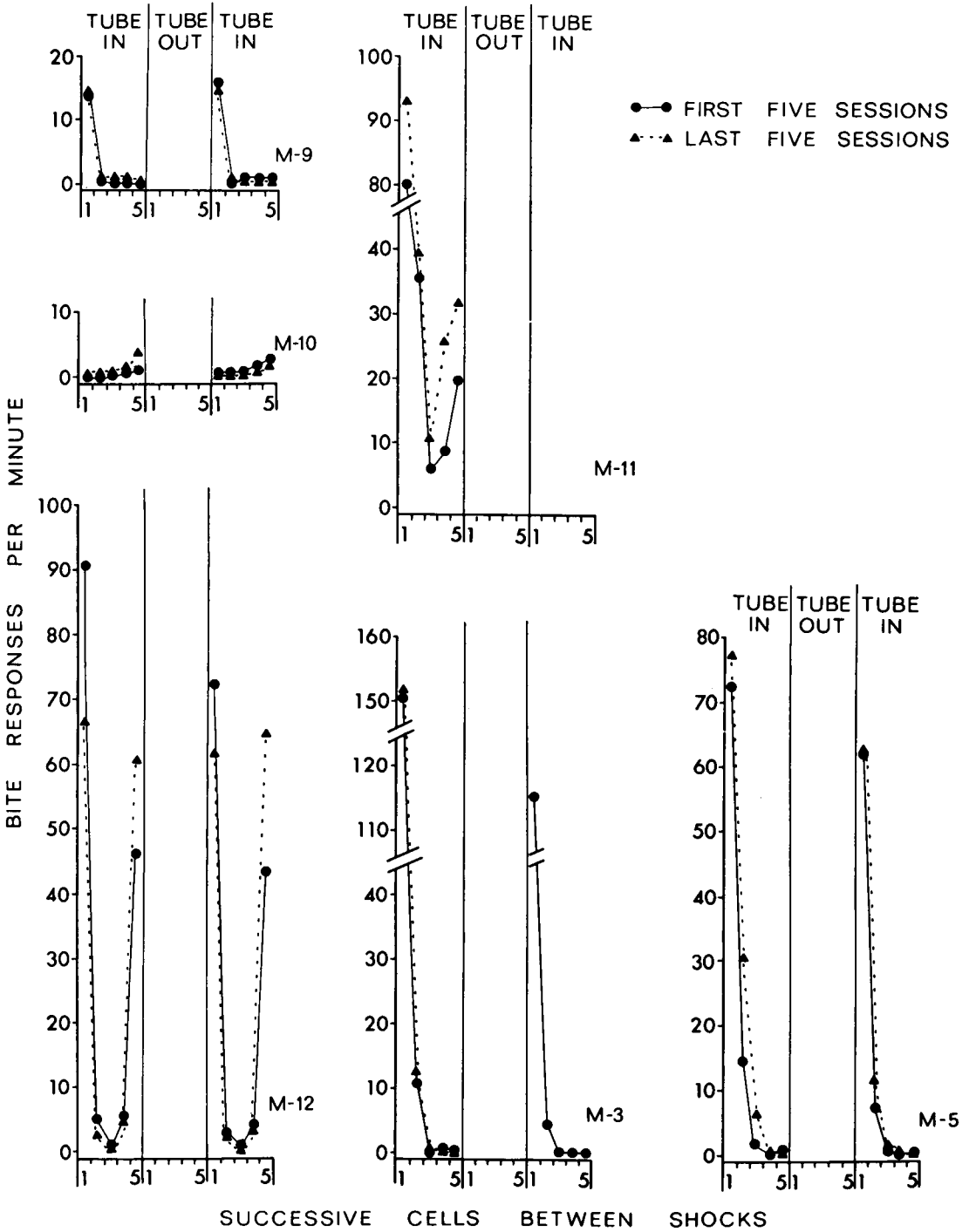


Fig. 10. Rate of biting responses during successive cells between shocks across conditions in which the bite tube was either present or absent.

inforcement procedure independent of the contingency in effect and that the responding generated is of at least two types. The char-

acteristics of the two types of shock-generated responding were determined most completely by providing two operanda, a bite tube that re-

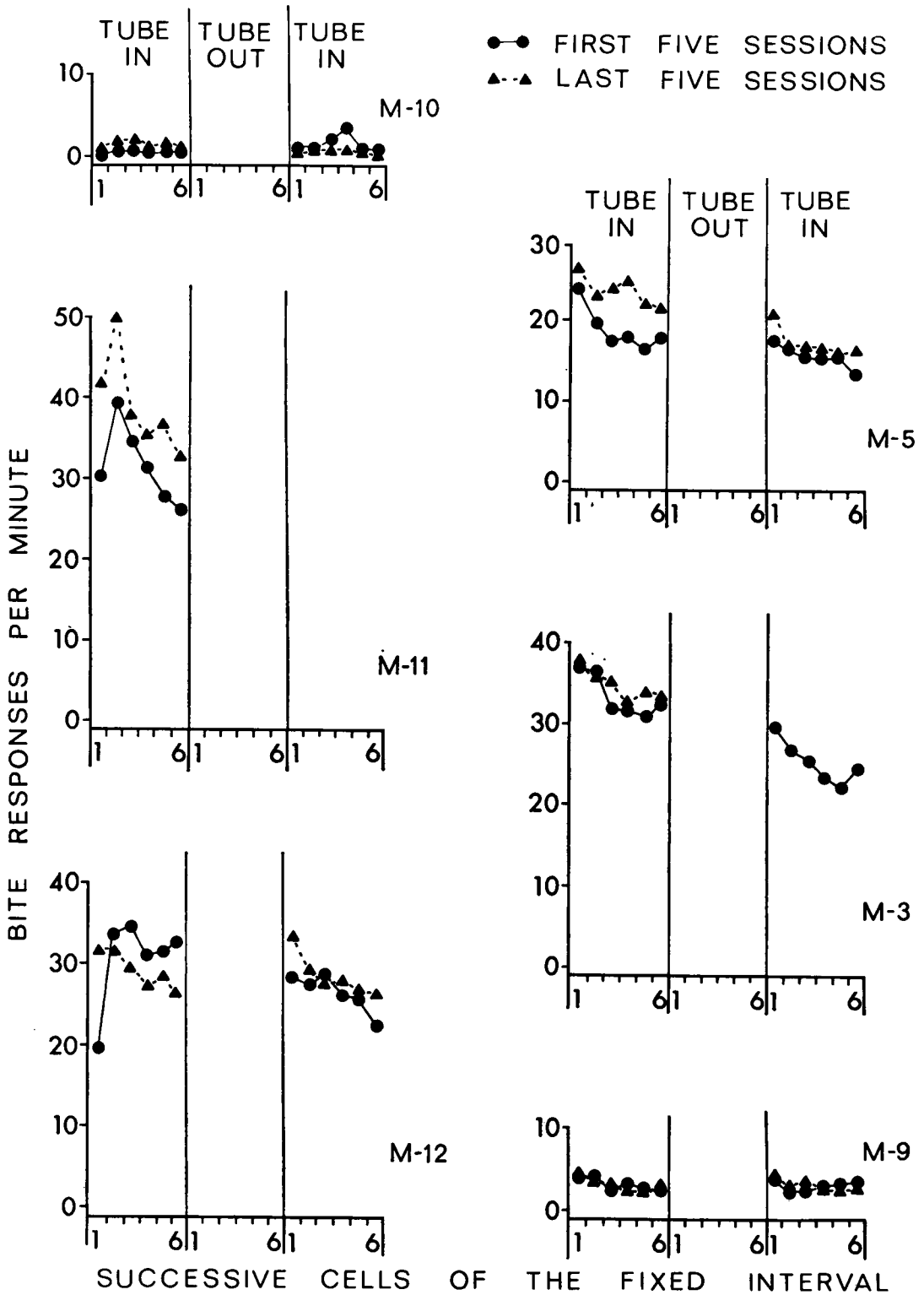


Fig. 11 Rate of biting responses during successive cells of the fixed-interval across conditions in which the bite tube was either present or absent.

quired an aggressive response topography and a recessed pigeon key that did not require an aggressive response topography. A post-shock pattern of responding developed on the bite tube, and a pre-shock pattern developed on the recessed key. Hence, the two types of shock-generated responding could be differentiated with respect to response topography as well as the between-shock pattern of responding.

These same patterns of shock-generated responding were also evident when only one operandum was available. Upon removal of the bite tube, most subjects showed an increase in key responding, and the pattern of key responding changed from a predominantly pre-shock pattern to a predominantly post-shock pattern, or to a pattern with both pre- and post-shock peaks in response rate. These results indicate that the post-shock key responding and post-shock biting were generated by the same conditions and that which operandum the subjects responded on after shock was governed by availability. Since biting was the preferred response when the bite tube was available, post-shock key responding that developed with the tube removed could be designated as aggression-motivated responding displaced to an operandum that does not require an aggressive response.

The same response patterns indicative of the two types of shock-generated responding also occurred when only a bar was available. That post-shock, aggression-motivated responding occurs on key and bar operanda indicates that such responding is not limited to one type of operandum or response topography. For example, aggression-motivated responding is not limited to an operandum such as a bar that allows biting, since it was also found using a recessed pigeon key and, for some subjects, a neck yoke, both of which prevented biting.

That the pre- and post-shock patterns of responding were generated by shock alone was indicated by (1) the level of responding maintained during extinction relative to conditions without shock, (2) the stability of the between-shock response patterns across reinforcement and extinction conditions, and (3) the development of the pre- and post-shock patterns of responding in subjects that had no history of reinforced responding. Previous studies have shown that shock alone can produce post-shock, aggressive responding (see reviews by Ulrich *et al.*, 1965; Azrin, 1967) and pre-shock

responding on an operandum that does not require an aggressive response (Hutchinson *et al.*, 1971). And other studies have shown that some responding during negative reinforcement procedures can be attributed to the shock alone (Hake, 1968; Powell and Peck, 1969). The present study showed that the responding generated by shock alone during negative reinforcement procedures is at least in part post-shock, aggressive responding and/or pre-shock, non-aggressive responding.

These results would appear to have implications for the type and number of operanda used in experiments designed to study negative reinforcement procedures. For example, shock alone is known to produce several behaviors, *e.g.*, sexual behavior (Barfield and Sachs, 1968; Cagguila and Eibergen, 1969), aggressive behavior (O'Kelly and Steckle, 1939; Ulrich and Azrin, 1962), and non-aggressive manual behavior (Hutchinson *et al.*, 1971). When a single operandum is used in studying negative reinforcement procedures, part of the responding could be due to other motivations generated by the negative reinforcer alone, as in the present experiment where there was displaced, aggression-motivated responding. In a multi-response situation, however, with response opportunities available for the possible responses that might result from shock alone, responding generated by shock alone would be expected to occur on the appropriate operandum and the responding on the reinforcement operandum would be expected to reflect accurately the control by negative reinforcement. If, on the other hand, rapid learning is what is being looked for, particularly without shaping, a single response situation might be preferable. A variety of motivations, in addition to operant reinforcement, directed toward a single response would be expected to produce faster learning of a specific response.

While the patterns of responding between shocks were predominantly pre- or post-shock, some secondary characteristics of the response patterns suggest two additional effects of shock alone. First, for some of the subjects the pattern of biting between shocks had two peaks in the response rate: the high rate of biting after shock dropped to a near-zero level and then increased slightly before the next shock. The regularly spaced shocks set up the conditions necessary for respondent temporal con-

ditioning, and the increase in biting before shocks is suggestive of such conditioning. The second departure from the major patterns was evident in the occasional decreases in the key responding just before shock. Hutchinson *et al.*, (1971) reported similar decreases for some of their subjects. Such effects are suggestive of conditioned suppression, another effect of shock alone.

The present results indicate that negative unconditioned stimuli can have generative and suppressive behavioral effects attributable to their occurrence alone independent of operant reinforcement. This determination, in conjunction with similar results from investigations involving positive unconditioned stimuli, suggests that unconditioned stimuli as a category can produce similar generative and suppressive effects regardless of their positive or negative defining characteristics. For example, in terms of the generative aspects of unconditioned stimuli, the negative unconditioned stimulus in the present study generated pre- and post-shock responding unrelated to its reinforcement function. Hutchinson *et al.*, (1971) found similar results, but it remains to be seen whether the pre-shock pattern observed with response-produced shock (*e.g.*, Kelleher and Morse, 1968) can be attributed entirely to the shock alone. These observations have elements in common with the generative aspects of food alone as evidenced in the pre-food behaviors produced in positive auto-shaping (Brown and Jenkins, 1968; Williams and Williams, 1969; Rachlin, 1969) and the post-food behaviors such as polydipsia, pica, and aggression (see review by Staddon and Simmelhag, 1971). Suppressive effects of both positive and negative unconditioned stimuli are documented in conditioned suppression procedures in which responding maintained by operant reinforcement is reduced during a conditioned stimulus followed by positive unconditioned stimuli such as food, water, and brain stimulation (Azrin and Hake, 1969; Meltzer and Brahlek, 1970; Hake and Powell, 1970; Miczek and Grossman, 1971), or negative unconditioned stimuli such as shock (see reviews by Davis, 1968; Lyon, 1968). Positive and negative unconditioned stimuli appear to have behavioral effects that have little to do with the positive or negative defining characteristics. Rather, other factors such as the magnitude or intensity of the stimulus, other

physical properties of the stimulus, or the conditions under which the stimulus occurs may be more important than the positive or negative defining characteristics in determining the suppressive or generative effects of a stimulus (also see Hake and Powell, 1970).

REFERENCES

- Azrin, N. H. Pain and aggression. *Psychology Today*, 1967, 1, 27-33.
- Azrin, N. H. and Hake, D. F. Positive conditioned suppression: conditioned suppression using positive reinforcers as the unconditioned stimuli. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 167-173.
- Azrin, N. H., Hutchinson, R. R., and Hake, D. F. Pain-induced fighting in the squirrel monkey. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 620.
- Azrin, N. H., Hutchinson, R. R., and Hake, D. F. Attack, avoidance, and escape reactions to aversive shock. *Journal of the Experimental Analysis of Behavior*, 1967, 10, 131-148.
- Barfield, R. J. and Sachs, B. D. Sexual behavior: stimulation by painful electrical shock to skin in male rats. *Science*, 1968, 161, 392-395.
- Brown, P. L. and Jenkins, H. M. Auto-shaping of the pigeon's key peck. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 1-8.
- Byrd, L. D. Responding in the cat maintained under response-independent electric shock and response-produced electric shock. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 1-10.
- Caggiula, A. R. and Eiberger, R. Copulation of virgin male rats evoked by painful peripheral stimulation. *Journal of Comparative and Physiological Psychology*, 1969, 69, 414-419.
- Davis, H. Conditioned suppression: a survey of the literature. *Psychonomic Monograph Supplements*, 1968, 2, 283-291.
- Hake, D. F. Actual versus potential shock in making shock situations function as negative reinforcers. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 385-403.
- Hake, D. F. and Azrin, N. H. An apparatus for delivering pain shock to monkeys. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 297-298.
- Hake, D. F. and Powell, J. Positive reinforcement and suppression from the same occurrence of the unconditioned stimulus in a positive conditioned suppression procedure. *Journal of the Experimental Analysis of Behavior*, 1970, 14, 247-257.
- Hutchinson, R. R., Azrin, N. H., and Hake, D. F. An automatic method for the study of aggression in squirrel monkeys. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 233-237.
- Hutchinson, R. R., Azrin, N. H., and Renfrew, J. W. Effects of shock intensity and duration on the frequency of biting attack by squirrel monkeys. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 83-88.
- Hutchinson, R. R., Renfrew, J. W., and Young, G. A. Effects of long-term shock and associated stimuli on

- aggressive and manual responses. *Journal of the Experimental Analysis of Behavior*, 1971, 15, 141-166.
- Kelleher, R. T. and Morse, W. H. Schedules using noxious stimuli. III. Responding maintained with response-produced electric shocks. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 819-838.
- Kelleher, R. T., Riddle, W. C., and Cook, L. Persistent behavior maintained by unavoidable shocks. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 507-517.
- Lyon, D. O. Conditioned suppression: operant variables and aversive control. *The Psychological Record*, 1968, 18, 317-338.
- McKearney, J. W. Maintenance of responding under a fixed-interval schedule of electric shock presentation. *Science*, 1968, 160, 1249-1251.
- McKearney, J. W. Fixed-interval schedules of electric shock presentation: extinction and recovery of performance under different shock intensities and fixed-interval durations. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 301-313.
- Meltzer, D. and Brahlek, J. A. Conditioned suppression and conditioned enhancement with the same positive UCS: an effect of CS duration. *Journal of the Experimental Analysis of Behavior*, 1970, 13, 67-73.
- Miczek, K. A. and Grossman, S. P. Positive conditioned suppression: effects of CS duration. *Journal of the Experimental Analysis of Behavior*, 1971, 15, 243-247.
- Morse, W. H., Mead, R. N., and Kelleher, R. T. Modulation of elicited behavior by a fixed-interval schedule of electric shock presentation. *Science*, 1967, 157, 215-217.
- O'Kelly, L. E. and Steckle, L. C. A note on long-enduring emotional responses in the rat. *Journal of Psychology*, 1939, 8, 125-131.
- Powell, R. W. and Peck, S. Persistent shock-elicited responding engendered by a negative reinforcement procedure. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 1049-1062.
- Rachlin, H. Auto-shaping of key pecking in pigeons with negative reinforcement. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 521-531.
- Staddon, J. E. R. and Simmelhag, Virginia L. The "superstition" experiment: a reexamination of its implications for the principles of adaptive behavior. *Psychological Review*, 1971, 78, 3-43.
- Stretch, R., Orloff, E. R., and Dalrymple, S. D. Maintenance of responding by a fixed-interval schedule of electric shock presentation in squirrel monkeys. *Science*, 1968, 162, 583-585.
- Ulrich, R. E. and Azrin, N. H. Reflexive fighting in response to aversive stimulation. *Journal of the Experimental Analysis of Behavior*, 1962, 5, 511-520.
- Ulrich, R. E., Hutchinson, R. R., and Azrin, N. H. Pain-elicited aggression. *Psychological Record*, 1965, 15, 111-126.
- Williams, D. R. and Williams, H. Auto-maintenance in the pigeon: sustained pecking despite contingent non-reinforcement. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 511-520.

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