JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR VOLUME 9, NUMBER 3 MAY, 1966

RECOVERY OF RESPONSES DURING MILD PUNISHMENT[1]

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Pigeons were punished with mild shock for pecking during one of two components of a multiple schedule. They eventually recovered so that they pecked at the same rate during both components. In one experiment they were extinguished after recovering. When punishment was maintained during extinction, they extinguished faster during the punished, than during the unpunished component. When punishment was stopped during extinction, they extinguished faster during the unpunished than during the previously punished component. In another experiment, punishment was programmed first during neither of the two components, then during one, then during both, and finally during the other component. The extent of recovery decreased with each successive cycle. It is concluded that, if transient emotional states are ignored, reward and punishment are symmetrical in their effects.

Certain stimuli tend to increase and others to decrease the rate of response with which they are associated. However, the increase and decrease are not symmetrical. The increase in rate of response is usually gradual (Youtz, 1938) while the decrease is usually quite sudden (Dinsmoor, 1952; Azrin, 1956; Azrin, 1959b; Azrin, 1960).

Another difference between the consequences of food and mild electric shock is that, once established, the high rate of responding associated with food is likely to be maintained (Ferster and Skinner, 1957), whereas the low rate of responding, which is the immediate consequence of introducing electric shock, may not be maintained (Azrin, 1959b; Azrin, 1960). Depending upon the intensity of the shock, the rate of responding may, after its initial decrease, recover to a value equal to or greater than the rate before the shock was introduced, to an intermediate value, or not at all, the latter only for intense shocks (Azrin, 1960).

This pattern of decrease and recovery occurs in various species with a number of aversive stimuli. Warden (1931) showed that grid-crossing by rats in an obstruction box was only temporarily inhibited by mild electric shock on the grid. Similarly, Skinner (1938) found that rats' bar-pressing was temporarily inhibited by having the bar slap their paws. Azrin (1960) found a comparable pattern with key-pecking pigeons shocked in the region of the pubis bone.

The present experiments investigated the recovery of inhibited behavior. Two of the explanations currently offered for this recovery correspond to two views about the very nature of reward and punishment themselves. According to one view (Skinner, 1938; Estes, 1944), punishment is basically different from reward: reward obeys the law of effect, but punishment does not. This theory holds that reward increases the probability of the form of response that it immediately follows, but that punishment acts as a generalized emotional stimulus, suppressing all behavior. Furthermore, the theory implies that the sudden suppression of responses caused by punishment is an elicited emotional disturbance which disappears as the organism becomes accustomed to the stimulus. Hebb (1949) has shown that many kinds of stimuli have a temporary emotional effect, which wears off with repeated presentation. This view of the nature of punishment predicts that punishment delivered immediately after each response and punishment delivered at random will have equal effects on the rate of responding. However, Azrin (1956) has shown that punishment

[1]This research was supported partly by National Science Foundation Research Grant GB 3121, and partly by National Science Foundation Research Grant GB 3723. The author is grateful to Dr. R. J. Herrnstein for his help and criticism. Reprints may be obtained from the author, Dept. of Psychology, Harvard University, William James Hall, 33 Kirkland St., Cambridge, Mass. 02138.

delivered immediately after responding has a greater effect on rate of responding than punishment delivered at random.

According to another view (Azrin, 1956), reward and punishment both obey the law of effect, with both instrumentally altering the probability of responses they immediately follow, but in opposite directions. Although proponents of the theory could explain recovery as a form of adaptation, an experiment by Azrin (1960) has precluded peripheral sensory adaptation. He showed that the course of recovery from electric shock as punishment of pigeons is not affected by changing the location of the electrode. Although it is possible that the organism adapts at a more central level, at least to the extent that the stimuli are no longer aversive, there is some evidence to refute this. Stimuli can be aversive as measured by escape responses even though these stimuli produce little or no decrease in rate of response when presented as punishment superimposed on a schedule of positive reinforcement (Azrin, Hake, Holz, and Hutchinson, 1965). This evidence is not conclusive because once escape responding started, the subjects were rarely exposed to the aversive stimuli and so had no chance to adapt to them.

The present experiments were designed to test the aversiveness of mild shock after recovery has occurred (Exp I) and to study the effects on recovery of repeated exposures to mild shock (Exp II).

EXPERIMENT I

Like the experiment of Azrin *et al.* (1965), this sought to gauge the aversiveness of stimuli by a measure other than rate of responding when punishment is superimposed on a schedule of positive reinforcement. However, in the present experiment, recovery was allowed to occur before the other measure was applied.

More specifically, the object was to see whether the loss of the effect of mild shock punishment would persist during extinction.

Subjects

Four adult, male, White Carneaux pigeons were maintained at about 80% of normal weight. All had previously served as subjects but none had previously been exposed to electric shock.

Apparatus

The experimental chamber, illuminated by an overhead light, contained a single response-key transilluminated by orange or green light. The response was a peck of at least 15 g force against the circular response key. Food reinforcement was a 3 sec grain presentation. The punishing stimulus was a brief 35 msec pulse of 60 cps ac delivered through an 11 K ohm series resistance and a variable resistance to gold wires implanted beneath the skin and anchored around the pubis bone on each side of the bird (Azrin, 1959a). When punishment was scheduled, a shock of about 3.0 ma was delivered immediately after each response.

Procedure

The difficulty with rate of responding during extinction as a measure is that this rate is constantly decreasing. Although presentations of reinforcement have been eliminated as a factor contaminating the study of the effects of punishment, their very removal produces an unstable rate of response. To overcome this difficulty, a multiple schedule was used as a baseline. Two distinctive stimuli alternated at regular intervals. First, identical schedules of positive reinforcement (1-min variable-interval (VI) schedules) were programmed during the two stimuli. Then, punishment was superimposed on the positive reinforcement schedule associated with one of the stimuli. The standard sequence of a sudden suppression of rate of responding and gradual recovery was allowed to occur. Suppression and recovery were measured by the rate of response during the stimulus period in which responses were punished, relative to the sum of the rates of response during both periods. When this relative rate of response stabilized, the subject was usually responding at an equal rate during the stimulus periods in which responses were punished and unpunished and was deemed to have recovered. At this point the schedule of positive reinforcement was changed to extinction during both stimulus periods. The measure of the effect of punishment was still the relative rate of response during the stimulus period in which responses were punished. Although during extinction the absolute rate of response decreases when responses are punished, the absolute rate of response also decreases during

the period in which responses are unpunished, thus serving as a control period with which punished responding can be compared.

The subjects were reinforced on 1-min VI schedules programmed separately during each key color. Each day's session lasted 50 min (five orange and five green periods) starting with orange and green periods on alternate days.

Reinforcement and punishment were programmed according to four different procedures. These were:

1. *Training.* Reinforcement during orange and green periods. No punishment.
2. *Shock.* Reinforcement during orange and green periods. Punishment during orange period. No punishment during green period.
3. *Extinction With Shock.* No reinforcement. Punishment during orange period. No punishment during green period.
4. *Extinction Without Shock.* No reinforcement. No punishment.

Each subject was exposed to each condition twice. Subjects 84 and 217 were exposed in the order: 1, 2, 3, 4, 1, 2, 4, 3. Subjects 39 and 91 were exposed in the order: 1, 2, 4, 3, 1, 2, 3, 4.

Thus, the cycle of conditions consisted of training, shock, extinction under one of two conditions, then continuation of extinction

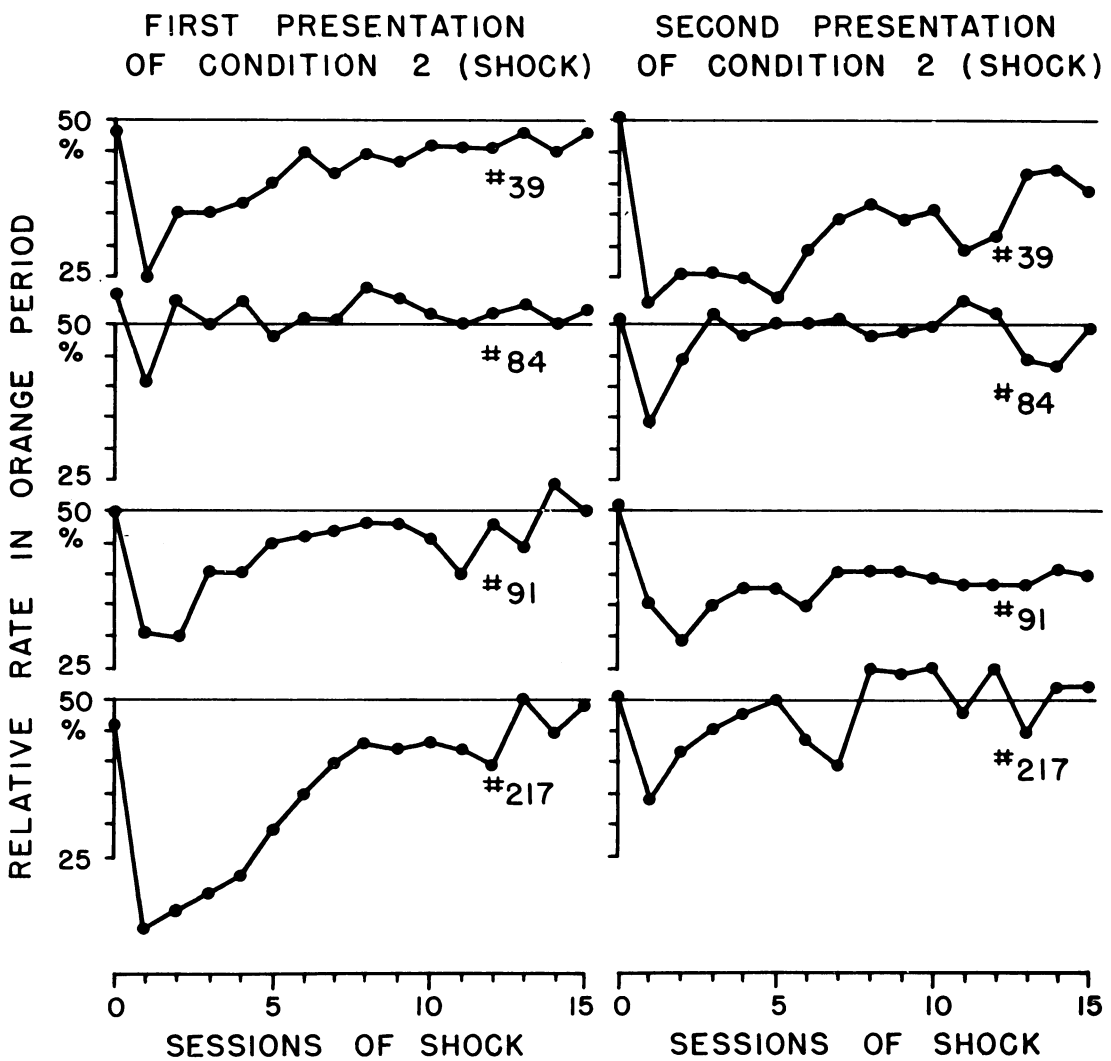

Fig. 1. The relative rates in the orange period for the last session of the training condition (point 0 on the abscissa) and the first 15 sessions of the shock condition. The first and second presentations of shock are shown separately for the four subjects.

under the other condition. Then, each subject was retrained, reshocked, and extinguished under the two conditions in an order opposite to that of the first cycle.

Conditions 1 and 2 (training and shock) were maintained until the relative response rate (rate during orange period divided by the sum of the rates during orange and green periods) was stable from day to day. The first extinction condition was maintained, for each subject, until two successive sessions contained fewer than 200 responses. Then, the other extinction procedure was introduced until two successive sessions contained fewer than 20 responses.

Results

Condition 2 (shock). Figure 1 shows the relative response rate during the orange (punished) period for the last session of condition 1 (training) and the first 15 sessions of condition 2.

The pattern is the same in all cases; a sudden drop in relative rate is followed by a more gradual rise. This confirms Azrin's (1960) finding that complete (or almost complete) recovery is obtained at levels of shock around 3 ma.

The recovery of two of the four subjects was less during their second exposure to condition 2 than during their first exposure. The other two subjects recovered completely both times.

Punishment (and the sudden drop in rate) during the orange period had little effect on the absolute response rate during the green period.

Conditions 3 and 4 (extinction). Figures 2

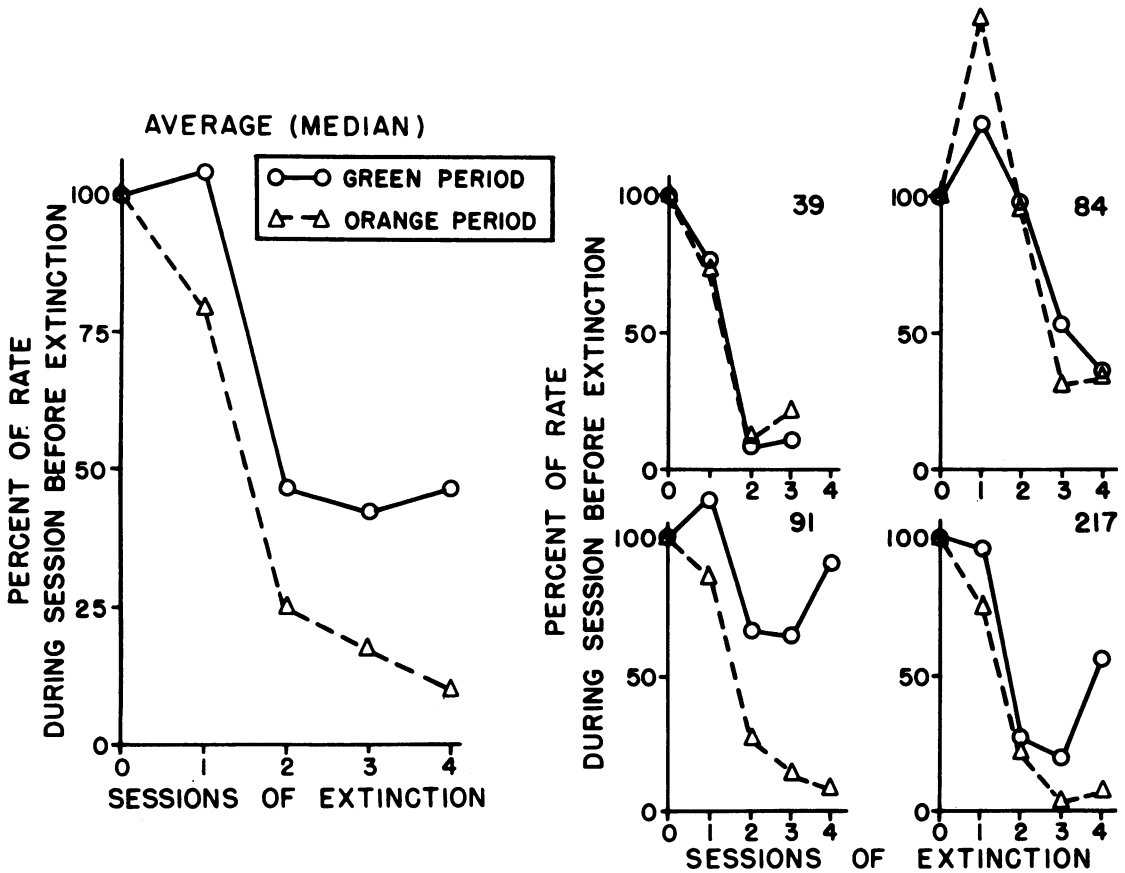

Fig. 2. Rates during the orange and green periods for the first four sessions of extinction with shock retained in the orange period are shown as a percent of the rate during the session before extinction (point 0 on the abscissa). All subjects made more than the criterion of 200 responses per session for all sessions shown except subject 39. In session 2 this subject dropped below the criterion. The average curves represent the medians of the corresponding points on the four individual curves.

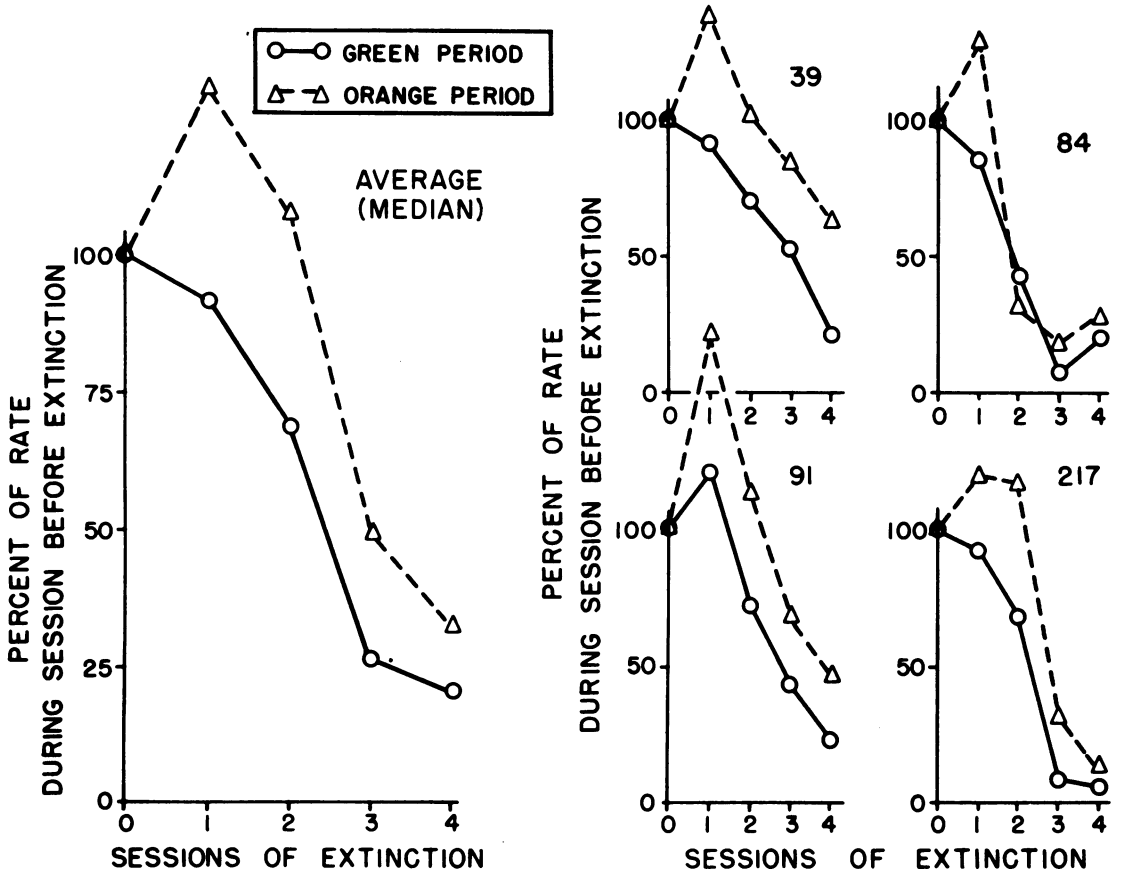

Fig. 3. Rates during the orange and green periods for the first four sessions of extinction with shock discontinued during the orange period are shown as a percent of the rate during the session before extinction (point 0 on the abscissa). All subjects made more than 200 responses per session for all sessions shown. The average curve represents the medians of the corresponding points on the four individual curves.

and 3 show response rates in the orange and green periods during extinction as a percent of the rate in the session before extinction. Figure 2 shows results with shock retained during the orange period. Figure 3 shows results with shock discontinued. When the pigeons were extinguished with shock they generally extinguished faster during the orange period than during the green. The relatively rapid extinction during the orange period is evidence that, despite a virtually complete recovery in rate, the shock still may retain aversive properties.

When the subjects were extinguished without shock, that is, when punishment and reinforcement were simultaneously withdrawn (Fig. 3), their response rate initially increased during the orange (previously punished) period and then decreased, remaining, however, greater than their rate during the green period. The sudden rise of response rate during the orange period when the subjects were extinguished without shock is in accord with Azrin's (1960) finding of a temporary rise in the rate when shock was removed after recovery.

Figure 4 shows the rates when extinction conditions were switched from condition 3 to condition 4, and *vice-versa*. Note that when the subjects were extinguished with shock and shock was removed at a later stage of extinction (upper half of Fig. 4) the rate during the orange period rose temporarily. A rise in response rate consequent upon removal of punishment seems to be a persistent phenomenon. It takes place while reinforcement is scheduled (Azrin, 1960), in the early stages of extinction (Fig. 3), and in the later stages of extinction (upper half of Fig. 4). When the subjects were extinguished without shock and

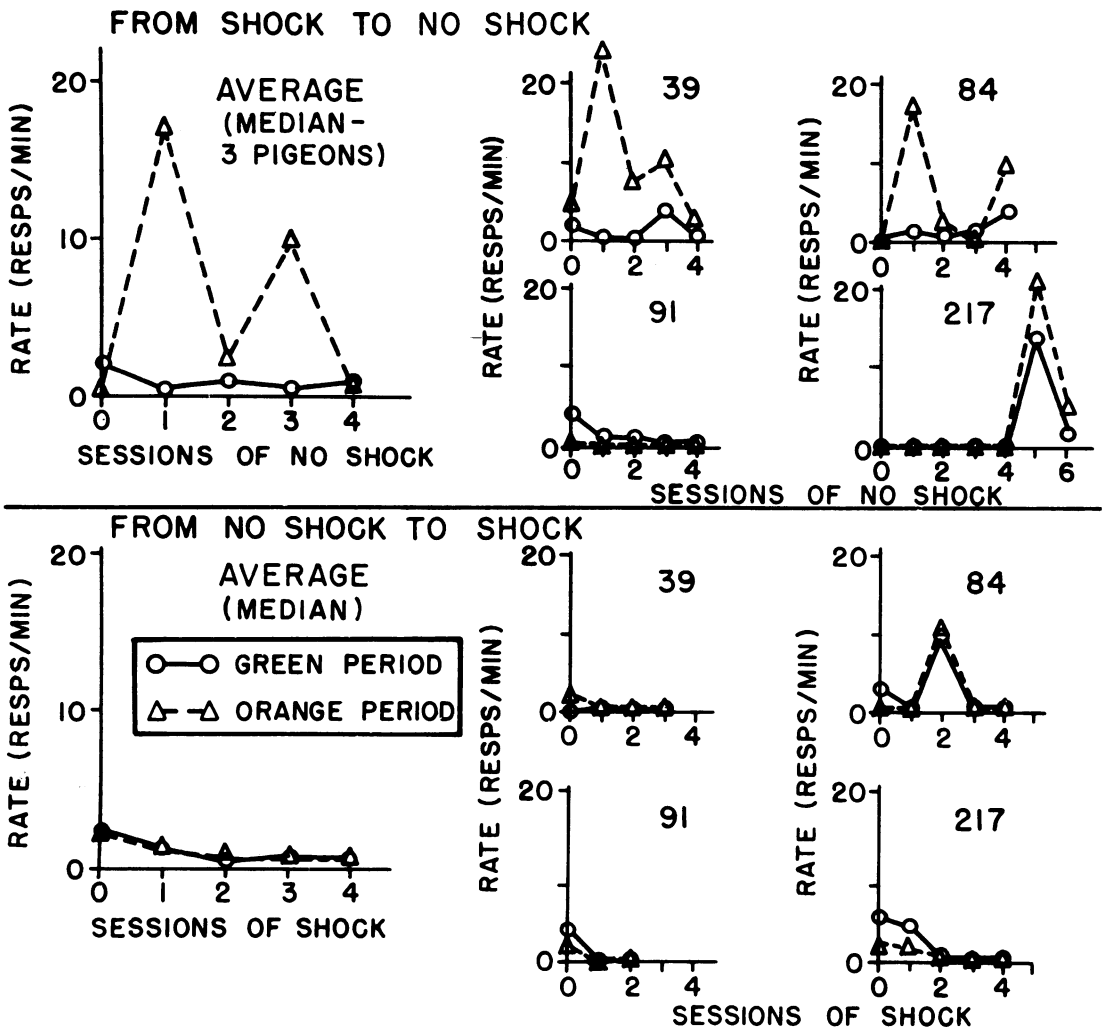

Fig. 4. Absolute rates during extinction for the first four sessions after extinction conditions were switched. At point 0 on the abscissa all subjects made less than 200 responses per session (four responses per minute) under the first extinction condition. Session 0 on Fig. 4 would correspond to session 4, 5, 6, or 7 on the scale of Fig. 2 and 3. All subjects made more than 20 responses per session for all points shown except subject 217 when switched from shock to no-shock. This subject made no responses during session 0-4. A single reinforcement was given during the first green period of session 5. The average curves represent the medians of the absolute rates of the four subjects, except for the shock to no-shock condition where subject 217 was not used in calculating the average.

shock was inserted at a later stage in extinction (lower half of Fig. 4), no such rise was found. Since, in condition 4, reward and punishment were discontinued simultaneously, shock might have served as a discriminative stimulus for reward. Since response rate is higher in the presence of a discriminative stimulus than in its absence, reintroduction of shock might have increased the response rate. The fact that it did not is evidence that shock did not function primarily as a discriminative stimulus for positive reinforcement.

Discussion

Despite an initial recovery in rate during mild shock punishment, the mild shock retains its aversive properties.

If an aversive stimulus is capable of reducing the probability of a response it follows, how can the initial complete recovery be explained without postulating an equally complete disappearance of the aversiveness of the stimulus?

The initial sudden suppression could have

been largely an emotional reaction to the sudden introduction of a strange stimulus—mild shock—and the recovery observed could have been a consequence of the reduction of this emotional effect. Once this explanation is accepted, the asymmetry between the effects of reward and punishment disappears. The sudden suppression upon introduction of shock and the initial recovery, which are the principal points of asymmetry between the effects of food and shock, can be ascribed not to the instrumental effect of the shock, but to its emotional effect. The instrumental effect of the shock would then appear gradually and remain permanently in a manner symmetrical to the gradual appearance and permanent nature of instrumental conditioning based on reward. The apparent asymmetry of reward and punishment, found in most experiments employing punishment, can be ascribed to the asymmetry of the experiments; that is, to the novelty of the punishing stimulus (which produces strong emotional effects).

This analysis implies that the instrumental effects of an aversive stimulus can be studied only after its transient emotional effects have died out. In the present experiment these instrumental effects are apparently small enough to be completely (or almost completely) masked by the effects of positive reinforcement. Assuming that punishment for a response which is also positively reinforced in some sense subtracts from reinforcement, then the value of the unpunished and punished responses may be represented as A and A-B respectively, where A is the value of the reinforcement and B is the amount subtracted by adding punishment to the consequences of the response. In the present experiment, after recovery, the ratio A—B/A may not be sufficiently different from unity to produce differential responding. However, during extinction the reinforcing consequence (A) of the response decreases, the ratio departs further from unity and produces differential responding. This is not meant to be a comprehensive model of the situation, but merely to show how relative rate of responding during extinction might be a more sensitive measure of aversiveness than relative rate during reinforcement. The analysis does not account for the effects of adaptation and the consequent increase in responding when punishment is removed.

EXPERIMENT II

On the basis of the results of Exp I it was concluded that the instrumental punishing effects of a mild shock do not clearly appear until the emotional effects have died down.

Experiment II compares the transient (mainly emotional) with the permanent (mainly instrumental) effects of shock on behavior in various components of a multiple schedule.

Subjects

Three adult, male White Carneaux pigeons were maintained at about 80% of normal weight. They were experimentally naive. Several conditions were rerun with two additional pigeons. The additional subjects had experience with shock as punishment.

Apparatus

The apparatus was identical to that of Exp I.

Procedure

A multiple schedule was the baseline, which was identical to the baseline of Exp I. Orange and green key colors alternated at 5-min intervals. Reinforcement was introduced according to 1-min VI schedules programmed separately for each key color. As in Exp I, punishment was a 3-ma shock delivered immediately after each key peck.

Punishment was programmed under the following four conditions:

1. No punishment during orange and green periods.
2. Punishment during orange period. No punishment during green.
3. Punishment during both orange and green.
4. Punishment during green. No punishment during orange.

The order and duration of each condition for each subject are shown in Table 1. Each of the three principal subjects received 2¾ cycles of the four experimental conditions.

The duration (in sessions) of each condition was determined, at first, by allowing the relative rate during the orange period of all three subjects to stabilize before continuing. When conditions were run for more than 20 sessions, relative rates during the 20th session did not

Table 1

Conditions of Experiment II

Subjects		*Conditions (in order)*	*Condition Duration (in sessions)*
361, 363, 364	First Cycle	1. Shock-neither	20
		2. Shock-orange	22
		3. Shock-both	14
		4. Shock-green	40
	Second Cycle	1. Shock-neither	31
		2. Shock-orange	20
		3. Shock-both	20
		4. Shock-green	20
	Third Cycle	1. Shock-neither	20
		2. Shock-orange	20
		3. Shock-both	20
357, 358		2. Shock-orange	20
		3. Shock-both	20
		2. Shock-orange	20
		3. Shock-both	20

differ considerably from those of later sessions. Therefore, condition length in the latter part of the experiment was fixed at 20 sessions.

Results

As in Exp I, the dependent variables are relative and absolute rates of response. The points of interest are rate changes from one condition to the next within a single cycle, and rate changes from one cycle of conditions to the next. The results are presented in two sections: the first shows results for the first cycle of the four conditions, and the second compares them to those obtained when the conditions were repeated in succeeding cycles.

Each point in the figures represents the arithmetic mean of two successive sessions. Since orange and green periods were alternated from session to session as the first period of the session, the averaging smooths out zigzag effects due to the order of the periods.

A. First cycle

1. Shock during neither period to shock during orange period. This condition is identical in both procedure and results to condition 2 (shock) of Exp I. Figure 5 shows the expected drop and subsequent recovery of rate.

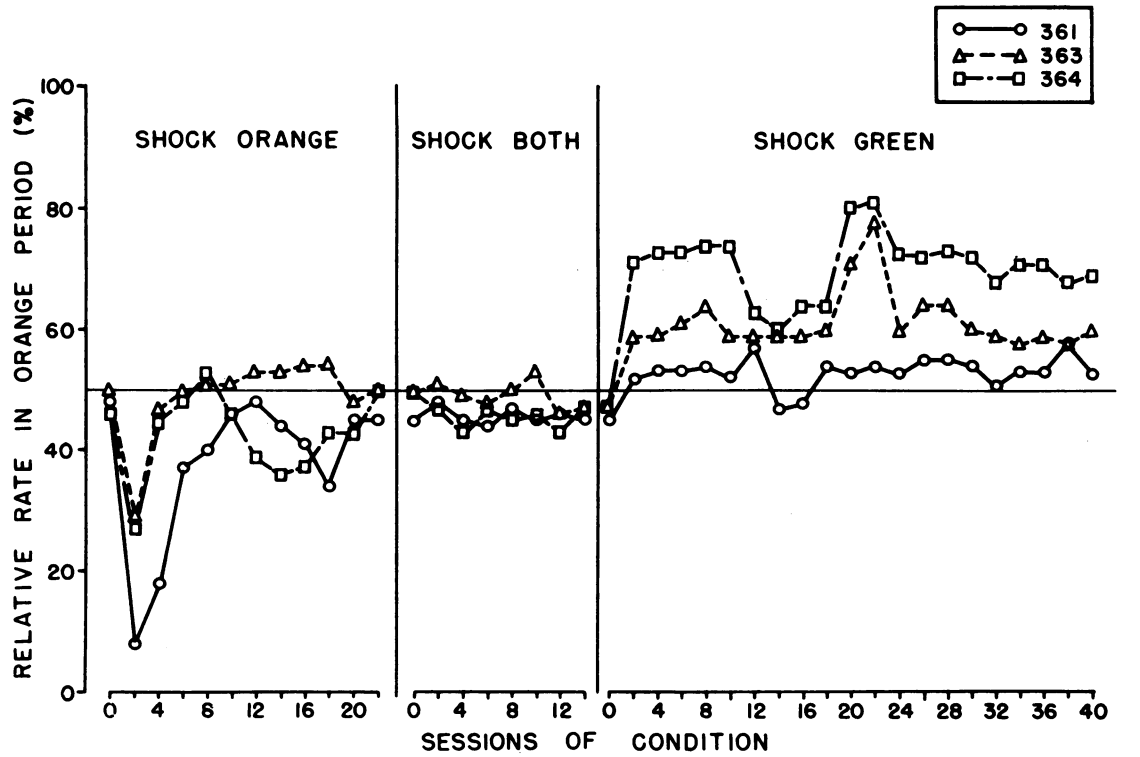

Fig. 5. Relative orange period rates of the three subjects during three conditions of the first cycle: shock-orange, shock-both, and shock-green. Point 0 on the abscissa represents the last session of the previous condition.

2. Shock during orange period to shock during both periods. Here, the subjects were punished during the green as well as during the orange period. If behavior during each of the two periods were truly independent, the rate during the green period should have decreased when punishment was introduced in the green, just as the rate during the orange period decreased when punishment was introduced there. As Fig. 5 shows, there was no such decrease in rate. (A decrease in rate during the green period would have been indicated by an increase in relative rate during the orange period.) Thus, the recovery generalizes from the orange period to the green.

3. Shock during both periods to shock during green period. Here, punishment was removed from the orange period. Azrin (1960) found that when punishment was removed after recovery, with a 1-min VI schedule (not a multiple schedule), rate increased slightly and returned to its previous value. Hence, the relative rate in the orange period was expected to rise and then fall back to around 50%. Figure 5 shows that relative rate in the orange period rose as expected and dipped slightly, but did not come back down permanently.

4. Shock during green period to shock during neither period. This transition marks the start of the second cycle. When punishment was removed, the relative rate in the orange period quickly stabilized at around 50%.

B. Second and third cycles

1. Shock during neither period to shock during orange period. This transition was repeated twice after the initial exposure. The depression upon introduction of shock remained, on the average, about the same each time. But the recovery was less. Figure 6 shows the relative rates for the three cycles.

The fact that recovery tended to diminish with repeated introductions of shock in the

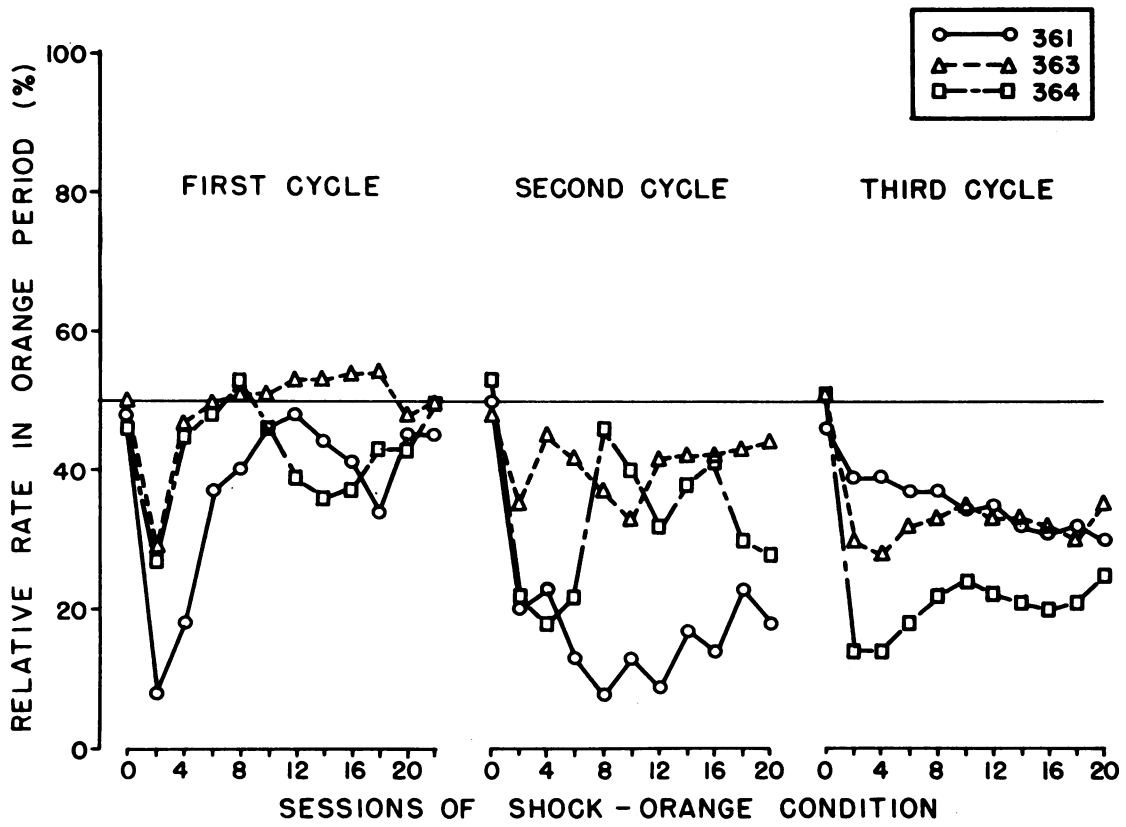

Fig. 6. Relative orange period rate of the three subjects during the shock-orange condition for the three cycles of shock orange. Point 0 on the abscissa represents the last session of shock-neither. Note that recovery decreases with repeated cycles of shock-orange.

orange period together with the lack of recovery previously, when shock was present only in the green period, adds to the weight of evidence showing that despite initial recovery in rate shock retains its aversive properties. The transient phenomenon is not suppression in response rate, but recovery. It is recovery which drops out with successive cycles.

The results have been given in terms of relative rate in the orange period. One may wonder whether the lack of recovery of relative rate in the orange period is nothing but an increase in rate during the green period (an example of behavioral contrast). Such contrast was found by Brethower and Reynolds (1962). However, neither of the present experiments revealed any noticeable rise in absolute rate during the green period when shock was introduced in the orange period.

2. Shock during orange period to shock during both periods. As expected, the relative rates during the orange period in the second and third cycles rose to 50% when shock was introduced during both periods. However, the absolute rates changed in a surprising way. When punishment was introduced during the green period, the rate in the orange period increased. For all three subjects, for both second and third cycles, the response rate in the orange period was higher after 20 sessions of shock during both periods than it was during the first session.

Since the three subjects increased only slightly in absolute rate during the third cycle and one (363) increased only slightly in the second cycle as well, two more subjects (357 and 358) were run. These subjects had prior experience with shock. They were started directly with shock during the orange period for 20 sessions and then changed to shock during both periods. Then the two conditions were repeated. Thus, they were each switched from shock during the orange period to shock during both periods two times. In neither of

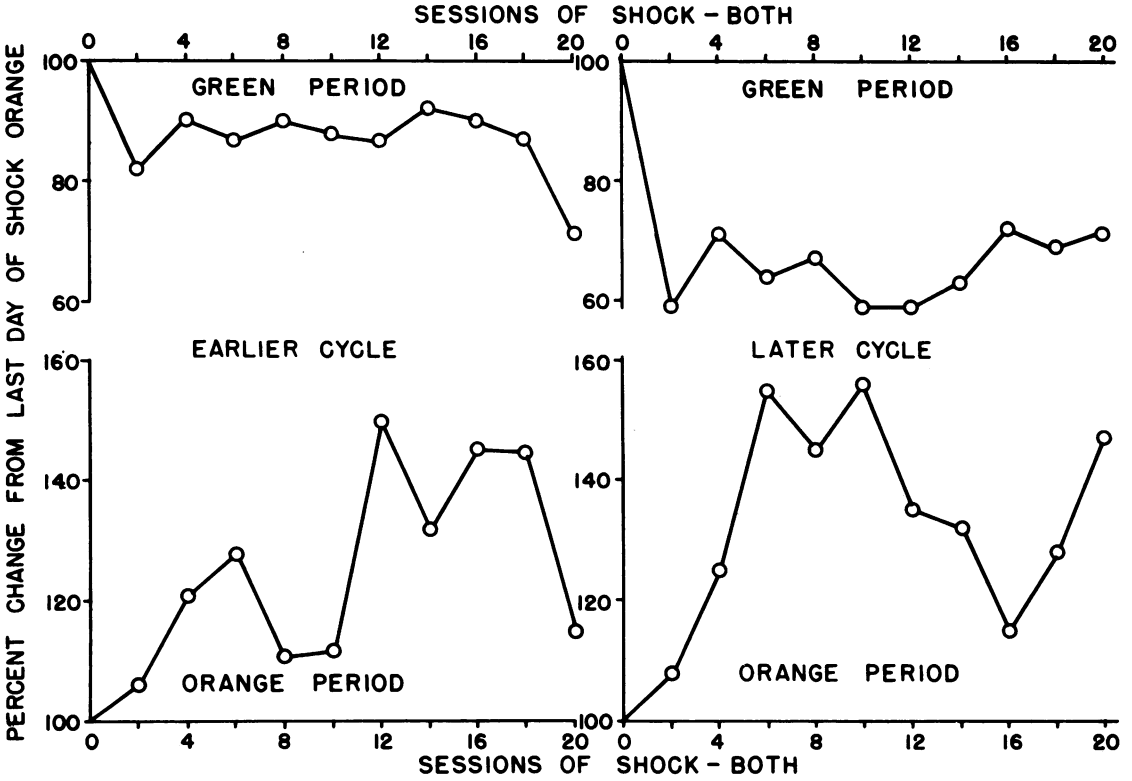

Fig. 7. Average of the normalized green and orange period rates of the five subjects during two cycles of the shock-both condition. These curves were obtained by taking the rates of each subject during sessions 1 through 20 as a percent of its rate during session 0 (last day of shock during the orange period). Then the medians of these normalized rates were plotted on the corresponding axes of the figure. Note that when punishment was introduced in the green period the rate in the orange period increased despite the continued presence of punishment in the orange period.

the times that shock was introduced in the orange period did they fully recover.

Figure 7 shows the median of the normalized orange and green period rates when shock was added to the green. Note that the rise in the orange period is equal to or greater than the drop in green. The effect was present in all five subjects for both cycles.

The increase in rate during the orange period when punishment was added to green implies that the suppression of rate during the orange period before punishment was added to the green was not due to a simple increase in sensitivity to shock. It implies that this suppression depended in some way on the lack of punishment in the green period. As soon as the contrast between the green and orange periods was removed, and punishment was present in both periods, the rate in the orange period increased.

3. Shock during both periods to shock during green period. Under this condition the behavior of the three principal subjects was similar in the second cycle to that of the first cycle. Figure 8 shows the absolute rates in the green and orange periods during the two cycles. Note that the decrease in response rate during the green period was equal to or greater than the increase in response rate during orange. For some subjects the rate during orange did not increase at all.

4. Shock during green period to shock during neither period. In all cases, the relative rates during the orange period returned immediately to 50%. In the second and third cycles the absolute rates during the green period rose to the level of the rates during the orange and both rates remained constant (in the first cycle, shock during neither period was the initial training).

Discussion

Figure 6 shows that as the experiment progressed, recovery decreased. This is supported by the incidental finding of Exp I, that recovery for two subjects was less during the second exposure to the shock condition than during the first exposure, and is consistent with the notion of a slowly developing permanent suppressive effect of the shock. Each time shock is introduced (after 20 sessions without shock) there is a sharp suppression and a recovery, a reflection of the emotional effect of the sudden shock. However, as the shock comes to act instrumentally, the temporary emotional suppression is superseded by a more permanent suppression.

Why does the permanent suppression develop so slowly? Even as late as the third cycle, about 180 sessions after shock was first introduced, the subjects showed some recovery. Perhaps the original emotional effect prevents the establishment of the relation between the consequences of a response (3 ma shock in this case) and a low rate of responding. Before shock was introduced the subjects responded at a fairly constant rate controlled by reinforcement. The process of reducing the rate when mild shock was introduced could be interpreted as the process of learning that a low response rate was invariably accompanied by a low shock rate. In any case, when the subjects had prior experience with shock (subject 357 and 358) their recovery was not complete even during the first cycle.

An example of the instrumental effect of punishment not masked by emotional effects is in the transition from condition 3 (shock during both periods) to condition 4 (shock during the green period alone). Here, the emotional effect, if it changes at all, should decrease when shock is removed from the orange period. Figure 8 shows, even in the first cycle, a separation of punished from unpunished rates in condition 4.

Figure 9 shows, in highly diagrammatic and hypothetical form, the terminal absolute rates in cycles after the first. Accepting the hypothesis previously advanced that two factors, emotional and instrumental, are responsible for response suppression and that the emotional factor is transitory, then after the first cycle (as in Fig. 9) the response rates were controlled primarily by the instrumental effects of reward and punishment.

Note in Fig. 9, that the rate when shock is present during both periods is higher than the punished rate when shock is present only during green or orange. Adaptation may explain the difference between punished rates when shock is present in both periods and punished rates with shock in one period. When shock and no-shock are alternated, the subjects may lose, during the no-shock period, whatever adaptation to shock they gained during the 5 min of shock. When the 5-min period of shock starts again, the shocks would be more aversive than at the end of this 5-min

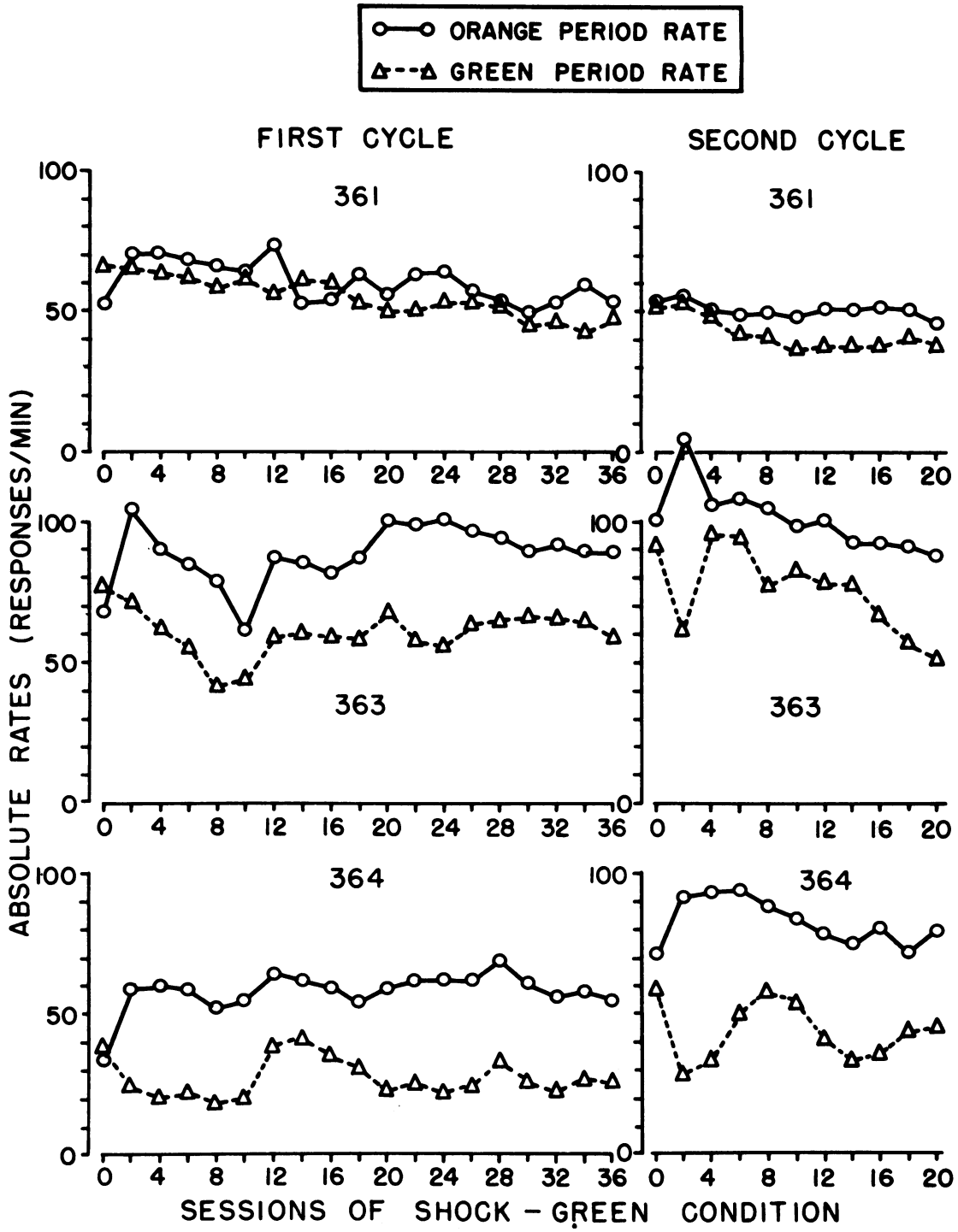

Fig. 8. Absolute green period and orange period rates of the three subjects during the first and second cycles of the shock-green condition. Point 0 on the abscissa represents the last session of shock-both. Note that the slow decrease in rate during the green period is, in the long run, equal to or greater than the rapid rise during the orange period. In the middle of the first cycle there were four consecutive sessions during which the subjects were overweight (because of overfeeding). The results for these sessions are not plotted. During these sessions absolute rates in both orange and green periods dropped sharply, but the rate difference remained.

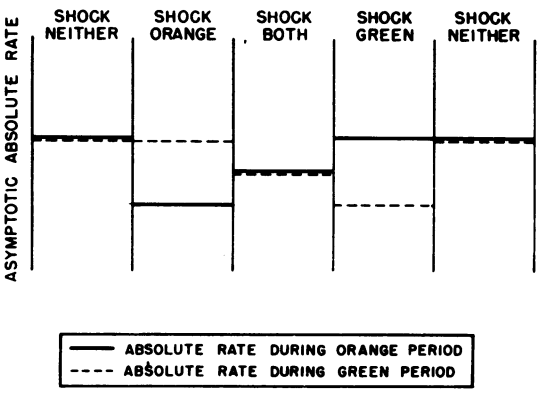

Fig. 9. A simplified schematic diagram of the terminal absolute orange and green period rates for cycles of conditions later than the first in Exp II.

period where the subject has re-adapted. Where shock is present throughout, no loss of adaptation would occur. Thus, the difference between punished rates with shock during both periods and those with shock during orange or green periods only would reflect a difference in aversiveness of shock under those two conditions.

CONCLUSIONS

The results stress the fact that the effects of shock on the behavior of an organism depend, to a large extent, on the organism's prior experience with shock. Experience with shock tends to increase the power of shock as an instrumental suppressor.

There were emotional effects consequent on punishment because the punishment used was novel whereas the reward was not. But novel reward would probably also have initial emotional effects which eventually wear out.

Thus, there are two effects of mild shock:

A. A strong, sudden, temporary emotional effect independent of any correlation between aversive stimulation and specific responses.

B. A gradually appearing permanent instrumental effect acting opposite to reward and depending on correlation between aversive stimulation and specific responses.

The two effects overlap. When shock is intense, effect A would be expected to last longer and effect B to appear sooner, thereby increasing the overlap. On the other hand, when shock is mild, as in the present experiments, the two processes could be expected to be more distinct.

This distinction implies that mild shock not contingent on response would have no permanent effect upon behavior. On the other hand, it may be assumed that extremely severe shocks would have some emotional effect each time they were presented, even after many presentations. Azrin (1956) found that a high intensity shock reliably reduced responding of pigeons even when it was not contingent on response. However, response-contingent shock reduced responding even more. In another study, Azrin (1958) found that response-contingent noise (a mildly aversive stimulus compared to shock) reduced responding of humans permanently while steady noise reduced it only temporarily.

The distinction also implies that a gradual (or stepwise) increase in shock intensity would have a less severe effect than a sudden increase. Such a difference in the severity of suppression has been found by Miller (1960).

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Received July 28, 1965