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CONDITIONED SUPPRESSION, PUNISHMENT, AND AVERSION[1]

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Three experiments were conducted to assess the aversive properties of a visual stimulus in the presence of which one group of birds received response-contingent shock (discriminated punishment) while a yoked group of birds received non-contingent shocks (conditioned suppression). In Experiment 1, presentation of the visual stimulus contingent on key pecking reduced the response rate (conditioned punishment effect) for birds under the conditioned suppression procedure but did not reduce the response rate of birds under the discriminative punishment procedure. Non-contingent shocks also produced greater suppression of responding maintained by positive reinforcement in the presence of a visual stimulus than did response-contingent shocks. In Experiment 2, a greater shock intensity (2 mA) was used. All the differences between the two groups found in Experiment 1 were also found in Experiment 2. Experiment 3 demonstrated that response-contingent shock did not result in a conditioned punishment effect even when positive reinforcers were unavailable during the discriminative punishment schedule. The exteroceptive stimulus that was paired with shock in the conditioned suppression procedure acquired the ability to punish behavior. The exteroceptive stimulus in the discriminative punishment schedule did not acquire this ability.

Under a conditioned suppression procedure, an exteroceptive stimulus precedes the occurrence of an unavoidable aversive event, *e.g.*, electric shock. A discriminative punishment schedule also provides an exteroceptive stimulus, but the occurrence of the aversive event is contingent on the subject's behavior and thus the aversive event is "avoidable"; if the particular response upon which shock is dependent is not made, then the shock is not delivered. The fact that behavior maintained by positive reinforcement is suppressed under both procedures does not necessarily indicate that the reasons for the suppression are the same under both conditions. A different test of the effectiveness of the exteroceptive stimulus in each procedure might provide data useful for an understanding of the way in which behavior comes to be suppressed under these two conditions. There are data that can be interpreted as evidence that a stimulus that precedes unavoidable shocks (conditioned suppression procedure) is more aversive than a stimulus that precedes response-contingent shocks (discriminative punishment procedure). Rachlin (1967) found that responding that led to a stimulus that preceded unavoidable shock was reduced more than responding that led to a stimulus in the presence of which response-contingent shock was scheduled. However, it was possible, as Rachlin pointed out, to interpret the outcome of that particular experiment in terms of differential shock frequencies encountered, rather than in terms of the conditioned aversive properties of the stimuli.

The purpose of the present study was to compare the conditioned aversiveness of a stimulus in a conditioned suppression procedure with that of a stimulus in a discriminative punishment procedure under conditions in which shock frequencies are equated.

EXPERIMENT 1

In this experiment, pairs of pigeons were run in a yoked-control design in which both

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subjects received shock whenever the punishment bird emitted a punished response. Contingent shock for the punishment bird and non-contingent shock for the yoked bird occurred only in the presence of a visual stimulus, which was occasionally presented during a baseline condition of food-reinforced key pecking.

To assess the aversive properties of the visual stimulus, a conditioned punishment test was periodically administered, during which the same visual stimulus was presented for a brief duration contingent on a key peck.

Method

Subjects

Six Silver King pigeons, which had been used in previous experiments on discriminative learning, were maintained at 85% of their free-feeding weights throughout the experiment. The present experiment began approximately 1 yr after the termination of the experiment in which the birds had served as subjects.

Apparatus

The experimental chambers measured 36 by 36 by 33 cm and each contained a translucent response key (R. Gerbrands Co.) mounted 23 cm from the cage floor. The key could be transilluminated by either a white or red 110-V 7-W GE lamp mounted behind the key. The response key in each chamber was operated by a force of 0.147 N. An audible click from a relay mounted behind the front panel provided feedback that the key had been operated. The reinforcing stimulus was the presentation of grain for 3 sec by a Lehigh Valley pigeon feeder.

The shock was generated by a Foringer Model 1154M11 shock generator and was delivered through an 80,000-ohm resistor to electrodes planted in the tail region of the pigeon (Azrin, 1959). The two chambers were served by two identical shock sources calibrated for equal shock intensities and timed from the same electronic timer. The tail electrodes were made of 0.018-gauge (0.457 mm) stainless-steel orthodontic-ligature wire.[2] This wire has the advantage of being pliable, strong, and chemically inactive. The electrodes were connected to a plug on the back of a vinyl jacket worn by each pigeon. This plug was in turn connected to a lead attached to a mercury pool commutator at the top of the chamber. The shock duration was 100 msec in all phases of the experiment. Shock intensity and duration were calibrated with an oscilloscope at the plug inside the experimental chamber. A meter was constructed to measure magnitude of impedance and each subject was checked daily before and after each session.[3] Individual magnitudes of impedance remained constant within approximately 5% over the five months of experimentation. The values for each subject ranged from 900 ohms to 1.4K ohms.

Procedure

Pairs of pigeons were matched for rates of responding following two weeks of training under a variable-interval (VI) schedule of reinforcement with a mean of 2 min and the distribution described by Fleshler and Hoffman (1962). During the preliminary VI training, and subsequently during the baseline condition, the key was transilluminated with white light. The subjects were then fitted with vinyl jackets and implanted with electrodes. Yoked pairs of subjects were run simultaneously for at least 10 additional sessions with the jackets before shock was introduced. The last four of these adaptation sessions consisted of exposing the subjects to the red light as it would be encountered during training but without shock. The red light was periodically presented for 1 min but no shocks were administered. The average interval between presentations of the red light during adaptation sessions was 3 min with a range of 2 to 4 min. Also, periodically a peck in the presence of the white light changed the color from white to red for 250 msec. The purpose of these sessions was to avoid later disruption of behavior due to a novel presentation of the red light as a discriminative stimulus (S^D) and as a stimulus contingent on a key peck. The three subjects that received a punishment regimen will be referred to as PUN subjects and the three yoked subjects will be referred to as YOKED subjects.

[2]We wish to thank Dr. H. L. Friedman for supplying the ligature wire.

[3]We wish to thank Mr. Melvin Kreithen for his technical assistance in the construction of the meter and calibration of the shock sources.

PUN and YOKED subjects received shock during 1-min periods when the key was transilluminated with red light: for PUN subjects, every key peck during red was followed by a shock; for the YOKED subjects, the red light was a signal for non-contingent shocks that a given YOKED subject received whenever its PUN partner was punished. To assess the conditioned aversive properties of the red light, conditioned punishment (CP) probes were used; during a 1-min probe each key peck changed the keylight from white to red for 250 msec. The probe tests were independently administered to both PUN and YOKED birds; the presentation of the 250-msec red light was contingent on a key peck for each bird. Shocks were not administered during the probe tests. These probes occurred after every third presentation of the red light in the presence of which shocks were delivered. Each sequence of three red lights (S^D will be used to refer to the red light for both conditioned suppression and discriminative punishment procedures) and one CP probe constituted a cycle and two cycles were presented per session. However, during the first shock session for 2850-PUN and 3950-YOKED, only one cycle was presented. The average interval between S^Ds was 5 min with a range of 4 to 6 min. After the third S^D, the S^D tape programmer stopped and a probe occurred 8 min later. The S^D tape programmer resumed operation 1 min after the probe terminated. Food reinforcement under the VI 2-min schedule was in effect during all experimental conditions. The average duration of a session was 65 min.

Subjects were run at a shock intensity of 1 mA until their rates of responding in the presence of the white keylight had recovered to pre-shock levels for five days. The shock was eliminated and they were run with no shock (0 mA) until key pecking in the red light and during the conditioned punishment probe had recovered to the pre-shock baseline level for at least four consecutive sessions.

Results

Discriminative punishment vs. conditioned suppression. In the presence of the S^D, non-contingent shocks produced greater suppression than did response-contingent shocks for all pairs of birds. This is shown in Figure 1 in which the suppression ratios are plotted for successive sessions for PUN and YOKED subjects. The suppression ratio is calculated as the response rate during S^D divided by the rate during the baseline (white keylight) for that session. A ratio of less than 1.0 represents a decrease in response rate during the S^D relative to the baseline rate.

Figure 1 shows that the effects of shock were immediate for both PUN and YOKED subjects. For YOKED subjects, suppression ratios went from approximately 1.0 on the last day of adaptation to approximately zero on the first day of shock, showing that responding was almost completely suppressed. The behavior of YOKED Subjects 2818 and 4397 continued to show complete suppression on all subsequent shock sessions and the behavior of YOKED Subject 3950 recovered to a level such that suppression ratios were approximately 0.3 for Sessions 7 to 12. In contrast, although the discriminative punishment procedure produced immediate effects, responding for PUN subjects recovered on subsequent shock sessions, as is shown by the recovery of suppression ratios to approximately 0.6 to 1.0 before shock was discontinued.

Point A on the graph for the second pair of subjects (3977-PUN and 4397-YOKED) indicates an apparatus failure in which the shock generator remained on and these two birds received continuous, non-contingent shock for approximately 5 min. The birds were then run for one session on the baseline condition with no S^D, no probe, and no shock. After this session, the normal procedure resumed. It might be noted that the suppression ratio for the PUN bird went from 0.58 before the appartus failure to 0.24 after the failure. Punished responding for 3977-PUN recovered in the next four sessions and then decreased slightly again on subsequent sessions, showing the pattern typical of recovery for the other two PUN birds. Responding remained completely suppressed as before for the YOKED subject.

Conditioned punishment for PUN vs. YOKED subjects. Figure 2 shows conditioned punishment ratios, measured as responses during the 1-min probe divided by responses in the 1-min period immediately preceding the probe. Most of the conditioned punishment ratios for the YOKED birds are below those of their PUN counterparts. An analysis of variance of the conditioned punishment ratios for

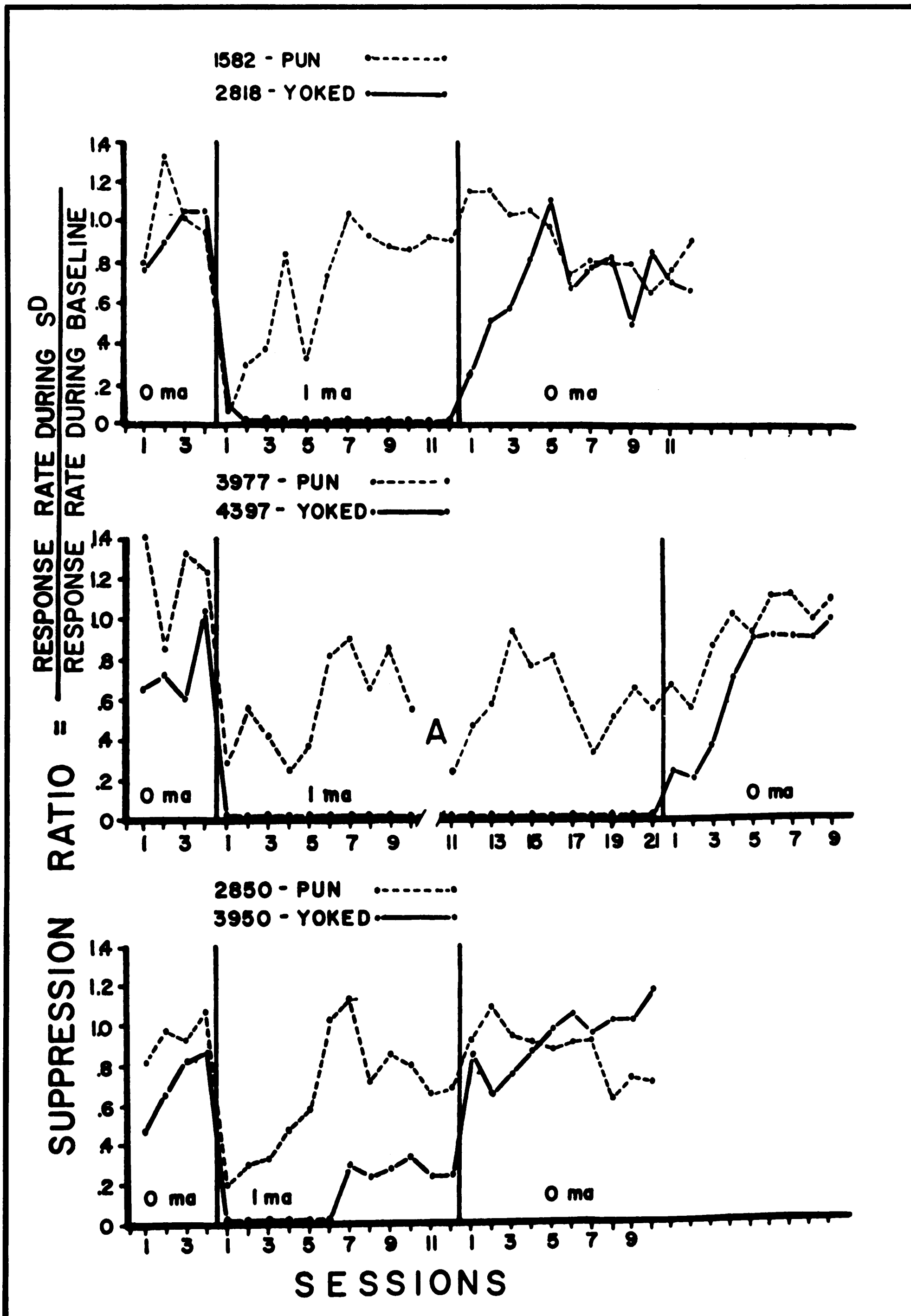

Fig. 1. Suppression ratios for PUN birds and YOKED birds: before any shock session (Panel 1); during 1-mA shock sessions (Panel 2); and under conditions in which shock was no longer presented (Panel 3). An apparatus failure occurred at "A" which resulted in the 3977-PUN and 4397-YOKED birds receiving continuous non-contingent shock for about 5 min. See text for further description of procedure for these two birds.

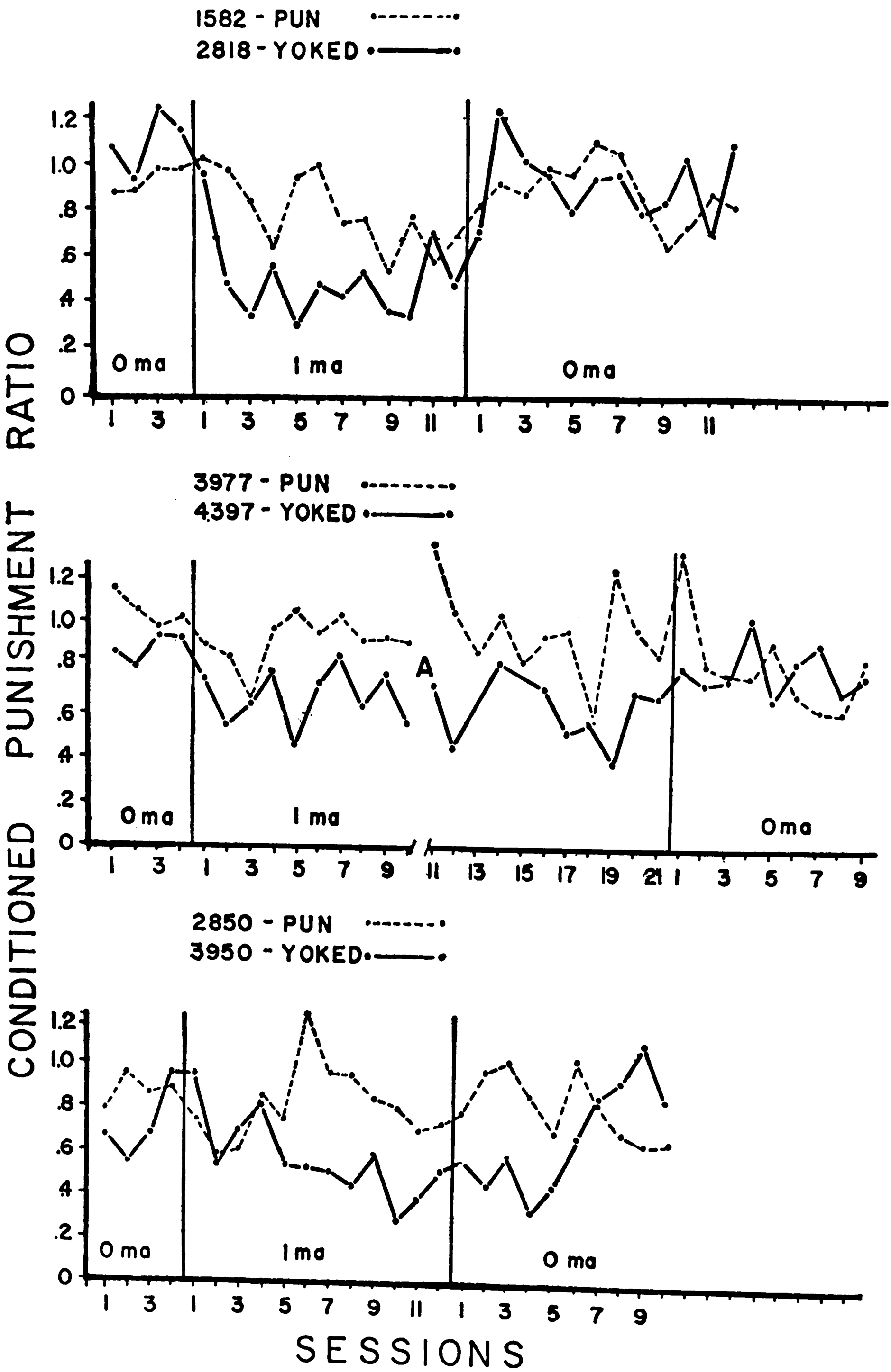

Fig. 2. Conditioned punishment ratios for PUN birds and YOKED birds: before any shock sessions (Panel 1); during 1-mA shock sessions (Panel 2); and under conditions in which shock was no longer presented (Panel 3). Conditioned punishment ratios in Sessions 13 and 15 were indeterminate for 4397-YOKED because the baseline rate in the 1-min period before the probe was zero in each case.

PUN and YOKED groups over the first 12 sessions reveals that the conditioned punishment ratio of the YOKED birds differed significantly from the conditioned punishment ratio of the PUN birds ($F = 17.99$, d.f. $= 1, 4$, $p < 0.05$).

Cumulative records illustrating the effect of response-contingent shock and non-contingent shock are shown in Figures 3, 4, and 5. In each figure a PUN subject and its YOKED partner are represented, with the top row of records for the PUN subject and the bottom row for the YOKED partner. Records are shown for five different sessions for each bird: the last day of the four adaptation sessions to the sequence of S^D and probes, the first day of shock, the fifth day of shock; the third from the last day of shock, and a post-shock session after recovery.

Figures 3, 4, and 5 show that on the last day before shock, the PUN and YOKED subjects had comparable response rates. Response rates under S^D and CP probe conditions were similar to baseline response rates. These records reveal that in addition to the effects already described, non-contingent shock also disrupted the baseline rate while contingent shock did not. From the first occurrence of shock, all YOKED subjects showed a pause in

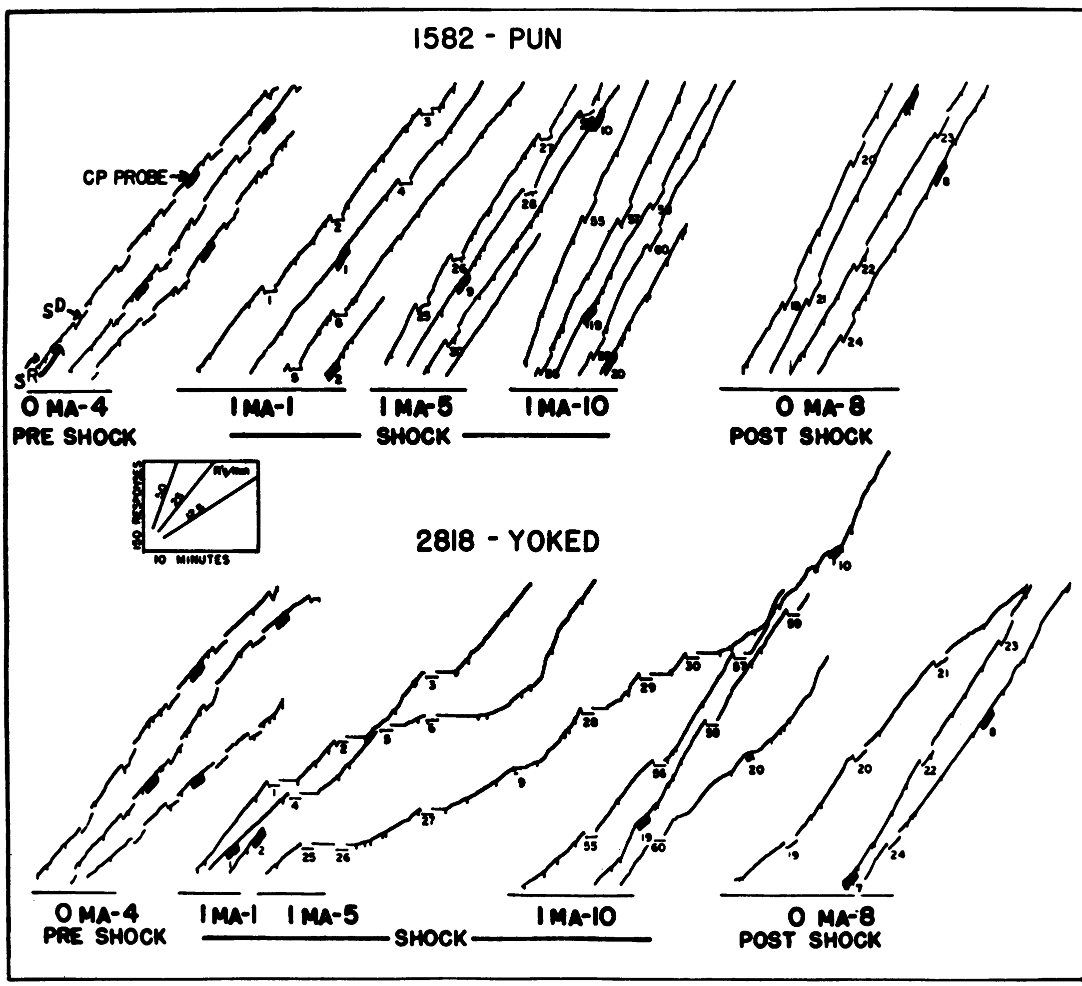

Fig. 3. Cumulative records for each pair of PUN and YOKED birds under conditions of pre-shock, 1-mA shock, and post-shock. Periods during which the red light was presented are labelled, "S^D" and are numbered consecutively within shock and post-shock conditions. Conditioned punishment probes are shown and are also consecutively numbered within each condition. Each key peck during conditioned punishment probes momentarily depressed the pen. The solid black areas reflect the emission of many key pecks during the probe. The digit after the shock intensity shown along the abscissa refers to session number.

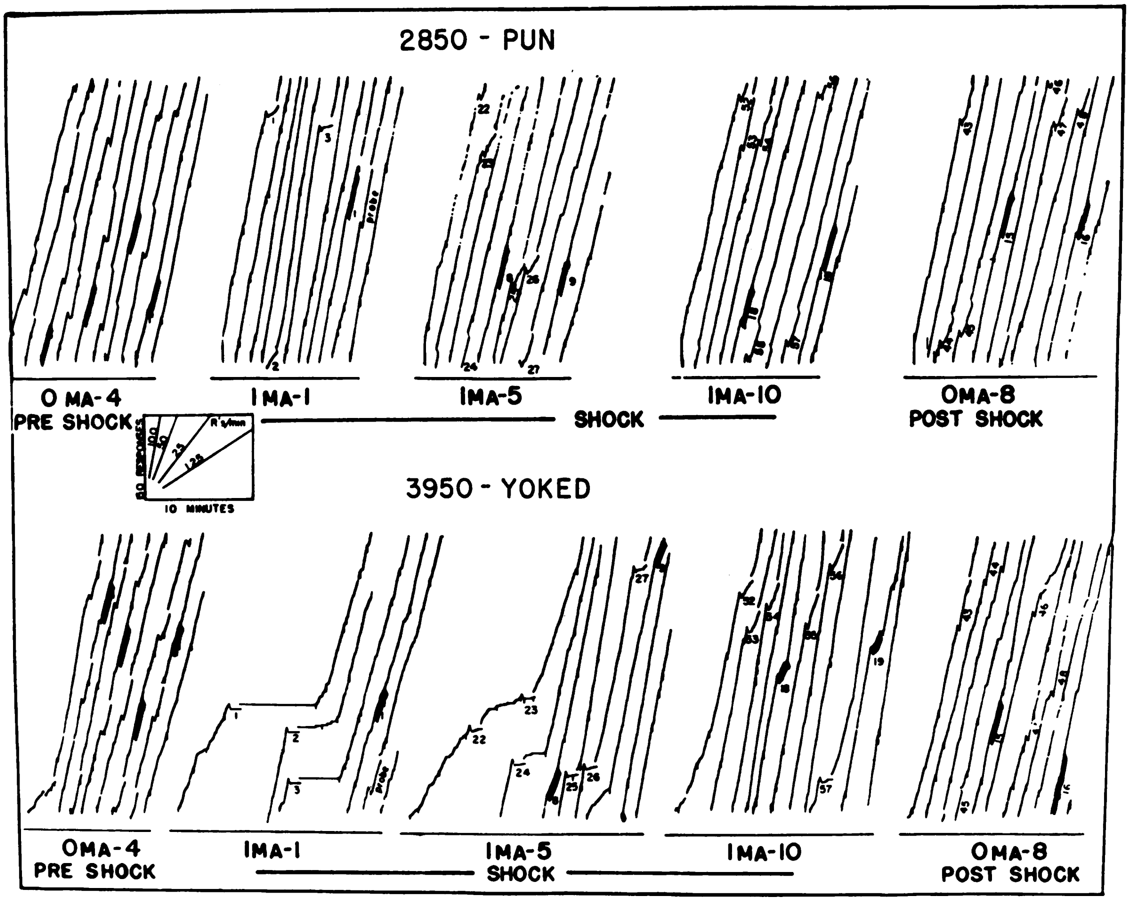

Fig. 4. Cumulative records for each pair of PUN and YOKED birds under conditions of pre-shock, 1-mA shock, and post-shock. Periods during which the red light was presented are labelled, "S^D" and are numbered consecutively within shock and post-shock conditions. Conditioned punishment probes are shown and are also consecutively numbered within each condition. Each key peck during conditioned punishment probes momentarily depressed the pen. The solid black areas reflect the emission of many key pecks during the probe. The digit after the shock intensity shown along the abscissa refers to session number.

responding after the S^D terminated while PUN subjects tended to begin responding immediately after the S^D terminated. For YOKED subjects, there was also a reduction in baseline responding at the beginning of a session. On the other hand, there was little disturbance of baseline responding for PUN birds.

The cumulative records also show the results of the conditioned punishment probes for PUN and YOKED subjects. On the first session of shock, neither PUN nor YOKED subjects showed conditioned punishment effects. However, YOKED subjects showed conditioned punishment effects on subsequent shock sessions, as indicated by a lower response rate during the conditioned punishment probes than before or after the probes. For example, 2818-YOKED made only three responses in the ninth CP probe (see Figure 3, 1 mA – 5), and only seven responses on the twentieth CP probe (see Figure 3, 1 mA – 10). Subject 4397-YOKED made only five responses on the ninth CP probe (see Figure 5, 1 mA – 5). Punished subjects, however, showed little evidence of a conditioned punishment effect.

It is apparent that the baseline response rates for YOKED subjects varied during shock sessions. The question arises as to whether the effectiveness of conditioned punishment was related to the baseline rate. To answer this question, the correlation between the conditioned punishment ratio and the baseline

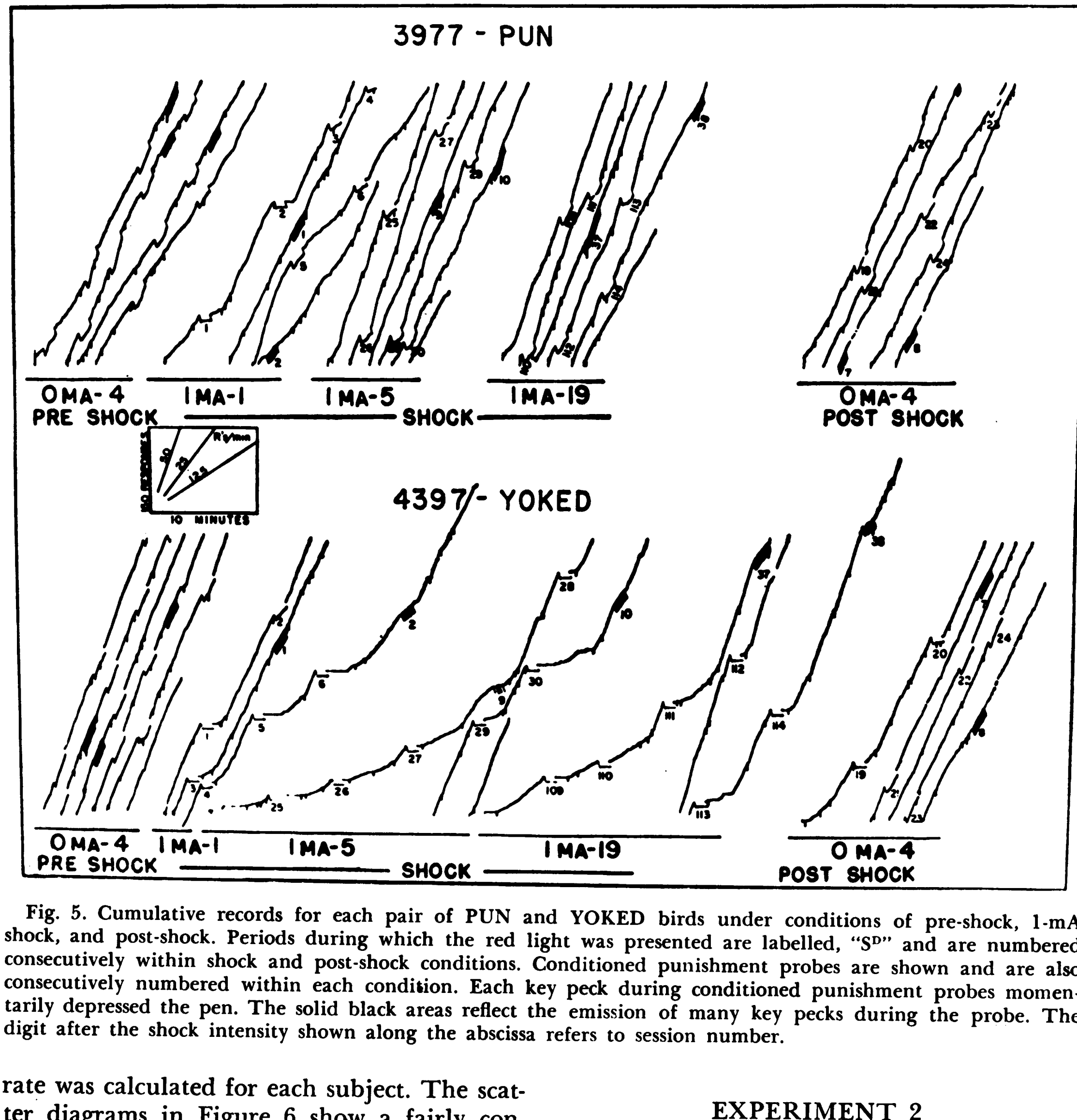

Fig. 5. Cumulative records for each pair of PUN and YOKED birds under conditions of pre-shock, 1-mA shock, and post-shock. Periods during which the red light was presented are labelled, "S^D" and are numbered consecutively within shock and post-shock conditions. Conditioned punishment probes are shown and are also consecutively numbered within each condition. Each key peck during conditioned punishment probes momentarily depressed the pen. The solid black areas reflect the emission of many key pecks during the probe. The digit after the shock intensity shown along the abscissa refers to session number.

rate was calculated for each subject. The scatter diagrams in Figure 6 show a fairly constant conditioned punishment effect over the range of baseline rates of Subjects 2818 and 4397, and a negative correlation for Subject 3950. The correlation coefficients for 2818 ($r = 0.20$) and 4397 ($r = -0.03$) are not statistically significant ($p > 0.10$), but the correlation coefficient of -0.80 for 3950 is statistically significant ($p < 0.02$). This result shows that the conditioned punishment ratio was independent of the baseline response rate for two subjects, but that for one subject, the higher the response rate going into a conditioned punishment probe, the greater the relative drop in response rate during that probe.

EXPERIMENT 2

The first experiment demonstrated that a stimulus in the presence of which shocks were contingent upon key pecks was not an effective conditioned punisher. When the same number and pattern of shocks were presented independently of the response, the stimulus was an effective conditioned punisher. Under the latter condition, there was also greater suppression of responding in the presence of the stimulus. Were the differences in the conditioned punishing effect of the stimulus under these two conditions a reflection only of differences in response rates in its presence? Would the stimulus become an effective con-

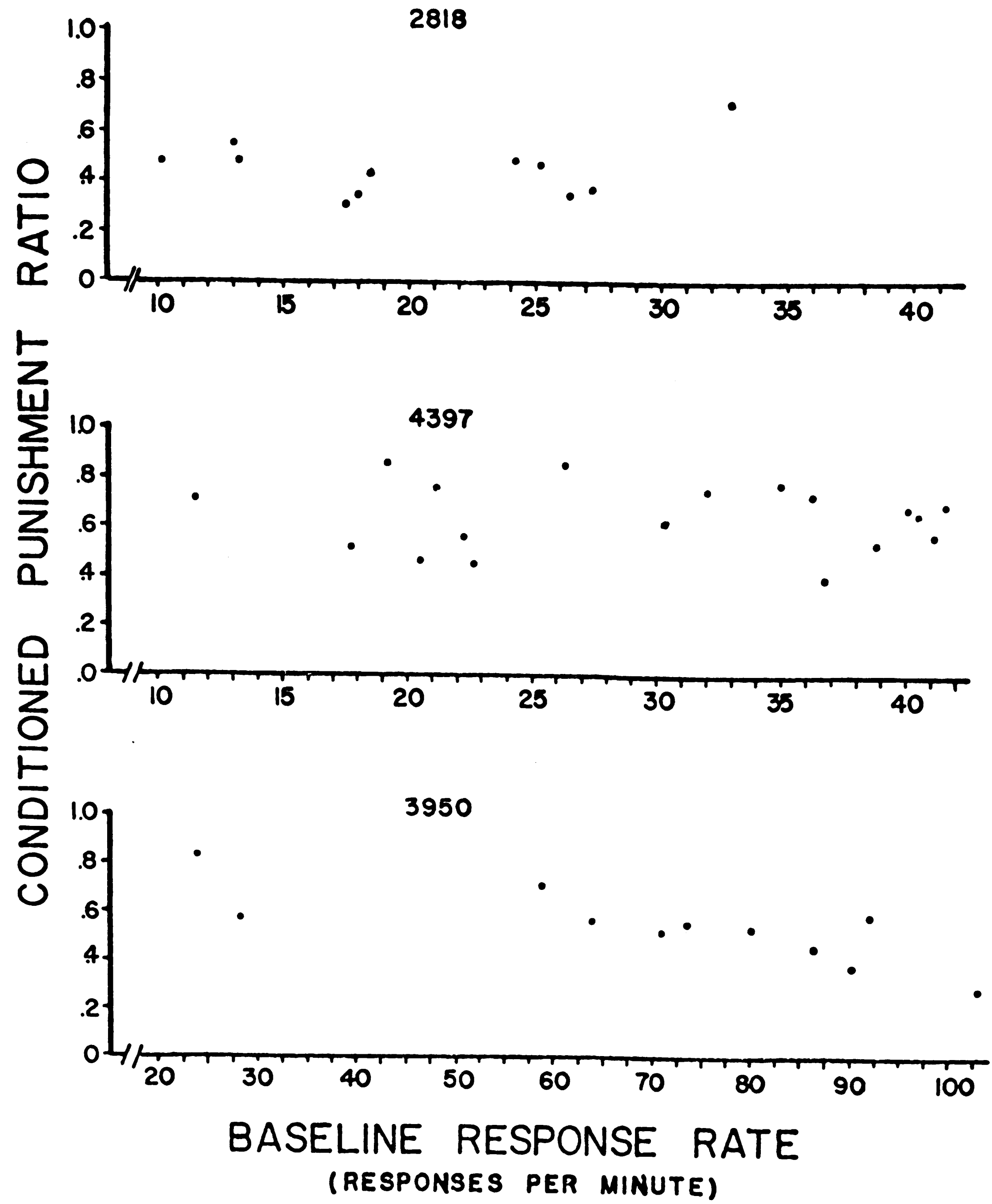

Fig. 6. Conditioned punishment ratios for YOKED birds as a function of baseline response rates.

ditioned punisher for PUN birds if the punishment effect in the presence of the stimulus was greater? The original purpose of Experiment 2 was to expose subjects to the procedures of Experiment 1, but with 2-mA shock instead of 1-mA shock. This was done, however, with only one pair of subjects because two of the YOKED subjects stopped responding when 2-mA non-contingent shock was introduced. The other two pairs were therefore run under a slightly different procedure, described below.

Method

Subjects and Apparatus

The subjects and apparatus were the same as those in Experiment 1 except that the shock intensity was now calibrated at 2 mA. The shock duration was 100 msec as before.

Procedure

After several sessions with no shock, 2-mA shocks were introduced. For PUN subjects, the 2-mA shock was contingent upon a key peck during the S^D (a red keylight as before) and simultaneously, non-contingent shocks occurred for the YOKED subjects. All other conditions, including the conditioned punishment probes, were the same as in Experiment 1.

One pair of subjects, 2850-PUN and 3950-YOKED, was run under this procedure until the baseline response rate of the YOKED animal recovered to the previous non-shock level and remained at that level for five days; this required 27 sessions. Shock was then discontinued for a number of sessions until the response rate during the S^D was similar to the response rate during the baseline.

The other two pairs were run for 10 sessions under the 2-mA condition with S^D and probes, but they stopped responding at this shock intensity. The shock was then eliminated and the subjects were run only under the baseline condition with no S^D periods nor with any probes, until responding recovered to previous non-shock levels. This required six sessions for 1582-PUN and 2818-YOKED and 10 sessions for 3977-PUN and 4397-YOKED. Conditioned punishment probes were then reintroduced and were scheduled to occur twice during the baseline condition at approximately the twenty-third and forty-sixth minute of the session. Conditioned pun-

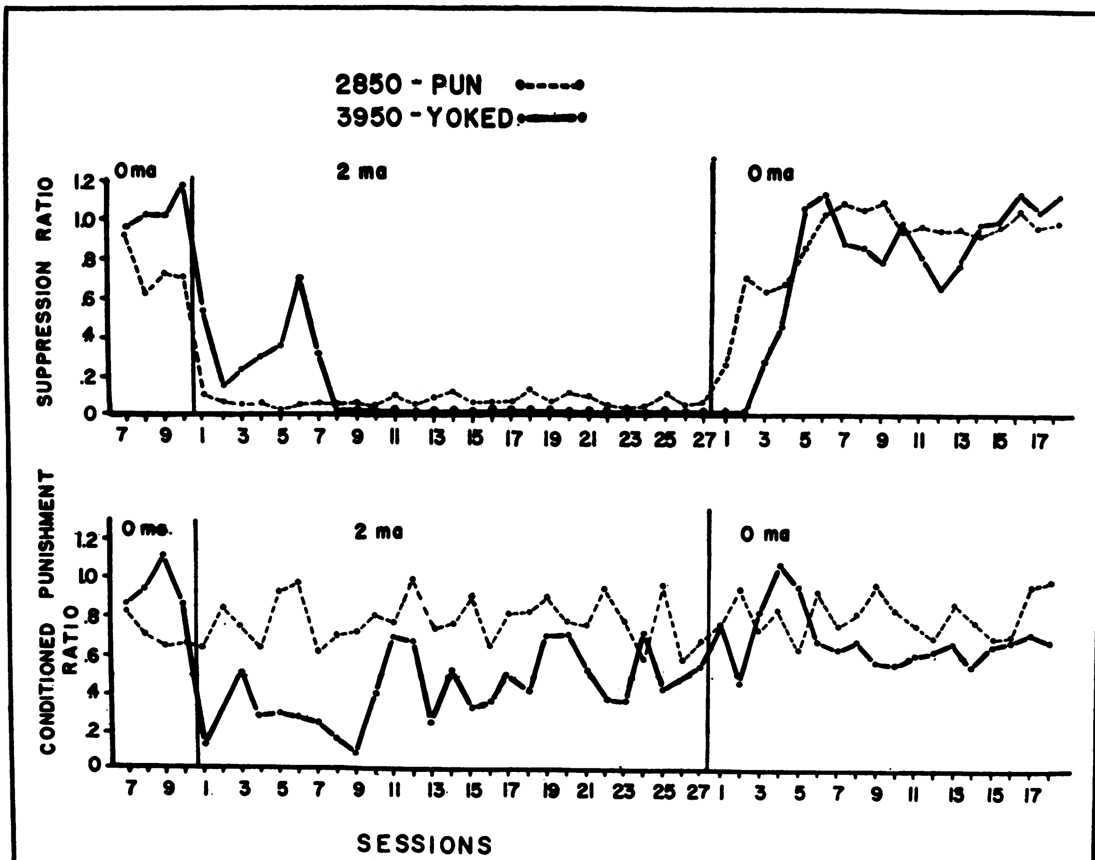

Fig. 7. Suppression ratios (top graph) and conditioned punishment ratios (bottom graph) for Birds 2850-PUN and 3950-YOKED: before any shock sessions (Panel 1), during 2-mA shock sessions (Panel 2), and during conditions in whick shock was no longer presented (Panel 3).

ishment probes were presented for several sessions until the response rates in the conditioned punishment probes approximately equalled baseline response rates, which took 17 sessions for 1582-PUN and 2818-YOKED and four sessions for 3977-PUN and 4397-YOKED. Then, the S^Ds were reintroduced and the usual procedure of two cycles with three S^Ds and one probe per cycle was conducted.

RESULTS

Figure 7 shows suppression ratios of about 0.1 for all shock sessions for Subject 2850-PUN, indicating that the response rate in the presence of the stimulus was about 10% of that under the baseline condition (the exact number of shocks received per session can be seen in Table 1). Conditioned punishment ratios, however, remained at the same level as during the 0-mA control sessions. Thus, for Subject 2850-PUN, even when there was a substantial punishment effect, there was no conditioned punishment effect.

Table 1

Frequency of 2-mA response-contingent shocks (PUN) during Experiment 2.

	Subject		
Session	*1582*	*3977*	*2850*
1	31	103	59
2	73	62	46
3	39	70	32
4	30	78	38
5	32	69	11
6	20	28	36
7	58	106	39
8	64	147	23
9	47	161	35
10	53	226	25
Mean	44.7	105.0	34.4

Suppression ratios for Subject 3950-YOKED were higher than for the PUN subject for the first seven sessions, but reached zero for the remaining 20 sessions. The YOKED subject also showed a conditioned punishment effect at 2 mA, which was greater than the conditioned punishment effect at 1 mA (Figure 2).

For the other two pairs of subjects, key-peck responding ceased during the shock sessions for YOKED birds while for PUN birds the response rate was reduced only during the S^D. Figures 8 and 9 show the suppression ratios and conditioned punishment ratios plotted for each pair of subjects under shock (2 mA) and control (0 mA) conditions. Both PUN subjects showed a substantial punishment effect but no obvious conditioned punishment effect. As Figure 8 shows, suppression ratios for 1582-PUN under 2-mA shock were approximately 0.2 for all 10 shock sessions, but conditioned punishment ratios were at about the same level as they were during the no-shock condition. As Figure 9 shows, there was a large punishment effect under 2-mA shock for 3977-PUN but again, conditioned punishment ratios were at about the same level as they were during previous 0-mA sessions.

Figures 8 and 9 also show that responding during S^D had completely ceased for both YOKED subjects under the 2-mA condition. When conditioned punishment probes were reintroduced (third panel), following recovery of the baseline response rate, YOKED subjects showed conditioned punishment effects but PUN subjects did not. Subject 2818-YOKED showed the largest conditioned punishment effect, which lasted for about 17 sessions before recovery to the previous 0-mA conditioned punishment ratio levels. Responding of Subject 4397-YOKED recovered after two sessions. For PUN subjects, conditioned punishment ratios were at about the same level when probes were reintroduced as they were under no-shock control sessions.

When the S^Ds were reintroduced after responding in the conditioned punishment probes had recovered (fourth panel of Figures 8 and 9), responding of YOKED subjects initially showed complete suppression. When S^D was introduced for PUN subjects, suppression ratios and conditioned punishment ratios were both similar to those at pre-shock levels, thus showing no suppression or conditioned punishment. For YOKED subjects, suppression ratios were initially quite low (at or near zero) when the S^D was introduced and they increased with successive sessions, finally reaching previous 0-mA control levels. Although there was substantial suppression of responding in the S^D during this phase, YOKED subjects did not show any conditioned punishment effect. This result would support the suggestion that the conditioned punishing effects of a stimulus may be weakened independently of the conditioned sup-

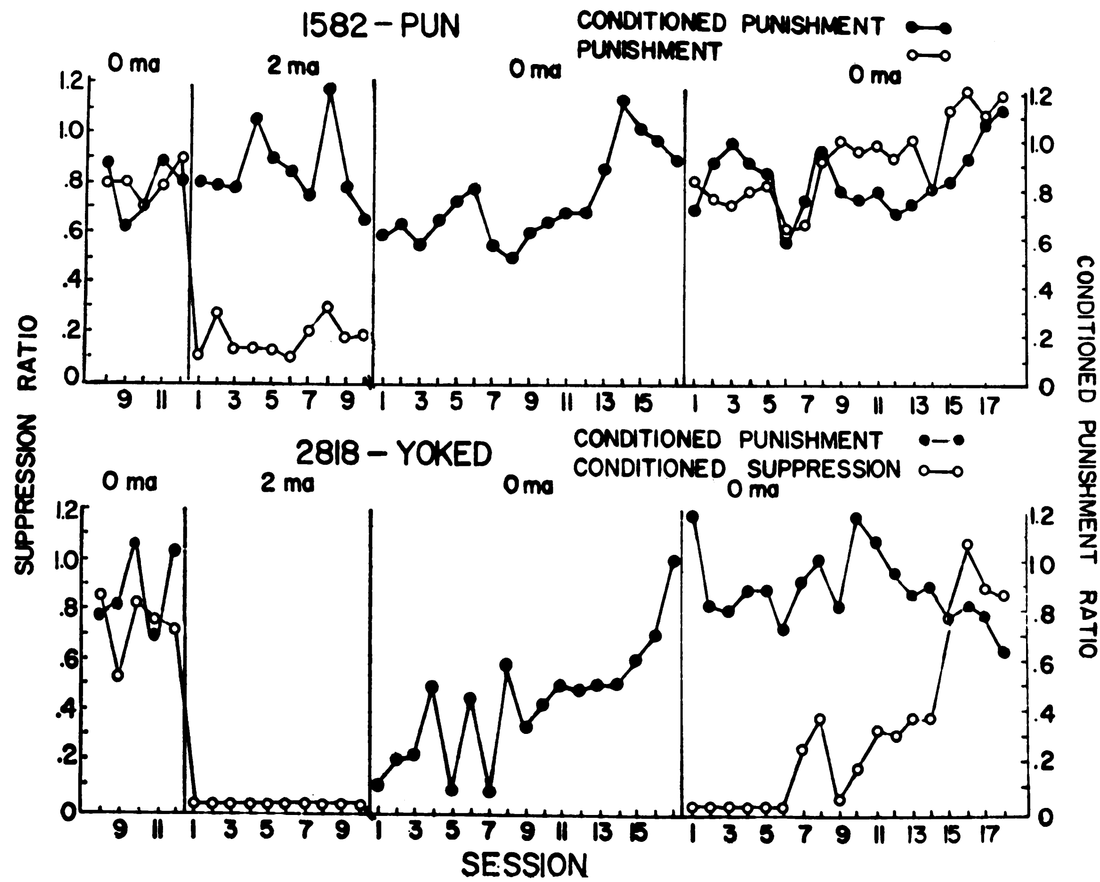

Fig. 8. Suppression ratios and conditioned punishment ratios for 1582-PUN and 2818-YOKED under four conditions: sessions before any shock sessions (Panel 1); 2-mA shock sessions (Panel 2); sessions in which shock was discontinued in an attempt to recover baseline response rates but conditioned punishment probes occurred (Panel 3); sessions that were the same as in the previous condition but in which the S^D was scheduled to occur (Panel 4). The open circles represent suppression ratios under the discriminative punishment schedule and under the conditioned suppression schedule. Conditioned punishment ratios are represented by closed circles.

pression effect observed in the presence of that stimulus.

Cumulative records showing the effects of 2-mA non-contingent shock for Subject 2818-YOKED are shown in Figure 10. The first set of records (labelled "CONTROL"), taken from the last sessions before shock, shows that response rates under the probe conditions and during the S^Ds were similar to baseline rates. The records from shock sessions (labelled 2-mA SHOCK") show that all responding ceased when the shock was introduced and that responding never recovered during shock sessions. When the shock was discontinued however, the response rate recovered before probes were introduced, as can be seen from the cumulative records during conditioned punishment sessions (labelled "CONDITIONED PUNISHMENT AFTER BASELINE RECOVERY"). A substantial conditioned punishment effect was maintained for several sessions with as few as one conditioned punishment response occurring during several of the probes (*e.g.*, 2, 5, 10, 13). During these CP probes, one 250-msec response-contingent flash of the red light was sufficient to suppress behavior for up to 4 min (*e.g.*, the fifth CP probe). Responding in the CP probes recovered over repeated sessions and by the seventeenth session the response rate in the CP probe was approximately equal to the baseline rate. Food reinforcement sometimes oc-

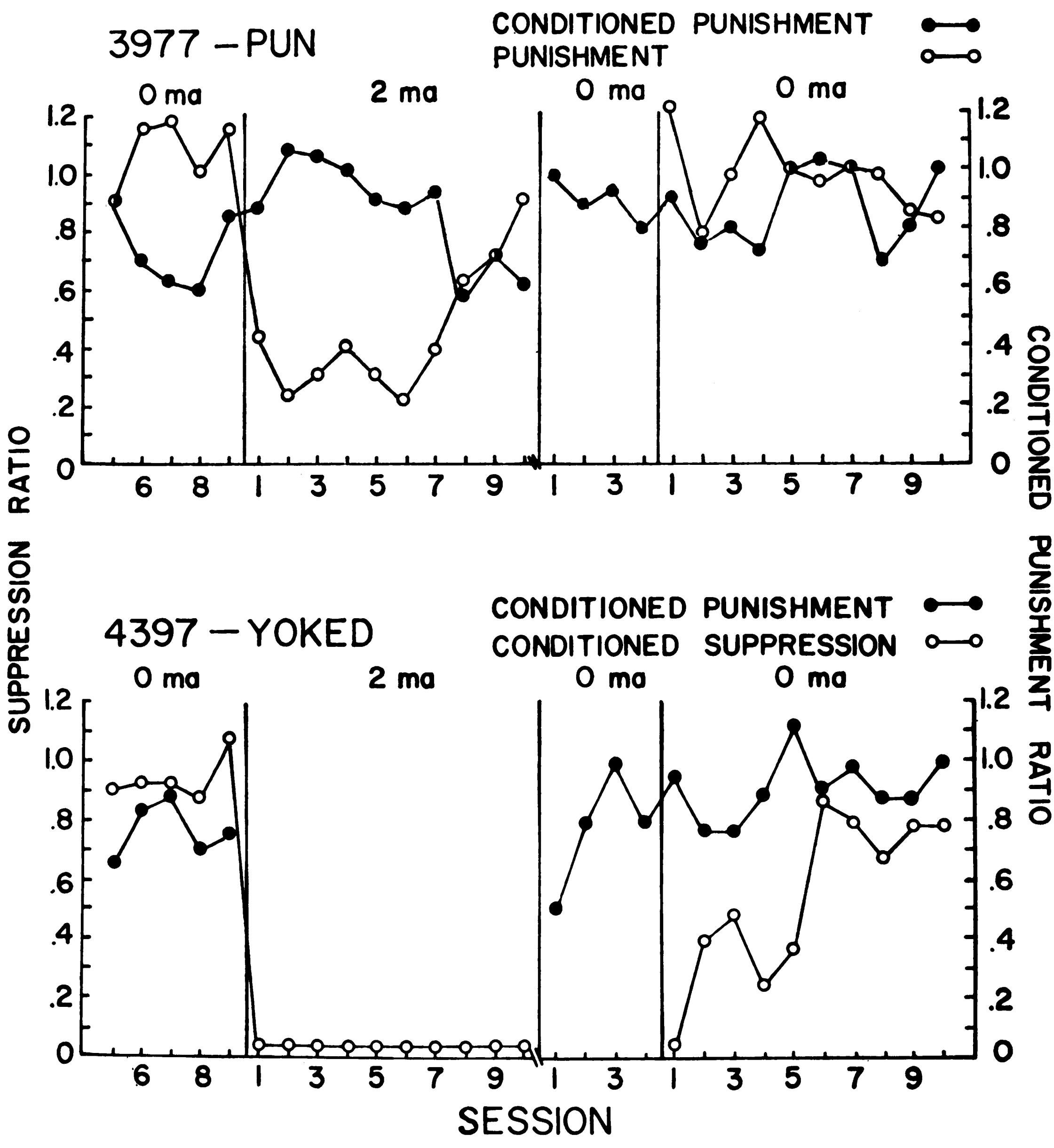

Fig. 9. Suppression ratios and conditioned punishment ratios for 3977-PUN and 4397-YOKED under four conditions: sessions before any shock sessions (Panel 1); 2-mA shock sessions (Panel 2); sessions in which shock was discontinued in an attempt to recover baseline response rates but conditioned punishment probes occurred. (Panel 3); sessions that were the same as in the previous condition but in which the pre-aversive stimulus was scheduled to occur (Panel 4). Open circles represent suppression ratios under the discriminative punishment schedule and under the conditioned suppression schedule. Conditioned punishment ratios are represented by closed circles.

curred during a CP probe and may have speeded recovery of responding during conditioned punishment.

Even though the conditioned punishing effects of the red light had already disappeared, the red light as an S^D completely suppressed behavior when it was reintroduced. This effect is shown in the records in Figure 10, labelled "REINTRODUCTION OF S^D AFTER CONDITIONED PUNISHMENT RECOVERY". Introduction of the S^D without shock not only suppressed behavior in its

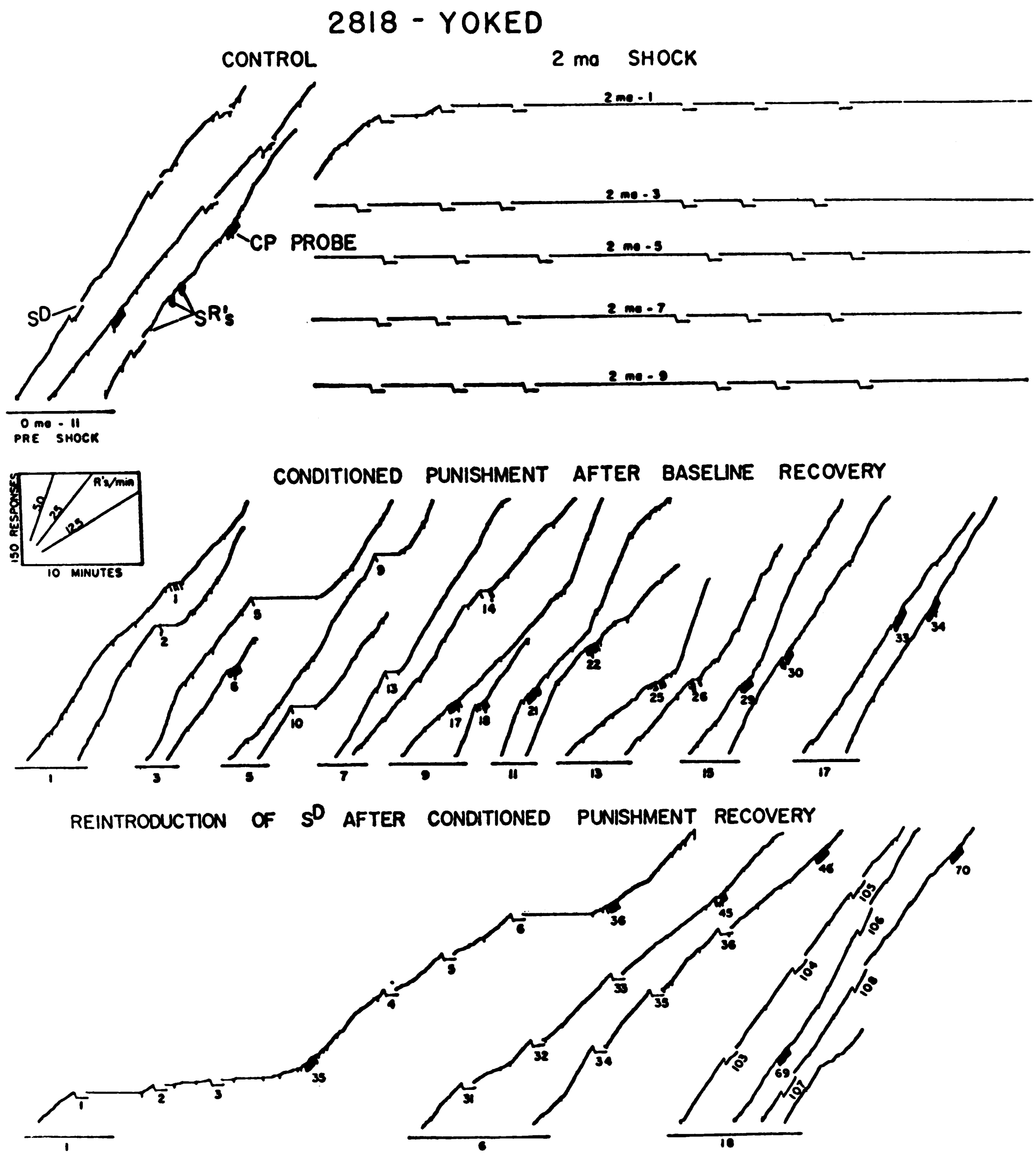

Fig. 10. Cumulative records for 2818-YOKED. The last session before shock session is labelled "control". Also shown is every other shock session, labelled "2-mA shock". Every other conditioned punishment session is shown during the attempt to recover the bird's baseline response rate, and is labelled "conditioned punishment after baseline recovery". The first, sixth, and eighteenth sessions after baseline rates had recovered are shown and are labelled, "reintroduction of S^D after conditioned punishment recovery".

presence but also disrupted baseline responding. Baseline responding recovered over successive sessions and by the sixth session there was no longer a pause when the S^D terminated, although responding by subjects in the presence of the S^D was almost completely suppressed.

In summary, this experiment demonstrated that increasing the punishment effect beyond that shown in Experiment 1 did not increase the conditioned punishing effect. Also, as in Experiment 1, non-contingent shock produced greater suppression than response-contingent shock.

EXPERIMENT 3

The difference in conditioned punishment effects between YOKED and PUN animals may have been due to the difference in the number of positive reinforcements received during the S^D. With the exception of 3950-YOKED at 1 mA, YOKED subjects did not receive any positive reinforcers during the S^D, simply because they never responded. Punishment subjects, however, never completely stopped responding during the S^D and therefore received occasional food reinforcers in its presence. Experiment 3 determined if subjects exposed to a discriminative punishment regimen showed conditioned punishment effects when no food reinforcers were available during the S^D.

METHOD

Subjects and Apparatus

The three PUN subjects from the previous experiments served as subjects and the apparatus was the same as in Experiments 1 and 2.

Procedure

When response rates under the previous experimental conditions recovered, Subjects 1582-PUN, 3977-PUN, and 2850-PUN were given 2-mA shocks contingent on responding in the presence of S^D with all experimental parameters the same as in Experiment 2, except that positive reinforcers were not scheduled during the S^D. Positive reinforcers were scheduled under a VI 2-min schedule during baseline and during the CP probes.

RESULTS

Punishment

The effects of withholding positive reinforcers during the discriminative punishment schedule are shown in Figure 11. The graphs on the left show the effects of punishment, measured by suppression ratios, under the condition in which positive reinforcers could occur in the presence of S^D. These data were taken from Experiment 2. Also shown are the effects under the condition in which positive reinforcers were not scheduled to occur in the presence of the S^D. For 2850-PUN, punishment without reinforcement produced about the same level of suppression as punishment with reinforcement. Punishment without reinforcement, however, produced slightly lower suppression ratios for 1582-PUN and substantially lower suppression ratios for 3977-PUN than did punishment with reinforcement.

Conditioned Punishment

The graphs on the right-hand side of Figure 11 show the conditioned punishment ratios obtained when reinforcers were available during the S^D (Experiment 2) and when reinforcers were not available during the S^D. There is little evidence of a difference in the conditioned punishment ratios.

DISCUSSION

The present study found that a stimulus paired with response-noncontingent shock became an aversive stimulus, *i.e.,* a stimulus that was an effective conditioned punisher. A stimulus paired with the same number and temporal patterning of response-contingent shocks, however, did not become an aversive stimulus. This difference offers support to the suggestion that response decrements observed in the presence of the stimulus were produced by different means for PUN and YOKED birds. One possibility is that for PUN subjects, the stimulus may have been primarily discriminative, that is, key pecking may have been reduced in its presence because other operant behavior that avoided the shock was negatively reinforced and strengthened. This other behavior might then have competed successfully with key-peck behavior. For YOKED birds, the stimulus may have been primarily aversive, and one property of an aversive stimulus is that it may act as an effective suppressor of a wide variety of operant behaviors maintained by positive reinforcement. The suppression of key pecking under the conditioned suppression schedule would thus have reflected this property of an aversive stimulus and would not have been due to competition between key pecking and some other operant behavior. If decrements in key-pecking behavior under a conditioned suppression procedure are due to competition with other operant behaviors, then one might expect to observe an increase in some operant behavior as the frequency of key-pecking behavior decreases. Hoffman and Barrett (1971), using pigeons, reported that under a conditioned suppression regimen there was marked sup-

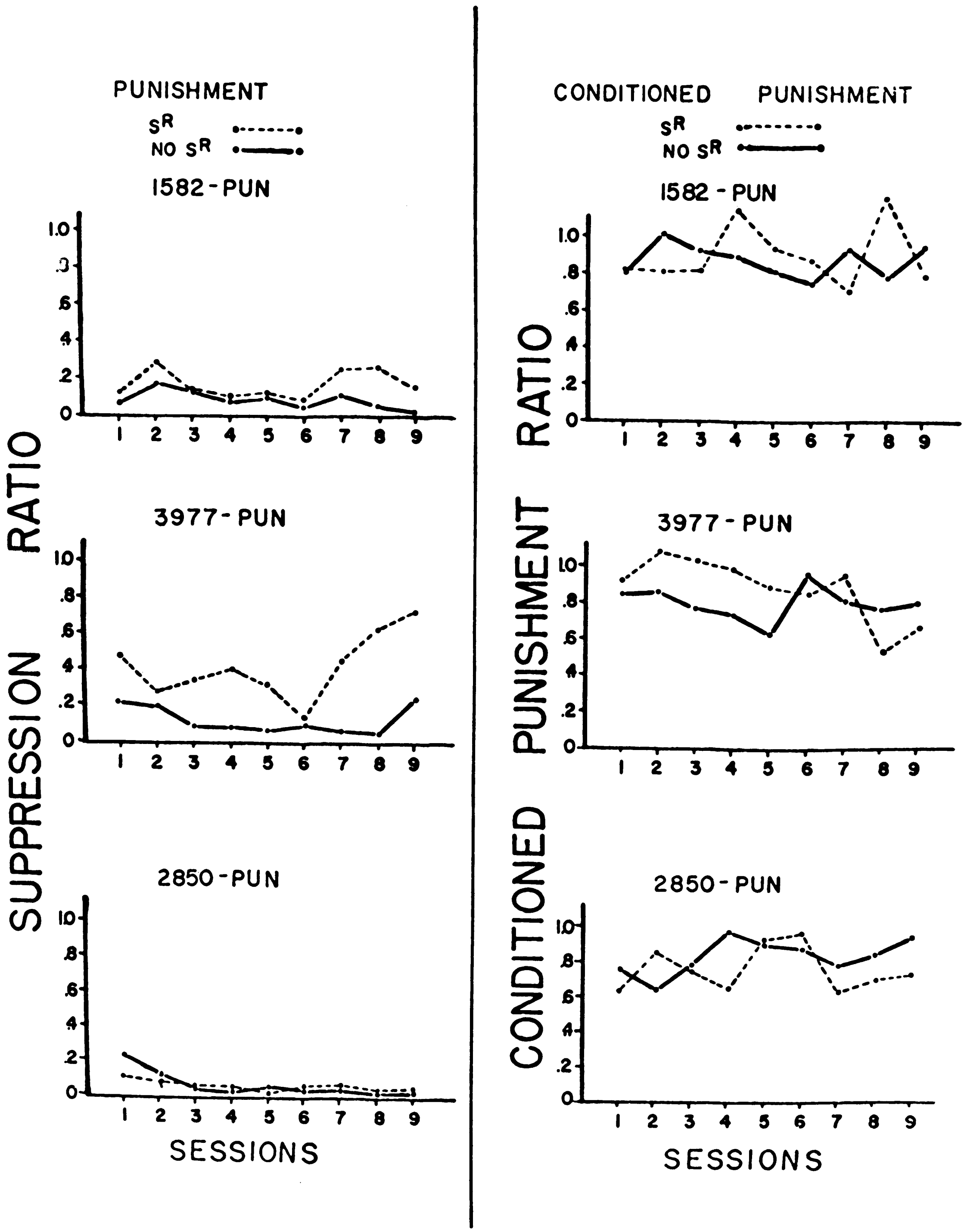

Fig. 11. Suppression ratios for three PUN birds during discriminative punishment are shown in the graphs on the left. Conditioned punishment ratios for the same birds are shown in the graphs on the right. The solid lines represent ratios obtained under conditions during which food reinforcers were unavailable in the presence of the S^D. The dotted line represents ratios obtained under conditions during which food reinforcers were permitted to occur in the presence of the S^D (data taken from Experiment 2).

pression of all recorded movements in the chamber. The exteroceptive stimulus acquired the capacity to suppress ongoing overt activity including, but not limited to, keypecking behavior.

The conditioned punishment effect for a stimulus paired with non-contingent shock is a replication of Hake and Azrin's (1965) finding that a stimulus for conditioned suppression can function as a conditioned punisher. As in Hake and Azrin's (1965) experiment, the conditioned punishing effect in the present experiment depended upon the shock intensity, was extinguished when shock was terminated, and was maintained as long as the stimulus was associated with shock. The conditioned punishment effects in the present experiments, however, were obtained at a much lower shock intensity than those used in Hake and Azrin's experiments (5 to 40 mA). This may have been due to the number of shocks associated with the stimulus per conditioned punishment exposure. In the present experiments, the stimulus occurred three times for every CP probe, and many shocks occurred during each stimulus (*e.g.*, 90 for Bird 3950). Thus, for a subject in the present experiment, as many as 270 shocks occurred during the stimulus for every 1 min of conditioned punishment. In Hake and Azrin's experiment, only one shock was associated with the stimulus for every 4 to 6 min of conditioned punishment. Thus, the conditioned punishment effect achieved at a low shock intensity for YOKED subjects in the present experiments may have been due to the high shock frequency.

Rachlin and Herrnstein (1969), relying primarily upon the data of Schuster and Rachlin (1968), concluded that the effects of aversive conditions are independent of the correlation between responding and the aversive stimulation but are dependent upon relative shock frequency. Application of that proposition to the present studies leads to the expectation that the exteroceptive stimuli would have acquired conditioned punishing properties under both conditioned suppression and discriminative punishment schedules, and that there would have been no difference between them because shock frequencies were equal. The present data do not support the Rachlin and Herrnstein position if it is offered as a general proposition. Their proposition describes adequately the data of the Schuster and Rachlin study, in which birds responded equally on two concurrently available keys, one of which led to a conditioned suppression regimen that was superimposed on a positive reinforcement schedule and the other of which led to a discriminative punishment condition that was superimposed on an identical positive reinforcement schedule. It may very well be that under conditions in which an animal is exposed to both conditions (response-contingent and response non-contingent shocks), as they were in the Schuster and Rachlin study, potential differences in conditioned aversiveness are overshadowed by other variables that are more powerful in that situation, *e.g.*, shock frequency.

Experiments 1 and 2 revealed, as did the data of Hoffman and Fleshler (1965), that non-contingent shock had a greater suppressive effect than punishment. Azrin (1956), Rachlin (1967), and Schuster and Rachlin (1968), on the other hand, found that punishment produced greater suppression than response non-contingent shocks, while Hunt and Brady (1955) found that both punishment and non-contingent shock produced complete suppression in the presence of a stimulus. Estes (1944) showed the two procedures to be equally effective in suppressing responding during extinction, while Boe and Church (1967), using the same procedure as Estes, showed punishment to be more effective than non-contingent shock. Whether punishment or non-contingent shock produces greater suppression during a stimulus apparently depends on a variety of procedural details. In Experiments 1 and 2, a non-contingent shock regimen not only produced greater suppression than did the punishment condition but recovery was slower when shock was discontinued, a replication of the findings of Hunt and Brady (1955) and Hoffman and Fleshler (1965). The disruption of baseline responding by non-contingent shocks found in Experiments 1 and 2 was also found in the Hunt and Brady and the Hoffman and Fleshler studies.

Most of the present results are consistent with the suggestion that the response-shock contingency considerably alters the effects of shock. The response-shock contingency during punishment may ensure that responses are paired with shocks with the result that the aversiveness of shock becomes classically conditioned to response-produced stimuli. This interpretation may be indirectly supported by the present experiments if one assumes that classical conditioning involving response-produced stimuli under the punishment schedule may have interfered with classical conditioning involving the exteroceptive stimulus. However, the precise stimulus control exerted by the S^D (suppression for PUN animals occurred only in the S^D) under the discriminative punishment schedule suggests that if response-produced stimuli do acquire aversive properties, they are aversive only in the presence of S^D, as Dinsmoor (1955) has indeed suggested.

A number of investigators have stressed the possible compound nature of the exteroceptive S^D and response-produced stimuli in their analyses of punishment (*e.g.*, Dinsmoor, 1954, 1955; Hoffman, 1969; Hunt and Brady, 1955). According to this analysis, the punishment situation is viewed as involving a stimulus compound that consists of an exteroceptive S^D and response-produced stimuli. The lack of conditioned aversiveness of the S^D might suggest that the presence of the response-produced stimulus element in the compound may in some way impede acquisition of aversiveness by the S^D element of the compound. In a punishment situation, one might expect conditioning to occur mainly to the response-produced stimuli, since they presumably are relatively brief and occur reliably before each shock, whereas the exteroceptive S^D is present for a much longer time and does not reliably predict the occurrence of each shock. If this account is correct, then it would appear that classical conditioning plays a major role in determining the behavioral effects of both punishment procedures and response non-contingent procedures. The differences between the effects of these procedures would be a difference in the nature of the conditioned stimuli in each: the conditioned stimuli are response-produced in the case of punishment and exteroceptive in the case of response non-contingent shock.

REFERENCES

Azrin, N. H. Effects of two intermittent schedules of immediate and non-immediate punishment. *Journal of Psychology,* 1956, **42,** 3-21.

Azrin, N. H. A technique for delivering shock to pigeons. *Journal of the Experimental Analysis of Behavior,* 1959, **2,** 161-163.

Boe, E. and Church, R. M. Permanent effects of punishment during extinction. *Journal of Comparative and Physiological Psychology,* 1967, **63,** 486-492.

Dinsmoor, J. A. Punishment: I. The avoidance hypothesis. *Psychological Review,* 1954, **61,** 34-46.

Dinsmoor, J. A. Punishment: II. An interpretation of empirical findings. *Psychological Review,* 1955, **62,** 96-105.

Estes, W. K. An experimental study of punishment. *Psychological Monographs.* 1944, **57** (3, Whole No. 263).

Fleshler, M. and Hoffman, H. S. A progression for generating variable-interval schedules. *Journal of the Experimental Analysis of Behavior,* 1962, **5,** 529-530.

Hake, D. F. and Azrin, N. H. Conditioned punishment. *Journal of the Experimental Analysis of Behavior,* 1965, **8,** 279-293.

Hoffman, H. S. Stimulus factors in conditioned suppression. In B. A. Campbell and R. M. Church (Eds.), *Punishment and aversive behavior.* New York: Appleton-Century-Crofts, 1969. Pp. 185-234.

Hoffman, H. S. and Barrett, J. Overt activity during conditioned suppression: a search for punishment artifacts. *Journal of the Experimental Analysis of Behavior,* 1971, **16,** 343-348.

Hoffman, H. S. and Fleshler, M. Stimulus aspects of aversive controls: the effects of response contingent shock. *Journal of the Experimental Analysis of Behavior,* 1965, **8,** 89-96.

Hunt, H. F. and Brady, J. V. Some effects of punishment and intercurrent "anxiety" on a simple operant. *Journal of Comparative and Physiological Psychology,* 1955, **48,** 305-310.

Rachlin, H. The effect of shock intensity on concurrent and single-key responding in concurrent chain schedules. *Journal of the Experimental Analysis of Behavior,* 1967, **10,** 95-108.

Rachlin, H. and Herrnstein, R. J. Hedonism revisited: on the negative law of effect. In B. A. Campbell and R. M. Church (Eds.), *Punishment and aversive behavior.* New York: Appleton-Century-Crofts, 1969. Pp. 83-109.

Schuster, R. and Rachlin, H. Indifference between punishment and free shock: evidence for the negative law of effect. *Journal of the Experimental Analysis of Behavior,* 1968, **11,** 777-788.

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