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Escape from Conditioned Suppression in the Pigeon

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ESCAPE FROM CONDITIONED SUPPRESSION IN THE PIGEON

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The behavioral phenomenon of conditioned suppression, first studied by Estes and Skinner (1941), is typically defined as a decline in response rate during a stimulus which terminates with a brief, unavoidable shock. The stimulus-shock pairing is usually superimposed on some type of positive reinforcement baseline, and is not contingent upon any response emitted by the organism. The response decrement during the stimulus is expressed as a ratio of some combination of the responses during the stimulus (CS) interval and the responses during an equal interval just prior to CS onset.

Previous investigators have mainly concentrated on determining those variables which influence the degree of suppression produced by the conditioned suppression paradigm. The effects of such variables as type of positive reinforcement used, deprivation schedule, and baseline response rate have been summarized in a review by Lyon (1968). The variables of CS duration and CS intensity have been summarized by Kamin (1965). The present study is aimed at the development of a modification of the conditioned suppression paradigm through the inclusion of a second operant response which allows the organism to escape from the conditioned suppression procedure; emission of the escape response results in termination of the CS and avoidance of the shock. This paradigm is similar to the discriminated avoidance paradigm in that in both paradigms a response leads to termination of the CS and avoidance of the shock (UCS). Thus the "escape from conditioned suppression" paradigm may be viewed as a discriminated avoidance paradigm superimposed on an operant baseline

maintained by positive reinforcement. One might also define the paradigm as a concurrent schedule of discriminated avoidance and positive reinforcement. However, in the implementation of the schedule in the present study, the CS duration was normally 60 seconds, with a mean inter-stimulus interval of 7.6 minutes. These values are more typical of conditioned suppression paradigms than of discriminated avoidance paradigms; accordingly, the label "escape from conditioned suppression" appears to be more accurate in describing the present paradigm than any other term, even though the actual behavior generated by such a schedule may be better classified as avoidance behavior.

The avoidance properties of the escape from conditioned suppression paradigm are of further interest since pigeons were used as the experimental subjects in the present study. Although avoidance behavior in the pigeon has been demonstrated using such responses as head raising (Hoffman and Fleshler, 1959) and flight (Bedford, 1968), no consistent data have been produced using the key peck as the avoidance response. The present paradigm thus offers another approach to the conditioning of avoidance behavior in the pigeon using the key peck as the avoidance response. The fruitfulness of the escape from conditioned suppression paradigm in developing "pure" avoidance behavior in the pigeon cannot be ascertained at this time, however, due to the major differences existing between this paradigm and the traditional discriminated avoidance paradigm. One of these differences is that in the present paradigm the subject's responding is being maintained on a food reinforcement baseline in both the presence and the absence of the CS-shock pairing. Maintaining the subject's

responding solely through the use of aversive stimuli presents a different set of problems.

The fact that pigeons can be conditioned to escape from aversive stimuli has already been well-documented. Azrin and Holz (1966) have demonstrated escape from punishment using pigeons as subjects. The present procedure is similar to the escape from punishment procedure used by Azrin and Holz in that the subject responds to escape aversive stimuli, and at the same time to produce reinforcing stimuli, in the form of re-exposure to the baseline schedule of reinforcement which is then free from a pairing with aversive stimuli. The major difference between the escape from punishment and the present procedure is that in the present procedure the subject's response terminates a highly discrete conditioned aversive stimulus, the CS, and thus avoids exposure to the UCS, the shock. In the escape from punishment procedure, the subject's response resulted in the escape from an aversive schedule in which all responses were punished. In such a schedule there are two possible ways of eliminating the aversive stimuli resulting from the schedule. First, the animal can emit the escape response, and second, the animal can simply not respond, and thus avoid the punishment contingency completely. In the present procedure there exists only one means of escaping the aversive stimuli, and that is through emission of the escape response.

METHOD

Subjects

Six white barren hen King pigeons were maintained at 70% of their free-feeding weight with a grain mixture of 50% Kaffir corn, 40% vetch, and 10% hempseed. This mixture was also used as the reinforcement in the experimental chamber. Grit and water were always available to the subjects in their home cages, but not in the experimental chamber. The subjects had been previously used in an experiment involving a color discrimination on variable-interval one-minute (VI 1-min) schedule of reinforcement.

Apparatus

The experimental chamber was constructed of aluminum, and measured 17 x 17 x 11.5 inches. One side of the chamber contained a plexiglas window for observational purposes. Two Gerbrands pigeon keys, with a .75 inch diameter, were located on the front wall of the chamber, 9.5 inches above the floor and 4.5 inches from either end of the wall. Each key was illuminated by a 12 volt bulb, with translucent white discs inserted between the bulbs and the keys to provide uniform illumination of the keys. A black cross was placed on the left key to facilitate a discrimination between the two keys by the subjects. The force required to operate the keys was 10-12 grams. Reinforcements were delivered by means of a Lehigh Valley pigeon feeder located behind the front wall, with a 2 x 2.5 inch opening located in the center of the wall, 2 inches above the floor. The CS was a Sonalert (P.R. Mallory and Co.) mounted outside of the chamber, which provided a 2800Hz tone

at 84 db (SPL). The houselight was a six-watt, 110-volt bulb mounted in the ceiling of the chamber.

The entire experimental chamber was shock mounted in a sound attenuating chamber, which contained an observation window and a blower for both air circulation and background noise. Shock was delivered to the subjects through permanent electrodes implanted in the base of the breastbone of each subject (Bedford, 1968), similar to the procedure of Azrin (1959). The electrode wires ran up through a phone jack in the ceiling of the chamber to the shock source. An A.C. shock was delivered through a variable transformer to the subjects, with a 4700-ohm resistor in series with the subjects. Shock intensity was constantly monitored with an A.C. voltmeter. Appropriate solid state circuitry was used for programming the various contingencies. The data were recorded from impulse counters and a Gerbrands cumulative recorder.

Initial Training

The subjects were initially placed on a VI 2-minute schedule of reinforcement. The VI 2-minute schedule was constructed so as to generate a constant probability of reinforcement at any given time. The probability of reinforcement ranged from 0.024 to 0.032. A reinforcement storage system was also used in programming the schedule to avoid changes in probability over time due to variations in response rate. Reinforcement consisted of a 3.5 second exposure to the grain mixture in the hopper. During reinforcement delivery a light illuminated the hopper, and the reinforcement key light and houselight remained on. The daily sessions were approximately 100 minutes in

length. Prior to starting each session, the experimental chamber remained dark for approximately one minute. The chamber was again darkened at the end of each session, which terminated automatically after 50 reinforcements had been delivered. During this training the right key was used as the food reinforcement key, and the left key, designated as the escape key, was never illuminated. In the latter part of the VI 2-minute training, the escape key was illuminated to measure the operant level of responding for each subject on that key. A change-over delay procedure required that at least 10 seconds elapse after each escape response before any reinforcement could be collected on the reinforcement key. This delay was in effect for the remainder of the experiment.

Escape from Time-out

When responding had stabilized on the VI 2-minute schedule, an escape from time-out procedure was instituted to establish the behavior of responding on the escape key prior to instituting the actual escape from conditioned suppression paradigm. Time-out periods were presented on a VI 7.6-minute schedule (constant probability, p=.017) to subjects T-101, T-107, T-301, and T-307. The minimum interval between time-out presentations was 5 minutes and the maximum interval was 12 minutes. The time-out periods consisted of reinforcement key light off, feeder disconnected, and CS on. Each time-out period remained in effect until a subject pecked the escape key, which resulted in termination of the time-out period. Throughout these sessions the escape key was always illuminated. A minimal amount of hand shaping was required to produce this behavior.

Escape from Conditioned Suppression

After escape responding from the time-out period had been well-established in the four subjects, all six subjects were placed on the escape from conditioned suppression paradigm. For all subjects the inital CS length was 14 seconds, and the inital shock duration was 35 milliseconds. CS onset was determined by the same VI 7.6-minute schedule used in the time-out procedure. Both key lights remained on throughout these sessions. The CS terminated simultaneously with shock onset. For subjects T-101, T-107, A-407, and A-507 the shock voltage was slowly increased in two-volt steps after every two CS presentations. For subjects T-301 and T-307 the voltage was increased in two-volt steps after every CS presentation. Suppression ratios were calculated for each session by dividing the total number of responses during the CS intervals by the total number of responses during equal intervals just prior to CS onset. When a suppression ratio value for a particular session dropped below .50, the shock voltage was not increased further for that particular subject. Complete suppression of responding was not desired, and when a subject's suppression ratio dropped below .10, the voltage was reduced accordingly. Subjects T-107 and T-307 showed no suppression at this time, using shock voltages of 112 volts and 100 volts, respectively. For these two subjects the shock duration was increased to 75 milliseconds, and the shock voltage was again lowered and raised until the suppression ratio criterion was reached. The values for CS length and the number of sessions run under the different values for each subject are given in Table 1 for this part of the procedure.

Reinforcement Key Light Off

When none of the subjects showed any signs of emitting the escape response after partial suppression was induced, the procedure was modified such that, for Subjects T-101, T-107, T-301, and T-307, who had previously received the time-out procedure, the reinforcement key light was turned off during the CS presentations. The purpose of this change was to establish responding on the escape key during CS presentations for these subjects. At the same time the CS duration was increased to 60 seconds for all subjects to allow a greater amount of time for the escape response to occur, as well as to decrease the probability of a subject receiving shock as he approached the escape key. Modifications in shock intensity and duration were also made for each subject to maintain the suppression ratios below .50. The various changes are outlined in Table 2.

When responding on the above procedure had been stabilized, each subject was switched to a different training procedure, in an attempt to bring the escape responding under the control of the CS-shock pairing only, not under the control of the offset of the reinforcement key light.

Alternation and Fading-in Procedures

Subject T-101 received alternating CS trials in which the reinforcement key light was off on the odd-numbered trials (escape from CS plus time-out trials), and remained on during the even-numbered trials (escape from CS trials). Subject T-107 received the same alternation procedure, only with a train of seven shocks paired with CS termination. The shocks were 35 milliseconds in duration and time between

Table 1

CS length and Number of Sessions for each Subject under the initial Escape from Conditioned Suppression Procedure.

Subject	CS Length	Number of Sessions
T-101	14	13
T-107	14	15
	60	3
T-301	14	6
T-307	14	11
	60	3
T-407	14	9
T-507	14	7

Table 2

Procedural Changes for each Subject following the Reinforcement Key Light Off Procedure. Included are the Fading-In (Fade S^r), Alternating (Alt S^r), Automatic Shaping (Auto), and Key Reversal (Rev) Procedures, along with CS Length, Shock Train (S.T.) Length, and Number of Sessions (No. of Sess.) under each Condition.

Subject	CS Length (sec)	S.T. Length	Alt S^r	Fade S^r	Rev	Auto	No. of Sess.
T-101	14	1	-	-	-	-	4
	60	1	-	-	-	-	5
	60	1	+	-	-	-	21
T-107	60	1	-	-	-	-	2
	60	7	+	-	-	-	5
	30	1	+	-	-	-	1
	60	1	+	-	-	-	2
	60	1	-	-	+	-	8
T-301	60	1	-	-	-	-	3
	30	1	-	+	-	-	5
	60	1	-	+	-	-	4
	60	1	+	-	-	-	12
T-307	60	1	-	-	-	-	2
	60	7	-	+	-	-	3
	60	7	-	-	-	-	3
	60	1	+	-	-	-	9
A-407	14	1	-	-	-	+	1
	60	1	-	-	-	+	7
	60	7	-	-	-	+	1
	60	1	-	-	+	-	6
A-507	60	1	-	-	-	+	9
	60	7	-	-	-	+	1

consecutive shock onsets was one second. The shock train terminated with either an escape response or CS termination. Subject T-301 received a "fading-in" procedure in which the voltage of the reinforcement key light was slowly increased over a number of sessions. Subject T-307 received the fading-in procedure with a shock train paired with CS termination. The shock train of this subject was identical with that of T-107. These changes in procedures are indicated for each subject in Table 2.

Auto Shaping

The two remaining subjects, A-407 and A-507, who had never received the previous time-out training, were placed on an automatic shaping procedure in which the reinforcement key light was terminated with CS onset, and the escape key was illuminated only during CS presentations. During these sessions the houselight was off. On their final sessions under this procedure, these subjects received a shock train paired with CS termination, which possessed the same characteristics as those of the train mentioned previously.

At this point in the experiment, only Subject T-101 showed any conditioning of the escape response. The other three subjects who had undergone the time-out training were then switched to the procedure of T-101, which was the alternating procedure with no shock train. For Subject T-107 the CS duration was also manipulated. Table 2 outlines these changes.

After Subject T-101 began to escape the CS during escape from CS trials, the number of escape from CS plus time-out trials was gradually reduced until only the first trial was given with the

reinforcement key light off. A criterion of five consecutive sessions of at least 80% escape responding to escape from CS trials was established, after which the subject was placed on extinction of the escape response through elimination of the shock. The extinction criterion was no escape responding during escape trials for three consecutive sessions. During extinction all CS trials, except the initial trial, were given as escape from CS trials. Following extinction the CS-shock contingency was reinstated. Again, all trials except the initial trial of each session were escape from CS trials.

Final attempts at conditioning the escape response in two of the subjects consisted of a key reversal; the functions of the escape key and the reinforcement key were reversed. This procedure was used on Subjects T-307, who had experienced the time-out training, and A-407, who had not. To initiate responding on the escape key for reinforcements, the initial sessions were run with the previous reinforcement key light out for both subjects. The reinforcement key light was turned on in the middle of the first session for Subject A-407, and in the middle of the second session for Subject T-307. CS trials were still presented, with the reinforcement key light coming on with the CS for those trials which occurred prior to the continual illumination of the reinforcement key.

RESULTS

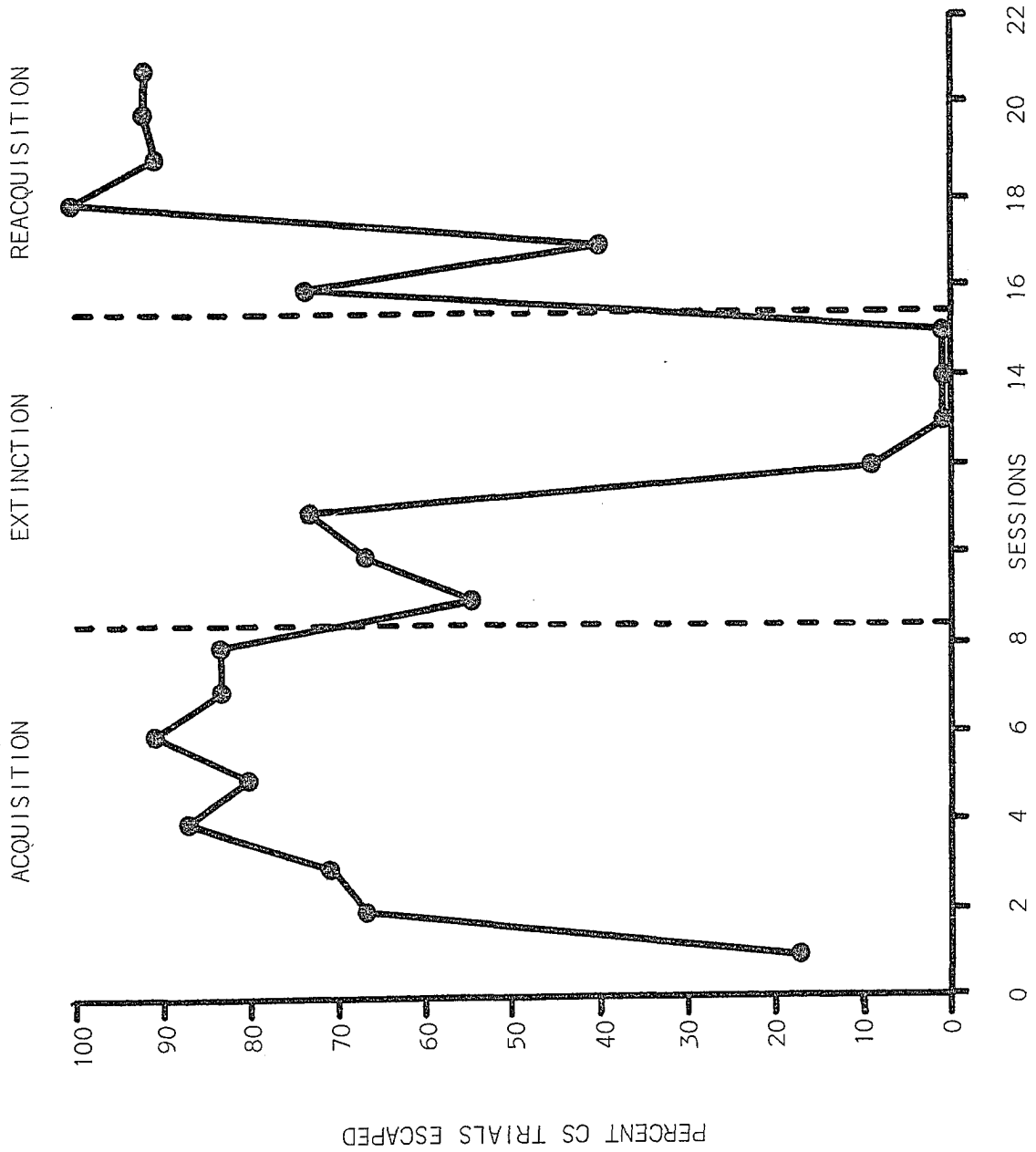
Of the six subjects exposed to the various training procedures, only Subject T-101 successfully acquired the escape from conditioned

suppression response. This subject began emitting the escape response during the first session of the alternating procedure, in which the odd-numbered CS presentations were escape from CS plus time-out trials, and the even-numbered CS presentations were escape from CS trials. After the fourth session of this procedure, the subject was above the established criterion of escape responses to 80% of the escape from CS trials. By the last three sessions of acquisition, the subject was receiving all CS trials, except for the initial one, with the reinforcement key light remaining on (escape from CS trials).

The percent CS presentations escaped by the subject per session are shown in Figure 1. These percentages are based only on the escape from CS trials, and not on escape from CS plus time-out trials. Also shown in Figure 1 are the percent CS presentations escaped by the subject during extinction, in which the shock source was disconnected, and subsequent re-acquisition, in which shock was again delivered upon CS termination when no escape responding occurred. During extinction and re-acquisition all CS trials, except the initial one, were escape from CS trials.

Figure 1 shows that during the first session of the alternation procedure, the subject escaped during 17% of the escape from CS trials. The following sessions show a marked increase in escape responding to the CS, with the last five sessions being above the criterion of escape responding to 80% of the CS trials. Institution of extinction of the escape response through elimination of the shock resulted in an initial decrease of escape responding of approximately 15% for the first three sessions. During the fourth session of extinction the percent escaped

Fig. 1. Percent CS presentations escaped by Subject T-101 per session during acquisiton, extinction, and re-acquisition of the escape response. Percentages are based only on escape from CS trials, and not on escape from CS plus time-out trials.



CS trials dropped sharply, with complete extinction occurring during the last three sessions. The first session of re-acquisition showed an abrupt increase in escape responding to 73% of the CS trials with a decrease to 40% occurring during the second session. The remaining sessions showed an increase in escape responding which peaked at 100% during the third re-acquisition session, and remained above 90% for the remaining three sessions.

The suppression ratios for Subject T-101 during the earlier escape from conditioned suppression training in which suppression was initially established are shown in Figure 2. The suppression ratios during acquisition, extinction, and re-acquisition of the escape response for each session are presented in Figure 3. The suppression ratio was calculated by dividing the mean response rate on the reinforcement key during CS trials in which the key light was on by the mean response rate during one-minute intervals preceding both escape from CS trials with key light on, and escape from CS plus time-out trials, key light off. These response rates were used since the length of the CS period varied, depending upon the latency of the escape response. The suppression ratio varies from zero, indicating complete suppression, to 1.0 indicating no suppression. Suppression during the initial acquisition of the escape response was generally comparable to that of the last three sessions of suppression conditioning in both Figures 2 and 3. During extinction of the escape response, the suppression ratios showed a gradual increase over the first three sessions, a slight decrease during the fourth session, and a sharp increase during the last three sessions. In the first two sessions of

Fig. 2. Suppression ratios per session of Subject T-101 for initial acquisition of conditioned suppression.

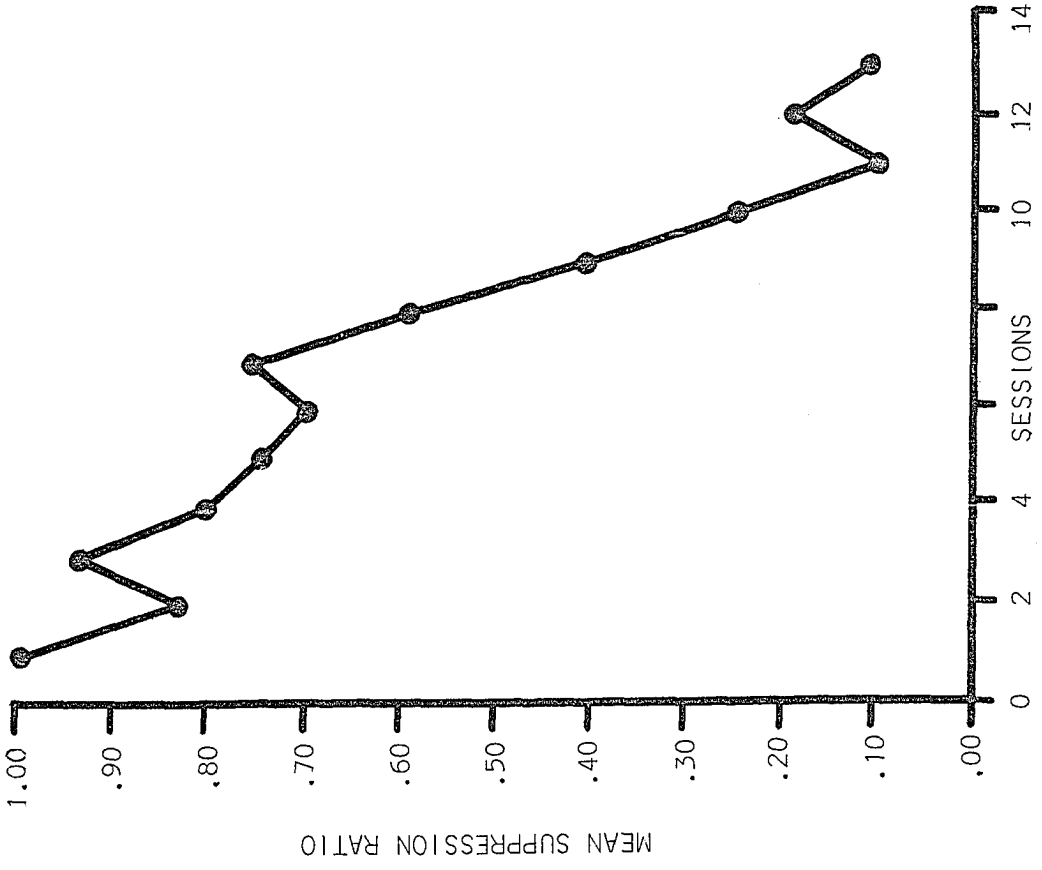
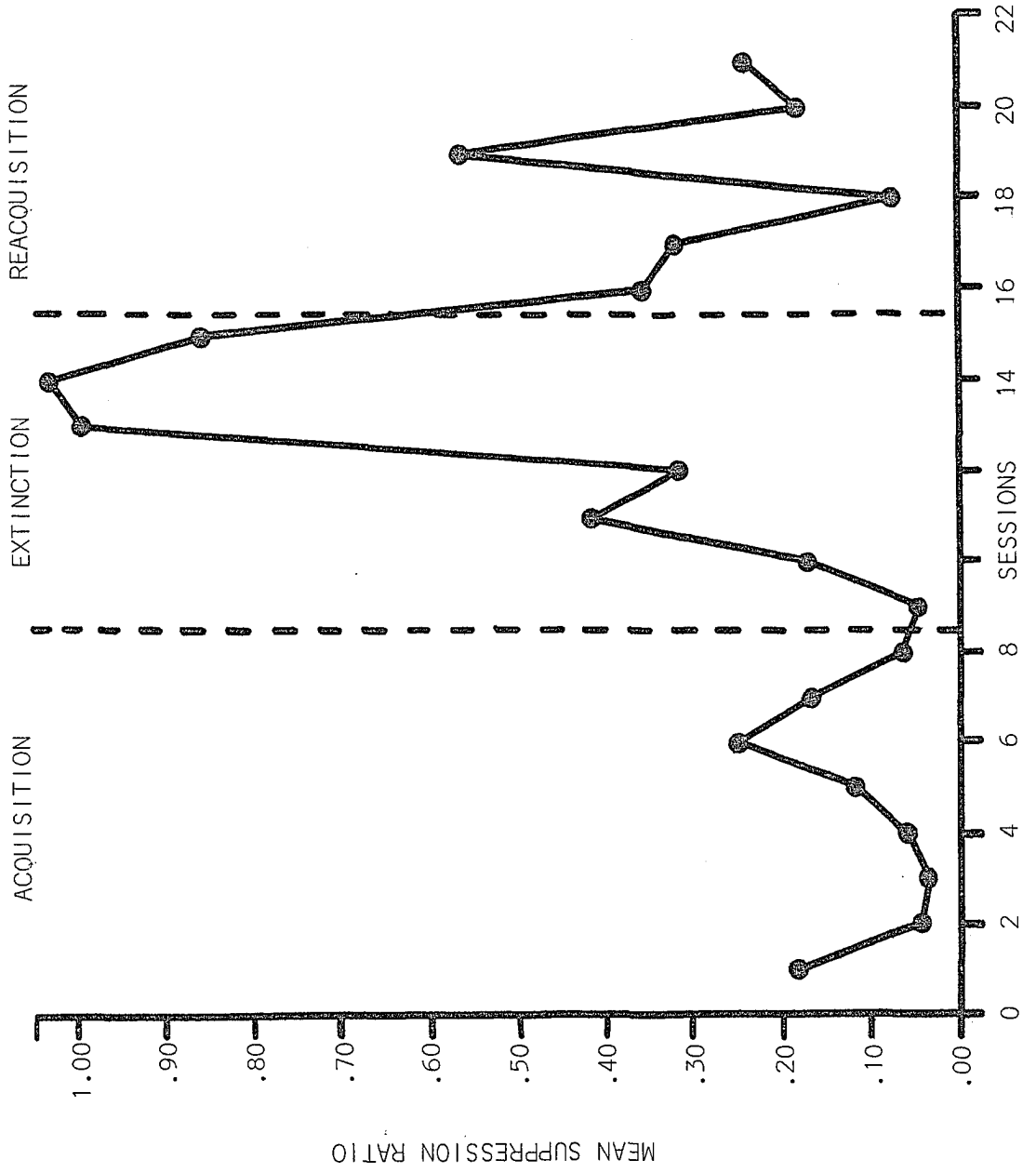


Fig. 3. Suppression ratios per session of Subject T-101 during acquisition, extinction, and re-acquisition of the escape response. Ratios are based only on escape from CS trials, and not on escape from CS plus time-out trials.



re-acquisition, the suppression ratios dropped sharply to .36 and .32, respectively. The following two sessions displayed a certain amount of variability in the suppression ratios with the last two sessions tending to stabilize around .21.

None of the five remaining subjects acquired the escape response. During the eighth session after instituting the escape from conditioned suppression paradigm, Subject T-307 emitted one escape response, but failed to emit another escape response for the duration of the experiment.

Subject T-301, who was on the "fading-in" procedure where the intensity of the reinforcement key light was gradually increased during CS trials where the reinforcement key light was initially dark, also failed to acquire the escape response. This subject responded on the escape key during CS trials until the intensity of the reinforcement key light exceeded nine volts, whereupon the subject stopped emitting the escape response. The full intensity of the reinforcement key light was reached at 11 volts.

The two subjects placed on the key reversal procedure, T-307 and A-407, responded on the escape key during CS presentations for the initial sessions of this procedure. Once the key peck on the original reinforcement key had extinguished, however, the subjects stopped responding on that key, which was then the escape key to CS presentations.

The subjects on the alternating procedure with shock train, the "fading-in" procedure with the shock train, and the automatic shaping procedure failed to emit any escape responses during escape from CS trials.

DISCUSSION

In general, the conditioning of the escape response in one of the subjects lends support to the notion that it is possible to generate avoidance behavior in the pigeon, using the key peck as the avoidance response. The avoidance behavior generated in the present study is, however, of a limited nature. First, the general tendency to emit the key peck response in the experimental situation was under the control of the food reinforcement baseline. Secondly, the initial pecking behavior on the escape key was reinforced through termination of time-out periods, not through escape from conditioned suppression. Thirdly, the use of time-out termination to reinforce the escape response was never completely eliminated. However, the acquisition, extinction, and re-acquisition data of Subject T-101 clearly indicate that maintenance of the escape response was due to the presence of the shock; thus avoidance-type behavior was conditioned in this subject. However, the failure to generate any such behavior in the five remaining subjects suggests that those contingencies necessary to the production and maintenance of the avoidance response were not explicitly under experimental control.

One of the major variables not under explicit experimental control in the training procedure was that of food reinforcement availability. The use of a storage system in programming the constant probability VI 2-minute schedule of food reinforcement was deemed necessary if the probability of reinforcement was to be held constant throughout a session. It follows, however, that long periods of

non-responding may be followed by single or multiple reinforcements due to the use of this storage system. During the escape from time-out training, it was found that the latency of responding on the escape key was highly variable, and that for three of the four subjects, the latencies displayed a general tendency to increase over sessions. Observations indicated that frequently the subjects were obtaining one or more reinforcements following termination of the change-over delay of ten seconds after an escape response. In addition, one subject displayed a sharp decrease in median latency of escape responding following a session of accidental food extinction. These data indicate that frequent adventitious reinforcements of delayed escape responding may have occurred at this time, giving rise to the increasing latency of escape responding.

The same conditions of possible adventitious reinforcement also existed during the institution of the escape from conditioned suppression paradigm. Observations indicated that after partial suppression had been established, subjects frequently received one or more reinforcements following CS termination and shock delivery. Furthermore, these reinforcements were delivered immediately following the first response on the reinforcement key after CS termination, since the change-over delay was only contingent upon the escape response. Finally, it should also be noted that after those CS trials where food reinforcements were not immediately available, the probability of reinforcement was greatly increased due to the lowered rate of responding during the CS period. Thus, although the probability of reinforcement over the entire session remained constant,

when partial suppression occurred, the probability of reinforcement immediately after CS trials, could increase, depending upon the amount and pattern of suppression responding. This suggests that the CS could have become a signal for both shock and food reinforcement availability since the subjects received not only shock paired with CS termination, but also frequent food reinforcements contingent upon the first one or two responses after CS termination.

Azrin and Hake (1968) have recently demonstrated conditioned suppression using positive reinforcers as the UCS. The adventitious reinforcement in the present study created a situation similar to the one of Azrin and Hake in that food reinforcement was frequently paired with CS termination, although in the present procedure these reinforcements were still response contingent, and shock was still being given upon CS termination. Thus the possibility presents itself that in the present study, the suppression generated may have been due to both the shock presentations and the frequent food reinforcements received after CS termination. Whether or not such an interpretation is correct, the conditioning of escape responding under the conditions of adventitious food reinforcement following CS termination would be hindered through a pairing of positive reinforcement with the existing aversive situation, with the result being a decrease in the aversiveness of the CS.

Another variable not under explicit experimental control was the escape response topography. Observations of Subject T-101 prior to and after acquisition of the escape response indicated that this subject frequently made pecking movements towards the escape key during

CS presentations without actually activating the escape key. Such responses were frequently followed by shock, with a variable amount of time between these movements and shock onset. Other subjects were observed to be in the immediate vicinity of the escape key when receiving shocks, with occasional incomplete responses to the escape key occurring at this time. Thus the CS trials frequently ended in immediate or delayed punishment of any "weak" escape-responses occurring during those trials. It was for this reason that the initial CS length of 14 seconds was changed to 60 seconds. In addition, the key reversal procedure was utilized in an attempt to insure that the response to the escape key was of sufficient strength to get around the problem of these weak escape responses. Due to the large number of sessions these subjects had on previous training procedures, it is difficult to ascertain whether or not the failure to generate escape responding under this reversal provides any control for the variable of response topography.

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