

THE EFFECT OF SHOCK INTENSITY AND NUMBER OF DAILY TRIALS ON
ON THE ACQUISITION AND EXTINCTION OF THE CONDITIONED
EMOTIONAL RESPONSE

A Thesis
Presented to
The Faculty of Graduate Studies and Research
University of Manitoba

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
Walter W. Mostoway
September, 1968



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TITLE OF THESIS... *THE EFFECT OF SHOCK INTENSITY*
AND A DAILY TRIALS ON ACQUISITION
NUMBER OF
AND EXTINCTION OF THE CONDITIONED EMOTIONAL
RESPONSE
UNIVERSITY... *U. OF MANITOBA*
DEGREE... *M.A.* YEAR GRANTED... *1968*

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FACULTY OF GRADUATE STUDIES AND RESEARCH

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THIS IS TO CERTIFY THAT the members of the examining committee
of the Master's (X) Ph.D. () thesis of:

WALTER MOSTOWAY

Major Subject: Experimental Animal Learning (Psychology)

Thesis Title: THE EFFECT OF SHOCK INTENSITY AND NUMBER OF

DAILY TRIALS ON ACQUISITION AND EXTINCTION OF THE CONDITIONED

EMOTIONAL RESPONSE.

have read the thesis and are unanimously agreed that it should be
graded

Approved

(approved or rejected)

Date: September 27th, 1968

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ACKNOWLEDGEMENTS

This research was supported by Grant No. APA-223 from the National Research Council to Dr. J. P. James.

I would like to express my gratitude to Dr. J. P. James, my advisor, for his encouragement, criticisms, suggestions, and assistance throughout this work. Sincere thanks are also due to the other two members of my committee, Dr. J. J. Pear for his ready assistance, criticisms, and suggestions, and to Dr. K. R. Hughes for his critical evaluation, comments, and suggestions.

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ABSTRACT

In previous studies (e.g., Leaf & Muller, 1965) utilizing the consummatory (licking) response as a baseline on which the strength of conditioned suppression is tested, the acquisition of conditioned suppression occurred in the absence of the referent baseline responding. It was not readily accessible to a trial by trial examination of the magnitude of conditioned suppression. In the present study, pairings of the conditioned stimulus with the unconditioned stimulus (CS-US pairings) were superimposed on the consummatory response baseline in a procedure which permitted a trial by trial examination of acquisition and extinction.

The experimental paradigm during acquisition of conditioned suppression consisted of two, 4 x 10 Mixed Designs. Within each design, four groups differed only in respect to shock intensity level (.10, .50, 1.0, or 2.0 milliamperes). The first design employed a one-trial per day conditioning procedure, while the second design employed a two-trial per day conditioning procedure.

The results indicated that acquisition and resistance to extinction were found to be positive monotonic functions of acquisition shock intensity. The group receiving one trial per day did not differ during acquisition, but showed less resistance to extinction than the group receiving two trials per day. A detailed comparison of the findings of the Annau and Kamin (1961) parametric study of shock intensity and conditioned suppression of operant responding with those

of the present study indicated that the conditioning phenomena were parallel.

The present procedure provides a sensitive trial by trial measure of the variables influencing the strength of conditioned suppression. This method yields behavioral data with a sensitivity comparable to that of a more prolonged procedure which utilizes operant responding as the behavioral baseline.

CHAPTER I

INTRODUCTION

I. CER Procedure

The suppression of ongoing operant responding by superimposing a neutral stimulus which terminates with a response-noncontingent aversive stimulus was first experimentally illustrated by Estes and Skinner (1941). This paradigm, later designated as the conditioned emotional response (CER), was systematically investigated by Kamin and his associates (Annau & Kamin, 1961; Brimer & Kamin, 1963; Kamin, 1961, 1963, 1965; Kamin & Brimer, 1963; Kamin, Brimer, & Black, 1963; Kamin & Schaub, 1965). In the intervening years (1944-1960) investigators were concerned primarily with differentiating CER produced suppression (response noncontingent shock) from other forms of aversive conditioning, namely, punishment-produced suppression (response contingent shock), conditioned avoidance behavior, and escape behavior. The conditioned emotional disturbance, "anxiety" (Estes & Skinner, 1941), indicated by immobility and defecation, was less marked in a punishment procedure than in a CER procedure (e.g., Hunt & Brady, 1955). Although Estes (1944) attributed the suppression produced by both the CER and punishment procedures to "anxiety", he suggested that in the case of punishment, an additional influence may result from the conditioning of withdrawal responses to stimuli arising from movements of punished bar press response (reported by Hunt & Brady, 1955). This latter position was the foundation for the interpretations of punishment-produced

suppression by Schoenfeld (1950), Dinsmoor (1954), and Hunt and Brady (1955). In the Hunt and Brady (1955) study, greater generalization of suppression, greater resistance to extinction, and a greater emotional disturbance was produced by the CER procedure than by the punishment procedures. In addition, the punishment and avoidance procedures differ from the CER procedure mediated by classical conditioning of fear, because avoidance responses are negatively reinforced and are thereby instrumentally conditioned. This has been postulated in a number of interpretations which assume two conditioning processes (e.g., Schoenfeld, 1950; Dinsmoor, 1954; Hunt & Brady, 1955).

In the Estes-Skinner study the subjects were 24 male albino rats, less than six months of age. Following two weeks of daily one-hour sessions of bar-press training reinforced on a periodic four-minute schedule (FI 4 minutes), two daily pairings of conditioned stimulus (CS) with unconditioned stimulus (US) were superimposed on the referent bar-press behavior. A three-minute tone (CS) coterminated with a brief shock. After the sixth session, tone duration was increased to five minutes, and one CS-US pairing was presented each session. The CS-US presentations were independent of the ongoing operant behavior. Another phase of their study investigated CER extinction. A prolonged tone (from time of initiation to the end of the session), without the terminating shock, was presented. The time required to recover to the previous response-rate was the indicant of resistance to extinction of conditioned suppression.

The CER procedure generally employed by Kamin and his associates involves three phases: preliminary training, CER training, and CER

extinction. Preliminary training consists of bar-press training and pre-test exposure of the potential CS. Initially, bar-press training is continued for five, two-hour sessions and maintained on a variable interval food reinforcement schedule (VI 2.5 minutes). On the last day of bar training, the CS is presented alone for four, three-minute periods. CER acquisition consists of four CS-US pairings during each session. The three-minute CS coterminates with a brief shock. The CER extinction procedure is similar to acquisition except the US is omitted.

The superimposition of CS-US pairings on behavioral baselines other than the appetitively-motivated operant baseline has been explored by several investigators. Sidman, Herrnstein, and Conrad (1957) superimposed CS-US pairings on the Sidman avoidance responding. In such a procedure the animal's response postpones, but does not terminate shock once it has begun. In another procedure, suppression of runway behavior is typically preceded by conditioning in a separate situation, e.g., partitioned Mowrer-Miller box (Strouthes & Hamilton, 1964; Strouthes, 1965) or a cylindrical capsule (Anderson, Plant, & Paden, 1967). Differential suppression of runway behavior between groups served as an indicant of suppression magnitude. Leaf and Muller (1965) have examined conditioned suppression of a consummatory (licking) response. Following CS-US pairings, the CS was superimposed on licking behavior in a one-trial test. Differential latency, time required to complete 10 licks, and number of licks made during the one-trial presentation of the CS were indicants of the magnitude of conditioned suppression. Also, autonomic respondents, alone or in conjunction with other referents, have been subjected to the

CER procedure. Conditioning of heart rate suppression (De Toledo & Black, 1966; Parrish, 1967) and decrease in basal skin resistance levels (Anderson et al., 1967) have been demonstrated.

II. Statement of the Problem

The purpose of the present study was to demonstrate trial by trial acquisition and extinction of conditioned suppression of licking behavior. In previous studies (e.g., Leaf & Muller, 1965) utilizing the consummatory response as a baseline on which the strength of CER is tested, CER acquisition occurred in the absence of the referent baseline response. It was not readily accessible to a trial by trial examination of CER strength. Also, the effect of varying the parameters of shock intensity and trials per session will be examined in the view of the results of other studies utilizing a baseline of operant responding.

III. A Review of the Variables Influencing the Conditioned Emotional Response

A positive relationship has been found between CER strength and CS intensity (Kamin & Schaub, 1963; Kamin & Brimer, 1963). In the first experiment, Kamin and Schaub (1963) employed a delayed conditioning procedure (the CS and US coterminated). Three groups of rats differed in respect to CS intensity (Strong = 81 decibels, Medium = 62.5 decibels, or Weak = 49 decibels) used during CER training. This training consisted of ten, four-trial daily sessions of CS-US pairings superimposed on food motivated bar-press behavior. The rate of acquisition was a positive monotonic

function of CS intensity. In their second experiment, a trace conditioning procedure was employed. The offset of a two-minute CS was followed, after one minute of silence, by shock. Two groups differed in the CS intensity used during the two-minute CS. The group receiving the weak CS (49 decibels) failed to suppress bar pressing during the trace interval. The strong-CS group (81 decibels), under identical training conditions, showed almost complete suppression during the period of silence. Kamin and Brimer (1963) investigated both CS intensity and US intensity simultaneously in a 3 x 3 factorial design. The CS intensities were 47, 60, or 81 decibels, and the US intensities were .28, .49, or .85 milliamperes. During acquisition, conditioned suppression magnitude was an increasing monotonic function of CS intensity. A significant interaction indicated that the weak CS was relatively ineffective for the medium intensity US and highly effective for the high intensity US.

Conditioned suppression has been found to be a positive monotonic function of shock intensity by Annau and Kamin (1961), Kamin and Brimer (1963) and Strouthes and Hamilton (1964). Annau and Kamin (1961) evaluated the effects of US intensity on CER suppression during acquisition and extinction. Five groups of rats were each assigned to a different level of shock intensity. Ten daily sessions of delayed conditioning CS-US pairings were superimposed on ongoing bar-press behavior. The data indicated that the .28-milliampere group failed to suppress; the .49 milliampere group demonstrated a U-shaped function over trials; the .85, 1.55, and 2.91 milliampere group was the most resistant to extinction. Kamin and Brimer (1963) reported that increasing US intensity monotonic-

ally increased CER strength. However, the degree of conditioned suppression produced by both high and low intensities of shock (.85 and .47 milliamperes, respectively) was relatively unaffected by CS intensity, while medium shock intensity was highly sensitive to varying CS intensity between groups during CER acquisition. Strouthes and Hamilton (1964) evaluated the effects of varying shock intensity between groups during conditioning in a Mowrer-Miller box. Testing for suppression involved the superimposition of the CS on stabilized runway behavior. Increasing shock intensity during conditioning resulted in decreased running speeds. The 90 microampere group was slower than the 50 microampere group which in turn was slower than the zero microampere group.

The following relationships between CS duration and conditioned suppression have been obtained (with the following procedures): (a) delayed conditioning procedure: facilitatory (Libby, 1951), inhibitory (Strouthes, 1965); (b) trace conditioning procedure: facilitatory when ISI was held constant (Kamin, 1961), no effect when CS was held constant (Leaf & Leaf, 1966), inhibitory when the CS-offset, US-onset interval was held constant (Kamin, 1965); (c) delayed conditioning and a variable CS duration procedure: facilitatory (Millenson & Hendry, 1967).

Libby (1951) varied CS durations between groups in a delayed conditioning procedure. The CS durations were either 0, 1, 4, 7, 10, 20, or 30, seconds. CS-US pairings preceded bar-press training. Testing for suppression consisted of superimposing a 10-minute CS on stabilized bar-press behavior. The results indicated a positive relationship between amount of suppression and CS duration during acquisition up to a maximum

duration of 10 seconds. A decrease in suppression was suggested by the data for CS durations greater than 20 seconds. Another study (Strouthes, 1965) employing the delayed conditioning procedure found an inverse relationship between CS duration acquisition and magnitude of runway suppression. The 1.95-second CS group suppressed less than the .85-second CS group, which in turn suppressed less than the .30-second group. In a trace conditioning procedure, increasing CS duration between groups with the ISI held constant, resulted in positively correlated differential suppression. During CER acquisition the .5-minute CS group showed no suppression. The one- and two-minute CS groups showed intermediate but equal suppression, and the three-minute CS group (delayed conditioned) manifested rapid and virtually complete suppression. Kamin (1965) examined the effects of varying ISI and CS duration in a trace conditioning procedure and concluded that the ISI and not the CS duration was the determinant in the inverse relationship obtained between CER strength and CS duration. In that experiment three groups were presented with a constant CS duration of 1.5 seconds and the ISI varied between groups (either 61.5, 75, or 180 seconds). A fourth group received a CS duration of 15 seconds and a 25-second ISI. The results indicated that CER strength was an inverse function of ISI and not CS duration. The 61.5-second ISI group acquired the CER while the 180-second ISI group failed to obtain the CER. The 75-second group acquired the CER very slowly. All three groups had a constant 60-second CS-offset, US-onset interval. These results were not substantiated in a trace conditioning procedure (Leaf & Leaf, 1966) in which the CS duration was held constant and the

ISI varied between groups. The pairing of the 10-second CS with a .4 milliamper shock, and an ISI of 20, 30, 40, 50, or 60 seconds during conditioning did not result in differential suppression between groups during the superimposition of CS on consummatory behavior during testing. Millenson and Hendry (1967) compared the effects of a fixed two-minute CS with that of a variable duration CS (average of two minutes) paired with either a mild (.5-milliamper) or an intense (2-milliamper) shock. Temporal discrimination of the fixed CS duration (paired with mild shock) occurred and responding was accelerated during the onset of the CS and declined over its duration. Acceleration did not occur during CS onset for the fixed CS paired with a strong shock, or for the variable duration CS paired with either the mild or intense US. Temporal discrimination of the fixed duration CS was reported earlier by Estes and Skinner (1941) and Hendry and Van Toller (1965).

No unequivocal relationship has been obtained between CS and US duration during conditioning and degree of runway suppression by Strouthes (1965) who assessed the effects of increasing CS and US durations in two factorial designs. Rats were conditioned in a partitioned Mowrer-Miller box, and tested for suppression in a runway. In Design 1 the duration of the CS varied between groups (.30, .85, 1.95 seconds), and the US duration was constant at .25 seconds. In Design 2 the CS duration was constant (.30 seconds) and the US duration varied between groups (.25, .80, 1.90 seconds). Both designs yielded an inverse relationship between CS-onset, US-offset interval and magnitude of conditioned suppression.

Varied relationships between the number of conditioning trials and CER strength have been disclosed: no relationship (Strouthes & Hamilton, 1964; Strouthes, 1965; Leaf & Muller, 1965) a monotonic function (Kamin & his associates), and a curvilinear function (Libby, 1951; Hendry & Van Toller, 1965). Libby (1951) varied the number of CS-US pairings between groups (0, 5, 10, 20, 40, or 80 trials). Subjects were then bar trained, and a 10-minute CS was superimposed during suppression testing. A curvilinear relationship between the number of pairings and response rate was obtained with maximum suppression occurring at 40 trials. Strouthes and Hamilton (1964) presented either 2, 6, or 12 CS-US pairings in a partitioned Mowrer-Miller box. During testing the CS was superimposed on food motivated runway behavior. The number of conditioning trials did not affect conditioned suppression strength. Strouthes (1956) confirmed the earlier Strouthes-Hamilton findings with 8, 16, or 32 delayed conditioning trials. The procedure was basically similar to the earlier study. Leaf and Muller (1965) examined the effect of number of pairings during conditioning on the conditioned suppression of a consummatory response. Two groups received either 4 or 16 forward conditioning trials. The superimposition of the CS on drinking behavior failed to have differential suppressing effects. These findings further substantiated the insensitivity of the CER to the number of conditioning pairings. Carlton and Vogel (1967) obtained conditioned suppression with only one conditioning trial. However, the CER acquisition and extinction gradients obtained in a within-subjects design were generally continuous and were monotonically related to the number of presentations (e.g.,

Annau & Kamin, 1961; Kamin & Brimer, 1963; Kamin & Schaub, 1963).

Increasing the number of trials in which a CS is paired with a mild shock (e.g., 0.50 milliamperes) resulted in a recovery from conditioned suppression (Annau & Kamin, 1961; Kamin & Brimer, 1963; Millenson & Hendry, 1967). Generally, trials are discontinued after suppression occurred and before the alleviation of conditioned suppression with a more intense US. Hendry and Van Toller (1965) presented 39, eight-trial daily sessions of acquisition training to two groups of rats. The group receiving 1.0 milliamperes shock from the first 24 sessions and 2.0 milliamperes shock for the remaining 15 sessions, showed weaker suppression, greater recovery from suppression, and a greater tendency to accelerate during the first portion of the CS than the group receiving 2.0 milliamperes shock throughout the 39 sessions.

The spacing of conditioned trials, or the number of trials per session, has received little attention. Brimer and Dockrill (1966) reported that four delayed conditioning trials per day resulted in slower acquisition than two trials per day. Beecroft (1967) suggested that the efficacy of one trial per day may be due to the relative insensitivity of the CER to more trials on the first day of acquisition.

Desiderato (1964) found that older rats (nine months old) showed a flatter gradient of generalization from a high frequency CS, than a younger group of rats (five months old). The generalization gradient was comparable to that of the younger rats when generalization stimuli were of higher frequency than the CS. Campbell and Campbell (1962) reported that CER strength was equal for three age groups of rats (25, 50, or 100

days) when resistance to extinction was the criterion. However, when retention was the criterion, age during conditioning (18, 23, 54, or 100 days) was monotonically related to CER strength. Rats conditioned at 100 days of age showed virtually complete retention, while rats conditioned at 18 or 23 days of age failed to suppress when tested for retention 42 days after conditioning.

Estes and Skinner (1941) reported that a low drive level group (low appetitive motivation) did not influence CER training or extinction other than failing to provide an adequate bar pressing baseline. Increasing drive level resulted in conditioned suppression comparable to that of a higher drive level group.

Leitenberg (1966) reported that pigeons failed to suppress to a stimulus paired with a high intensity tone US. Neither a white noise of 115-120 decibels, nor a tone of 110 decibels served as an effective US in a CER paradigm. However, Brody (1966) was able to establish conditioned suppression of the bar-press response by Rhesus monkeys with a 115 decibel white noise US.

IV. Pavlovian Conditioning Phenomenon Demonstrated

with the CER Procedure

Stimulus generalization has been demonstrated in a number of CER studies (Ray & Stein, 1959; Hoffman & Fleshler, 1961; Desiderato, 1964; Winograd, 1965). Ray and Stein (1959) subjected rats to discrimination training in which shock followed the 1800 cycles-per-second (cps) tone but not the 200 cps tone. Generalization test stimuli ranged from

560-1500 cps. Periodic reconditioning trials occurred during generalization testing. Strength of suppression was an inverse function of the difference between the CS and the generalization test stimuli. Similar results were obtained by Hoffman and Fleshler (1961) with pigeons in a procedure which omitted discrimination training during CER conditioning and periodic reconditioning during generalization testing. Conditioning occurred to a single stimulus (1000 cps) and the stimuli used during generalization testing ranged from 300-3400 cps. A bidirectional gradient was obtained. Desiderato (1964) also omitted discrimination training during conditioning and reconditioning during generalization testing with rats. His results confirmed the earlier findings of the Hoffman and Fleshler (1961) study utilizing pigeons as subjects.

Winograd (1964) employed a multiple discrimination training procedure in which all stimuli (clicker) during testing were presented throughout the experiment. This procedure permitted the observation of the formation of early generalization. Prior to CER conditioning, response rate was a flat gradient across the five stimuli. One stimulus from either extreme of the frequency range presented (.62 or 26.7 cps) served as the positively reinforced (shock) stimulus during CER training. As in previous studies, response rate was a function of the difference between the conditioned stimulus and generalization test stimulus.

Habituation of the potential CS prior to CS-US pairings has resulted in an attenuation of conditioned suppression (Carlton & Vogel, 1967; Leaf, Kayser, Andrews, Adkins, & Leaf, 1968). Also, the effect of extinction was found to be similar to that of habituation (Leaf et al.,

1968). Carlton and Vogel (1967) evaluated the effect of habituation of a potential CS on the magnitude of conditioned suppression. During the first phase of the experiment a Tone (the potential CS) Group and a Clicker Group received habituation to a tone and a clicker, respectively. Three other groups did not receive habituation training. In the second phase of the experiment, the Tone and Clicker Groups, and one of the nonhabituated groups (Habituation Control) received one CS-US pairing. The second nonhabituated group (Shock-alone Group) received one presentation of shock, and the third nonhabituated group received neither tone nor shock. All groups received identical suppression testing: the superimposition of the CS (tone) on licking behavior. During suppression testing the habituated Tone Group suppressed less than the nonhabituated Habituation Control Group and the habituated Clicker Group, but did not differ from the nonhabituated Shock-alone Group. In a subsequent experiment the effect of additional CS-US pairings on habituated and nonhabituated groups was examined. Three habituated and three nonhabituated each received either one, two, or four CS-US presentations. The attenuation due to habituation was partially alleviated by the presentations of additional CS-US pairings. Leaf et al. (1968) compared the effects of presenting the potential CS alone 30 times prior to conditioning (habituation) with the presentation of the CS alone after conditioning (extinction). Conditioning consisted of three CS-US pairings in a delayed conditioning procedure. The appropriate control groups received conditioning at intervals corresponding to the experimental groups but they did not receive either habituation or extinction trials. Testing

in all groups involved the superimposition of the CS on consummatory lick behavior. During suppression testing the habituation and extinction groups suppressed less than did the habituation and extinction controls. However, the former two groups did not differ; nor did the latter two groups differ. Habituation and extinction experimental groups were quantitatively equal in attenuating suppression.

Presentation of free shock prior to CER conditioning has resulted in a severe attenuation of CER strength (Kamin, 1961a; Brimer & Kamin, 1963). Kamin (1961a) studied the effects of free shock administered prior to CER training. The free shock group received 10 daily sessions of free shock (US alone) followed by 10 daily CER acquisition sessions. The control group received 20 CER training trials. During CER acquisition the free shock group showed retarded acquisition of the CER. These findings suggest that emotional reactivity to shock was weakened as a result of free shock. In a second experiment (Kamin, 1961a) an increase in US intensity above the free shock intensity resulted in an alleviation of this decrement. Shock intensity during CER training was .85 milliamperes for all groups, while shock intensity of the preceding free shock training period was varied between groups (.28, .49, or .85 milliamperes). Rate of CER acquisition was an increasing monotonic function of free shock intensity. Furthermore, it was demonstrated in a subsequent experiment that retardation of CER acquisition occurred whether or not subjects had access to the bar during free shock training. One group received free shock training with access to the bar, while another group had a false partition shielding the bar. Control groups received

corresponding treatments. During CER training, with the bar accessible to all groups, the experimental groups suppressed less than did the control groups which did not differ. However, access to the bar during free shock training reduced the magnitude of conditioned suppression.

However, further experiments cast doubt on the hypothesis of habituation of emotional reactivity to shock (Brimer & Kamin, 1963). The first experiment investigated free shock intensity patterns (ascending, descending, or irregular). The shock intensities ranged from .28 to 2.91 milliamperes. The control subjects received further bar-press sessions during this period without the presentation of shock. The crucial observation, substantiated in subsequent experiment, was that high intensity free shock presentations depressed the baseline both during free shock and CER training. Further, a high relative rate of operant responding occurred to the CS during the first session of CER training. These findings suggest that a sort of Pavlovian disinhibition was occurring. Experiment 2 gave further impetus to this interpretation. Permitting the recovery of the free-shock-depressed baseline by additional bar training sessions resulted in the absence of both the suppression decrement during CER and the supernormal ratio on the first day of CER acquisition. The perseverance of the tendency to accelerate by the free shock group to the CS (without the opportunity to recover to the preshock response rate baseline) was five days. During this time subjects did not receive CER training but CS-alone presentations. The group permitted to recover to the preshock baseline prior to CS presentations did not increase the response rate to the CS relative to the

response rate in the absence of the CS. Furthermore, this five day period of "acceleration tendency" corresponds to the CER decrement period. The adaptation effect appears to be the result of two conflicting tendencies: the tendency to accelerate during the CS, and the tendency to suppress because of CER training.

Conditioned inhibition of the CER has been demonstrated and an interpretation attributing active reinforcing properties to a conditioned inhibitor has received empirical support (Hendry, 1965). Conditioned inhibition is a theoretical process which is assumed to occur as a result of conditioning and actively inhibits the occurrence of the conditioned response (Pavlov, 1927). Conditioned inhibition involves the repeated omission of the US when the CS is paired with another stimulus, the conditioned inhibitor. The presentation of the CS is always terminated with a shock. Low response rates occurred during the presentations of CS-US pairings and high rates during the pairings of the CS and the conditioned inhibitor (Hendry, 1965). The active properties of the conditioned inhibitor were probed by making the conditioned inhibitor, a response produced consequent. Response rates on bar 2 increased when the Conditioned Inhibitor was response produced, and decreased when the CS was response produced. Bar 1 was programmed for the VI food reinforcement schedule.

Differential CER is a reliably occurring phenomenon with differential response rates obtained with bar pressing (Hammond, 1966, 1967; Ayres, 1966) and with both bar pressing and heart beat rate (De Toledo & Black, 1966; Parrish, 1967). Hammond (1966) utilizing a within-subject

design, compared bar-press rates to differentially conditioned stimuli. One stimulus terminated with shock (CS+), while the other was presented alone (CS-). In addition, a control group received the presentations of the two stimuli at intervals corresponding to that of the differentially conditioned group. Differential bar-press rates to each of the two stimuli occurred: a low rate to the CS+ and a high rate to the CS-. The active enhancement of responding to the CS- (above the control group baseline) occurred temporarily during a period coinciding with the suppression of the baseline (absence of CS+ or CS-) during differential conditioning. The control group did not respond differentially to the two stimuli. Following differential CER training and recovery of the bar press response baseline, Ayer (1966) examined the rates of responding during differential CER extinction. Response rate to the CS+ converged to that of the CS- during the four days of extinction. A pseudo-conditioned control group did not respond differentially to the CS+ and CS-. Hammond (1967) compared a group receiving CS- randomly with a group receiving the CS- in a specified relationship (temporally distant) to the CS+ and US pairings during differential CER training. During extinction the CS+ and CS- were combined for both groups. The group receiving CS+ presentations temporally distant from the CS- presentations showed less suppression during testing than the group receiving the CS- randomly. These findings support the hypothesis of active inhibitory properties of the CS-. De Toledo and Black (1966) employed two behavioral referents during differential CER training: bar press and heart beat rate. CER training preceded differential CER training. Conditioned

suppression of both bar-press and heart beat rate occurred. Differential rates of responding occurred to the CS+ and CS- on the first day of differential CER training. Parrish (1967) examined the effect of differential CER training throughout the experiment on rates of bar press and heart beat responding to the CS+ and CS-. Differential rates of bar-press and heart beat occurred to the CS+ and CS-; thereby confirming the earlier De Toledo and Black study. Both studies found that conditioned suppression heart beat rate is slower than that of bar press rate; and while suppression occurred throughout the CS+ interval, heart beat rate increased in the latter half of the CS+ interval.

Higher order conditioning of the CER has been demonstrated in several studies (e.g., Davenport, 1966; Kamil, 1968). Davenport (1966) summarized the general findings of four out of six higher order CER studies. Following CER conditioning (the superimposition of CS₁-US pairings on ongoing bar-press behavior), the subjects were divided into two groups. In higher order conditioning CS₁ replaces the US as the unconditioned stimulus. One group received CS₂-CS₁ pairings (onset of CS₁ preceded by onset of CS₂). A control group received CS₁-CS₂ in backward order, and with a temporal interval separating the two stimuli. Higher order conditioning was obtained in all four studies by the experimental groups but not by the control groups. In sum, 38 out of 44 second order attempts were successful. The CS₂ acquired the capacity to suppress bar-press behavior without ever having been paired with the US. Two out of four subjects, in which third order conditioning was attempted, showed partial suppression. Kamil (1968) utilized basically

the same procedure to obtain second order conditioning. The control group received CS_1 independently of CS_2 . Second order suppression was shown by the experimental subjects but not by the control subjects. These findings support the earlier Davenport (1966) results.

Slower rates of CER acquisition during partial shock reinforcement has been demonstrated in all of the following studies: Geller, 1964; Brimer and Dockrill, 1966; Willis and Lundin, 1966; Wagner, Siegel and Fein, 1967. However, partial reinforcement effect (PRE) has not occurred under certain conditions (Geller, 1964; Wagner et al., 1967). Geller (1964) investigated the effect of partial reinforcement on CER strength in goldfish. The group which received 50% of the CSs paired with shock acquired the CER slower and extinguished faster than a 100% control group. The PRE was not obtained. However, when the same conditions were superimposed on bar-press behavior in rats, both slower acquisition and PRE were obtained. These findings confirmed those of an earlier study by Geller, Karlan, Stein, and Brady (1957; reported by Geller, 1964) which also investigated partial reinforcement in rats. The group which received 25% reinforcement during acquisition extinguished slower than the 100% reinforcement group. These findings were confirmed in two studies by Brimer and Dockrill (1966). In the first experiment, a 50% partial reinforcement group acquired the CER slower and extinguished slower (PRE) than a 100 percent trial equated and 100% reinforcement-equated control groups. In their second study, a 25% reinforcement group acquired the CER and showed greater resistance to extinction than the control group. Another experiment, utilizing a within-subject

design (Willis & Lundin, 1966) examined the magnitude of the CER suppression in partially reinforced (shock) rate. Each of three CSs were paired with either 10, 50, or 90 percent shock reinforcement. The results on this experiment confirmed the earlier findings, that CER suppression magnitude was a function of the percentage of shock reinforcement. Wagner, et al. (1967) obtained the PRE effect with CER training superimposed on bar-press behavior. However, the PRE did not occur when CS-US pairings occurred in a situation in which the subject did not have access to the bar (false partition). In a preceding experiment (which initiated this inquiry), a 50 percent reinforced CS paired with a habituated startle stimulus exhibited slower acquisition and more rapid extinction of startle potentiation than a 100 percent trial-equated group. These findings suggest that bar pressing contingencies interact with CER training to produce a PRE.

Several studies have investigated the retention of a CER. Retention of a highly trained CER was complete after 2.5 years (Hoffman, Fleshler, & Jensen, 1963) and five years (Hoffman, Selekman, & Fleshler, 1966). Similar findings were obtained with an incompletely learned CER over a period of 96 days (Gleitman & Holmes, 1967). Testing for retention over shorter periods (.03 hour to 21 days) resulted in an increased magnitude of the CER as a function of time (McMichael, 1966). Hoffman et al. (1963) tested retention in pigeons which, 2.5 years earlier, had received CER training to a 1000 cps tone and generalization testing to seven tones. The retention was complete. Hoffman et al. (1966) retested these subjects 1.5 years later and obtained no decrement due to memory

disruption. These subjects were highly overtrained and were permitted to recover their earlier keypecking baseline. Gleitman and Holmes (1967) tested the retention of an incompletely learned CER without re-establishing the earlier baseline bar-press base level. The group tested 96 days after CER training did not differ from the group which was tested during the session following CER training. McMichael (1966) tested for CER retention with nine training-testing intervals ranging from .03 hours to 21 days. The results indicated that suppression was a positively related function of training-testing interval with stabilization occurring after six hours.

Hoffman et al. (1963) obtained nearly complete restoration of generalization gradients and suppression to the CS following the introduction of free shock on almost completely extinguished conditioned suppression behavior. Although the subsequent removal of free shock resulted in a sudden recovery of response rate to the generalization stimuli, the suppression to the warning stimulus continued for several sessions before returning to its previous pre-free-shock-period level.

Estes and Skinner (1941) reported almost complete spontaneous recovery within a session following extinction. Extinction consisted of the presentation of a prolonged CS superimposed on bar-press behavior, and was considered to be complete upon the recovery of the pre-CS baseline. An identical procedure was used to test for spontaneous recovery. Burdick and James (unpublished) found the degree of spontaneous recovery to be curvilinear function of the extinction-testing interval. Spontaneous recovery reached a maximum after an ex-

inction-testing interval of 24 hours. Testing for spontaneous recovery involved the superimposition of the CS on consummatory lick behavior, which was identical to the procedure used during acquisition, except the US was omitted on the test trial.

Schedules of food reinforcement have been reported to influence the magnitude of conditioned suppression. These studies investigated the type of schedule (Brady, 1955), opportunity for reinforcement (Stein, Sidman, Murry, & Brady, 1958), rate of reinforcement (Carlton & Didamo, 1960; Lyon, 1963; 1965), and response rate (Blackman, 1966). A low response rate maintained by a reinforcement schedule was suppressed (Leaf & Muller, 1964) and temporal discrimination was not affected by superimposing CS-US pairings (Migler & Brady, 1964). Brady (1955) found that operant responding during extinction of conditioned suppression occurred more rapidly with a ratio food reinforcement schedule (FR 6 and FR 12) than with a VI food reinforcement schedule (VI 30 seconds, VI 1 minute), although recovery with a FR 1 was slow (reported by Beecroft, 1967). Stein et al. (1958) manipulated various stimulus-on (followed by shock) and stimulus-off duration combinations. A correlation was obtained between the stimulus-on, stimulus-off ratio and percentages of reinforcement missed if suppression occurred during the "on" stimulus ($r = .92$). The authors concluded that subjects will suppress only to the extent that suppression does not appreciably reduce the opportunity for positive reinforcement. The distinction between rate of reinforcement and total reinforcement obtained was examined by Carlton and Didamo (1960). Three stimulus-on, stimulus-off ratios (3:57, 3:3, 3:1) were

examined. The number of reinforcements obtained in the first phase (3:57), determined the number of reinforcements the animals obtained in the other two phases. The negatively accelerated function obtained indicated that changes in reinforcement frequency were more easily discriminated at high rates of reinforcement than at low rates of reinforcements. Lyon (1963) studied the influence of CER on rate of responding maintained by a Multiple VI 1 VI 4 minute food reinforcement schedule. Responding during the VI one-minute component was suppressed more than rate on the VI 4 minute component. Increasing CS duration from 100-300 seconds resulted in an increase in the number of responses made during the CS for both components, but the differential magnitude was maintained. Recovery of responding was more rapid during the VI 1 minute component than for the VI 4 minute component. Differences in reinforcement frequency and rate of responding were both potential explanations of the results obtained. Lyon (1965) examined the influence of baseline responding rate and reinforcement frequency on conditioned suppression. Following stabilization of conditioned suppression on a Multiple FR 50, VI 3 minute food reinforcement schedule, the FR component was increased from 50 to 75. Increased baseline responding on the VI component occurred in the absence of the CS, but not during its presence. Since reinforcement rate was not increased on the VI component, these findings suggest that reinforcement frequency influenced conditioned suppression. However, by means of a yoked box design, Blackman (1966) found that rate of responding was a determinant, and not the rate of reinforcement which in this situation was held constant.

The first experiment indicated that more intense suppression occurred during the CS on bar press behavior of rats maintained on a VR 100 schedule than that of rats maintained on a VI schedule. The VR 100 schedule was in effect for the leading rats (set up reinforcements). In the second experiment rats received CER training prior to bar training. The CS (extinction) was superimposed on response rates maintained by a VI 1 minute schedule (leading rats) and VI 1+ minute DRH .3 seconds schedule for the follower rats (following rats must respond within .3 seconds after the reinforcement has been set up by the leading rats). The results of the second experiment confirmed that of the first. The discrepancy with these findings with those of Lyon (1965) may be due to the insensitivity to the CER of the method employed. Although high response rates are more readily suppressed than lower response rates (Blackman, 1966), very low baseline rate maintained by a DRL seconds food reinforcement schedule was suppressed during the CS (Leaf & Muller, 1964). Migler and Brady (1964) demonstrated that time behavior (critical temporal interval between two responses, response A to response B) was not disrupted by the CER, although the number of response A to B sequences were suppressed.

The notion that CER is mediated by Pavlovian conditioning has been discussed by a number of investigators (e.g., Kamin, 1961, 1965; Beecroft, 1967; Bolles, 1967). The similarities between the CER and classical conditioning processes have been noted (see Beecroft, 1967) not only as identical operationally defined procedures, but also in terms of determining variables, and phenomena demonstrated. Generally, both the

CER and classical conditioning processes are positively influenced by CS and US intensity, number of trials, while they are negatively influenced by the interstimulus interval variable. The phenomena demonstrated with both CER and classical conditioning include CS generalization, forward conditioning versus backward or random conditioning, trace conditioning, CS habituation, conditioned inhibition, discriminative conditioning, higher order conditioning, partial reinforcement, retention, and spontaneous recovery. The effect of reinforcement schedules on the CER has not as yet been clarified. The procedural similarity of continuously pairing two stimuli, S_1 (CS) and S_2 (US), and measuring the change in behavior to S_1 , is met in both the CER and classical procedures. Similarly, it is thought that variables manipulated in the present study should influence the acquisition and extinction of aversive properties of the CS over trials in a fashion similar to the way that respondent strength is influenced by similar variables. That is, acquisition and resistance to extinction of conditioned suppression of the licking response should be a positive function of shock intensity. This relationship was obtained in a parametric study by Annau and Kamin (1961) which investigated the effect of shock intensity on the conditioned suppression of operant responding. However, the effect of number of trials per session on CER magnitude has not as yet been formally examined, although Brimer and Dockrill (1961) reported that part of their study indicated an inverse relationship between trials per day and CER magnitude.

CHAPTER II

THE INVESTIGATION

The subjects were 64 male Holtzman albino rats, with one age group (N = 35) of 90-day-old experimentally naive subjects, and a second age group (N = 29) of 250-day-old subjects. The latter group had previously served as subjects in a runway study investigating the effects of response effort magnitude on the frustration effect. In the present experiment, the older age group served as subjects in the first and second replications, while the younger animals were subjects in the third and fourth replications. The total number of subjects in each replication was 11, 18, 19, and 16, respectively.

The apparatus consisted of a 9 x 8 x 7 1/2 inch Skinner Box (Scientific Prototype, Model A-100) modified to meet the requirements of the present experiment. These modifications included the removal of the manipulation, food cup, and magazine. The resulting openings were covered by a metal panel. A 5 x 3 inch portion of the front panel (four inches above the grid floor and one and one-half inches from either side of the box) was replaced by a clear Plexiglas panel. Two six-watt, 120 volt incandescent lamps mounted behind this panel six inches above the grid floor provided one component of a compound conditioned stimulus (CS). Continuous illumination was provided by one six-watt, 120-volt lamp located four inches above the grid floor outside the rear 6 x 6 inch clear Plexiglas panel (modified) of the conditioning chamber. The illumination inside the conditioning chamber was considerably reduced

by a 3 1/2 x 2 1/2 inch patch of electrician's plastic tape attached to the Plexiglas panel. The tube of a water bottle, filled with tap water, protruded into the chamber through a hole in the front panel located two inches above the grid and two inches from the right side of the chamber. The tube was wound with electrician's tape to ensure the recording of individual tongue licks, that is, to eliminate mouth contacts. A mouth contact with the metal tube would increase the duration of the pulse and obscure the actual number of tongue contacts. The hole at the end of the tube was 0.15 inches in diameter. The conditioning chamber was housed in a Lehigh Valley sound attenuated chamber (Model A-64). Programming and recording equipment, located in an adjacent room, consisted of a Grason-Stadler Drinkometer (E4690A-L) and the necessary programming and counting units.

Since the grid floor served two incompatible functions, a shock grid and a ground grid for the drinkometer, four relays constituted a device to switch these functions. The 16 common contacts of these relays were individually connected to the 16 grid bars of the conditioning chamber. The 16 normally closed contacts were connected together and terminated at the negative terminal of the drinkometer amplifying unit. The 16 normally open contacts were individually connected to 16 points of a 18-point plug, which was connected to the shock generator. Thus, the number of licking responses was recorded continuously except during each shock presentation.

The compound CS was composed of white noise provided by a Grason-Stadler Noise Generator (901A) and an increase in illumination provided

by the two lamps. An interstimulus interval of 30 seconds was programmed by a Grason-Stadler Interval Timer (E4300). The ambient noise level, with exhaust fan operating, was 80 decibels; the presentation of the white noise increased the sound intensity to 82 decibels (re: .0002 dynes/cm²) as measured by a Brüel and Kjaer Sound Level Meter (type 4131/32). The 500 millisecond unconditioned stimulus (US), which terminated simultaneously with the CS, was supplied by a Grason-Stadler Shock Generator (E1064GS).

The experiment proceeded through three phases: preliminary training, CER conditioning, and CER extinction. Preliminary training involved six days of water deprivation adaptation and two daily ten-minute sessions of habituation to the apparatus cues and the potential CS. During water deprivation adaptation, the water bottle was mounted on the subject's home cage for 20 minutes daily. Subjects had continuous access to food in their home cages during the entire experiment. Habituation to the CS consisted of alternating 30-second periods of the potential CS and silence. The cumulative number of licking responses made in the two sessions during periods of stimulation and silence were recorded separately on two counters. During the two CS-adaptation, 10 acquisition, and 10 extinction sessions, the subjects received their entire daily allotment of water in the conditioning chamber.

The experimental paradigm during CER acquisition consisted of two 4 x 10 Mixed Designs. Within each design, four groups differed only in respect to shock intensity level (.10, .50, 1.0, or 2.0 milliamperes). Design One groups received 10 daily sessions of one CS-US pairing each

day, while Design Two groups received two trials per day during each of the 10 daily sessions. Each of the eight independent groups were randomly constituted of eight subjects.

Each 10-minute session was initiated by each subject's first licking response. The onset of the CS was presented after the completion of 20 licking responses and a subsequent interval of either 30, 60, or 90 seconds (randomly selected for each experimental day). This procedure was followed for the one-trial per session groups and for the first trial (of two trials) for the two-trials per sessions groups. The two-trials per session groups received the second of its two trials, three minutes after the onset of the first trial. All subjects remained in the chamber for a total of 10 minutes.

The number of licking responses were recorded for each trial during each of the following periods: a 30-second period immediately preceding the CS (pre-CS period), the 30-second CS period, a 30-second period immediately following the offset of the CS (post-CS period), and the entire 10-minute session.

The temporal parameters, procedures, and recording of the data during the 10 days of CER extinction was identical to that during acquisition with the exception of US elimination.

CHAPTER III

RESULTS

Each subject's daily suppression ratio was calculated by the formula, $B/(A + B)$ where A represents the number of licking responses produced during the 30-second pre-CS period, and B represents the number of licking responses produced during the 30-second CS interval. For each subject in the two-trials-per-day group, the first trial pre-CS and CS response frequencies were combined with the second trial pre-CS and CS frequencies, respectively. Suppression ratio values range from 0.00 to 1.00 with 0.0 representing complete suppression, 0.50 representing no suppression, and 1.00 representing the complete reverse of suppression.

During the first and second days of habituation to the CS (preliminary training), the response rates during periods of silence and stimulation did not differ significantly in either the one-trial-per-day group ($t_{\text{day 1}} = .6705$, $df = 31$, $p > .30$; $t_{\text{day 2}} = .1384$, $p > .40$) or in the two-trial-per-day group ($t_{\text{day 1}} = .5058$, $df = 31$, $p > .50$; $t_{\text{day 2}} = -.0762$, $p > .90$).

The mean daily acquisition suppression ratio data are shown in Figure 1 for both the one-trial-per-day (left panel) and the two-trial-per-day (right panel) subgroups. Two separate shock intensity \times day (4×10) analyses of variance of individual suppression ratios for the one-trial-per-day group (Table 1) and for the two-trial-per-day group (Table 2), indicated that both main effects and the interaction were significant. A Newman-Keuls test of the ordered difference of means

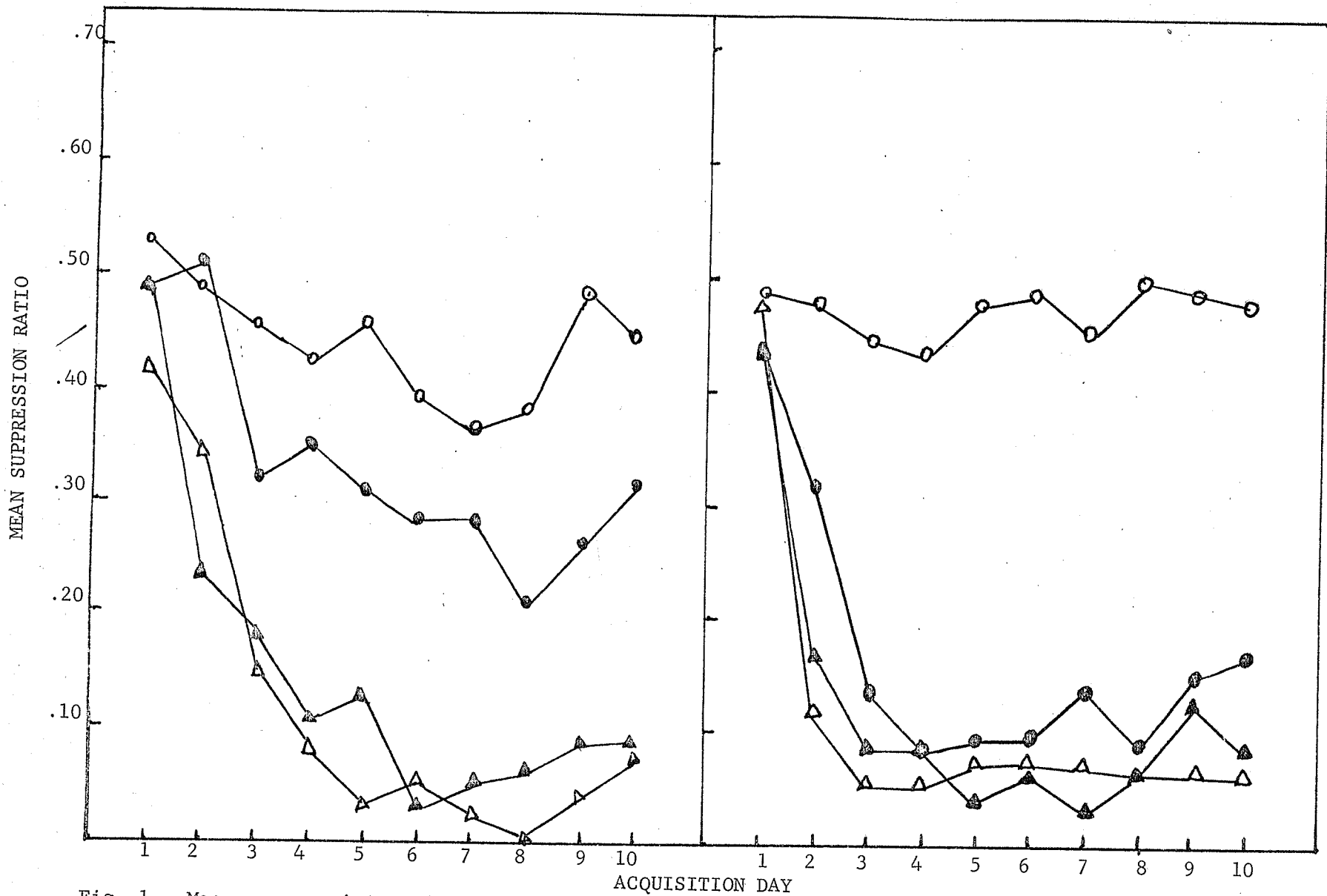


Fig. 1. Mean suppression ratios of the one-trial-per-day, left panel, and the two-trials-per-day group, right panel, as a function of shock intensity over the ten acquisition trials. The .10, .50, 1.0 and 2.0 shock intensities are represented by the open circle, solid circle, open triangle, and solid triangle, respectively. The panels and notations represent the respective groups and shock intensities on all subsequent figures (Fig. 1 to 8), with the exception of Fig. 9.

TABLE I

ANALYSIS OF VARIANCE OF INDIVIDUAL SUPPRESSION SCORES (RATIOS)
FOR SUBJECTS RECEIVING ONE TRIAL PER DAY

Source	df	SS	MS	F
Between Subjects	31	6.5057		
Shock Intensity	3	5.0521	1.6840	32.4413***
Error	28	1.4536	.0519	
Within Subjects	288	6.8741		
Day	9	2.5543	.2838	37.8400***
Shock Intensity x Day	27	.6537	.0242	3.2267***
Error	252	1.9006	.0075	
Total	319	13.3798		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

TABLE 2

ANALYSIS OF VARIANCE OF INDIVIDUAL SUPPRESSION RATIOS DURING
ACQUISITION FOR THE GROUP RECEIVING TWO TRIALS PER SESSION

Source	df	SS	MS	F
Between Subjects	31	6.5228		
Shock Intensity	3	6.2553	2.078	21.85***
Error	28	.2875	.0103	
Within Subjects	288	4.9977		
Days	9	2.0261	.2251	25.88***
Shock Intensity x Days	27	.7760	.0288	3.311***
Error	252	2.1936	.0087	
Total	319	11.5205		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

(Winer, 1962) in the one-trial-per-day group indicated that with the exception of the 1.0 versus 2.0 milliamperes comparison, all differences between the shock intensity groups were significant ($p < .01$). A Newman-Keuls test of the differences between the means of the two-trial-per-day subgroups revealed that the three higher intensity groups differed from the lowest, .10 milliamperes shock intensity group. No other difference was significant ($p < .01$).

A t-test of the individual means (each subject's mean across ten days of acquisition training) indicated no differential effect due to the two age groups ($t = .4406$, $df = 62$, $p > .20$).

The CER extinction daily subgroup mean suppression ratios are portrayed in Figure 2 for both the one-trial-per-day shock intensity groups (left panel) and for the two-trial-per-day shock intensity groups (right panel). Two separate intensity shock x day analyses of variance of individual suppression ratios, one analysis for the one-trial-per-day shock intensity subgroups (Table 3) and the second analysis for the two-trials-per-day shock intensity subgroups (Table 4), revealed significant main and interaction effects. A Newman-Keuls test of the difference between the means of the one-trial-per-day shock intensity subgroups disclosed that all means differed from each other, with the exception of the two lower (.10 and .50 milliamperes) shock intensity groups ($p < .01$). A Newman-Keuls test of the difference between means of the two-trial-per-day shock intensity groups indicated that the higher shock intensity group means (.50, 1.0, and 2.0 milliamperes) did not differ among each other but did differ from the lowest intensity shock group ($p < .01$).

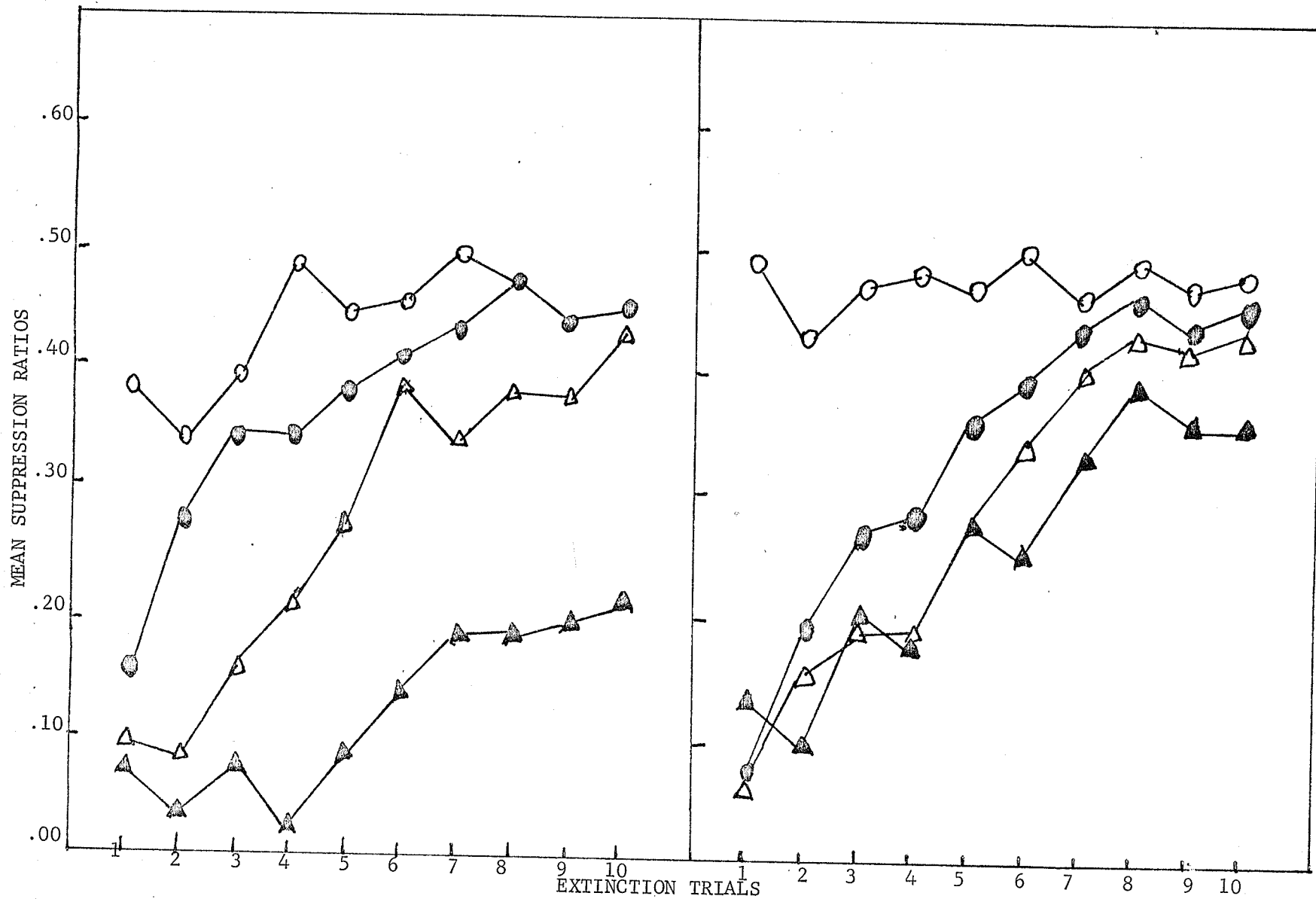


Fig.2. Mean suppression ratios by the one-trial-per-day group, left panel, and the two-trials-per-day group, right panel, as a function of shock intensity during acquisition over ten daily extinction sessions. The .10, .50, 1.0, and 2.0 milliamperes shock intensities are represented by the open circle, solid circle, open triangle, and solid triangle, respectively.

TABLE 3

ANALYSIS OF VARIANCE OF INDIVIDUAL SUPPRESSION RATIOS DURING
EXTINCTION FOR THE ONE-TRIAL-PER-DAY GROUP

Source	df	SS	MS	F
Between Subjects	31	5.7305		
Shock Intensity	3	4.5618	1.5206	36.4652***
Error	28	1.1687	.0417	
Within Subjects	288	4.9910		
Days	9	1.8806	2.0895	20.8325***
Shock Intensity x Days	27	.5810	.0215	2.1456**
Error	252	2.5294	.0100	
Total	319	10.7215		

TABLE 4

ANALYSIS OF VARIANCE OF INDIVIDUAL SUPPRESSION RATIOS DURING
EXTINCTION FOR THE GROUPS RECEIVING TWO TRIALS PER DAY

Source	df	SS	MS	F
Between Subjects	31	4.2043		
Shock Intensity	3	2.1837	.7291	10.0831***
Error	28	2.0206	.0722	
Within Subjects	288	5.0519		
Days	9	2.4540	.2727	40.7015***
Shock Intensity x Days	27	.9067	.0336	5.015***
Error	252	1.6912	.0067	
Total	319	6.2249		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

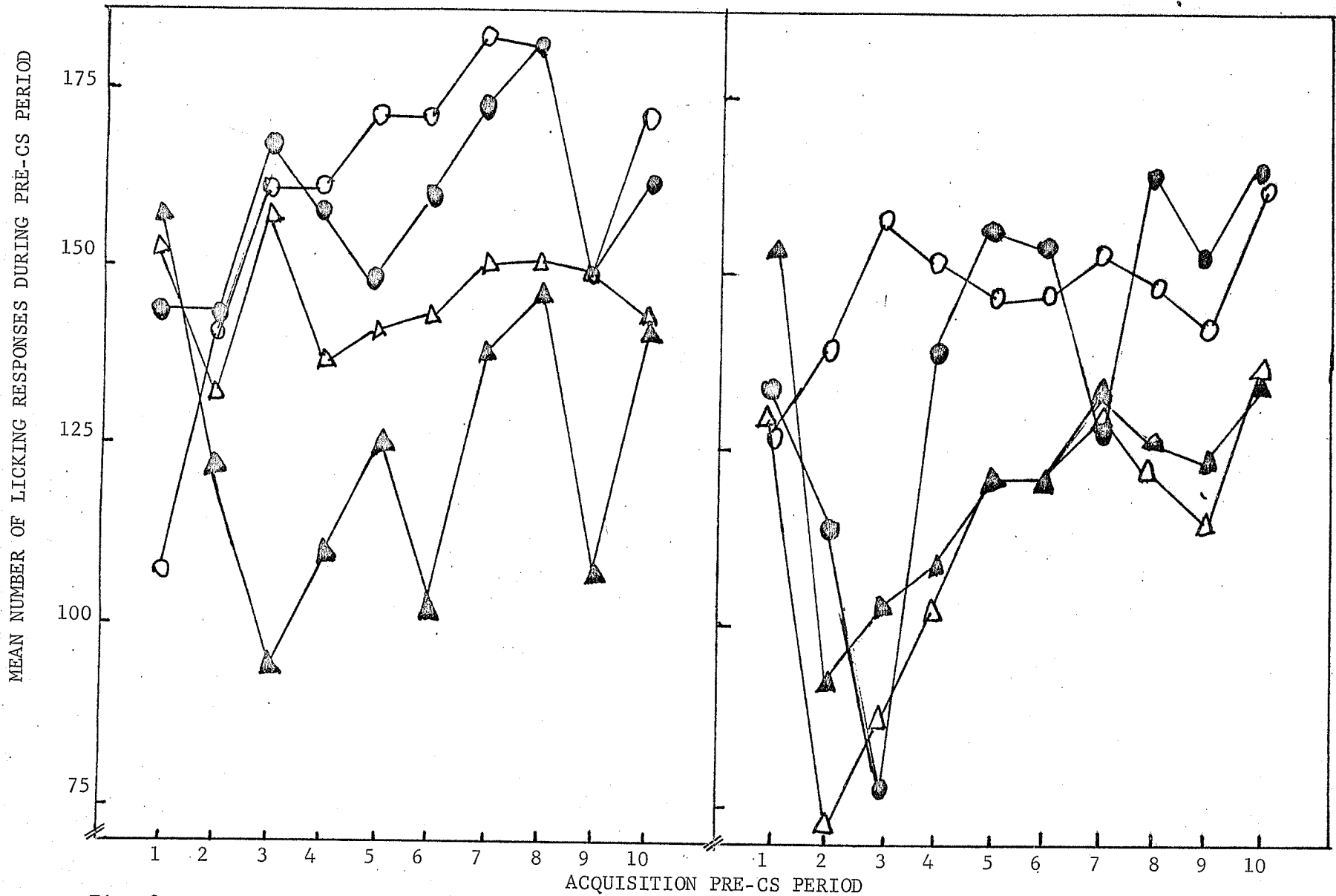


Fig. 3. Mean number of licking responses during the 30-second period preceding the CS presentation as a function of shock intensity over the 10 acquisition days. The gradients for the group receiving one trial per day are presented in the left panel, while the gradients for the group receiving two trials per day are shown in the right panel. Shock intensities, .10, .50, 1.0, and 2.0 are symbolized by the open circle, solid circle, open triangle, and solid triangle respectively.

A t-test of the individual subject's means (mean of the 10-day suppression ratios during extinction) did not signify any differential effect due to the two age groups ($t = -1.7486$, $df = 62$, $p > .05$).

Figure 3 portrays the daily acquisition pre-CS response frequency means for each of the one-trial-per-day (left panel) and two-trial-per-day (right panel) subgroups. Each of the two-trial subject's means of the two daily pre-CS periods represents an individual's subject's pre-CS baseline rate of licking. Two separate shock intensity \times days analyses of variance of individual response rates, one analysis for the one-trial subgroups (Table 5) and the second analysis for the two-trial subgroups (Table 6), indicated significant main and interaction effects. A Newman-Keuls test of the difference between means of the one-trial shock intensity groups indicated that the only difference occurred between the .50 and 2.0 milliamperage-groups ($p < .01$). No differences between shock intensity groups were indicated by the Newman-Keuls test ($p < .01$).

Figure 4 presents the pre-CS extinction data for both the one-trial-per-day (left panel) and two-trial-per-day (right panel) subgroups. Each of the two-trial subject's means was the average of two daily pre-CS periods. Two separate shock intensity \times days analyses of variance, one analysis for each of the two groups (one-trial group; Table 7; two-trial group: Table 8), found that the main effect due to days was significant. The shock intensity main effect and interaction were significant for the one-trial subgroups, but were not for the two-trial subgroups. A Newman-Keuls test of the differences between one-trial shock intensity group means indicated that the .10 and .50 milliamperage shock intensity groups

TABLE 5

ANALYSIS OF VARIANCE OF THE INDIVIDUAL LICK FREQUENCIES
DURING ACQUISITION PRE-CS FOR GROUPS RECEIVING ONE TRIAL PER DAY

Source	df	SS	MS	F
Between Subjects	31	175,733.0625		
Shock Intensity	3	61,136.5039	20,378.8320	4.9793**
Error	28	114,596.5586	4,092.7342	
Within Subjects	288	292,203.8750		
Days	9	29,317.8125	3,257.5347	3.9417***
Shock Intensity X Days	27	54,626.8750	2,023.2175	2.4482***
Error	252	208,259.1875	826.4253	
Total	319	467,936.9375		

*p < .05.

**p < .01.

***p < .001.

TABLE 6

ANALYSIS OF VARIANCE OF INDIVIDUAL SCORES DURING PRE-CS
 ACQUISITION PERIODS FOR SUBJECTS RECEIVING TWO
 TRIALS PER DAY

Source	df	SS	MS	F
Between Subjects	31	221,829.38		
Shock Intensity	3	54,969.29	18,323.09	3.0747*
Error	28	166,860.09	5,959.29	
Within Subjects	288	332,057.13		
Days	9	59,921.84	6,657.98	7.5747***
Shock Intensity x Days	27	50,631.88	1,875.25	2.1334**
Error	252	221,503.41	878.98	
Total	319	553,886.51		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

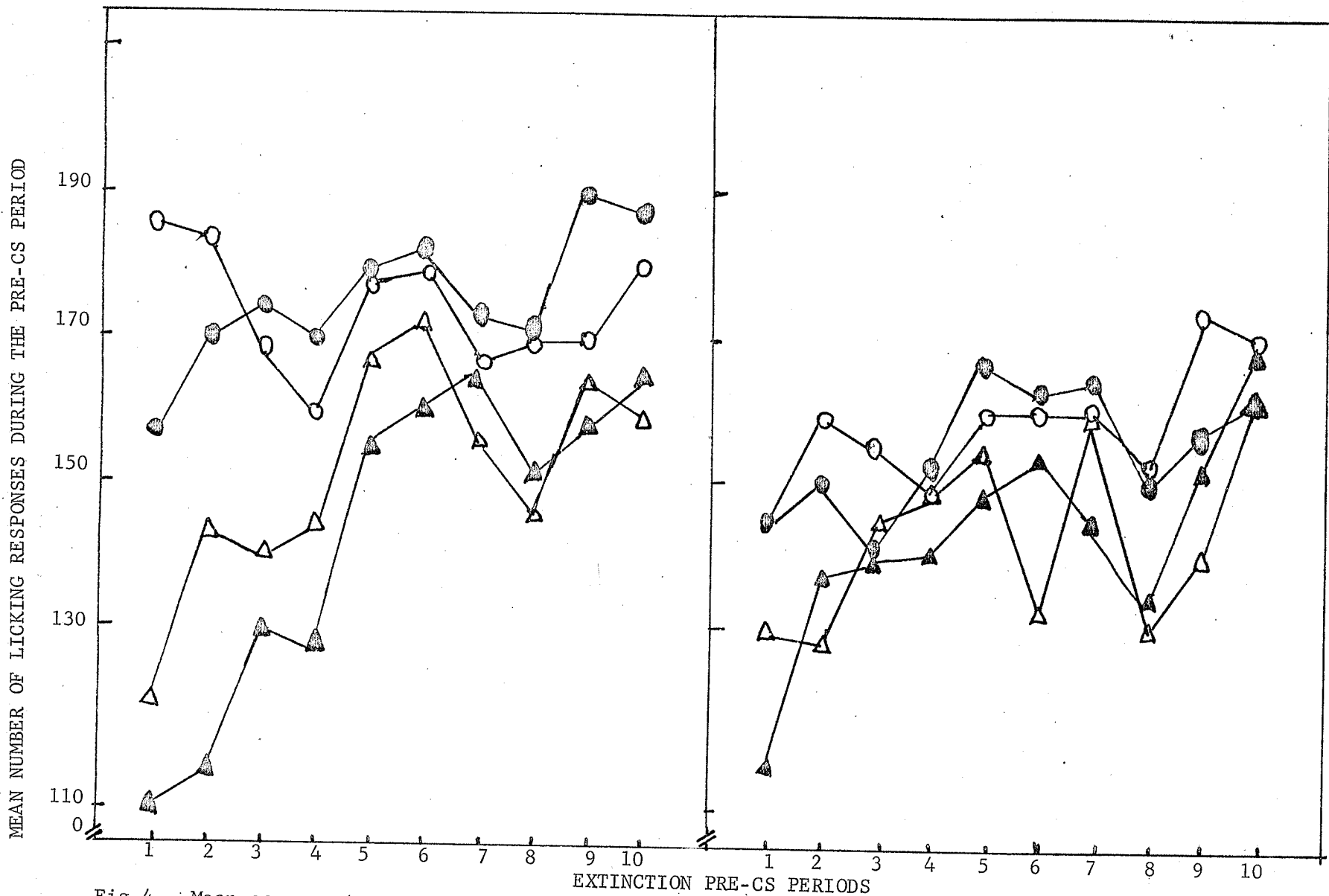


Fig.4. Mean consummatory response rate during pre-CS periods as a function of acquisition-shock intensity over the ten daily extinction sessions. The shock intensity subgroups (.10, .50, 1.0, and 2.0 milliampere) of the one-trial-per-day group (left panel) and of the two-trials-per-session group (right panel) are represented by the open circle, solid circle, open triangle, and solid triangle, respectively.

TABLE 7

ANALYSIS OF VARIANCE OF INDIVIDUAL FREQUENCIES DURING
PRE-CS EXTINCTION PERIODS FOR SUBJECTS RECEIVING ONE TRIAL PER DAY

Source	df	SS	MS	F
Between Subjects	31	142,366.8750		
Shock Intensity	3	63,948.6289	21,316.2070	7.6112***
Error	28	78,418.2461	2,800.6516	
Within Subjects	288	238,668.3750		
Days	9	38,368.0937	4,263.1211	6.3540***
Shock Intensity x Days	27	31,225.1562	1,156.4871	1.7237**
Error	252	169,075.1251	670.9330	

* $p < .05$.

** $p < .01$.

*** $p < .001$.

TABLE 8
 ANALYSIS OF VARIANCE OF INDIVIDUAL LICK-FREQUENCIES DURING
 EXTINCTION PRE-CS PERIODS
 FOR SUBJECTS RECEIVING TWO TRIALS PER DAY

Source	df	SS	MS	F
Between Subjects	31	85,240.94		
Shock Intensity	3	15,643.32	5,214.44	2.0978
Error	28	69,597.62	2,485.63	
Within Subjects	288	183,920.13		
Days	9	27,011.36	3,001.26	5.2320***
Shock Intensity x Days	27	12,352.07	457.48	.7975
Error	252	144,556.70	573.64	
Total	319	269,161.07		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

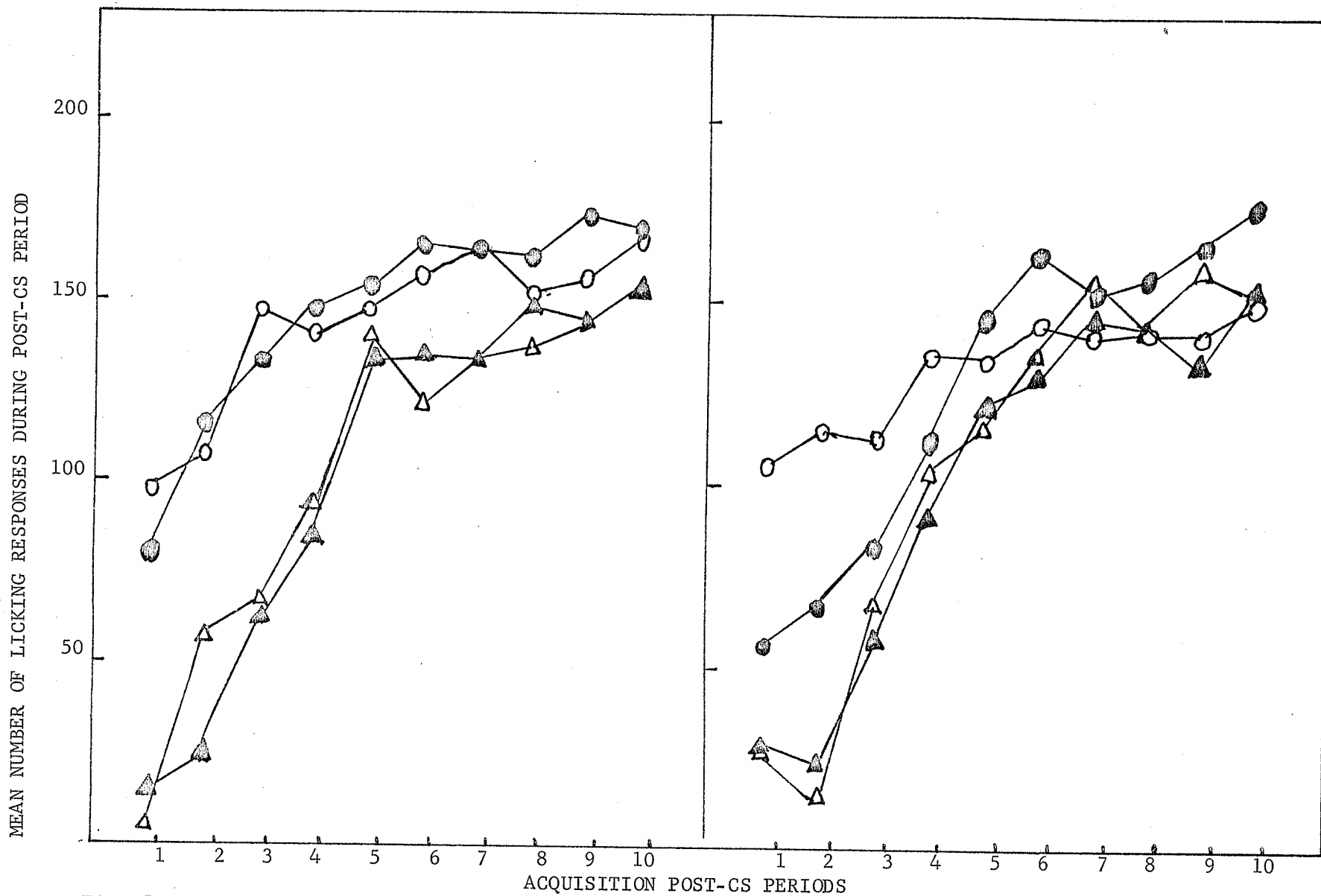


Fig. 5. Mean baseline rate, represented by the post-CS indicant, as a function of acquisition shock intensity over ten daily acquisition sessions. The one-trial-per-day and the two-trials-per-day shock intensity groups, .10, .50, 1.0, and 2.0 milliamperes, are represented by the open circle, solid circle, open triangle, and solid triangle, respectively. The gradients produced by the one-trial group are shown in the left panel, while those of the two-trial group are shown in the right panel.

differed from the 2.0 milliamper shock intensity groups ($p < .01$). No other significant differences were indicated.

Another potential indicant of the baseline response rate is the post-CS lick frequency (not used in the calculation of the suppression ratios in the present experiment). Figure 5 portrays the daily acquisition post-CS response frequency means for the one-trial-per-session (left panel) and two-trial (right panel) subgroups. The mean of the two post-CS daily periods served as the response baseline rate for each two-trial subject. Two separate analyses of variance of individual post-CS response rates, one analysis for the one-trial group (Table 9) and the second analysis for the two-trial group (Table 10), disclosed that the days main effect was significant for the one-trial subgroups, but not for the two-trial subgroups. A Newman-Keuls test of the difference between one-trial shock intensity means indicated that the .10 and .50 milliamper shock intensity groups differed from the 1.0 milliamper group, but no other differences were found ($p < .01$).

Figure 6 shows the daily extinction post-CS frequency means of the one-trial-per-day subgroups (left panel) and the two-trial-per-day subgroups (right panel). The two-trial subject's baseline was represented by the mean of the daily two post-CS response rates. Two separate analyses of variance, one for the one-trial group (Table 11) and the second analysis for the two-trials group (Table 12), indicated that neither shock intensity main effects nor interaction was significant. The days main effect was significant for the one-trial subgroups, but was not significant for the two-trials subgroups.

TABLE 9

ANALYSIS OF VARIANCE OF THE POST-CS DATA FOR SUBJECTS
RECEIVING ONE TRIAL PER DAY

Source	df	SS	MS	F
Between Subjects	31	299,481.6250		
Shock Intensity	3	125,775.1875	41,925.0625	6.7580**
Error	28	173,706.4375	6,203.8013	
Within Subjects	288	801,752.1875		
Days	9	419,350.7500	46,594.5273	37.2250***
Shock Intensity x Days	27	66,971.5000	2,480.4258	1.9820**
Error	252	315,429.9375	1,251.7061	
Total	319	1,101,170.8125		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

TABLE 10

ANALYSIS OF VARIANCE FOR INDIVIDUAL POST-CS FREQUENCIES DURING
ACQUISITION FOR THE GROUP RECEIVING TWO TRIALS PER DAILY SESSION

Source	df	SS	MS	F
Between Subjects	31	222,495.94		
Shock Intensity	3	50,570.57	16,856.86	2.7453
Error	28	171,925.37	6,140.19	
Within Subjects	288	786,678.44		
Days	9	484,042.88	53,782.54	60.4325***
Shock Intensity x Days	27	78,364.56	2,902.39	3.2613***
Error	252	224,271.00	889.96	
Total	319	1,009,174.38		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

MEAN NUMBER OF LICKING RESPONSES DURING POST-CS PERIOD

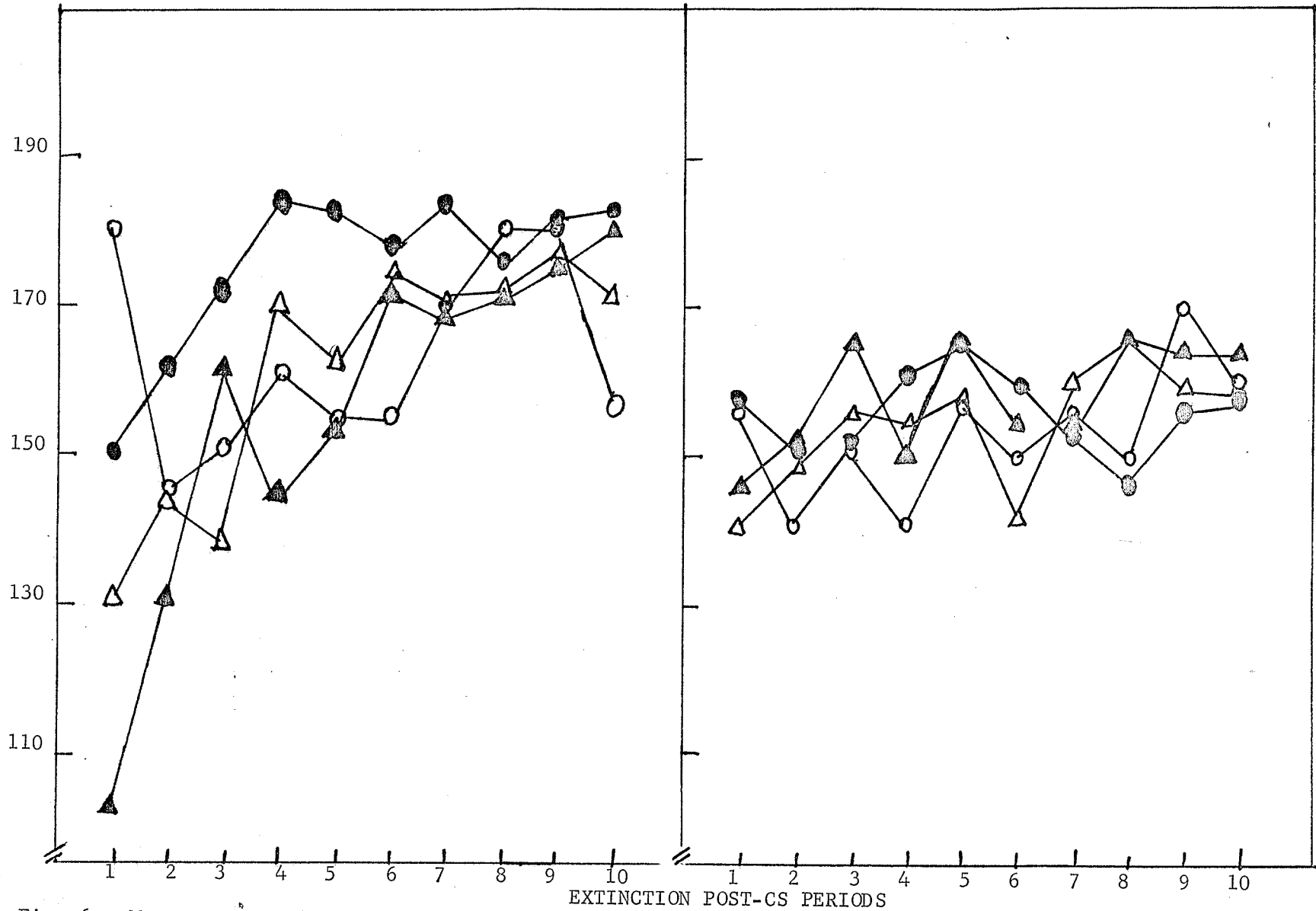


Fig. 6. Mean response baseline rate, represented by the post-CS indicant, as a function of acquisition shock over the 10 extinction trials. The one- and two-trial-per-session groups are represented by the left and right panels, respectively. The .10, .50, 1.0, and 2.0 shock intensity subgroups are represented by notations: open circle, solid circle, open triangle, and solid triangle, respectively.

TABLE 11

ANALYSIS OF VARIANCE OF POST-CS DATA DURING EXTINCTION FOR THE
GROUP RECEIVING ONE TRIAL PER DAY

Source	df	SS	MS	F
Between Subjects	31	67,253.6875		
Shock Intensity	3	15,139.2187	5,046.4063	2.7113
Error	28	52,114.4688	1,861.2310	
Within Subjects	288	329,628.8125		
Days	9	45,024.7812	5,002.7500	5.0782***
Shock Intensity x Days	27	36,349.6562	1,346.2834	1.3466
Error	252	248,254.3751	985.1364	
Total	319	396,882.5000		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

TABLE 12
 ANALYSIS OF VARIANCE OF INDIVIDUAL POST-CS FREQUENCIES
 DURING EXTINCTION FOR THE GROUP RECEIVING
 TWO TRIALS PER DAY

Source	df	SS	MS	F
Between Subjects	31	106,721.00		
Shock Intensity	3	1,266.24	422.08	.1121
Error	28	105,454.76	3,766.24	
Within Subjects	288	163,675.56		
Days	9	7,164.32	796.04	1.3675
Shock Intensity x Days	27	9,813.82	363.47	.6244
Error	252	146,697.42	582.13	
Total	319	270,396.56		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Figure 7 presents the daily mean total-response-per-session baseline rate as a function of shock intensity over the 10 daily acquisition sessions for both the one-trial-per-day (left panel) and two-trials-per-day group (right panel). One analysis of variance for the data of the one-trial group (Table 13) and a second analysis of variance of the data of the two-trials group (Table 14) indicated that the days main effect and interaction were significant, and the shock intensity main effect was not significant.

Figure 8 depicts the mean total response rate per session as a function of shock intensity over extinction sessions for both the one-trial-per-day and two-trials-per-day groups (left and right panel, respectively). The analysis of variance for the data of the group receiving one trial per day (Table 15) and the analysis of variance for the data of the group receiving two trials per day (Table 16) indicated that the shock intensity main effect was not significant and the days main effect was significant. The interaction was significant for the two-trials group but was not for the one-trial group.

An analysis of variance was performed to determine the effect of the number of trials per daily session on the rate of acquisition. A trials per day x shock intensity x trials ($2 \times 4 \times 10$) analysis of variance (Table 17) of the individual suppression ratios across ten acquisition trials of the one-trial-per-day group and the suppression ratios during the first 10 trials of the 20 acquisition trials of the two-trials-per-day group, revealed that the trials per day main effect was not significant, while the trials and shock intensity main effects

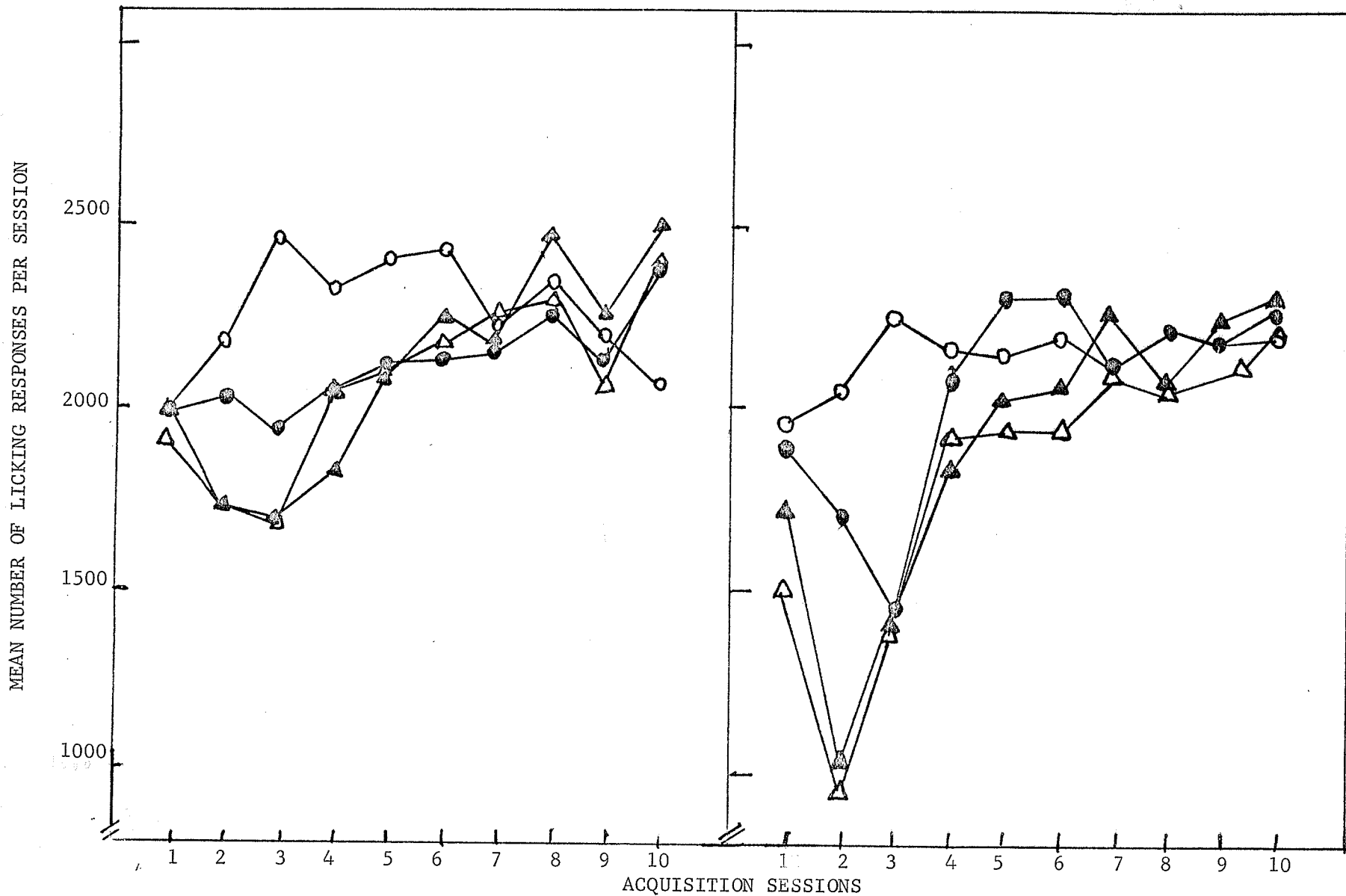


Fig. 7. Mean baseline response rate, indicated by the mean total responses per session, as a function of shock intensity over the ten acquisition sessions. The shock intensity subgroups (.10, .50, 1.0, and 2.0 milliampere) of both the one-trial-per-day group, left panel, and the two-trials-per-day group, right panel, are symbolized by the open circle, solid circle, open triangle, and solid triangle, respectively.

TABLE 13

ANALYSIS OF VARIANCE OF INDIVIDUAL TOTAL-RESPONSES-PER-SESSION
 DATA DURING ACQUISITION FOR THE ONE-TRIAL-PER-DAY-GROUP

Source	df	SS	MS	F
Between Subjects	31	49,682,384.00		
Shock Intensity	3	2,032,146.00	677,382.00	.3980
Error	28	47,650,238.00	1,701,794.21	
Within Subjects	286	39,524,416.00		
Days	9	6,575,474.00	730,608.19	6.6871***
Shock Intensity x Days	27	5,634,951.00	208,701.88	1.9102**
Error	250	27,313,991.00	109,255.96	
Total	317	89,206,800.00		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

TABLE 14

ANALYSIS OF VARIANCE OF THE TOTAL RATE DATA DURING ACQUISITION
FOR THE GROUP RECEIVING TWO TRIALS PER SESSION

Source	df	SS	MS	F
Between Subjects	31	37,242,560		
Shock Intensity	3	5,893,133	1,964,377.00	1.7545
Error	28	31,349,427	1,119,622.39	
Within Subjects	288	77,947,328		
Days	9	20,608,800	2,289,866.00	12.0580***
Shock Intensity x Days	27	9,482,816	351,215.37	1.8494**
Error	252	47,855,712	189,903.62	
Total	319	115,189,888		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

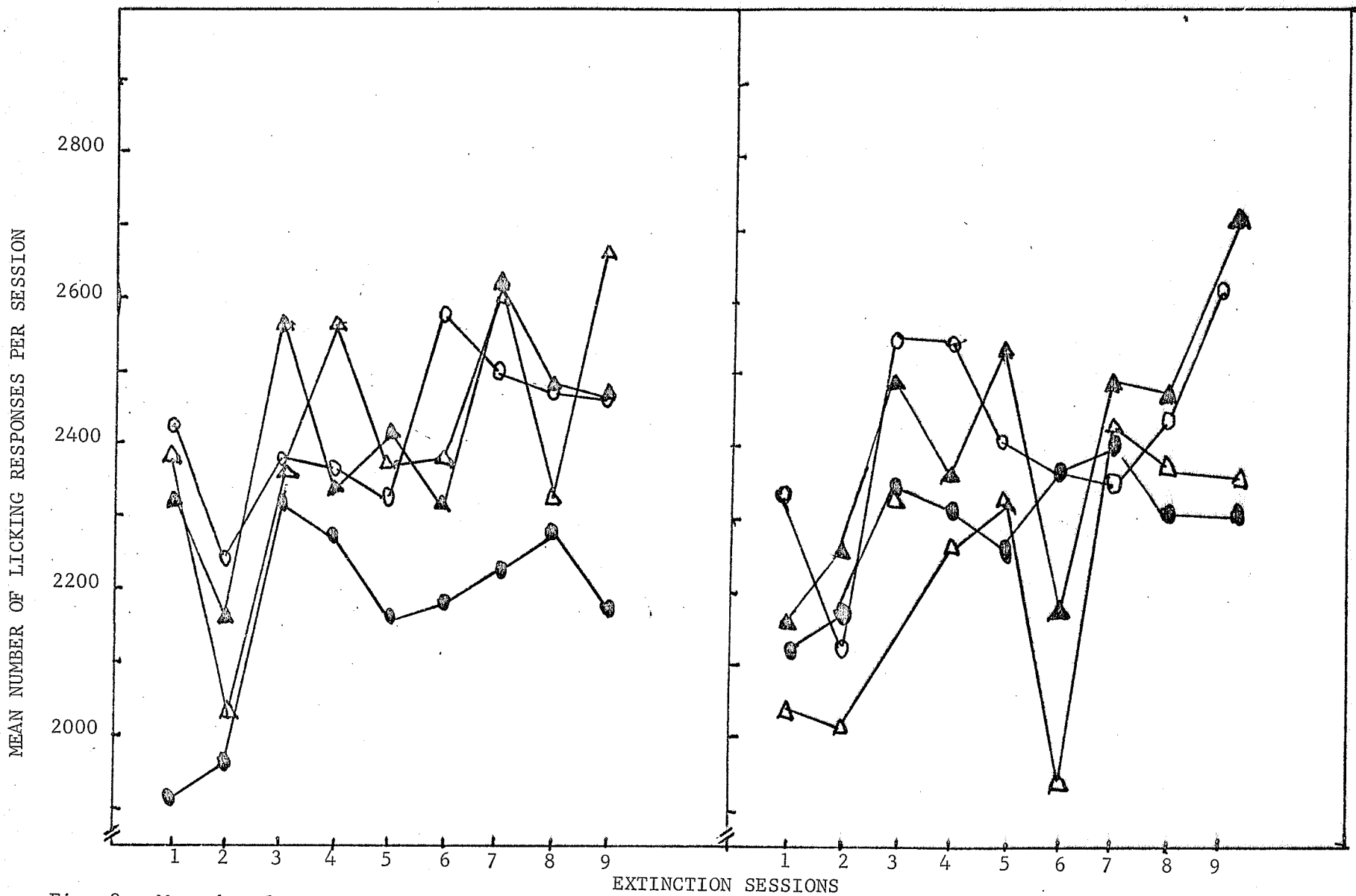


Fig. 8. Mean baseline rate, indicated by mean number of licking responses per session, as a function of acquisition shock intensity over the extinction sessions. The acquisition shock intensity subgroups, .10, .50, 1.0, and 2.0 milliamperes, of both the one-trial-per-day (left panel) and two-trials-per-day (right panel) groups are depicted by the open circle, solid circle, open triangle, and solid triangle, respectively.

TABLE 15

ANALYSIS OF VARIANCE OF THE INDIVIDUAL TOTAL RESPONSE FREQUENCIES
DURING EXTINCTION FOR THE GROUP RECEIVING ONE TRIAL PER DAY

Source	df	SS	MS	F
Between Subjects	31	27,327,488		
Shock Intensity	3	3,281,565	1,093,855.00	1.2737
Error	28	24,045,923	858,782.96	
Within Subjects	255	31,618,720		
Days ¹	8	3,399,790	424,973.75	3.6332***
Shock Intensity x Days	24	2,134,513	88,938.00	.7603
Error	223	26,084,417	116,970.48	
Total	286	58,946,208		

¹Total response frequencies were not recorded on the last day of extinction.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

TABLE 16

ANALYSIS OF VARIANCE OF INDIVIDUAL TOTAL-RATE-PER-SESSION FREQUENCIES
DURING EXTINCTION FOR THE GROUP RECEIVING TWO TRIALS PER DAY

Source	df	SS	MS	F
Between Subjects	31	19,650,480		
Shock Intensity	3	1,700,416	566,805.31	.8841
Error	28	17,950,064	641,073.71	
Within Subjects	256	31,385,968		
Days ¹	8	4,306,368	566,805.00	5.0253***
Shock Intensity x Days	24	1,814,520	538,296.00	4.7725***
Error	224	25,265,080	112,790.54	
Total	287	51,036,448		

¹Total response scores were not recorded on the last day of extinction.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

TABLE 17

ANALYSIS OF VARIANCE OF INDIVIDUAL SUPPRESSION RATIOS DURING ACQUISITION
FOR THE TEN TRIALS OF THE ONE-TRIAL-PER-DAY GROUP AND FOR THE FIRST
TEN (OF TWENTY) TRIALS OF THE TWO-TRIAL-PER-DAY GROUP

Source				
Between Subjects	63	11.4084		
Trials Per Day	1	.1023	.1023	3.2170
Shock Intensity	3	8.9529	2.9843	93.8459***
Trial x Shock Intensity	3	.5732	.1911	6.0094**
Error	56	1.7800	.0318	
Within Subjects	554	14.8143		
Trials	9	5.6708	.6301	42.0067***
Trials Per Day x Trials	9	.2013	.0224	1.4933
Shock Intensity x Trials	27	1.3464	.0499	3.3267***
Trials Per Day x Shock Intensity x Trials	27	.3664	.0136	.9067
Error	482	7.2294	.0150	
Total ¹	617	26.2227		

¹Total of df does not include scores in which no responding occurred during the pre-CS.

* $p < .05$.

** $p < .01$.

*** $p < .001$

were significant. The trials per day x shock intensity, the shock intensity, and the shock intensity x trials effects were significant. The trials per day x trials, and the trials per day x shock intensity x trials interactions were not significant. The significant trials per day x shock intensity interaction is presented graphically in Figure 9 (left panel).

A trials x shock intensity x days (2 x 4 x 10) analysis of variance (Table 18) for the individual suppression ratios during the 10 days of extinction for the one-trial-per-day group, and the individual suppression ratios of the first 10 of the 20 extinction trials of the two-trials-per-day group indicated that all main effects and interactions were significant except the trial x shock intensity x days interaction. The significant trial x shock intensity interaction is presented in Figure 9 (right panel).

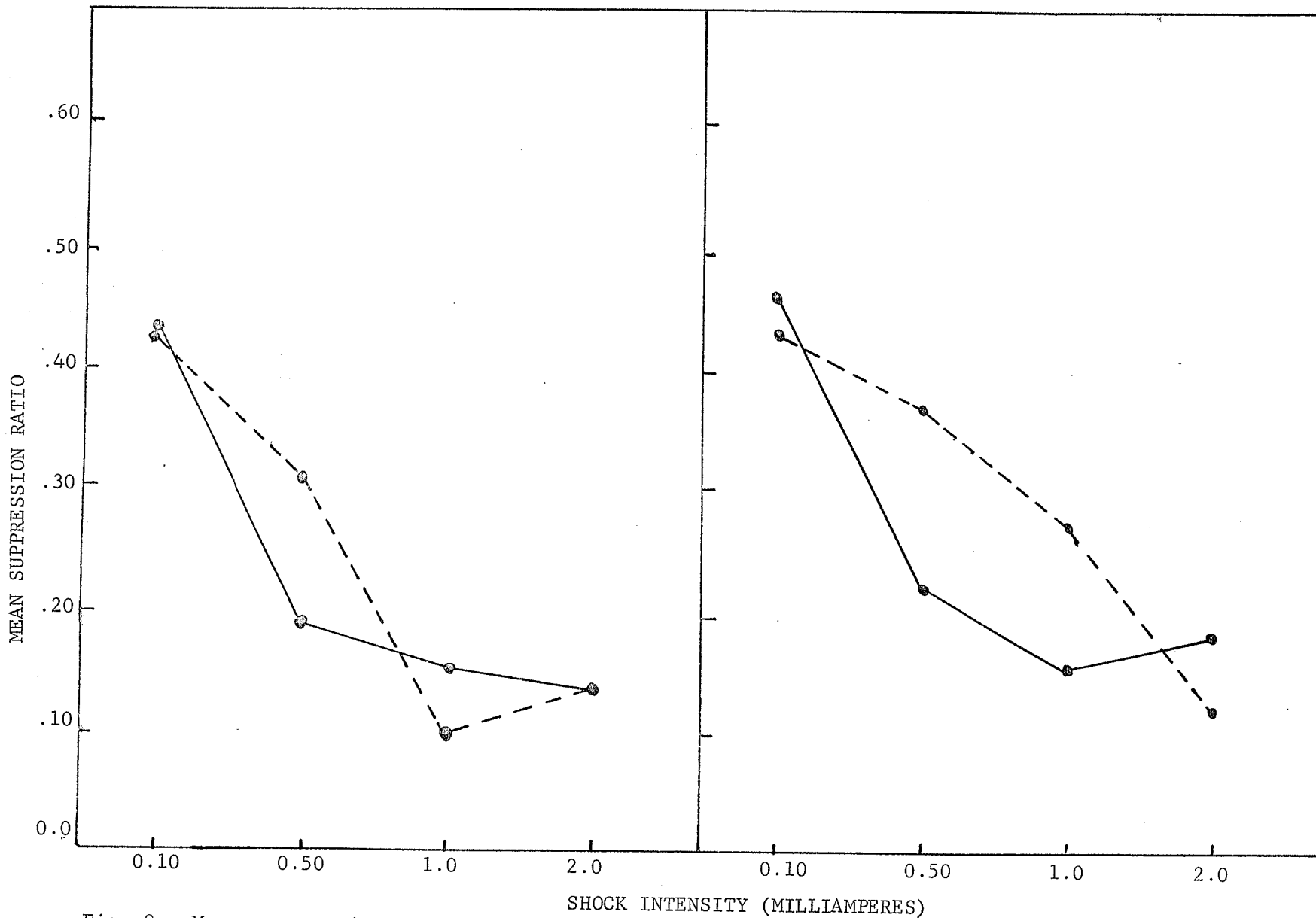


Fig. 9. Mean suppression ratio by the one-trial-per-day group --broken line-- and two-trials-per-day group --solid line-- as a function of acquisition shock intensity during acquisition (left panel) and extinction (right panel).

TABLE 18

ANALYSIS OF VARIANCE OF INDIVIDUAL SUPPRESSION RATIOS DURING
EXTINCTION FOR THE TEN TRIALS OF THE ONE-TRIAL-PER-DAY GROUP
AND THE FIRST TEN TRIALS OF THE TWO-TRIALS-PER-DAY GROUP

Source	df	SS	MS	F
Between Subjects	63	13.1413		
Trial	1	.2497	.2497	6.3056*
Shock Intensity	3	8.0637	2.6879	67.8763***
Trial x Shock Intensity	3	1.2416	.4139	10.4520***
Error	56	2.2197	.0396	
Within Subjects	576	10.1533		
Day	9	2.7498	.3055	26.3362***
Trial x Day	9	.2478	.0275	2.3707***
Shock Intensity x Day	27	1.0299	.0381	3.2845***
Trial x Shock Intensity x Day	27	.2639	.0098	.8534
Error	504	5.8619	.0116	
Total	639	23.2946		

* $p < .05$.

** $p < .01$.

*** $p < .001$.

CHAPTER IV

DISCUSSION

The differential effects of age on either acquisition or extinction were not observed in the present study. This is consistent with the data of Campbell and Campbell (1962) in which three age groups ranging from 25 to 100 days of age during conditioning did not show a differential effect during extinction.

The results of the present study utilizing a consummatory response as the behavioral reference baseline is comparable to a parametric study (Annau & Kamin, 1961) on shock intensity and conditioned suppression of operant responding. A number of similarities are observed during CER acquisition in both studies. In the Annau-Kamin study and in the present study CER acquisition was a positive monotonic function of US intensity. In the Annau-Kamin study the .28 milliamper shock produced no suppression, .85, 1.55, and 2.91 milliamper shock yielded maximum suppression, and the .49 milliamper shock produced an intermediate level of suppression. Similarly, in the present study for the groups receiving one trial per session, the magnitude of conditioned suppression was directly related to shock intensity with the two highest shock intensity groups exhibiting nondifferentiated behavior. The two-trials-per-day groups showed equal suppression of licking to the .50, 1.0, and 2.0 milliamper US. However, little suppression was found to the .10 milliamper shock. All groups receiving one trial per day showed, in the present study, a slight recovery of suppression toward the end of

acquisition, but this was not as pronounced as the U-shaped curve of the .49 milliampere group in the Annau-Kamin study. Another similarity between Annau and Kamin (1961) and the present study was that suppression reached asymptote relatively early in the CER acquisition period. Asymptotic conditioned suppression of operant responding (Annau & Kamin) was reached at about the third day after approximately 12 CS-US pairings, while in the present study, asymptotic suppression occurred on about the sixth day for the one-trial-per-day group and on about the fourth day for the two-trials-per-day group after approximately six and eight CS-US pairings (see Figure 1). The continuous acquisition gradient across CS-US pairings contrasts with studies which utilized between-subject's design to investigate the number of trials variable (e.g., Strouthes, 1965; Leaf & Muller, 1965). These investigations found that the CER is insensitive to the number of CS-US pairings.

Resistance to extinction, both in the Annau-Kamin (1961) study and in the present study, was a positive monotonic function of acquisition shock intensity. The higher intensity shock groups, in the Annau-Kamin study and in the one-trial-per-day group of the present study, did not produce different magnitudes of suppression during acquisition yet yielded differential rates of extinction. The .85, 1.55, and 2.91 milliampere groups of the Annau-Kamin study differed in the degree of resistance to extinction, while the 1.0 and 2.0 milliampere groups which received one trial per day also differed in degree of resistance to extinction. However, the two-trials-per-day groups which were not differentiated during acquisition remained undifferentiated during

extinction. The trend toward differentiation in these groups shown in Figure 2 (right panel) was not significant.

Another similarity between the Annau and Kamin (1961) findings and the results of the present study is that baseline responding diminished as a function of shock intensity. Specifically, there was a tendency for the 2.91 milliamper group in the Annau-Kamin study, to show an initial marked reduction in baseline responding followed by a gradual recovery. In the present study, the rate of pre-CS responding as depicted in Figure 3, tended to be inversely related to shock intensity. The higher shock intensity groups generally reduced mean response rate during the pre-CS period. An analysis of variance for the one-trial-per-day groups (Table 5) indicated that both main and interaction effects were significant. Overall mean differences were significant between the .10 or .50 and the 2.0 milliamper group. A reduction in baseline responding during the early acquisition trials is suggested in Figure 3 for the 2.0 milliamper group which received one trial per session and for the .50, 1.0, and 2.0 milliamper groups which received two trials per session.

Another indicant of baseline response rate used in the present experiment is the number of licks produced during the post-CS period. Figure 5 presents the mean post-CS response rate as a function of shock intensity over the 10 acquisition trials. The left panel shows the significant effect of shock intensity for the one-trial-per-session group. The two-trials-per-session group showed no overall differentiation of groups as a function of shock intensity. The analysis of variance indicated that the shock intensity effect was nonsignificant (Table 10).

The tendency depicted in Figure 5 (right panel), of a greater reduction in baseline response rate by higher shock intensities, was supported by the significant interaction.

Figure 7 also shows the reduced mean total responses per session baseline as a function of shock intensity. The significant shock intensity by trials interaction in both the one- and two-trial groups indicate that the total baseline was reduced. A greater decrease in total baseline response rate occurred in the two-trial-per-day group (right panel) than in the one-trial-per-session group (left panel).

It should be noted, as Annau and Kamin (1961) emphasize, that reduced baseline responding does not account for the greater suppression by the higher intensity shock, as the relative baseline (pre-CS) responding is used to calculate the suppression ratios.

The recovery of baseline responding during extinction were observed in both the Annau-Kamin study and in the present study. In the present study, Figure 4 shows the means of baseline response rate during the pre-CS extinction period as a function of shock intensity. Generally, the higher shock intensity groups which received one trial per day, depicted in the left panel of Figure 4, continued to recover throughout the extinction period but did not equal the baseline rate of the lower intensity groups. The two-trials-per-day group (right panel) did not differ in response rate during the pre-CS. Mean response rate during the extinction post-CS periods (Figure 6) and mean total response rates did not reflect reduced baseline response rates as a function of higher shock intensity for either the one- or the two-trial-per-day groups. The

reverse tendency of increased baseline responding in the higher shock intensity groups is suggested by the significant interaction (Table 16) and is depicted in Figure 8.

In brief, the finding (Annau & Kamin, 1961) of a positive monotonic relationship between shock intensity on the one hand and CER acquisition and resistance to extinction on the other were confirmed by the present study. Except for the pronounced recovery from suppression of the .49 milliamper group of Annau-Kamin, the one- and two-trial groups of the present study parallel the Annau-Kamin findings. Reduction in baseline response rate as a function of shock intensity was reflected most sensitively by the response rate during the pre-CS, both during acquisition and extinction, while the least sensitivity was shown by the total response baseline. The Annau-Kamin findings of a reduced baseline response rate as a function of shock and the sudden decrease in baseline response rate in the early acquisition trials were confirmed in the present experiment.

The sensitivity of the consummatory response baseline response appears to be superior to other non-operant baselines. The conditioning of the heart beat rate, an autonomic response, occurred less rapidly than the conditioned suppression of a concomitant operant response. This was shown by De Toledo and Black (1966) and Parrish (1967). Anderson et al. (1967) reported that although the basal skin resistance level (BSL) reflected the presence of conditioned fear, it did not differentiate between the CS paired with a 1.0 milliamper shock versus a CS paired with a 2.0 milliamper shock, while a competing response

indicant was highly effective in differentiating between the two US intensity groups. The failure of the BSL to reflect these differences was attributed to the gross measure used and to a ceiling effect. Overmier (1966) obtained classical conditioning of the heart beat rate (acceleration) utilizing curarized dogs, but did not find a differential CR rate to a CS paired with a .5-second shock versus a CS paired with a 50.0-second shock. Upon subsequent shuttle box avoidance extinction testing, the 50.0-second US subjects showed superior instrumental avoidance performance. Overmier concluded that the failure to obtain differential conditioned heart beat rate to the two US durations may reflect the insensitivity of the autonomic response. In sum, the consummatory response reference baseline provides a sensitive CER index, comparable to that of the operant response, and apparently more sensitive than a number of autonomic behavioral baselines.

However, discrepancies in CER strength as a function of a number of variables appears to depend on whether the bar-press response or the consummatory response is utilized as the behavioral baseline. Leaf and Muller (1965) found the CER insensitive to the number of trials variable. Leaf and Leaf (1966) did not obtain differential trace conditioning with the consummatory index with trace intervals ranging from 10 to 50 seconds. Kamin (1965) reported decreasing conditioned suppression with increases in the trace duration interval with the operant response baseline. Both the Leaf-Muller procedure and the present procedure utilizes the consummatory response baseline. This discrepancy between the present study and the Leaf-Muller (1965) investigation on the effect of the number-of-trials

variable may be due to procedural differences. The present procedure provides for a trial by trial examination of CER strength, i.e., it provides an indicant of CER strength by permitting testing and conditioning within the same trial. The Leaf-Muller procedure has no behavioral referent baseline during conditioning. In the present study acquisition trials are identical to conditioning trials with the exception of the elimination of the US. In the Leaf-Muller technique the subject does not have access to the watering bottle during acquisition, but the water bottle is presented during extinction. The different conditions during conditioning and testing may lead to a generalization decrement. The intertrial interval of the present study is longer, an FI 3 minute versus the VI 1 minute of the Leaf-Muller study. During the one-trial test in the Leaf-Muller procedure, the CS is presented and either differential latency, time required to complete 10 licks, or number of licks made during the CS serves as the index of conditioned suppression. In the present study many extinction trials (10 or 20 over 10 days) are presented to the subject.

The procedure of the present study also differs from that of Annau and Kamin (1961). The present procedure does not require preliminary training as the consummatory response is reflexive behavior. In the Annau-Kamin procedure, operant training requires at least 10 hours per animal. Session lengths of the present procedure were 10 minutes, while the Annau-Kamin procedure requires two hours. The CS duration of the present study was 30 seconds versus the three-minute CS in the Annau-Kamin procedure. One or two trials per session were presented, while

four trials are presented in the Annau-Kamin investigation.

The present procedure accommodates the adaptation of the Leaf-Muller procedure to the CER procedure as developed by Kamin. Similarities between this procedure and the Annau-Kamin procedure include pre-test exposure of the potential CS, constant environmental cues for acquisition and extinction, suppression-ratio formula, and pre-CS indicant of the baseline. The present procedure provides a sensitive trial by trial examination of the variables influencing the CER. This method yields behavioral data with a sensitivity comparable to that of a more prolonged procedure, which utilizes operant responding as the behavioral baseline.

An issue to which this study may have relevance is the superiority of the one-trial per day versus several trials per daily session. Brimer and Dockrill (1966) reported that superior conditioned suppression of operant responding was obtained with a one-trial conditioning procedure versus a four-trial conditioning procedure. The present study, however, did not confirm these findings. The one-trial-per-session group was inferior, although not significantly, than the two-trial per session group during CER acquisition. If the assumption that asymptotic conditioning occurs within ten trials, then the resistance to extinction data would support the superiority of the two-trials-per-day group.

One of the reasons for hypothesizing the superiority of a one-trial group in a trial-equated experimental design (Beecroft, 1967), is the relative ineffectiveness of the other trials on the first conditioning day. This aspect may be compensated for by the earlier recovery of

baseline rate in the two-or-more-trials session. In the present study the higher intensity groups receiving two trials per session did not reduce baseline responding during the extinction pre-CS, while the higher intensity groups receiving one trial per day continued to show baseline recovery during the pre-CS period throughout extinction. Recovery during acquisition of the .50 milliamper group receiving one trial per day as contrasted with the greater conditioned suppression of the two-trials-per-day group for that intensity does not support the interpretation of superior conditionability of the one trial per session procedure.

However, contaminating factors other than the trials-per-session factor may account for the discrepancy in results between the present study and the Brimer and Dockrill (1966) study. The two-trials-per-day group received twice as many trials during acquisition as did the one-trial-per-day group. Secondly, the rapid flux in drive level within a session may have had a determining effect. With the present procedure the animal is satiated in less than ten minutes. Estes and Skinner (1941) investigated the effects of drive between sessions, or within subjects between sessions, and concluded that drive has no effect on acquisition other than performance. These conclusions may not apply to a rapid diminution of drive within a ten-minute session. A third confounding variable is temporal discrimination (Beecroft, 1967). The pre-CS response rate increased over sessions and did not decrease as would be expected if the animal were suppressing to the temporal interval. However, a reduction in response rate during the pre-CS extinction

periods occurred in the high intensity groups receiving one trial per day, while a similar reduction did not occur during the post-CS and total-responses-per-session indicants of the baseline (see Figure 4, left panel; Figure 6, left panel; and Figure 8, left panel).

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