CLASSICAL CONDITIONING OF THE HINDLIMB FLEXION REFLEX IN THE PARTIALLY DECEREBRATE ACUTE SPINAL CAT

by

Linda A. Fitzgerald, M.S.

A THESIS

Presented to the Department of Medical Psychology and
the Graduate Division of the University of Oregon Medical School
in partial fulfillment of
the requirements for the degree of
Doctor of Philosophy

May 1969

APPROVED:

[redacted]

.....

(Professor in Charge of Thesis)

[redacted]

.....

(Chairman, Graduate Council)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

ACKNOWLEDGMENT

The author would like to acknowledge her profound gratitude to Dr. Richard F. Thompson who encouraged me to carry out this study. Without his continued advice and encouragement this study would not have been possible.

For emergency help in the lab, including both a sense of humor and extra hands, my deepest thanks go to Mary Meikle and Hilton Smith.

The contributions of the thesis committee, Dr. D.S.Phillips, Dr. F. R. Brush, and Dr. R. D. Fitzgerald, are also acknowledged.

Last, but by no means least, my thanks go to my husband and my father, both of whom now believe in miracles.

INTRODUCTION

The classical conditioning procedure appears to be very simple. Two stimuli, designated as the conditioned stimulus (CS) and the unconditioned stimulus (UCS), are presented in a temporally fixed sequence, the CS preceding and, usually, overlapping the occurrence of the UCS. Both stimuli may terminate simultaneously. After several paired presentations of these stimuli a response similar to the response to the UCS occurs after the CS. This response to the CS is termed the conditioned response (CR) and the response to the UCS is termed the unconditioned response (UCR).

The simplicity of the procedure is limited to the experimental operations. The neural or physiological mechanisms underlying conditioning have not yet been identified. A model system against which conditioning theories can be tested would be useful to elucidate these mechanisms. Major interest has centered around the search for a relatively simple neuronal system in which confounding influences, such as movement, light, and age are minimized. Such a system, whether an isolated section of a more complex system (ganglion, nerve, spinal cord) or the intact system of a relatively primitive organism, would be of value to conditioning theorists. This accounts for the vast amount of work expended in attempts to condition planaria and spinal animals.

The work by Thompson and McConnell (1955) on classical conditioning in planaria aroused a great deal of interest, but later investigators (Cummings and Moreland, 1959; Halas, James and Stone, 1961; Van Deventer and Ratner, 1964) have pointed out significant weaknesses in

the planaria conditioning experiments. Some specific variables, which significantly influence responsiveness of planaria to light (the CS used by Thompson and McConnell, 1955), have been shown by VanDeventer and Ratner (1964) to include temperature, dark adaptation and size of the animal. These factors were uncontrolled in the Thompson and McConnell study. In a review of studies on learning in paramecia and planaria, Jensen (1964) concludes that the results of these studies do not support the hypothesis that learning can occur in these animals. The possibility of a spinal conditioning model thereby assumes more importance.

The ability to develop a conditioned reflex without involvement of cortical structures was first reported by Lebedinskia and Rosenthal (1935). Their subject, a dog, had both cerebral hemispheres removed. The response conditioned was salivation to a metronome, the first CR appearing after 250 trials.

Five years later Shurrager and Culler (1940) reported evidence indicating the presence of conditioning of a spinal preparation. This report generated much controversy. Because portions of the technique subsequently have been incorporated into other experiments, the general method that Shurrager and Culler used is of interest.

The spinal cord of dogs was transected, the level of transection varying from second cervical to third lumbar levels. Both semitendinosus muscles of the hind limbs were dissected out with nerve and blood supply intact. Fine threads were attached to the fascia over a pit-like depression in the muscle and these threads and tendon were then attached to a kymograph lever.

In the conditioning procedure the CS was either a moderate electric shock or a stiff-bristle brush tap applied to the tail or to the forepaw opposite the hind leg receiving the UCS. The UCS was an electrical shock of sufficient intensity to elicit full contraction of the semitendinosus muscle when applied to the homolateral hind paw. At the beginning of the conditioning series, thirty to sixty presentations of three CSs at 1 second intervals were administered as a control for the possibility of increased responsiveness of the semitendinosus muscle to a repeated CS. Following this series of the CS alone, another series of stimuli was presented in which the third CS in the above pattern was paired with the UCS. These paired presentations occurred every 15, 30, or 60 seconds.

The CR was a muscle twitch which was recorded on the kymograph. After the establishment of the CR no stimuli were given for at least 10 minutes. The extinction procedure followed this rest period and was identical to the conditioning procedure except the UCS was omitted.

The authors set three commonly accepted criteria as their criteria for conditioning. First the CR had to be distinguishable from the original response to the CS alone. Second, the occurrence of the CR had to be dependent upon paired presentations of the CS and UCS. Third, the CR had to diminish in frequency during the extinction procedure (repeated presentation of the CS alone).

One control procedure consisted of approximately 200 presentations of the CS alone at various time intervals. There was no evidence of a CR to the CS before pairing with the UCS. To meet the second criterion, Shurrager and Culler alternated a series of three UCS presentations with

three CS presentations or presented the UCS followed by two CS presentations. Neither of these combinations produced a CR. Regular extinction procedures reduced the CR to zero values. Extinction was effective whether initiated immediately or after a delay of several hours.

Other controls were included by Shurrager and Culler to establish that the results were not the result of recovery of spinal reflexes from anesthetic nor an artifact produced by direct electrical stimulation.

Shurrager and Culler plotted their data in a vincentized form, percent conditioned responses versus percent conditioning or extinction (i.e., successive tenths of the whole number of trials required for complete conditioning or extinction) trials. The extinction curve, when rotated 180 degrees, could almost be superimposed on the conditioning curve. Repeated series led to fewer trials to criterion (10 CRs in 10 successive trials) for both conditioning and extinction. These two observations led the authors to conclude they had demonstrated conditioning in a spinal preparation and they suggested that conditioning and extinction were based on similar mechanisms.

Shurrager and Culler (1940) employed several control procedures to eliminate nonconditioning phenomena, such as recovery from anesthesia, and these controls appear to have been adequate. Little criticism has been given to this aspect of the investigation by other workers. Many other aspects of the method and/or interpretation of their results, however, have been criticized. The usual starting point is that, of the 196 dogs that received the conditioning procedure, only 98 gave positive evidence of spinal conditioning. The remaining 98, or 50%,

failed to show any evidence of conditioning. The failure to demonstrate conditioning in 50 percent of the animals does raise serious questions. Shurrager (1947) has apparently made only one statement in rebuttal to this criticism: "It is not uncommon to find a normal animal which fails to learn a simple differential flexion response in hundreds of conditioning trials." Shurrager and Shurrager (1946) reported positive evidence of spinal conditioning in dogs but the total number of dogs used was not reported.

A second point of the Shurrager and Culler (1940) study that has been criticized has to do with the character of the CR. Although initially the CR was a very small localized muscle twitch, on later trials it became more diffuse and included more muscle fibers. This change in the nature of the response has been questioned because the usual progression seen in classical conditioning in the intact animal is one in which a diffuse general response gradually becomes more and more localized and restricted (Kimble, 1961; Hilgard and Marquis, 1940).

A third criticism leveled at the Shurrager and Culler experiment was that an increase in CS intensity failed to produce an increase in the magnitude of the CR (Pinto and Bromiley, 1950). This point has not been settled conclusively.

Since the initial investigation by Shurrager and Culler (1940) a variety of studies have been reported in which no evidence of spinal conditioning was found (Kellogg, 1947; Pinto and Bromiley, 1950; Forbes and Mahan, 1963). One of the most well known studies, by Kellogg, Deese, Pronko and Feinberg (1947), used an experimental preparation so different from that of Shurrager and Culler that it is difficult to make a meaningful comparison between the two studies. Kellogg

et al. used a chronic preparation similar to one which Shurrager and Culler had tried unsuccessfully (Shurrager, 1947). The CS consisted of two brief shocks 1 second apart delivered to one of the hind limbs. The UCS, a single brief shock delivered to the other hind limb, occurred 1 second after the termination of the CS. A major problem with this technique of presenting the CS and UCS is that it can elicit two antagonistic and mutually exclusive reflexes in the leg receiving the UCS. Thus a CS of moderate intensity would be expected to produce flexion of the leg stimulated by the CS and extension of the leg that was to receive the UCS. In the Kellogg et al. study the CS was of sufficient intensity to change the response pattern to one of flexion in both hind legs. During the course of the experiment, however, the flexion response to the CS in the leg stimulated by the UCS alternated in dominance with the crossed-extension reflex. The authors concluded that their data gave no evidence in support of spinal conditioning since, after approximately 600 trials the frequency of the flexion reflex in the UCS leg was close to zero.

Shurrager (1947) also had found a bilateral hindlimb flexion reflex in response to a strong CS. The magnitude of this response increased with further increases in CS intensity. It is difficult to understand why Kellogg et al. used these responses or what the implications of their results are for understanding spinal conditioning.

Kellogg (1947) stated that usually about 100 to 400 conditioning trials were required for a normal intact animal to reach 100 percent conditioning under the stimulus conditions employed by Shurrager and Culler (1940). The problem then is to explain the 100 percent conditioning which Shurrager and Culler reported was obtained in 30 to 40

conditioning trials. A search of the literature reveals no studies of the number of trials required to reach a conditioning criterion under different experimental conditions, especially the conditions employed in spinal conditioning. Since neither the Shurrager group nor the Kellogg group could get spinal conditioning in chronic animals, Kellogg suggested that the results of Shurrager and his associates was an artifact due to some post-operational factor. It would appear to be equally possible for the physiological deterioration in the chronic animal to affect important neural units involved in spinal conditioning and thus prevent the changes involved in conditioning.

Deese and Kellogg (1949) studied flexion response of the whole leg in chronic spinal dogs. Two brief shocks to the tail (CS) were followed by a shock to the right hind foot (UCS). The authors reported both the CS and UCS produced a twitch in both legs, and concluded that the response to the CS was not a conditioned response since it occurred to the CS alone without having been reinforced by the UCS. This was presented as evidence against spinal conditioning. It must be remembered that Shurrager and Culler (1940) used a response of much smaller magnitude than that in the Deese and Kellogg (1949) study and this response did not occur to the CS alone.

Forbes and Mahan (1963) conditioned intact cats to escape tail shock by hind limb flexion. There was no evidence of this response after cord transection or during etherization. The results, from only two animals, each of which was subjected to a different experimental procedure, were interpreted as evidence that the learning which occurred prior to cord transection was cortical and that spinal conditioning, if possible, is very difficult to achieve.

One is forced to conclude, after consideration of all the above reports, that they have provided no conclusive evidence in support of, or contradictory to, the establishment of spinal conditioning. The following are some of the weak points in this group of studies.

First, several studies used an unusual pattern of multiple stimuli as the CS. In addition, 1 sec. intervals were used between presentation of CS and UCS. The optimum interstimulus interval for some classically conditioned responses, as indicated by results from several studies (cf. Kimble, 1961, Table 13), appears to be close to 0.5 sec. Thus, 1 sec. can be considered a long interstimulus interval in these studies.

Second, most experiments have allowed the animal to recover from general anesthesia following cord transection. The foreparts of subjects have not been immobilized and Pinto and Bromiley (1950) reported that movements of the foreparts markedly affected the excitability of the isolated cord of a spinal animal.

Contrary to general opinion, Shurrager and Culler (1940) did run all controls necessary to show conditioning. Those studies which have failed to verify their results also failed to replicate the essential aspects of their experimental procedure, thereby limiting the generality of the negative results. Some results in the Shurrager and Culler work have been singled out because they do not match results from intact animals. One ordinarily would not presume to generalize results from one preparation to a vastly different preparation without experimental work, and therefore it seems rather illogical to reject results derived from a spinal animal, i.e., a preparation very different from the intact animal.

The results of Shurrager and Culler (1940) were supported in a pilot study by Fitzgerald and Thompson (1967). Using partially decerebrate spinal cats, the latter investigators presented a shock (CS) to the hip followed by shock (UCS) to the footpad. During acquisition training the amplitude of the flexion response in the conditioning group was significantly greater than in a control group given an identical number of stimuli in an unpaired pattern. A major portion of the response increase appeared in the first 20 trials, and an interstimulus interval of 0.5 sec. appeared to give better conditioning than any of a number of other interstimulus intervals used in this study although this could not be determined statistically.

The results of that pilot study led to the following investigation. The general procedure follows the early work of Shurrager and Culler, with specific modifications introduced to eliminate certain possible sources of error, such as large movements. The most drastic change introduced was surgically to render the subject comatose instead of allowing it to recover from anesthesia. As a result of this procedure there was very little skeletal muscle activity in the foreparts of the subject other than respiratory movements. Another change was to equate the tension of the individual muscles involved by using each muscle's response pattern to the UCS as a reference.

The purpose of this study was to test for spinal conditioning, using a method based on the original work by Shurrager and Culler (1940) with modifications introduced to meet most of the methodological objections from other investigators.

APPARATUS:

The Ss were anesthetized with ether and then immobilized by an RF lesion in the midbrain tegmentum. To make the brain lesion, current from a Grass Instrument Lesion Maker (Model LM-3), set at 85 volts for 35 seconds, was delivered through stainless steel electrodes 1 mm in diameter and insulated except for 4 mm at the tip. The distance between the centers of these electrodes was 4 mm. Location of the lesion is described below.

The electrodes through which the CS and UCS were delivered were stainless steel fish hooks, size 1/0. Trials were initiated automatically by a 35 mm punched tape, run through a Gerbrand Model 3A programmer. Presentation of the CS and UCS at interstimulus intervals greater than 10 seconds was also controlled by the tape programmer. Interstimulus intervals shorter than 10 seconds were timed by Tektronix V 162 and 161 units.

Muscle tension was measured by a Grass Model FT 10C force displacement transducer connected to the input of a Grass 5P 1 low level DC polygraph preamplifier. From there the signal was led into a Grass DC driver amplifier and written out by means of an oscillograph. Tension was calibrated for the complete system in grams.

A small plastic cannula was used to connect the femoral artery to a Statham blood pressure transducer which led into another preamplifier and amplifier combination in the polygraph consol. In a few subjects, blood pressure was recorded simultaneously with muscle tension.

PREPARATION:

The Ss were 42 cats supplied by the Animal Care Department of the University of Oregon Medical School. Atropine (1 mg/kg) was injected intramuscularly into the right hind limb of each S at least 30 minutes before etherization. This effectively prevented excess fluid from accumulating in the respiratory tract. A soft plastic endotrachael tube was inserted into the trachea. A small gauze compress, moistened with ether, was clipped to the end of the endotrachael tube to maintain anesthetization.

The S's head was placed in a Kopf stereotaxic apparatus and all tissue was retracted from the top of the skull. Bilateral trephine holes were made in the skull and small slits were cut in the dura. The brain lesion electrodes were positioned over these slits, straddling the sagittal sinus.

The anterior-posterior plane of the lesion was AP_0. The most medial portion of the lesion was made first with the electrodes lowered to 6 mm below H_0. After this region was lesioned the electrodes were raised and cleaned. The electrode position was moved to the right hemisphere until the left electrode was directly above the opening made by the right electrode during the first penetration. The electrodes were lowered to a position 4.5 mm below H_0 and a lesion was made. The electrodes were raised 2.0 mm and another lesion was made. The process then was repeated in the left hemisphere. Histology was not done to determine the extent of the lesions, but some of the brain structures located at the level of the lesion are the superior colliculus, interpeduncular nucleus, decussation of the superior cerebellar peduncle and mesencephalic reti-

cular formation (Snider and Niemer, 1961).

The exposed area of the brain and skull were covered with saline soaked gauze compresses which were kept moist throughout the experiment to prevent stimulation of this area by the drying of the exposed tissues.

The tissues over the tenth to the twelfth thoracic vertebrae were retracted and the dorsal part of the vertebrae and tissue surrounding the cord were removed. Immediately after the spinal cord was cut, oxycel soaked with thrombin was packed into the point of transection to facilitate coagulation of the severed blood vessels. If the transection was complete the two ends of the cord retracted leaving a space of several millimeters between them. In all cases the transection was visually inspected after bleeding was reduced to ascertain whether transection was complete, and whenever there was any doubt the process of transection was repeated and rechecked. Administration of ether ceased at this time. The area of the spinal transection was covered with gauze pads kept moist for the duration of the experiment, again to prevent stimulation arising from drying of exposed tissues.

The exact location of the spinal transection varied among Ss, but was always located between the tenth and the twelfth thoracic vertebrae. The transection at this level avoided the blood vessels entering the cord at the level of the third lumbar vertebra, which form the major vascular supply to the caudal section of the cord.

On each hip the lateral aspect of the ischium, just below the crest, was cleared of tissue for later placement of the hip pins.

The left tibialis anterior muscle and its tendon of insertion were carefully separated from surrounding tissue. The tendon was ligated and

then cut distal to the ligature. Pins were driven into both ends of the tibia in order to fix the position of the leg.

In two control animals the right femoral artery was cannulated for recording of blood pressure.

An aluminum framework was bolted to the table. Bilaterally, the sharply tapered end of an aluminum rod was driven into the ischium just below the ischial crest and the rod was clamped to the metal frame. The left hind limb was immobilized by clamping metal bone pins to the frame. A padded clamp held the foot firmly.

The string attached to the muscle tendon was fastened to the transducer mounted on the frame. To equate resting muscle tension the transducer position was varied by a rack and pinion device. The muscle length was increased slowly in 2 mm steps during which the resting muscle tension increased in fairly uniform increments. When the change in resting muscle tension suddenly increased more than usual, the length was reduced until the muscle shortened 4 to 6 mm. The transducer was then moved away from the animal in 2 mm steps, a footshock being given 60 sec. after every step, until a length was reached at which the muscle response was of lower amplitude than the response at the previous length. The muscle was returned to that previous length and held there for the duration of the experiment. This procedure made it possible to limit the number of footshocks during this phase of the experiment to a maximum of five shocks. There was a 15 min. rest period between the end of the muscle tension adjustment and the beginning of the experimental shock series.

At the completion of the experimental series 1.0 cc Nembutal (50 mg.) was injected into the brain stem. For a few animals a CS alone

series was presented until there was no observable heart beat or respiration to eliminate the possibility that responses comparable to those of a live S could be elicited from a dead S.

PROCEDURE:

The Ss were randomly assigned to one of four groups: one conditioning group and one control group, both with fixed inter-trial intervals; one conditioning and one control group both with variable intertrial intervals. Each S received in sequence, 2 to 5 UCSs during the time that the adjustments of muscle tension were being made, 40 trials with the CS alone, 30 CSs and UCSs (paired in the two conditioning groups, unpaired in the two control groups), and 30 extinction trials with CS alone.

The CS was a 100 pps, 1.0 sec. shock delivered through electrodes in the skin over the left hip. Intensity of the CS was varied during the first 10 CS alone habituation trials and finally held at a value which resulted in an "intermediate" muscle response, i.e., the response was not the maximum possible with hip shock nor was it such a weak response that there was danger of it habituating below baseline. These 10 CS alone habituation trials were not considered part of the habituation series in the final tabulation of the data.

The UCS was a 100 pps, 0.5 sec. shock delivered through the electrodes in the footpad of the left hind leg. The intensity of the UCS was set at 50 volts, the maximum intensity from a Tektronix 161 unit. The measured output at this setting was 48 volts.

Following the habituation trials to the CS alone, the Ss in the two conditioning (C) groups were given an acquisition series of paired CS-UCS trials. The interstimulus interval from CS onset to UCS onset was 0.5 sec. The CS and UCS terminated simultaneously (Figure 1A and 1C). One of the C groups, CF, received the paired stimuli at fixed 60 sec. intertrial intervals, measured from CS onset to CS onset (Figure 1A).

Figure 1. A diagrammatic representation of the time interval relationships used with each of the experimental groups. For each group, the CS duration was held constant at 1.0 sec. and the UCS duration was held constant at 0.5 sec.

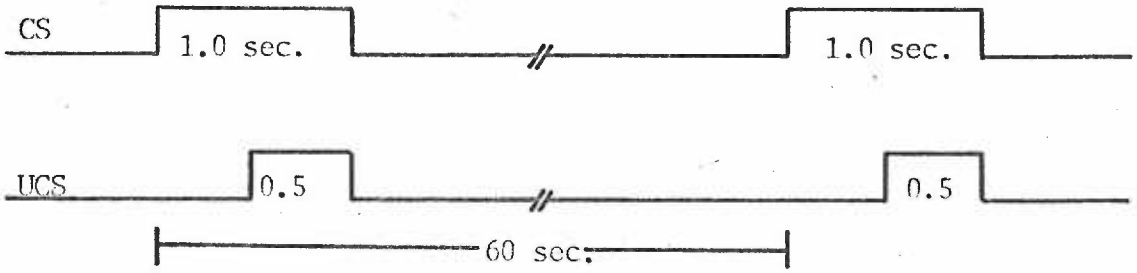
A. Group CF. The interval between the onsets of any two successive CSs was equal to 60 sec. The interval between the onset of the CS and the onset of the UCS was equal to 0.5 sec.

B. Group UF. The interval between the onsets of any two successive CSs was equal to 60 sec. The interval between the onset of the CS and the following UCS was equal to 30 sec.

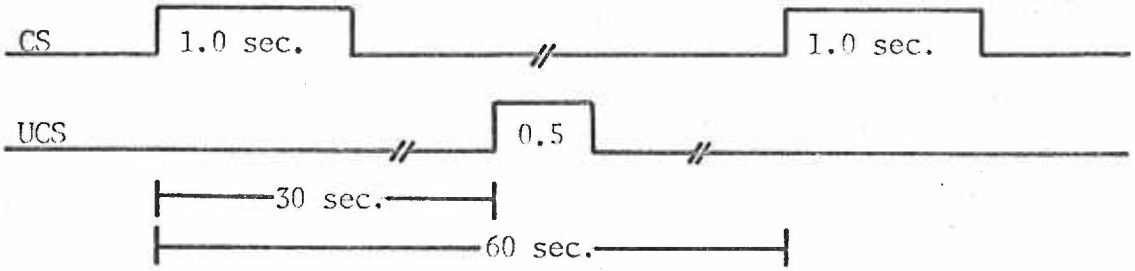
C. Group CV. The interval between the onsets of any two successive CSs was 40, 50, 60, 70, or 80 sec. The average interval between CS presentations was 60 sec. The interval between the onset of the CS and the onset of the UCS was equal to 0.5 sec.

D. Group UV. The interval between the onsets of any two successive CSs was 40, 50, 60, 70, or 80 sec. The average interval between CS presentations was 60 sec. The interval between the onset of the CS and the onset of the UCS was equal to one-half the interval between successive CSs.

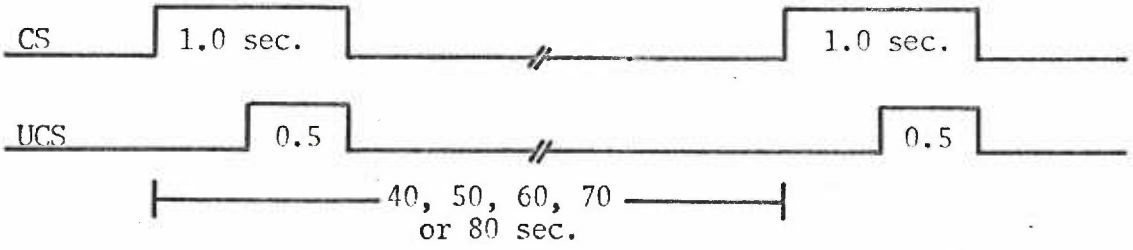
A. Group CF



B. Group UF



C. Group CV



D. Group UV

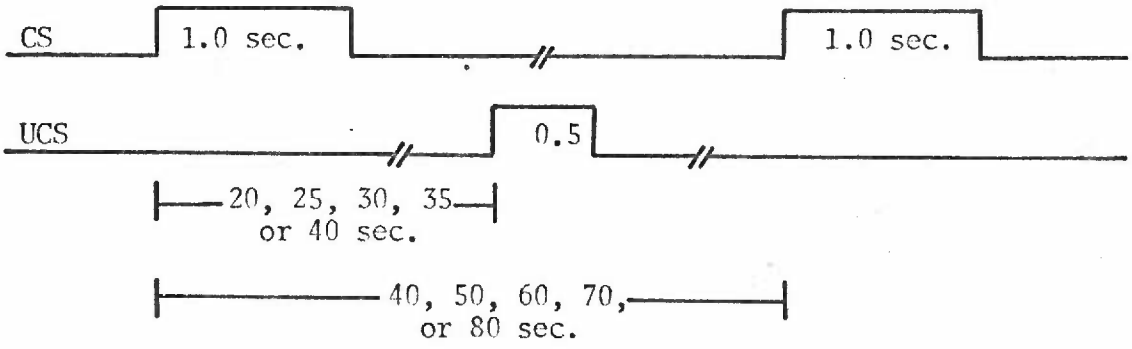


Figure 1

In the other conditioning group, CV, intertrial interval measured from CS onset to CS onset was 40, 50, 60, 70, or 80 seconds, (Figure 1C) with an average of 60 sec.

The other two groups (U) were given unpaired CS and UCS following the CS alone series. For one group, UF, the CS onset to UCS onset interstimulus interval was fixed at 30 sec., while the CS onset to CS onset intertrial interval was held at 60 sec. (Figure 1B). In the second unpaired group, UV, intertrial interval measured from CS onset to CS onset was 40, 50, 60, 70, or 80 sec., with the UCS being presented halfway between any two CSs (Figure 1D). The pattern of intertrial intervals was the same for groups CV and UV.

The response to the CS was measured in millimeters and converted to grams tension.

RESULTS:

The responses of each S on each trial are given in Tables I, II, III, and IV of the Appendix for the UF, CF, UV, and CV groups resepctively. Trial by trail plots of the mean and median response amplitudes of each group to the CS are shown in Figures 2, 3, 4, and 5, for the UF, CF, UV, and CV groups, respectively. These figures reveal that during the habituation series group UF showed an increase in response amplitude whereas the other three groups showed a decrease in response amplitude across trials. Wilcoxin matched-pairs signed-ranks tests, using the data from the 1st and 30th trial for each S, indicated that the change across trials was significant only in the CF group. Figures 2 through 5 also indicate very little overlap between the responses of the UF group and those of the other three groups, but Mann-Whitney U tests indicated no significant differences between groups in response amplitude on the final habituation trial.

The median response to the CS (in grams tension) during the last five trials of the habituation series was taken as a control level for each S. In order to adjust for different base lines, the acquisition and extinction series were each divided into ten blocks of 3 trials each and the median response of each block was converted to a percentage measure relative to the control level for that S. Figure 6 shows the median percentages of all four groups during acquisition and extinction series, with the control level set at 100 percent. Both conditioning groups, CF and CV, and one unpaired control group, UF, show a slight increase in response amplitude across acquisition trials. Response amplitude is greater in UF than in CF. The fourth group, UV, shows no increase in response amplitude

Figure 2. The amplitude of the mean and median responses to the CS (grams tension) of Group UF for each trial of CS alone (habituation), acquisition, and extinction (N = 10).

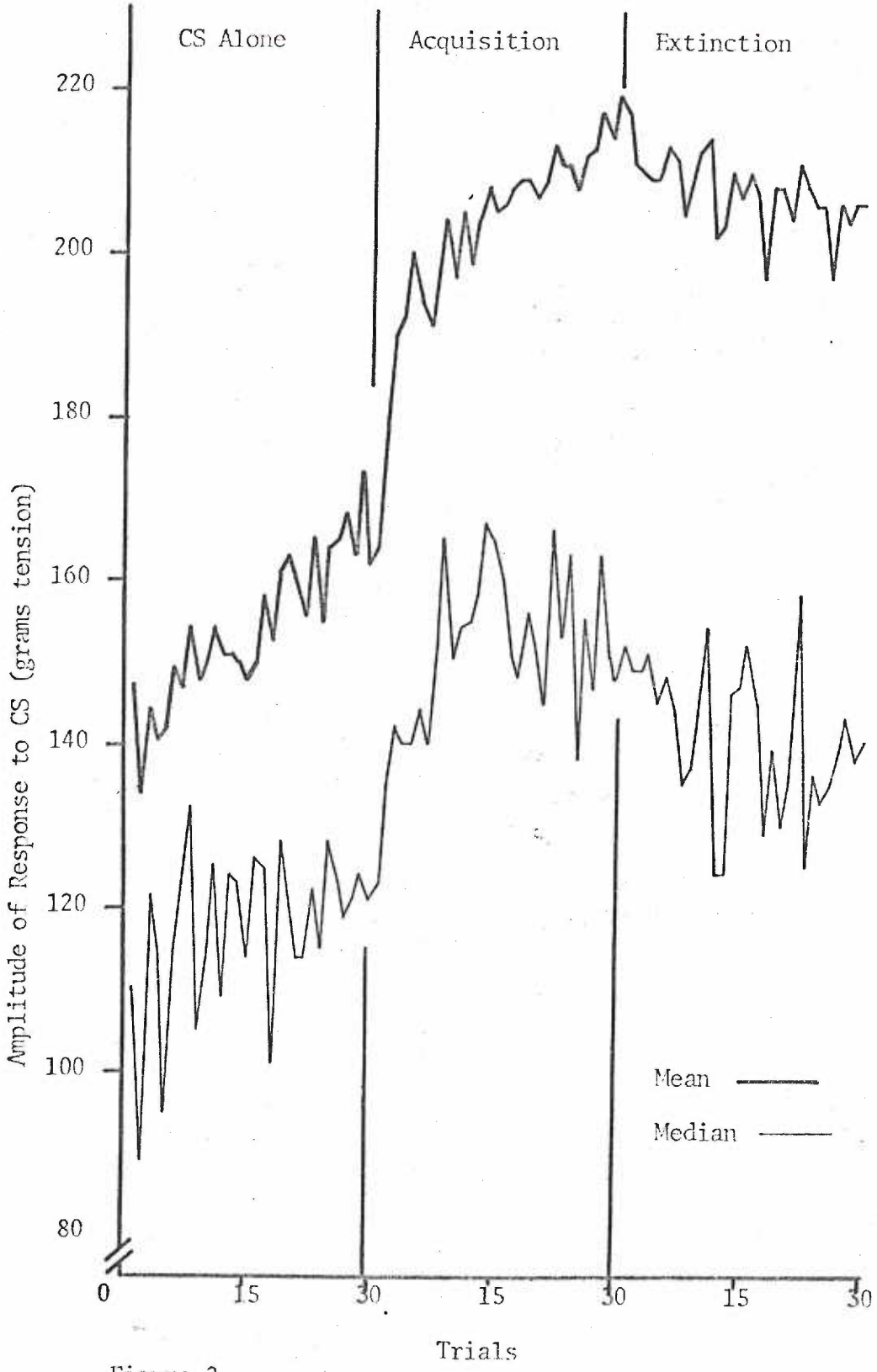

CS Alone
Acquisition
Extinction
220
200
180
160
140
120
100
80
Amplitude of Response to CS (grams tension)
Mean
Median
0
15
30
15
30
15
30
Trials

Figure 2.

Figure 3. The amplitude of the mean and median responses to the CS (grams tension) of Group CF for each trial of CS alone (habituation), acquisition, and extinction . (N = 10)

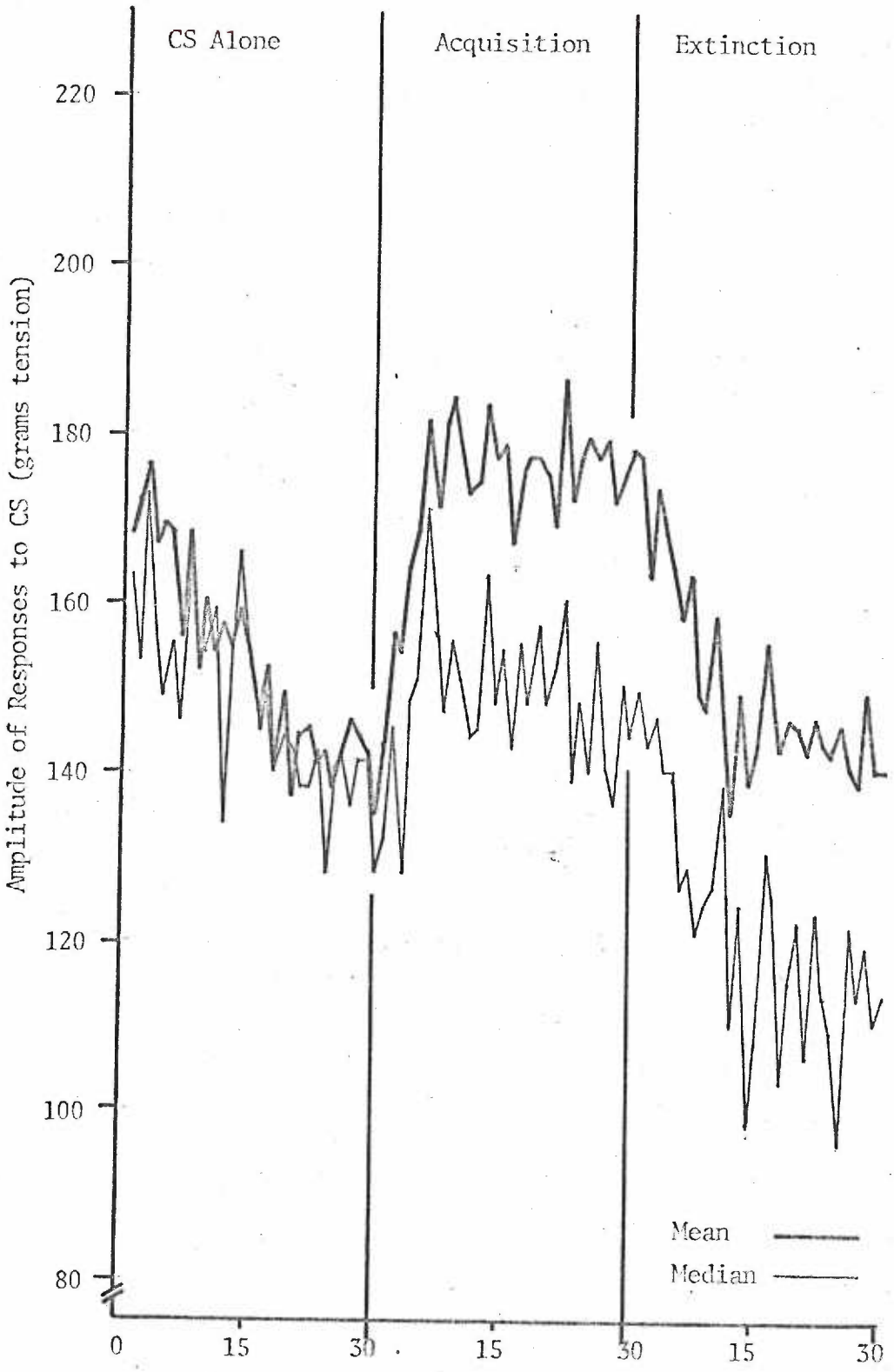

CS Alone
Acquisition
Extinction
Amplitude of Responses to CS (grams tension)
220
200
180
160
140
120
100
80
0
15
30
15
30
15
30
Mean
Median

Figure 3.

Figure 4. The amplitude of the mean and median responses to the CS (grams tension) of Group UV for each trial of CS alone (habituation), acquisition, and extinction. (N = 10)

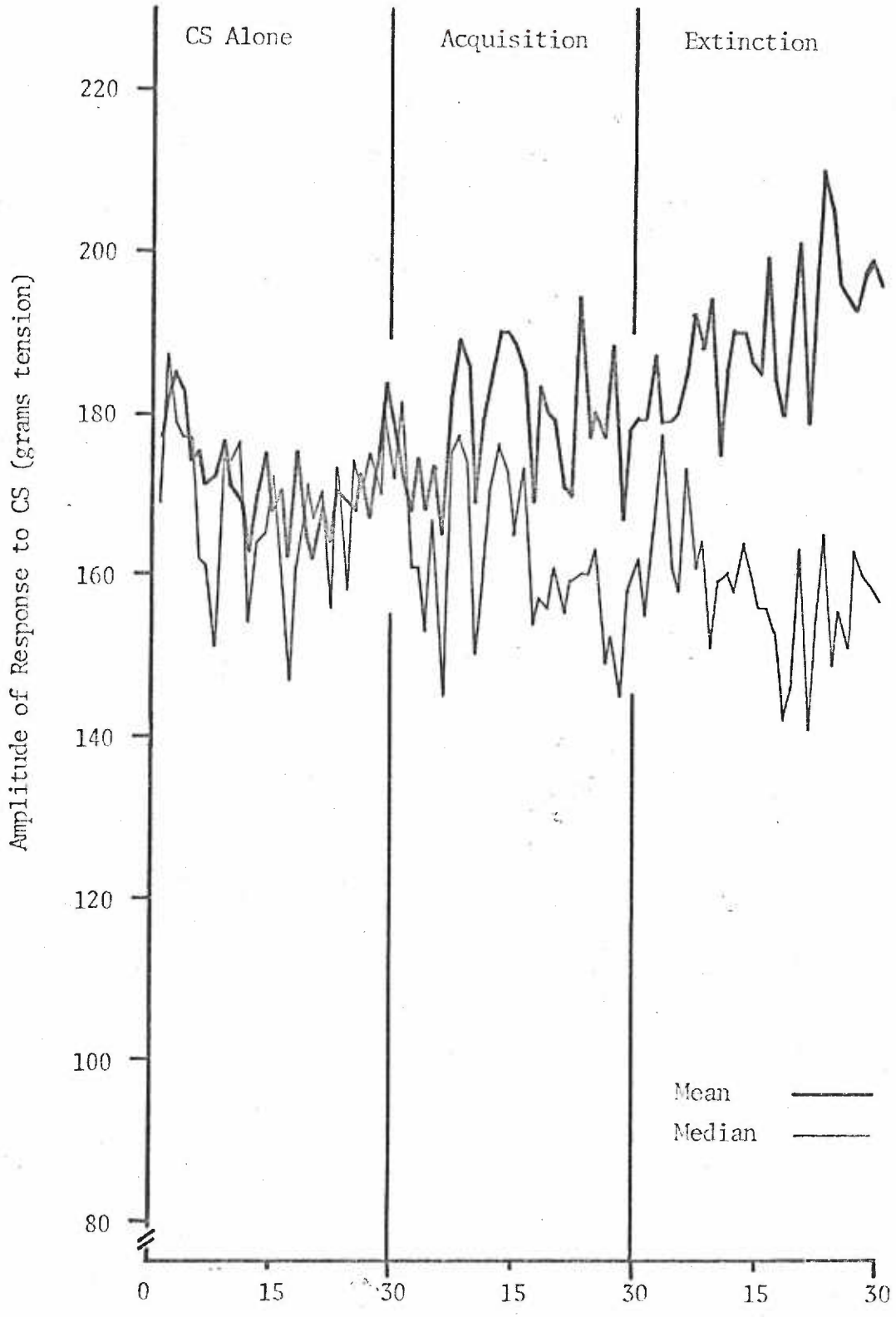

CS Alone
Acquisition
Extinction
220
200
180
160
140
120
100
80
Amplitude of Response to CS (grams tension)
Mean
Median
0
15
30
15
30
15
30

Figure 4

Figure 5. The amplitude of the mean and median responses to the CS (grams tension) of Group CV for each trial of CS alone (habituation), acquisition, and extinction. (N = 10)

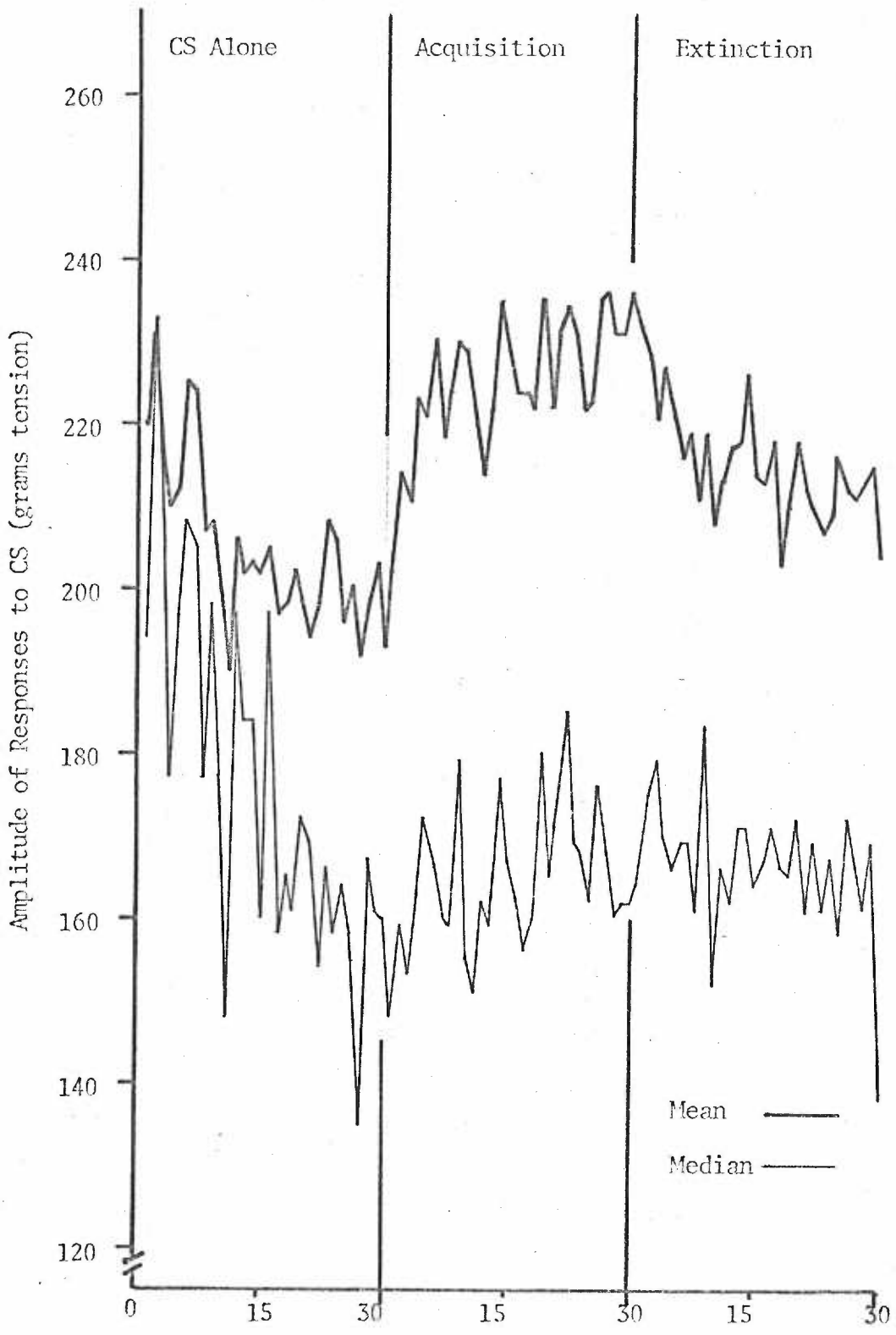

CS Alone
Acquisition
Extinction
260
240
220
200
180
160
140
120
Amplitude of Responses to CS (grams tension)
0
15
30
15
30
15
30
Mean
Median

Figure 5

Figure 6. The median percent change in the response to the CS (grams tension), N = 10 for each group. For each group the median response of the final 5-trial block of the CS alone (habituation) series = 100 percent (control level.) The median response amplitude of successive 3-trial blocks in acquisition and extinction are presented as a percentage of the control level.

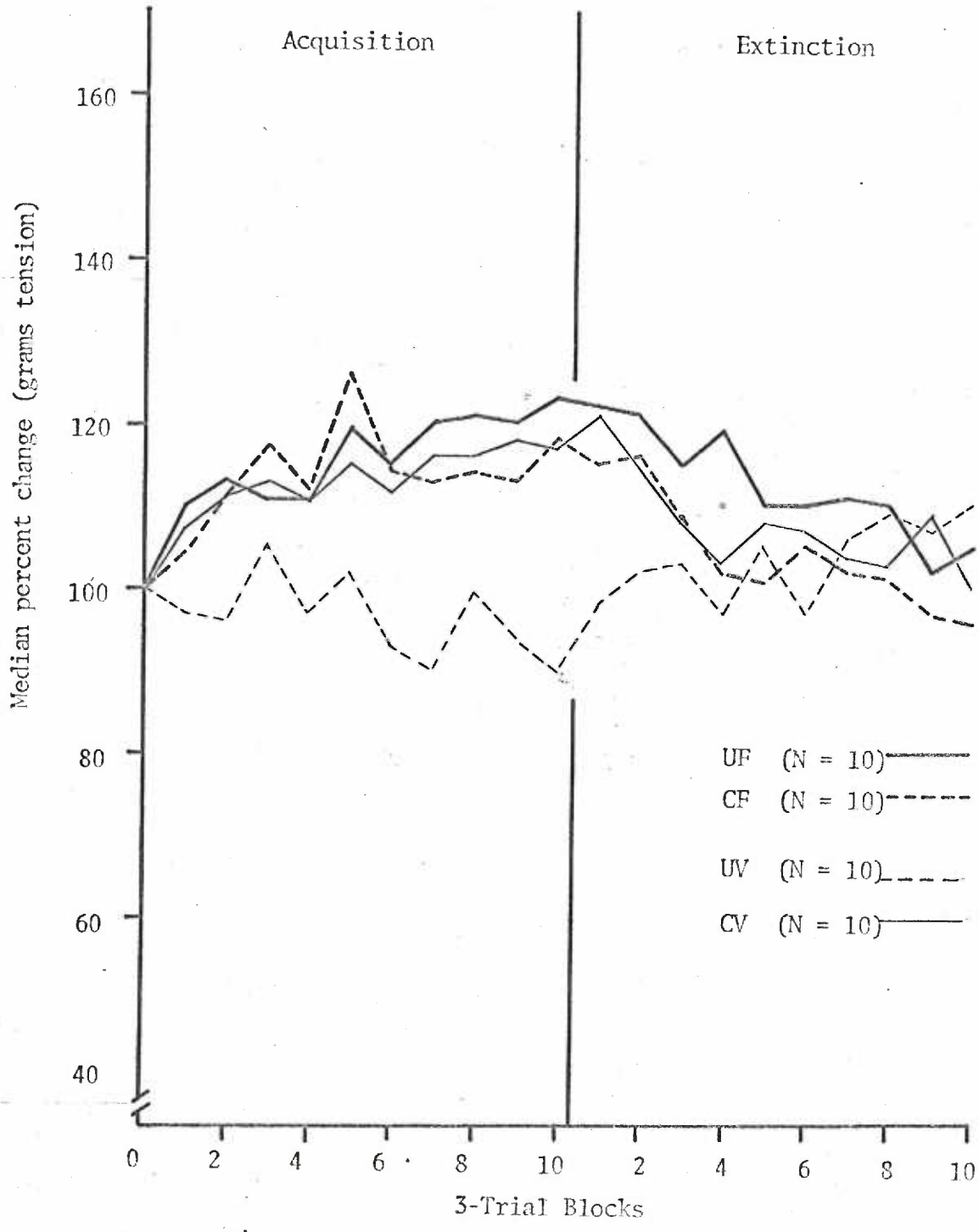

Acquisition
Extinction
160
140
120
100
80
60
40
Median percent change (grams tension)
UF (N = 10)
CF (N = 10)
UV (N = 10)
CV (N = 10)
0
2
4
6
8
10
2
4
6
8
10
3-Trial Blocks

Figure 6

by the end of acquisition trials. During extinction all groups approached their original control level.

A 2 x 2 x 10 analysis of variance with the factors being conditioning vs control, fixed vs variable intertrial intervals, and trial blocks, failed to demonstrate any significant effects in either acquisition or extinction.

The variable intertrial interval groups, UV and CV, were tested separately for the presence of conditioning. Kolmogorov-Smirnov two-sample tests on the median percent scores of each block of 3 trials for both acquisition and extinction indicated a significant difference between these two groups during acquisition ($p \leq .01$) and no significant difference during extinction.

Since the UV and CV groups differed from the other two groups (UF and CF) only in the nature of the intertrial interval, it is possible that some feature of the variable time interval, or one of the specific time intervals (40, 50, 60, 70, or 80 seconds) acted to prevent an increase in the response amplitude of the UV group during acquisition. The median response amplitudes for all Ss in each group, arranged in order of the interval from the preceding CS, are in Tables 1 (habituation), 2 (acquisition), and 3 (extinction). In groups CF and UF the interval between any two consecutive CS presentations is always 60 seconds, but the trials, for comparison purposes, are groups as if these Ss were under the variable intertrial interval program. Mann-Whitney U tests, comparing the CF and CV, UF and UV, groups at each intertrial interval were not significant, indicating that the responses of the variable intertrial interval groups, with any particular time interval, were not different from the corresponding re-

Table 1. Median response amplitudes (grams tension) arranged in order of the magnitude of the interval from the preceding CS, CS alone habituation series.

Group CF

	Seconds				
	60	60	60	60	60
Subject					
66-64	200.5	186.5	177.5	220.0	193.0
66-65	240.0	235.0	222.5	286.0	225.0
67-39	103.8	110.5	111.3	122.5	109.0
67-66	95.5	93.0	85.0	90.5	75.0
67-78	336.5	348.5	340.0	362.0	324.0
67-89	56.8	54.0	55.0	65.5	60.5
67-107	193.0	187.0	191.5	181.0	190.0
67-115	41.0	47.0	42.5	44.0	50.0
67-122	42.8	43.0	41.5	41.0	46.0
67-136	201.3	214.8	206.5	198.0	186.0

Group CV

	Seconds				
	40	50	60	70	80
Subject					
67-40	46.8	49.8	55.8	55.0	55.0
67-43	307.0	288.5	288.5	294.0	283.0
67-57	117.8	101.0	105.5	173.0	116.0
67-71	492.0	492.0	500.5	477.0	500.0
67-86	198.5	195.0	200.0	221.0	197.0
67-91	355.0	363.5	358.0	352.0	362.0
67-104	30.8	32.5	30.8	31.0	25.0
67-113	120.0	119.0	123.3	124.0	124.0
67-123	143.0	151.3	142.0	149.5	156.0
67-135	211.0	175.0	203.5	221.0	200.0

Table 1 (continued).

Group UF

	Seconds				
	60	60	60	60	60
Subject					
67-41	78.5	65.0	82.8	83.5	72.0
67-55	42.8	38.0	40.5	42.0	43.0
67-60	250.0	243.0	269.0	214.0	262.0
67-76	168.0	155.3	159.5	156.0	163.0
67-81	98.3	102.5	108.8	97.0	103.5
67-87	345.0	352.0	357.0	362.0	352.0
67-108	67.5	67.0	70.8	72.5	76.0
67-118	27.8	32.8	23.0	26.0	31.0
67-124	126.8	138.5	134.5	126.0	136.0
67-134	324.5	305.5	321.8	290.5	304.0

Group UV

	Seconds				
	40	50	60	70	80
Subject					
67-46	228.0	229.5	243.0	262.0	238.0
67-49	82.8	79.3	77.0	72.0	80.5
67-69	200.5	198.5	205.5	200.0	193.0
67-73	333.0	340.0	335.0	328.0	338.0
67-84	150.3	167.3	144.5	151.0	154.5
67-95	52.5	50.0	47.5	67.0	65.5
67-97	148.5	152.0	152.0	151.0	146.0
67-120	225.5	215.0	216.5	201.5	224.5
67-121	195.0	181.5	172.5	204.0	190.0
67-133	80.5	75.8	106.0	87.0	93.0

Table 2. Median response amplitudes (grams tension) arranged in order of the magnitude of the interval from the preceding CS, acquisition series.

Group CF

Seconds

Subject	60	60	60	60	60
66-64	207.0	204.0	196.5	208.0	193.0
66-65	344.0	326.5	328.5	317.0	301.0
67-39	97.3	104.0	93.8	106.0	95.5
67-66	88.0	89.5	92.3	89.0	92.0
67-78	431.0	435.5	456.0	456.0	432.0
67-89	56.3	50.0	51.8	48.5	56.5
67-107	210.5	211.5	216.3	214.5	211.5
67-115	71.3	62.5	73.8	67.0	78.0
67-122	47.8	60.8	44.0	47.0	41.5
67-136	202.3	199.5	195.5	204.5	200.0

Group CV

Seconds

Subject	40	50	60	70	80
67-40	36.5	47.3	46.5	55.0	48.0
67-43	399.0	378.8	379.0	372.0	379.0
67-57	74.3	78.0	82.0	70.5	82.0
67-71	574.5	578.0	578.0	571.0	571.0
67-86	180.0	176.5	164.5	176.5	176.5
67-91	457.0	454.0	466.5	452.0	462.0
67-104	41.3	38.0	39.0	47.0	38.0
67-113	155.3	153.0	150.3	149.5	147.5
67-123	144.5	160.3	144.5	143.0	147.5
67-135	219.5	210.5	204.0	214.0	221.0

Table 2 (continued).

Group UF

Seconds

Subject	60	60	60	60	60
67-41	33.3	54.0	61.8	40.5	48.0
67-55	33.5	36.0	45.0	29.5	33.0
67-60	442.0	443.5	453.5	419.0	432.0
67-76	183.8	178.0	186.3	186.0	173.0
67-81	154.5	156.8	142.0	139.5	153.0
67-87	455.0	460.0	462.0	464.0	445.0
67-108	110.5	110.0	114.5	103.0	107.0
67-118	24.0	24.0	23.3	22.0	17.0
67-124	148.5	150.3	151.3	153.0	149.5
67-134	451.5	438.5	460.0	456.0	464.0

Group UV

Seconds

Subject	40	50	60	70	80
67-46	166.5	170.0	179.8	180.0	186.0
67-49	61.8	60.0	53.8	63.5	62.0
67-69	226.5	219.5	214.0	218.0	231.0
67-73	389.0	387.5	392.5	383.0	389.0
67-84	144.5	144.3	151.3	139.5	146.0
67-95	35.0	40.0	34.3	46.0	41.0
67-97	140.3	152.0	148.5	151.0	151.0
67-120	290.5	295.0	302.0	280.0	283.0
67-121	193.5	271.0	179.5	228.0	248.0
67-133	87.3	93.0	75.5	83.0	103.0

Table 3. Median response amplitudes (grams tension) arranged in order of the magnitude of the interval from the preceding CS, extinction series.

Group CF

Seconds

Subject	60	60	60	60	60
66-64	138.0	154.0	131.0	149.0	141.0
66-65	270.0	275.5	254.0	270.0	250.0
67-39	83.5	82.0	92.0	104.0	89.0
67-66	84.5	89.8	85.0	94.5	95.5
67-78	331.0	327.5	324.0	329.5	331.0
67-89	63.0	60.5	62.0	59.5	60.0
67-107	210.0	208.3	214.5	211.5	211.5
67-115	65.5	67.0	58.0	75.3	61.5
67-122	36.5	38.8	50.0	36.8	49.5
67-136	194.0	185.5	191.5	177.5	179.5

Group CV

Seconds

Subject	40	50	60	70	80
67-40	34.3	45.0	45.0	53.8	49.5
67-43	362.0	365.0	342.0	343.5	342.0
67-57	76.3	54.0	60.0	70.5	74.0
67-71	543.5	550.0	557.0	557.0	523.0
67-86	175.3	183.8	186.0	177.8	184.5
67-91	461.0	455.0	458.0	457.0	468.0
67-104	29.5	30.5	30.5	39.8	37.0
67-113	152.8	156.8	151.0	156.8	157.7
67-123	115.5	104.0	124.0	130.3	124.0
67-135	191.5	203.5	180.0	186.5	211.0

Table 3 (continued).

Group UF

	Seconds				
	60	60	60	60	60
Subject					
67-41	20.0	40.3	30.0	30.0	30.0
67-55	32.8	29.8	41.5	31.8	31.0
67-60	489.5	489.5	488.0	481.0	491.0
67-76	220.8	217.5	218.0	220.8	221.5
67-81	120.0	120.0	127.5	122.3	119.0
67-87	367.0	338.5	376.0	377.5	379.0
67-108	121.5	114.0	124.0	116.8	122.0
67-118	27.5	26.0	23.5	25.8	27.0
67-124	151.0	152.0	153.0	160.3	156.0
67-134	515.5	500.0	504.0	508.5	497.0

Group UV

	Seconds				
	40	50	60	70	80
Subjects					
67-46	152.0	149.3	170.0	159.5	156.0
67-49	44.5	53.0	53.0	54.8	56.5
67-69	269.5	276.0	310.0	276.0	283.0
67-73	403.0	397.5	405.0	404.0	405.0
67-84	157.5	146.8	157.5	149.3	156.0
67-95	53.5	48.5	41.0	62.8	55.5
67-97	149.3	147.8	149.5	147.8	154.5
67-120	348.0	334.5	342.0	360.0	331.0
67-121	264.0	226.0	241.0	245.0	238.0
67-133	67.0	69.8	62.0	73.5	73.5

sponses of the fixed intertrial interval groups.

A detailed examination of the responses on successive trials during habituation disclosed that several Ss failed to show a decrease in response amplitude, with some Ss actually showing an increase in response amplitude. Under the conditions employed in this study, i.e., repeated applications of a stimulus (the CS) which elicited a response, the expected result would be a decrease in response amplitude (Harris, 1943; Thompson and Spencer, 1966). Therefore, Ss showing an increased response amplitude did not follow the normal pattern. It could also be argued that any S which did not show a decrease in response amplitude across trials also did not follow the normal pattern. However, in the case of the present study it must be remembered that there was a series of ten trials immediately preceding the habituation series which were not counted. It is possible that the responses of some Ss habituated completely during these ten uncounted trials. Therefore, simple failure to show a decrease in response amplitude during the remaining habituation trials cannot be taken as evidence that habituation did not occur.

In order to check on the possible effects of including Ss showing an increase in response amplitude during habituation on the analysis of acquisition and extinction, their data were eliminated and further tests were made. An increase in response amplitude during habituation was arbitrarily defined as an increase of at least 10 percent in the medians of the last two 5-trial blocks, as compared to the median of the first 5-trial block of the habituation series. This eliminated 3 Ss (67-60, 67-124, and 67-134) from group UF, 4 Ss (66-67, 67-78, 67-115, and 67-122) from group CF, 1 S (67-71) from group CV and no S from

group UV (Table 4). The results for the remaining Ss are given in Figure 7. A Kolmogorov-Smirnov two-sample test indicated a significant difference between the CV and UV groups in both acquisition ($p \leq .01$) and in extinction ($p \leq .01$) and a significant difference ($p \leq .05$) between broups CF and UF in acquisition but not in extinction. Response amplitude is greater in UF than in CF.

An example of another response pattern which appeared is given in Figure 8, for a S in the UF group. With the introduction of the UCS the response amplitude abruptly shifted, and by the end of the acquisition trials the response amplitude was at a much higher level than at the end of the habituation trials. During the extinction trials the response amplitude remained at this high level. Several Ss showed an increased response amplitude during the acquisition series which persisted throughout the extinction series. This could be considered an example of high resistance to extinction. Another possibility is that it reflected a physiological deterioration of the S (for example, acid-base changes), which was unconnected with a specific pattern of stimulus presentation and which ultimately resulted in an increase in response amplitude.

Thompson and Spencer (1966) demonstrated that sensitization reflects a process separate from habituation and cannot be considered merely as disruption of habituation. Therefore, an increase in response amplitude during the acquisition series in this study could indicate conditioning or sensitization or the deterioration of the preparation. Increases relfecting conditioning or sensitization would be expected to decrease during the extinction phase. The increase resulting from deterioration of the preparation would not necessarily decrease during the extinction series and might well become more pronounced. Assuming

Table 4. Subjects remaining after elimination of Ss showing an increase in median response amplitude during the CS alone habituation series.

Group UF	Group CF
67-41	66-64
67-55	67-39
67-76	67-66
67-81	67-89
67-87	67-107
67-108	67-136
67-118	

Group UV	Group CV
67-46	67-40
67-49	67-43
67-69	67-57
67-73	67-86
67-84	67-91
67-95	67-104
67-97	67-113
67-120	67-123
67-121	67-135
67-133	

Figure 7. The median percent change in the response to the CS (grams tension) after elimination of those Ss which failed to show habituation during the CS alone (habituation) trials. For each group, the median response of the final 5-trial block of the CS alone (habituation) seris = 100 percent (control level). The median response amplitude of successive 3-trial blocks in acquisition and extinction are presented as a percentage of the control level. Group UF, N = 6; Group CF, N = 7; Group UV, N = 10; Group CV, N = 9.

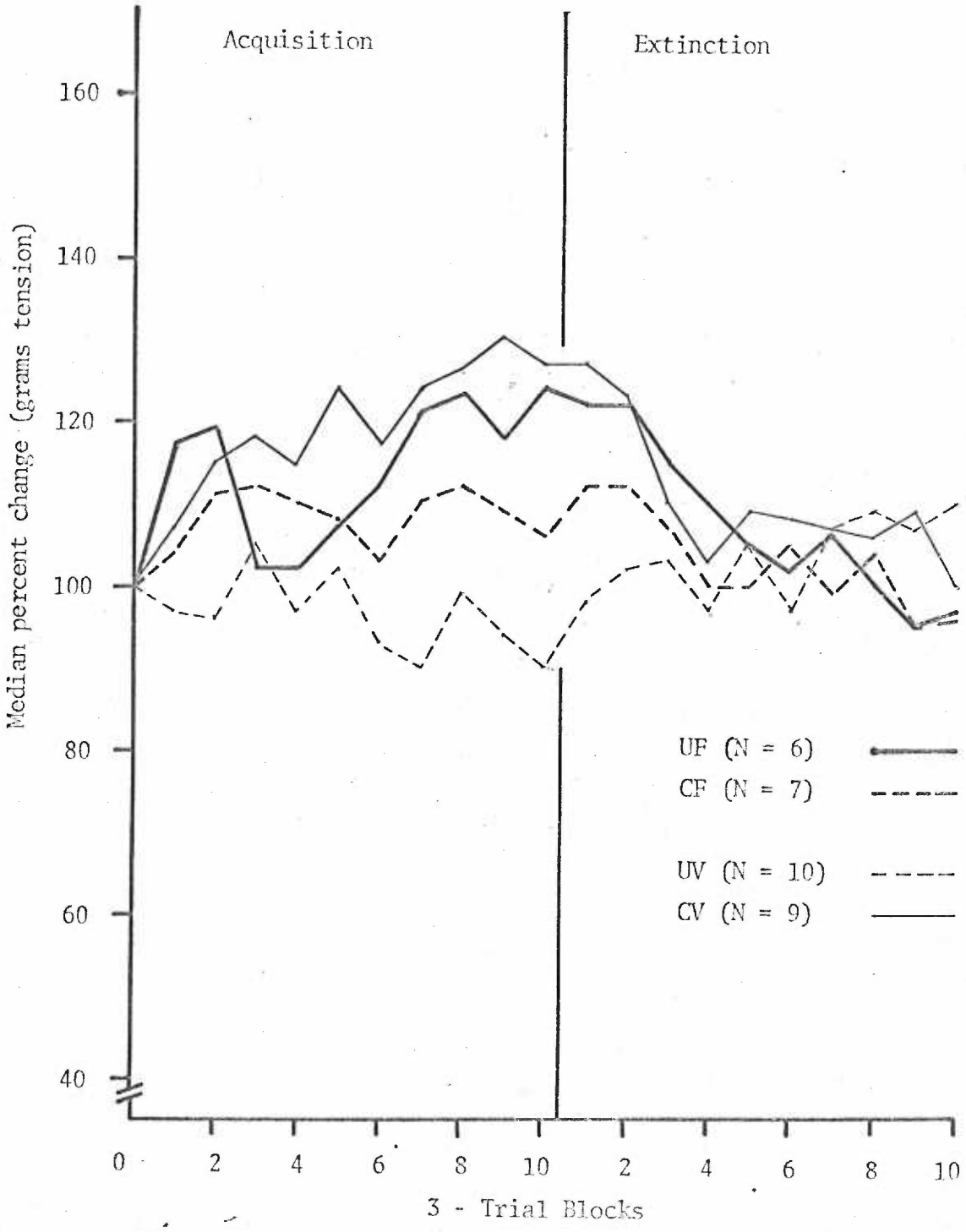

Acquisition
Extinction
160
140
120
100
80
60
40
Median percent change (grams tension)
UF (N = 6)
CF (N = 7)
UV (N = 10)
CV (N = 9)
0
2
4
6
8
10
2
4
6
8
10
3 - Trial Blocks

Figure 7

Figure 8. Amplitude of the response to the CS (grams tension) for S 67-108 from Group UF, for each trial of CS alone (habituation), acquisition, and extinction.

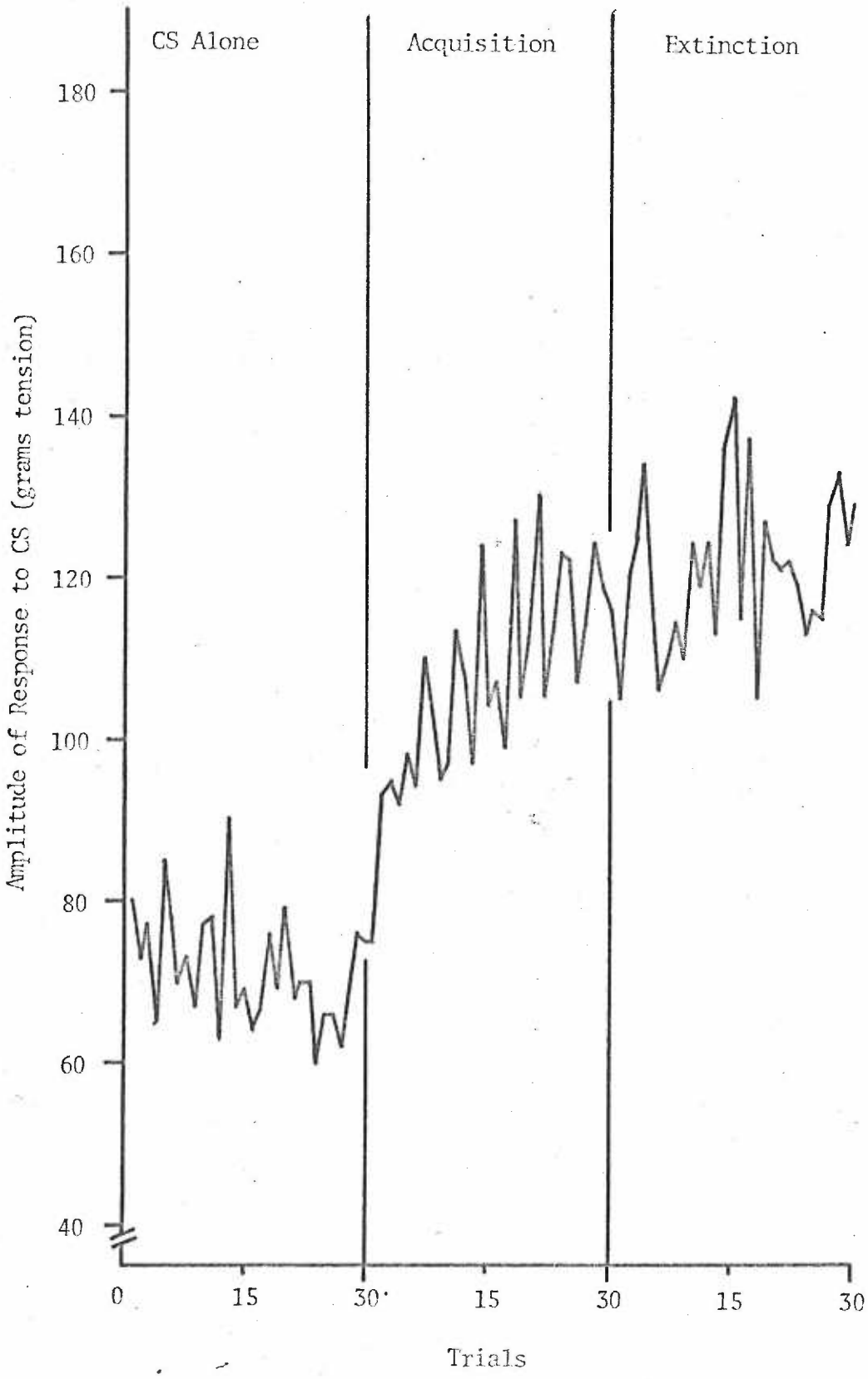

CS Alone
Acquisition
Extinction
180
160
140
120
100
80
60
40
Amplitude of Response to CS (grams tension)
0
15
30
15
30
15
30
Trials

Figure 8

that the failure of some Ss to show decrease in response amplitude during extinction reflected physiological deterioration and not simply an unusually high level of resistance to extinction, Ss in which the median response during the last two blocks of 3 trials in the extinction series was at least 15 percent greater than the median response during the last 5 habituation trials were eliminated from the list of Ss which showed habituation. This removed 2 Ss (67-76 and 67-108) from group UF, 1 S (67-89) from group CF, 3 Ss (67-43, 67-91, and 67-113) from group CV and 4 Ss (67-69, 67-73, 67-95, and 67-120) from group UV. The remaining Ss in each group are shown in Table 5. The data of these Ss are given in Figure 9. A Kolmogorov-Smirnov two-sample test indicated a significant difference between a) the fixed interval groups, CF and UF, in acquisition ($p \leq .01$) but not in extinction, and b) the variable interval groups, CV and UV, during acquisition ($p \leq .01$) and extinction ($p \leq .01$). Response amplitude is greater in UF than in CF.

Heart-rate data can be presented for only one S, 67-142. Instability of the record of the second control S made it impossible to obtain accurate heart-rate data for that S The responses of the tibialis anterior muscle to the CS in S 67-142 are given in Figure 10. The number of beats was tabulated for the 2.5 second period immediately preceding and following the onset of the CS (Table 6). Wilcoxin matched-pairs signed-ranks tests indicated no significant differences between these two heart-rate measures during habituation, acquisition, or extinction.

The muscle responses of S 67-142 on each trial were tested for randomness by a one-sample runs test in habituation, acquisition, and extinction. The results were significant ($p \leq .05$) only for habituation

Table 5. Subjects remaining after elimination of Ss showing an increase in median response amplitude during the CS alone habituation series or an increased median response amplitude at the end of the extinction series.

Group UF	Group CF
67-41	66-64
67-55	67-39
67-81	67-66
67-87	67-107
67-118	67-136

Group UV	Group CV
67-46	67-40
67-49	67-57
67-84	67-86
67-97	67-104
67-121	67-123
67-133	67-135

Figure 9. The median, percent change in the response to the CS (grams tension) after elimination of those Ss which failed to show habituation during the CS alone (habituation) trials and those Ss which had a response level at least 15 percent above control on the last two 3-trial blocks of extinction trials. For each group, the median response of the final 5-trial block of the CS alone (habituation) series = 100 percent (control level). The median response amplitude of successive 3-trial blocks in acquisition and extinction are presented as a percentage of the control level. Group UF, N = 5; Group CF, N = 5; Group UV, N = 6; Group CV, N = 6.

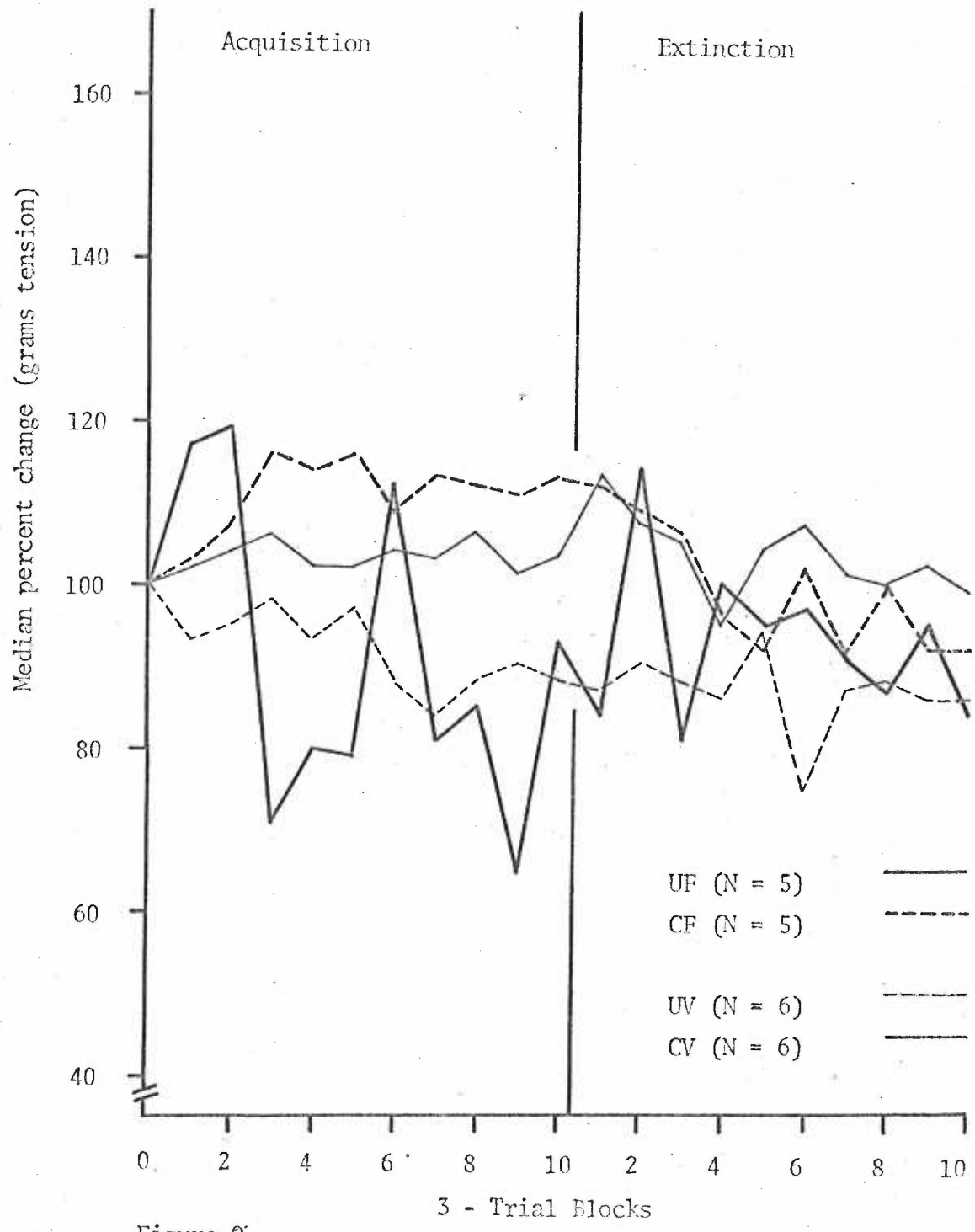

Acquisition
Extinction
160
140
120
100
80
60
40
Median percent change (grams tension)
UF (N = 5)
CF (N = 5)
UV (N = 6)
CV (N = 6)
0
2
4
6
8
10
2
4
6
8
10
3 - Trial Blocks

Figure 9

Figure 10. Amplitude of the response to the CS (grams tension) for S 67-142 for each trial of the CS alone (habituation), acquisition, and extinction. The heart rate recorded from this S 2.5 sec. before and 2.5 sec. after the CS are presented in Table 10.

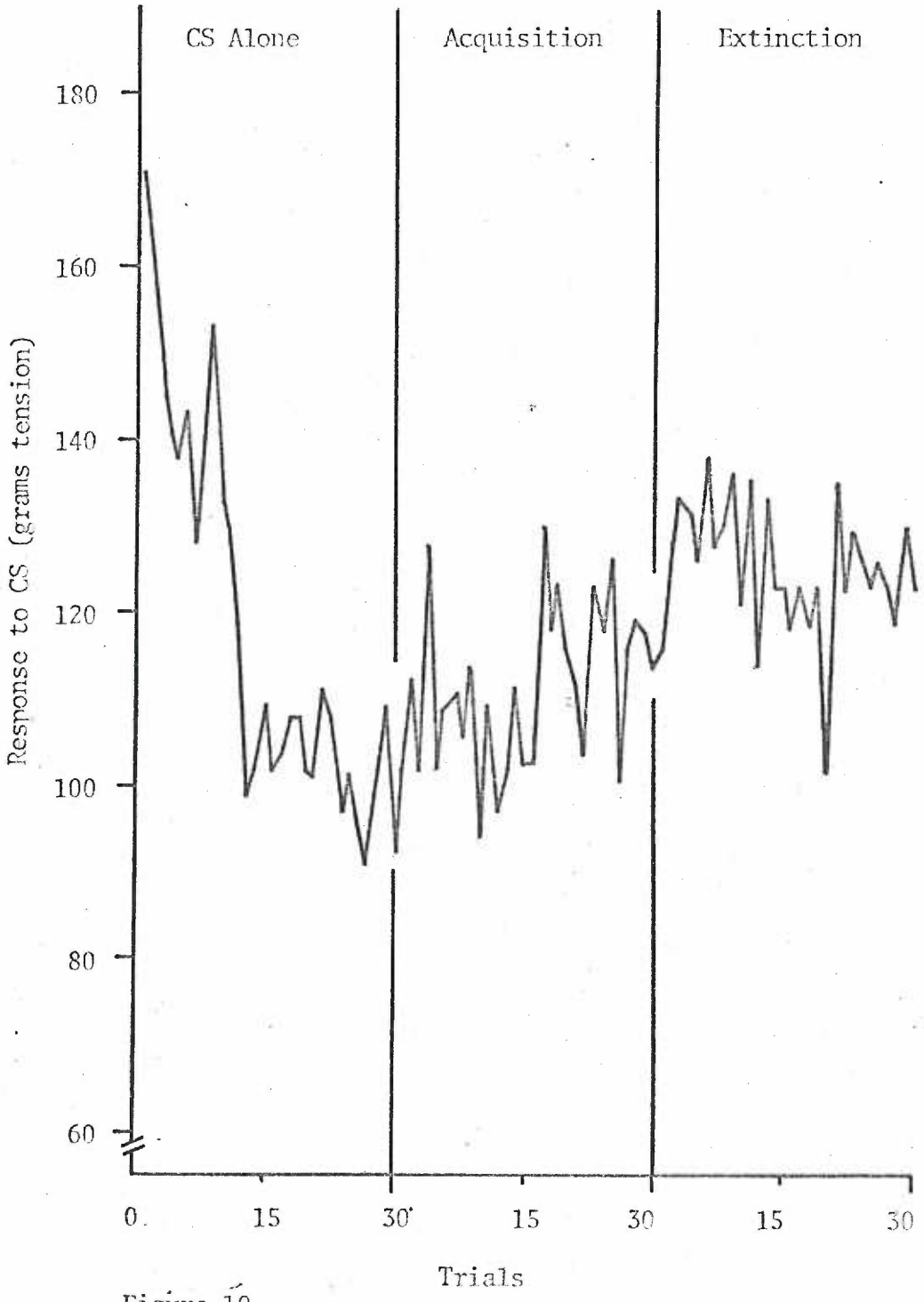

CS Alone
Acquisition
Extinction
180
160
140
120
100
80
60
Response to CS (grams tension)
0
15
30
15
30
15
30
Trials

Figure 10

Table 6. Number of heart beats in 2.5 second period preceding CS onset and 2.5 second period following CS onset.

	CS Alone		Acquisition		Extinction	
Trial	Pre-CS 2.5 sec	Post-CS 2.5 sec	Pre-CS 2.5 sec	Post-CS 2.5 sec	Pre-CS 2.5 sec	Post-CS 2.5 sec
1	7	8	7	7	7	7
2	8	7	7	7	6	7
3	7	8	7	7	7	7
4	8	7	7	7	7	7
5	7	8	7	7	7	7
6	7	8	7	7	6	7
7	7	7	7	7	6	7
8	7	8	7	7	7	7
9	7	8	8	7	7	7
10	7	8	7	7	7	7
11	7	7	7	8	7	6
12	7	7	7	7	7	7
13	7	8	8	7	7	7
14	8	7	7	7	7	7
15	7	7	7	7	7	7
16	8	7	7	7	6	7
17	8	7	7	7	7	7
18	7	7	7	7	7	7
19	8	7	7	7	7	7
20	8	7	7	7	7	6
21	8	7	7	7	7	7
22	7	7	7	7	7	6
23	7	7	7	6	7	7
24	7	7	7	7	6	7
25	7	7	7	7	6	7
26	7	7	7	7	7	6
27	7	7	7	7	6	7
28	7	7	7	6	7	7
29	7	7	7	7	7	6
30	7	7	7	7	7	6

trials, indicating that the distribution of scores deviated from randomness in habituation trials.

The occurrence of the CS or UCS did not produce any visible change in the blood pressure of the control S. In addition, there was no visible change in blood pressure during the muscular contractions following the CS or UCS. The effect on blood pressure of the muscular response to the CS and UCS was not determined in the left hind leg.

DISCUSSION:

The results of the analysis of variance, using data from all Ss in all groups, did not provide support for the presence of spinal conditioning under the conditions of this experiment.

The large inter-S variability in the muscle response of the Ss may be attributed, in part at least, to differences in the size and the strength of the Ss. An attempt was made to control these variables by restricting the Ss in terms of size and weight and by equating the amplitude of the muscle responses before starting the experimental procedures.

When the variable intertrial interval groups (UV and CV) were tested apart from the fixed intertrial interval groups, some evidence of spinal conditioning was obtained. The analysis of the responses of the UV and CV groups indicated that they were not substantially different from the responses that occurred on identical trials under a constant intertrial interval. This would seem to indicate that any effect attributable to the variable intertrial interval procedure cannot be from any one of the particular intervals that were used. It may be that any fixed intertrial interval would produce the same results found in groups UF and CF or that any combination of variable time intervals would produce results similar to those of groups UV and CV. Fitzgerald and Thompson (1967) did find positive results of spinal conditioning. In that study, however, the CS-UCS interval and the intertrial intervals were deliberately varied between Ss, while the intervals used with any individual S were held constant.

Habituation, defined as "response decrement as a result of repeated stimulation" (Harris, 1943), has been repeatedly demonstrated in a variety of animals and with several responses (Engen and Lipsitt, 1965; Harris, 1943; Lethlean, 1965; Marsh, McCarthy, Sheatz and Galambos, 1961). The failure of some Ss in the current experiment to exhibit habituation during the pre-test CS alone trials under conditions similar to those used in previous studies is difficult to explain. Thompson and Spencer (1966) demonstrated habituation of the flexion response of the tibialis anterior muscle in the acute unanesthetized decerebrate cat with spinal transection. However, the intertrial intervals in the present study were quite long as compared to those used by Thompson and Spencer, and it may be that this difference accounts for the failure of some Ss to show habituation.

Another possible explanation is that in those Ss that failed to exhibit habituation there was a general deterioration of physiological functioning. This could also explain the increase in response amplitude during extinction trials which was shown by some Ss. It is, however, entirely possible that, under the conditions employed in this experiment, resistance to extinction is more pronounced than in intact Ss that are classically conditioned. It is also possible that the Ss with severe physiological deterioration are the same ones whose response level returned to control level during extinction trials.

Shurrager and Culler (1940) used extinction of the CR as one of their criteria for conditioning. Using 15 percent above control level as the criterion for failure to extinguish the CR eliminated 4 Ss (66-65, 67-89, 67-107, and 67-115) from group CV.

The first conditioning criterion listed by Shurrager and Culler

(1940) was that the "CR is not present upon the original presentation of the CS." One can argue that, in the present study, the CR was the original response to the CS. The position taken here, however, is that the original response pattern to the CS is a decrease in response amplitude across trials, i.e. habituation, and that a shift to a pattern of an increase in response amplitude across conditioning trials was not the same response. In Figure 9 of the present study, 45 percent of the Ss given the conditioning procedure were eliminated for failing to habituate or failing to extinguish the CR. This approximates the 50 percent Shurrager and Culler (1940) reported as failing to show conditioning. Unfortunately, Shurrager and Culler did not report how many animals failed to meet each conditioning criterion.

The 55 percent of the Ss which showed conditioning did so in 30 trials. This also agrees with Shurrager and Culler's report of conditioning in 30 to 40 trials, a point questioned by Kellogg (1947). It must be remembered that the results of analyses not involving all Ss included in this study should be considered as coming from biased samples and therefore no strong conclusion can be drawn from them.

The large inter-S variability suggests that amplitude of the muscle response employed in this study may be an inappropriate measure to use in a test of spinal conditioning because the factors influencing it cannot be adequately controlled. Therefore, it would seem desirable that another test for spinal conditioning be made, employing a variety of physiological monitors to determine the stability of the preparation and recording responses of spinal motor neurons instead of muscle twitches. In such a preparation it might be possible to analyze the effects of many conditioning factors and, hopefully, to obtain a bet-

ter understanding of what happens in the spinal neurons during classical conditioning.

The unusual pattern of stimulus presentations employed in some of the previous spinal conditioning studies was mentioned earlier in this paper. The present study employed one of the most common and simple CS-UCS patterns in order to avoid the problem of overlapping effects of several discrete stimuli which, as a unit, are termed the CS (Shurrager and Culler, 1940; Kellogg, et al., 1947).

Immobilization of the foreparts of S has been shown by Pinto and Bromiley (1950) to be important in any assessment of changes in responsiveness posterior to the spinal transection. In the present study immobilization of the foreparts was accomplished by a large bilateral lesion of the reticular formation which rendered the S comatose. This does not mean that there were no movements at all anterior to the section, for respiratory movements continued throughout the experimental period. But large movements involving repositioning of the limbs and all movements which could be considered as "struggling" were absent.

The heart-rate results from the control animal in the present study cannot be used as the basis for strong conclusion. They do seem to indicate that there was no direct effect from using electrical stimuli.

SUMMARY AND CONCLUSIONS:

In summary, the data from all four groups in this study, taken together, do not support spinal conditioning. The performance of the fixed interval control group essentially matches that of the fixed interval experimental group. The two groups in which a variable intertrial interval was used do differ in their performance across trials in a manner suggesting conditioning and extinction of the flexion reflex. Of all the Ss given the conditioning procedure, 55 percent (11 Ss) met conditioning criteria used originally by Shurrager and Culler (1940) while 45 percent (9 Ss) did not meet the criteria through failure to habituate or failure to show extinction. Conditioning in these 11 Ss occurred within 30 trials. These results agree with the results of Shurrager and Culler (1940). It is possible that certain factors in the experimental situation relating to the physiological condition of the subject might account for the response patterns of several subjects, and these factors should be tested in any future experimental work on this topic.

It is suggested that perhaps a better test of spinal conditioning would involve analysis of responses from spinal motor neurons in a preparation similar to that used in this study, with physiological monitoring to indicate the physiological stability of the preparation.

APPENDIX

Table I. Individual response records for subjects in Group UF. Response amplitude to the CS is in grams tension.

GROUP UF

67-41

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	82	49.5	49.5
2	69	16	16
3	83.5	48	18
4	69	35	22
5	82	70.5	51
6	95.5	58	55
7	48	35	42.5
8	82	42.5	45
9	75	63.5	30
10	106	42.5	0
11	48	63.5	53
12	83.5	48	24
13	79	40.5	49.5
14	94	49.5	30
15	65	31.5	20
16	79	48	46.5
17	85	45	22
18	72	53	45
19	109	36.5	14
20	82	35	24
21	55	16	38
22	53	62	30
23	79	55	46.5
24	51	31.5	16
25	97	63.5	20
26	65	33.5	14
27	65	36.5	30
28	85	40.5	30
29	85	56.5	30
30	35	60	12

GROUP UF

67-55

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	21	42	36
2	43	19	27.5
3	28.5	42	37
4	41	62	49
5	44	51	38
6	51	38	50
7	31	27	45
8	24	29.5	21
9	57	38	27.5
10	33	34.5	56
11	55.5	37	25
12	36	34	30
13	49	59	45
14	22.5	33	31
15	35	34	52
16	36	34.5	47
17	59	50	41.5
18	52	48	22.5
19	41.5	11.5	39
20	54	18	41
21	48.5	33	12.5
22	29.5	27	24
23	42	18	36
24	34	20	26
25	46	25	17
26	49	24	16
27	40	32	51
28	47	40	36
29	43	30	36
30	31	65	27.5

GROUP UF

67-60

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	225	335	481
2	197	345	477
3	218	349	494
4	204	389	471
5	197	379	471
6	207	405	477
7	231	429	471
8	234	419	485
9	225	416	497
10	214	432	488
11	221	416	504
12	231	435	504
13	234	416	488
14	248	432	491
15	248	432	497
16	238	449	475
17	262	445	507
18	262	452	488
19	252	445	488
20	276	458	477
21	262	452	510
22	273	464	491
23	290	458	485
24	290	484	485
25	269	462	491
26	300	458	491
27	307	488	504
28	310	488	477
29	321	477	504
30	314	497	494

GROUP UF

67-76

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	174.5	186	223
2	153	176	214.5
3	146	161	206.5
4	149.5	168	220
5	171.5	170	213
6	134.5	161	214.5
7	143	161	223
8	157.5	166	228
9	173	171.5	223
10	166	176	223
11	161	166	213
12	190	163	213
13	159.5	173	220
14	141	190	226.5
15	139.5	174.5	218
16	149.5	173	221.5
17	166	179.5	216.5
18	183	184.5	214.5
19	164.5	206.5	220
20	159.5	193	220
21	153	196.5	226.5
22	163	203	230
23	156	200	230
24	181	191.5	231.5
25	161	193	221.5
26	156	211.5	213
27	168	193	221.5
28	159.5	201.5	220
29	163	200	218
30	166	213	226.5

GROUP UF

67-81

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	102	109	133
2	70	127.5	141
3	97	143	129.5
4	102	142	136
5	62	143	134.5
6	94.5	143	136
7	103.5	143	131
8	130	149	126
9	103.5	176	120.5
10	103	149.5	136
11	113	164.5	144.5
12	97	156	112
13	103.5	151	122.5
14	107	176	119
15	89	163	117.5
16	109	170	124
17	100	143	112
18	103	163	117.5
19	138	159.5	122.5
20	117.5	157.5	129.5
21	91	143	104
22	97	139.5	116
23	115	147.5	106
24	93	176	109
25	119	133	102
26	109	153	109
27	100	133	104
28	119	141	97
29	111	159.5	127.5
30	103	133	106

GROUP UF

67-87

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	362	349	475
2	362	419	471
3	362	432	449
4	352	458	396
5	355	468	438
6	396	449	429
7	369	449	416
8	389	464	358
9	345	462	403
10	331	435	409
11	376	475	386
12	362	438	358
13	328	464	324
14	345	442	396
15	352	477	335
16	342	445	358
17	362	481	358
18	338	458	310
19	345	484	372
20	352	471	379
21	412	477	342
22	352	458	365
23	362	475	376
24	335	452	369
25	331	449	392
26	352	484	335
27	392	475	324
28	317	449	328
29	372	449	352
30	345	456	362

GROUP UP

67-108

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	79.5	75	105
2	72.5	92.5	120
3	77	95	125
4	65	91.5	133.5
5	84.5	98	115
6	78	94	106
7	70	110	109.5
8	72.5	103	114
9	67	95	110
10	77	96.5	124
11	78	113	118.5
12	63	108	124
13	90	96.5	113
14	66.5	123.5	135.5
15	69	103.5	141.5
16	64	107	115
17	67	99	136.5
18	76	127	105
19	69	104.5	127
20	79	112	122
21	68	130	121
22	70	104.5	122
23	70	113	118.5
24	60	122.5	113
25	65.5	122	116
26	65.5	107	115
27	61.5	114	129
28	69	124	132.5
29	76	117.5	124
30	75	116	128.5

GROUP UF

67-118

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	34.5	18	27
2	19	41.5	19
3	25	68	25
4	35.5	30.5	27.5
5	25	65.5	30.5
6	22	32	30.5
7	34	17	27
8	31	22	25
9	40	24	22
10	56.5	21	23.5
11	55	24	31
12	26	24	32
13	17	24	35.5
14	33	17	23.5
15	26	19	22
16	31	16	15
17	21	15	19
18	17	22.5	27
19	30.5	27.5	27.5
20	48	20	35.5
21	16.5	25	24
22	26	17	17
23	32	25	27
24	19	24	27.5
25	32	22.5	29.5
26	31	20	23.5
27	19	20	31
28	10	34	25
29	35.5	24	18
30	34.5	17	27.5

GROUP UF

67-124

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	117.5	137.5	171.5
2	106	143	157.5
3	149.5	141	168
4	127.5	137.5	166
5	106	137.5	154.5
6	136	144.5	159.5
7	139.5	136	156
8	133	153	143
9	106	157.5	153
10	126	149.5	154.5
11	137.5	143	163
12	120.5	154.5	124
13	144.5	164.5	126
14	139.5	157.5	156
15	147.5	166	153
16	143	149.5	179.5
17	149.5	159.5	153
18	119	133	139.5
19	117.5	153	151
20	126	146	129.5
21	136	147.5	149.5
22	131	191.5	193
23	129.5	157.5	131
24	136	149.5	159.5
25	137.5	143	149.5
26	139.5	156	154.5
27	137.5	161	149.5
28	122.5	184.5	153
29	136	143	147.5
30	139.5	163	151

GROUP UF

67-134

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	275	339	471
2	251.5	412	468
3	253.5	416	449
4	263.5	403	464
5	288.5	416	449
6	275	419	477
7	298.5	405	484
8	288.5	429	500
9	288.5	432	500
10	290.5	438	504
11	298.5	445	500
12	302	432	497
13	304	456	514
14	304	464	488
15	305.5	445	517
16	305.5	464	517
17	305.5	458	507
18	304	445	500
19	345	458	514
20	338	456	520
21	358	471	510
22	365	464	523
23	372	458	520
24	355	458	520
25	379	462	523
26	379	475	500
27	386	481	520
28	389	468	540
29	386	481	504
30	379	471	527

Table II. Individual response records for subjects in Group CF. Response amplitude to the CS is in grams tension.

GROUP CF

66-64

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	223	175	204
2	241	188	200
3	223	160	173
4	208	204	185
5	237	200	173
6	225	235	167
7	230	204	160
8	191	220	160
9	208	200	145
10	220	210	160
11	193	193	160
12	220	193	120
13	193	214	158
14	220	204	112
15	200	220	131
16	180	193	153
17	188	210	131
18	193	208	120
19	193	208	145
20	167	208	145
21	185	191	128
22	214	223	141
23	188	180	128
24	163	193	128
25	193	185	96
26	175	193	150
27	160	173	131
28	160	208	145
29	175	210	128
30	167	193	131

GROUP CF

66-65

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	305	235	352
2	325	250	258
3	360	266	344
4	305	289	332
5	364	321	270
6	321	286	262
7	225	278	289
8	305	317	297
9	210	340	230
10	286	364	348
11	266	309	258
12	270	317	173
13	293	297	289
14	230	336	220
15	208	332	237
16	220	352	282
17	225	336	225
18	180	332	250
19	250	352	270
20	208	321	258
21	254	317	262
22	210	332	250
23	175	317	245
24	220	344	220
25	175	372	274
26	241	301	237
27	250	329	235
28	220	321	286
29	214	344	254
30	191	336	254

GROUP CF

67-39

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	143	89	102
2	122.5	102	92
3	153	95.5	119
4	109	95.5	106
5	116	112	92
6	129.5	136	85
7	106	112	85
8	136	102	82
9	112	109	102
10	126	122.5	92
11	129.5	89	116
12	106	119	82
13	122.5	106	79
14	133	95.5	72
15	116	99	82
16	109	112	106
17	109	106	119
18	99	99	85
19	95.5	106	85
20	116	92	99
21	89	112	75
22	89	119	85
23	109	92	95.5
24	92	85	82
25	109	95.5	95.5
26	109	92	75
27	112	106	89
28	122.5	79	79
29	109	72	92
30	82	92	75

GROUP CF

67-66

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	117.5	65	104
2	127.5	89	87
3	106	79	90.5
4	129.5	95.5	104
5	99	95.5	107.5
6	89	85	85
7	102	104	95.5
8	102	99	77
9	94	94	99
10	99	89	80.5
11	80.5	95.5	82
12	90.5	104	99
13	65	114	89
14	99	95.5	83.5
15	95.5	87	77
16	80.5	92	97
17	85	77	92
18	73.5	85	82
19	87	82	72
20	51	77	87
21	97	79	83.5
22	75	104	104
23	58	97	97
24	85	102	89
25	67	89	92
26	65	89	92
27	102	82	95.5
28	65	85	92
29	94	80.5	85
30	90.5	95.5	95.5

GROUP CF

67-78

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	349	324	425
2	365	389	429
3	335	392	416
4	362	389	399
5	335	409	412
6	365	438	386
7	338	442	383
8	358	456	352
9	355	497	352
10	355	458	335
11	352	462	303
12	362	464	328
13	352	458	338
14	352	432	338
15	335	425	345
16	355	335	328
17	352	445	324
18	310	458	317
19	338	449	303
20	300	449	314
21	314	442	310
22	324	491	331
23	331	442	303
24	328	429	331
25	338	462	317
26	314	456	307
27	314	484	317
28	345	456	328
29	324	432	300
30	345	456	294

GROUP CF

67-89

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	58	55	60
2	57	59	48
3	60	56.5	57
4	54	66.5	51
5	49.5	48	63
6	65.5	72.5	59
7	60.5	56.5	62
8	50	45	54
9	58	41	59
10	58	51	66.5
11	54	60	53
12	72.5	62	56.5
13	76	67	51
14	60	49.5	54
15	65	52	66.5
16	44	44	60
17	69	26	58
18	68	46	59
19	59	47	63
20	67	54	65.5
21	55.5	60.5	65.5
22	58	27.5	62
23	71	46	66.5
24	47	60.5	74
25	53	54	60.5
26	78	60	81
27	61.5	48.5	63
28	50	49.5	67
29	43	42.5	62
30	42.5	63	68

GROUP CF

67-107

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	183	196.5	213
2	177.5	191.5	211.5
3	193	200	206.5
4	183	203	210
5	181	201.5	204.5
6	181	206.5	208
7	186	230	204.5
8	190	226.5	210
9	200	214.5	213
10	181	213	214.5
11	188	211.5	210
12	198	211.5	210
13	190	211.5	206.5
14	198	211.5	211.5
15	191.5	208	210
16	181	206.5	213
17	193	218	214.5
18	203	208	210
19	193	214.5	210
20	188	211.5	210
21	186	214.5	214.5
22	194.5	221.5	211.5
23	194.5	211.5	214.5
24	193	213	218
25	188	220	204.5
26	190	218	210
27	193	216.5	213
28	190	218	208
29	191.5	208	214.5
30	186	214.5	211.5

GROUP CF

67-115

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	36	42.5	63
2	48.5	55.5	61.5
3	42.5	57	85.5
4	55.5	58	84
5	45	56.5	72
6	44	38	59
7	57	46	79.5
8	42.5	79	59
9	29.5	52	51
10	34.5	54	58
11	37	63	73.5
12	28.5	60	52
13	24	91.5	53
14	56.5	78	61.5
15	44	84.5	41.5
16	50	106	94
17	41	84	58
18	50	91.5	63
19	34	40	72.5
20	33	65.5	61.5
21	37	32	71
22	54	98	50
23	45	87	51
24	45	102	60
25	38	73.5	59
26	37	117.5	52
27	60	67	32
28	54	74	77
29	55.5	91	55.5
30	34.5	79.5	93

GROUP CF

67-122

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	68	43	55
2	43	41	49.5
3	46	36	54
4	43	43	39
5	54	41.5	34
6	38	96.5	51
7	35.5	41.5	43
8	39	72	37
9	44	72.5	33
10	41	48.5	36
11	32	48.5	34
12	61.5	34.5	52
13	50	60.5	36
14	41.5	70	41
15	55.5	52	36
16	31	55.5	41
17	45	45	41
18	51	49.5	41.5
19	40	48.5	41
20	40	65	40
21	39	41.5	27
22	46	47	60.5
23	39	56.5	40
24	45	52	43
25	48.5	43	34.5
26	27.5	41.5	34
27	43	47	34
28	30.5	46	34.5
29	43	47	34.5
30	48.5	39	37

GROUP CF

67-136

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	190	204.5	193
2	213	193	193
3	244.5	200	179.5
4	223	200	174.5
5	204.5	190	213
6	224.5	213	216.5
7	216.5	200	233
8	268.5	191.5	163
9	204.5	220	188
10	198	179.5	186
11	211.5	198	179.5
12	161	170	179.5
13	184.5	213	193
14	204.5	200	186
15	228	220	191.5
16	218	173	177.5
17	211.5	203	203
18	186	196	188
19	198	221.5	196.5
20	198	203	166
21	179.5	204.5	183
22	186	200	166
23	198	193	191.5
24	198	193	173
25	171.5	193	213
26	196.5	203	166
27	168	234.5	170
28	201.5	186	177.5
29	173	220	173
30	164.5	214.5	136

Table III. Individual response records for subjects in Group UV. Response amplitude to the CS is in grams tension.

GROUP UV

67-46

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	317	204	156
2	269	166	176.5
3	273	176.5	207
4	266	190	170
5	241	197	159
6	262	170	190
7	276	190	173
8	294	197	170
9	269	190	163
10	262	160	173
11	248	200	166
12	245	186	152
13	266	193	156
14	225	200	149
15	241	160	125
16	218	186	149
17	255	176.5	163
18	221	163	139
19	214	170	128.5
20	218	170	166
21	204	170	132
22	218	180	152
23	221	149	170
24	231	163	146
25	207	183	152
26	211	166	142.5
27	190	163	166
28	186	176.5	156
29	238	170	152
30	197	166	152

GROUP UV

67-49

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	82	49.5	70.5
2	126	63.5	56.5
3	112	72	49.5
4	89	60	53
5	92	51	46.5
6	104	69	49.5
7	73.5	62	51
8	80.5	79	51
9	89	60	56.5
10	69	63.5	53
11	56.5	53	58
12	60	60	63.5
13	70.5	58	70.5
14	80.5	53	63.5
15	85	55	49.5
16	139.5	56.5	46.5
17	99	67	60
18	85	58	55
19	80.5	63.5	33.5
20	69	49.5	55
21	85	48	55
22	109	48	51
23	72	75	62
24	63.5	72	48
25	60	56.5	40.5
26	72	65	36.5
27	73.5	70.5	51
28	73.5	48	56.5
29	80.5	63.5	51
30	60	58	42.5

GROUP UV

67-69

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	214	204	273
2	218	204	259
3	204	190	231
4	180	204	252
5	204	176	252
6	173	190	255
7	166	193	266
8	211	221	259
9	218	221	283
10	228	228	252
11	200	214	269
12	200	218	283
13	204	218	269
14	186	234	269
15	207	218	234
16	211	252	290
17	204	214	310
18	186	231	300
19	197	248	321
20	211	228	331
21	183	225	294
22	193	207	294
23	193	197	317
24	207	238	269
25	214	200	280
26	186	231	283
27	197	241	300
28	200	252	290
29	193	238	314
30	180	228	317

GROUP UV

67-73

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	321	355	405
2	294	376	403
3	310	355	389
4	321	389	392
5	321	389	403
6	328	386	392
7	338	362	396
8	328	383	399
9	324	389	405
10	331	389	376
11	331	389	396
12	328	379	405
13	321	392	399
14	321	389	379
15	349	389	403
16	331	396	403
17	328	386	405
18	335	392	392
19	342	383	403
20	342	386	392
21	355	403	409
22	349	396	416
23	342	399	419
24	345	392	422
25	349	412	409
26	362	396	416
27	358	405	422
28	372	399	412
29	355	389	412
30	355	396	409

GROUP UV

67-84

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	174.5	157.5	139.5
2	171.5	139.5	149.5
3	133	139.5	147.5
4	173	146	170
5	157.5	154.5	146
6	151	141	156
7	147.5	159.5	133
8	144.5	143	157.5
9	156	147.5	139.5
10	141	124	157.5
11	173	164.5	139.5
12	126	139.5	124
13	146	143	146
14	141	126	159.5
15	171.5	170	157.5
16	136	149.5	157.5
17	143	124	157.5
18	136	133	166
19	141	126	143
20	164.5	151	159.5
21	156	124	157.5
22	168	127.5	156
23	153	166	159.5
24	144.5	144.5	141
25	146	143	157.5
26	154.5	146	139.5
27	131	139.5	159.5
28	153	153	163
29	166	144.5	166
30	163	149.5	161

GROUP UV

67-95

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	76	39	59
2	67	39	62
3	102	27.5	60
4	75	31	59
5	58	36	54
6	76	36	36
7	65.5	41	38
8	55	51	56.5
9	55	50	48
10	48.5	36	52
11	62	60	54
12	89	40	49.5
13	68	46	47
14	51	41	55.5
15	42.5	48.5	54
16	50	54	66.5
17	40	34.5	43
18	68	40	41.5
19	47	32	46
20	31	35.5	56.5
21	42.5	32	53
22	52	47	48
23	63	45	65.5
24	54	45	65.5
25	31	34	38
26	41	41.5	50
27	44	57	51
28	41	33	85.5
29	48	34	51
30	50	28.5	53

GROUP UV

67-97

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	146	143	154.5
2	156	156	153
3	153	146	146
4	133	136	144.5
5	147.5	147.5	157.5
6	149.5	149.5	144.5
7	156	159.5	149.5
8	149.5	156	147.5
9	153	157.5	139.5
10	154.5	139.5	159.5
11	149.5	154.5	153
12	141	153	163
13	154.5	159.5	171.5
14	144.5	146	161
15	154.5	141	154.5
16	147.5	159.5	154.5
17	151	149.5	147.5
18	136	151	141
19	145	141	151
20	144.5	149.5	154.5
21	149.5	143	143
22	143	151	147.5
23	151	153	153
24	163	157.5	151
25	151	143	146
26	146	151	159.5
27	166	141	139.5
28	153	137.5	144.5
29	153	139.5	149.5
30	161	157.5	139.5

GROUP UV

67-120

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	177.5	216.5	310
2	201.5	250	328
3	224.5	273.5	310
4	208	260	324
5	234.5	295	280
6	223	276	338
7	200	276	331
8	203	276	328
9	220	287	324
10	193	228	321
11	208	297	358
12	166	280	331
13	214.5	290	328
14	228	283	338
15	210	287	338
16	226.5	307	379
17	190	307	342
18	228	303	362
19	204.5	294	358
20	210	328	369
21	236.5	331	338
22	234.5	310	379
23	210	310	379
24	223	321	369
25	223	287	383
26	224.5	345	376
27	257	280	324
28	253.5	335	362
29	234.5	294	355
30	220	324	358

GROUP UV

67-121

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	163	255	193
2	218	180	193
3	218	248	211
4	283	159	152
5	197	200	234
6	190	122	241
7	190	273	300
8	152	280	245
9	193	259	297
10	193	207	139
11	180	132	200
12	204	283	255
13	173	324	241
14	310	297	225
15	173	324	262
16	170	218	262
17	128.5	159	142.5
18	280	300	142.5
19	214	228	252
20	170	214	252
21	193	166	139
22	116	166	238
23	241	358	307
24	152	180	342
25	197	269	266
26	228	146	255
27	183	303	255
28	193	67	228
29	266	238	287
30	280	204	273

GROUP UV

67-133

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	94	97.5	33
2	87	105	84.5
3	116	114	43
4	98	105	70
5	90	84	72.5
6	91	113	46
7	93	103	78
8	103.5	108	61.5
9	87	99	88
10	94	114	62
11	78	124	53
12	72.5	110	69
13	72.5	81	74
14	63	127	73.5
15	49.5	102	74
16	71	69	77
17	84.5	75	73.5
18	77	59	60.5
19	69	74	38
20	62	74	77
21	74	72.5	65.5
22	60.5	65	75
23	58	87	64
24	108.5	60	94
25	105	73.5	83
26	103	84.5	77
27	73.5	83	63
28	117	73.5	68
29	98	70	50
30	108.5	76	50

Table IV. Individual response records for subjects in Group CV. Response amplitude to the CS is in grams tension.

GROUP CV

67-40

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	80.5	55	53
2	51	94	49.5
3	55	48	46.5
4	62	35	60
5	40.5	33.5	62
6	65	33.5	53
7	67	60	60
8	67	82	33.5
9	55	56.5	56.5
10	69	35	40.5
11	53	49.5	42.5
12	53	48	48
13	53	58	33.5
14	40.5	36.5	33.5
15	58	38	26
16	46.5	31.5	48
17	77	53	49.5
18	62	46.5	36.5
19	36.5	36.5	31.5
20	42.5	45	65
21	53	42.5	45
22	51	49.5	62
23	55	48	42.5
24	56.5	28	51
25	40.5	45	42.5
26	55	48	45
27	45	38	38
28	33.5	40.5	60
29	53	49.5	45
30	45	48	35

GROUP CV

67-43

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	269	287	383
2	294	324	392
3	276	314	365
4	310	372	349
5	314	365	409
6	314	422	321
7	353	324	338
8	300	396	300
9	300	335	310
10	294	452	335
11	283	379	352
12	290	342	352
13	294	365	389
14	273	425	396
15	287	412	362
16	300	379	314
17	287	386	379
18	280	405	310
19	321	389	352
20	290	392	349
21	269	386	365
22	280	372	328
23	300	365	342
24	342	365	335
25	300	383	386
26	283	383	345
27	290	419	342
28	276	379	365
29	300	416	362
30	234	379	362

GROUP CV

67-57

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	180	139	74
2	234	85.5	70.5
3	146	101	52
4	125	104	70.5
5	163	89	37
6	183	98	63.5
7	135.5	74	56
8	135.5	70.5	70.5
9	107	107	60
10	116	101	48.5
11	110	101	41
12	173	45	74
13	98	52	45
14	163	82	89
15	107	37	85.5
16	95	82	101
17	93	82	60
18	113	89	74
19	128.5	56	56
20	98	52	52
21	82	78	56
22	132	56	60
23	149	67	60
24	107	56	70.5
25	78	52	95
26	107	52	41
27	85.5	74	82
28	104	74	74
29	116	70.5	89
30	95	82	82

GROUP CV

67-71

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	477	541	570
2	491	556	570
3	464	571	570
4	468	578	570
5	452	578	563
6	456	586	557
7	456	578	567
8	464	571	560
9	458	578	557
10	452	586	560
11	471	578	560
12	477	578	547
13	462	571	557
14	477	571	520
15	500	578	550
16	484	571	557
17	497	578	557
18	500	578	537
19	507	578	537
20	504	578	520
21	523	571	543
22	520	578	517
23	537	578	550
24	518	571	534
25	518	578	520
26	518	578	534
27	541	578	523
28	541	571	500
29	548	571	507
30	541	571	517

GROUP CV

67-86

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	207	156	166
2	231	180	196.5
3	252	166	200
4	204	183	181
5	231	190	177.5
6	225	173	191.5
7	231	173	183
8	218	176.5	176
9	214	197	176
10	204	163	171.5
11	183	159	174.5
12	221	170	208
13	234	163	184.5
14	231	193	184.5
15	221	180	170
16	211	176.5	183
17	193	163	196.5
18	190	183	176
19	183	200	174.5
20	207	176.5	184.5
21	183	183	170
22	176.5	180	181
23	200	176.5	170
24	176.5	180	179.5
25	183	173	164.5
26	197	180	186
27	186	170	190
28	170	166	166
29	166	166	186
30	166	160	191.5

GROUP CV

67-91

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	355	383	488
2	352	396	468
3	358	409	458
4	352	435	462
5	345	419	458
6	352	445	458
7	365	442	464
8	355	438	449
9	355	452	452
10	355	435	458
11	369	429	458
12	352	456	456
13	358	452	449
14	352	462	462
15	358	456	468
16	349	462	442
17	358	456	449
18	362	458	452
19	358	468	464
20	355	452	464
21	355	458	449
22	355	464	471
23	365	464	464
24	365	458	462
25	365	477	458
26	379	484	462
27	369	484	471
28	365	481	464
29	369	491	475
30	369	497	491

GROUP CV

67-104

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	64	21	37
2	58	34.5	41.5
3	60.5	34.5	36
4	65.5	23.5	49.5
5	50	40	37
6	55	33	30.5
7	57	48.5	30.5
8	43	41	27
9	34.5	42.5	38
10	27.5	48	36
11	20	31	43
12	31	25	40
13	25	52	31
14	30.5	44	44
15	47	41	33
16	34	31	41.5
17	30.5	35.5	36
18	26	37	15
19	17	52	21
20	26	40	32
21	25	44	22.5
22	24	47	21
23	22	39	16
24	31	27.5	22.5
25	20	42.5	32
26	21	38	30.5
27	16.5	55.5	24
28	20	38	31
29	23.5	41.5	21
30	31	44	15

GROUP CV

67-113

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	124	133	161
2	124	137.5	153
3	124	139.5	157.5
4	117.5	139.5	159.5
5	127.5	147.5	154.5
6	124	146	157.5
7	124	147.5	146
8	119	141	146
9	124	151	159.5
10	114	147.5	151
11	119	137.5	157.5
12	131	154.5	151
13	122.5	149.5	157.5
14	114	161	157.5
15	117.5	154.5	157.5
16	124	147.5	151
17	122.5	149.5	146
18	119	153	156
19	116	159.5	156
20	109	153	159.5
21	112	159.5	151
22	124	154.5	157.5
23	124	157.5	156
24	124	156	154.5
25	124	151	151
26	133	163	157.5
27	119	166	153
28	124	153	156
29	133	157.5	151
30	120.5	159.5	147.5

GROUP CV

67-123

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	156	127.5	149.5
2	170	116	110.5
3	157.5	133	92
4	149.5	143	134.5
5	143	154.5	122.5
6	191.5	159.5	149.5
7	179.5	147.5	154.5
8	120.5	129.5	120.5
9	181	161	190
10	149.5	114	127.5
11	126	143	126
12	106	107.5	124
13	164.5	154.5	139.5
14	143	149.5	154.5
15	156	146	97
16	183	143	97
17	109	129.5	112
18	143	166	92
19	139.5	157.5	134.5
20	144.5	149.5	141
21	154.5	139.5	102
22	119	190	119
23	143	161	109
24	139.5	153	100.5
25	151	134.5	110.5
26	120.5	171.5	106
27	137.5	143	107.5
28	163	146	139.5
29	168	151	124
30	153	164.5	75

GROUP CV

67-135

Trial	Response to CS (grams tension) CS Alone	Acquisition	Extinction
1	290	173	234
2	303	214	231
3	262	193	234
4	245	214	238
5	252	193	193
6	280	207	180
7	273	193	193
8	252	193	231
9	248	214	193
10	221	207	152
11	170	190	180
12	221	218	173
13	204	207	193
14	204	228	221
15	163	241	190
16	221	221	193
17	207	211	197
18	186	109	186
19	218	255	173
20	200	183	211
21	183	252	221
22	200	248	180
23	183	255	166
24	197	225	180
25	176.5	197	197
26	183	248	214
27	132	234	180
28	183	262	176.5
29	156	197	193
30	180	255	128.5

SYMBOLS AND ABBREVIATIONS

CS	Conditioned stimulus
UCS	Unconditioned stimulus
CR	Conditioned response
UCR	Unconditioned response
S	Subject
N	Number of subjects in a group
AP_0	Midpoint of the anterior-posterior plane of the stereotaxic co-ordinates of the brain
H_0	Midpoint of the anterior-posterior, lateral, and horizontal planes of the stereotaxic co-ordinates of the brain
T_{10-12}	Tenth to twelfth thoracic vertebrae
cc	Cubic centimeter
Kg.	Kilogram
mg.	Milligram
mm	Millimeter
pps	Pulse per second

REFERENCES

1. Cummings, S. B., and Moreland, C. C. Sensitization vs. conditioning in Planaria: Some methodological considerations. American Psychologist, 1959, 14, 410 (Abstract).

2. Deese, J., & Kellogg, W. M. Some new data on the nature of "spinal conditioning." Journal of comparative and physiological Psychology, 1949, 42, 157-160.

3. Engen, T., & Lipsitt, L. P. Decrement and recovery of response to olfactory stimuli in the human neonate. Journal of comparative and physiological Psychology, 1965, 59, 312-316.

4. Fitzgerald, L. A., & Thompson, R. F. Classical conditioning of the hindlimb flexion reflex in the acute spinal cat. Psychonomic Science, 1967, 8, 213-214.

5. Forbes, A., & Mahan, C. Attempts to train the spinal cord. Journal of comparative and physiological Psychology, 1963, 56, 36-40.

6. Halas, E. S., James, R. L., and Stone, L. A. Types of response elicited in planaria by light. Journal of comparative and physiological Psychology, 1961, 54, 302-305.

7. Harris, J. D. Habituatory response decrement in the intact organism. Psychological Bulletin, 1943, 40, 385-422.

8. Hilgard, E. B., & Marquis, D. G. Conditioning and learning. New York: Appleton-Century-Crofts, 1940.

9. Kellogg, W. N. Is "spinal conditioning" conditioning? A reply to "a comment." Journal of experimental Psychology, 1947, 37, 263-265.

10. Kellogg, W. M., Deese, J., Pronko, N. H., & Feinberg, M. An attempt to condition the chronic spinal dog. Journal of experimental Psychology, 1947, 37, 99-117.

11. Kimble, G. A. Hilgard and Marquis' conditioning and learning. New York: Appleton-Century-Crofts, 1961.

12. Lebedinskia, S. I., & Rosenthal, J. S. Reactions of a dog after removal of the cerebral hemisphere. Brain, 1935, 58, 412-419.

13. Lethlean, A. K. Habituation in the rat spinal cord--a triggered process. Federation Proceedings, 1965, 24, 517.

14. Marsh, J. T., McCarthy, D. A., Sheatz, G., & Galambos, R. Amplitude changes in evoked auditory potentials during habituation and conditioning. Electroencephalography and clinical Neurophysiology, 1961, 13, 224-234.

15. Pinto, T., & Bromiley, R. B. A search for 'spinal conditioning' and for evidence that it can become a reflex. Journal of experimental Psychology, 1950, 40, 121-130.

16. Shurrager, P. S. A comment on "an attempt to condition the chronic spinal dog." Journal of experimental Psychology, 1947, 37, 261-265.

17. Shurrager, P. S., & Culler, E. Conditioning in the spinal dog. Journal of experimental Psychology, 1940, 26, 133-159.

18. Shurrager, P. S., & Shurrager, H. D. The rate of learning measured at a single synapse. Journal of experimental Psychology, 1946, 36, 347-354.

19. Snider, R. S., & Niemer, W. T. A stereotaxic atlas of the cat brain. Chicago, Ill.: University of Chicago Press, 1961.

20. Thompson, R., and McConnell, J. V. Classical conditioning in the planarian, Dugesia dorotocephala. Journal of comparative and physiological Psychology, 1955, 48, 65-68.

21. Thompson, R. F., & Spencer, W. A. Habituation: A model phenomenon for the study of neuronal substrates of behavior. Psychological Review, 1966, 173, 16-43.

22. VanDeventer, J. M., and Ratner, S. C. Variables affecting the frequency of response of planaria to light. Journal of comparative and physiological Psychology, 1964, 57, 407-411.