ACTIVITY-LEVEL CONTINGENT SHOCK AND LATER SHUTTLEBOX AVOIDANCE LEARNING

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ABSTRACT

Prior to shuttlebox avoidance training rats were exposed to 30 trials of a punishment situation in which shock was contingent on activity level. The period during which contingencies were effective on each pretraining trial was divided into two halves. During each half one of three treatments was administered: (a) an inactivity-shock contingency (IS), (b) a no shock condition (NO), (c) an activity-shock contingency (AS). Nine experimental groups were formed from the factorial combination of the three treatments possible during the first half of pretraining with the three possible during the second half. After pretraining all subjects were immediately run 100 trials in a shuttlebox avoidance task.

Results indicated that subjects receiving the IS treatment during the first half of the pretraining interval performed better in avoidance training then those receiving the NO treatment which, in turn, performed better than those receiving the AS treatment. The treatment administered during the second half of the pretraining interval did not significantly affect later avoidance performance. Results also indicated that amount of movement during pretraining was positively related to level of later avoidance performance.

These results were interpreted as support for the hypothesis that in the early stages of avoidance training activity increases and an avoidance response becomes more probable through the action of the inactivity-shock contingency inherent to the avoidance task.

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The avoidance learning paradigm, as a unique experimental procedure, developed from classical conditioning procedures in which electric shock was the UCS. Typical of these procedures was that used by Bechterev and first described in 1913. Bechterev presented dogs with a neutral stimulus followed by electric shock to the forepaw. Leg flexion followed shock presentation and the outcome of the procedure was that the previously neutral stimulus came to produce leg flexion (Kimble, 1961). An important experimental parameter, which was not controlled in these early studies, was the effect of the conditioned response on shock presentation. In certain of Bechterev's procedures, for example, the CR served to preclude the presentation of shock, whereas in others it did not.

Hunter (1935) was one of the first to provide evidence that the two operations resulted in different behaviours. In his procedure rats were presented with a buzzer CS followed by a shock UCS. In one of the groups of animals, performance of a running response after CS presentation but before UCS onset served to preclude shock. In the other group the UCS followed the CS regardless of the animal's behaviour. Results showed that in the group in which running precluded shock, a running response was more likely than in the other group. A similar experiment with similar results, using guinea pigs as subjects, was performed in a widely cited study by Brogden, Lipman, & Culler (1938).

It will be recognized that the procedure in which shock preclusion was dependent on the subject's behaviour is operationally similar to what we now term the avoidance learning situation. According to

Herrnstein (1969), avoidance learning, with the publication of the above studies, "had crystallized as a study in its own right and was no longer one of the various conditioned-reflex procedures." (Herrnstein, 1969; p.52). The term "avoidance training," came into use about this time and was derived from the animal's ability to avoid shock.

A common form of the avoidance situation and the one with which this paper is concerned is locomotor avoidance training. In locomotor avoidance a neutral stimulus is presented a short time prior to presentation of a noxious stimulus (usually electric shock). The subject is required to perform a locomotor response in order to avoid shock. If the response occurs prior to shock presentation the neutral stimulus is terminated and shock withheld. The response is then designated an avoidance. If the response occurs after shock onset, shock and the neutral stimulus are terminated and the response termed an escape.

Perhaps the most frequently encountered type of locomotor avoidance situation employs a shuttlebox as used by Solomon, Kamin, & Wynne (1953). A shuttlebox is simply a compartment somewhat longer than it is wide which is divided into two equal compartments with access between them. The floor of the shuttlebox is a grid connected to a shock source. With this apparatus the required locomotor avoidance response is that of running from the compartment the subject occupies at the beginning of a trial to the opposite compartment.

If an animal is required to perform an active response to avoid shock, then the probability of the performance of this response should certainly depend, in part, on the level of the animal's general activity. That is, an animal that is for some reason more active than another will be more likely to perform a locomotor avoidance response (Church, 1971).

Freezing and activity in avoidance learning

Many investigators have observed the tendency of rats to freeze when presented with the CS in the avoidance situation (Bolles, 1967, 1970; Brown & Jacobs, 1949; Hoffman, 1966; Meyer, Cho, & Weseman, 1960; Miller, 1951). Although descriptions of this behaviour vary, all accounts have in common a reference to a posture of complete immobility that the animals assume, either on all fours or crouched on the hind legs. There is little doubt that these descriptions refer to the same form of behaviour.

Until recently little experimental attention was paid to the role of activity in the development of avoidance behaviour, although previous investigators were not unaware of the problem (Hoffman, 1966). Among the first research designed specifically to examine this question was that performed by Weiss, Kriekhaus, & Conte (1968). Their first experiment employed a prior training procedure in which shock was paired with a tone stimulus; this tone was later used as the CS in a shuttlebox avoidance task. Their dependent measures were: (a) movement during the tone during both prior training and avoidance, and (b) level of avoidance responding. The experimental group in which the avoidance CS was the same as the prior training tone moved less during the avoidance CS and avoided less in comparison to control groups that received: (a) shock alone during prior training, (b) tone without shock during prior training, or (c) prior training with a stimulus different from that used as a CS in the avoidance situation. Also, the amount of movement shown by the experimental subjects during the presentation of the tone in prior training correlated +0.83 ($p < .01$) with the total number of avoidance responses. This correlation in the stimulus-alone control was +0.20 ($p > .05$). These results clearly indicate that the reduction in movement and the avoidance decrement shown by the experimental group is related to the prior pairing of the avoidance CS with shock, since all of the control groups differed from each other. Weiss, et al. hypothesized that the reduction in movement shown by the experimental group was a result of increased freezing as a response to conditioned fear. This hypothesis led them to reason that if strong fear leads to increased freezing and thereby to an avoidance deficit then animals avoiding poorly should perform better if fear level were decreased. A further experiment supported this suggestion. Two groups of rats were selected from the population of poor avoiders in a previous experiment and matched according to avoidance performance. One group received continued avoidance training, the other underwent an extinction procedure in which the avoidance CS was presented without shock. The extinction group was then replaced in the avoidance situation. The result of this procedure was that the extinction subjects showed a marked improvement in avoidance performance whereas the other group continued to avoid poorly. This improvement was not merely a result of the "rest" provided by the extinction procedure. These same subjects had been given "rests" of similar length in the previous experiment but showed no such improvement in avoidance performance.

Evidence supporting the suggestion of Weiss, et al. that immobility is a response to stimuli present during prior shock exposure is provided by a series of experiments performed by Blanchard, Dielman, & Blanchard (1968a, 1968b) and Blanchard & Blanchard (1969). These studies indicated that a group of rats that had received a single 2-second foot-shock showed a greater incidence of an immobile "crouching response" than non-shocked controls. Further evidence showed that this increase in crouching was not an after-effect of the shock alone but was a response to cues that were present during shock administration. Specifically, shocked rats differed from non-shocked controls in incidence of crouching only in the situation in which shock had been administered.

The observation that a decline in activity is a common response after shock administration has also been reported in studies of exploratory behaviour (Montgomery & Monkman, 1955) and investigations of punishment employing electric shock (Blanchard & Blanchard, 1968; Estes, 1944; Church, 1963). In the punishment studies it was found that the decline in the rate of a punished response is often dependent on a general reduction in activity as a result of shock rather than the effect of a specific response-shock contingency. The conditioned emotional responding (CER) procedure introduced by Estes & Skinner (1941) in which presentation of a stimulus previously paired with shock results in a decrement in ongoing operant behaviour may depend on a similar phenomenon (Bolles, 1967).

The evidence that freezing disrupts avoidance learning is complemented by evidence that avoidance learning is facilitated by factors that result in an increase in activity. Hearst & Whalen (1963), and Kriekhaus, Miller, & Zimmerman (1965) have demonstrated that administration of _d_-amphetamine produces an increase in movement in non-avoidance situations and enhances performance of a locomotor avoidance task. Bolles & Moot (1970) have shown that activity in a non-avoidance situation is an inverse function of shock intensity. This finding lends support to the explanation by Moyer & Korn (1964) of results showing that performance of a shuttlebox avoidance task is an inverse function of shock intensity. Moyer & Korn suggested that these results, which were later replicated by Levine (1966) and Theios, Lynch, & Lowe (1966), are due to increased shock intensity leading to increased freezing and thereby to poorer avoidance. Moyer & Korn's explanation has, however, been criticized by McAllister, McAllister, & Douglass (1971). They point out that increased shock intensity leads to improved avoidance behaviour in a one-way avoidance task (Moyer & Korn, 1966) and suggest that with increased shock intensity in shuttlebox avoidance the rat may be reinforced less for avoiding due to increased fear being attached to the opposite compartment. While this interpretation may account for some of the effect, they fail to consider evidence indicating that non-avoidance is more often a result of freezing in a shuttlebox than in one-way avoidance. Wahlsten & Sharp (1969) compared shuttle and one-way avoidance learning and found that when a subject in the shuttle group failed to avoid, freezing was observed more often than when a subject from a one-way group failed to avoid.

The above studies appear to indicate that presentation of stimuli that have been previously paired with shock leads to an increase in the incidence of freezing; however this conclusion is inconsistent with two observations that have been made of the avoidance learning process. Firstly, it is self-evident that in order to avoid shock an animal must move. It might be expected that shock would lead to a decreased level of activity with a subsequent increase in the probability of the subject being shocked in avoidance conditioning which in turn would result in a further decrease in activity. Secondly, there is a substantial body of evidence that indicates that prior exposure to CS-shock pairings can facilitate later avoidance performance. A comprehensive review of this evidence is provided by Anisman (1970). Again it might be expected, from the experiments cited previously, that this exposure to shock would result in decreased activity and impaired avoidance learning.

In an attempt to resolve the first inconsistency Bolles (1970), elaborating the position taken by Dinsmoor (1954), has proposed that when freezing occurs in the locomotor avoidance situation, a freezing-shock contingency that is inherent to the task results in a decrease in its incidence. Avoidance of shock in a shuttlebox avoidance situation requires that the subject move in the right direction sometime during the CS-UCS interval. Lack of movement is invariably followed by shock. In shuttlebox avoidance learning then, freezing is regularly punished.

Bolles' suggestion, which may be termed the inherent contingency hypothesis, rather easily accounts for the decline of freezing in locomotor avoidance learning. An explanation of the facilitation of later avoidance learning by prior shock exposure, while not as obvious, is also possible.

The experiments in which prior shock facilitated later avoidance learning employed a Pavlovian paradigm in which the avoidance CS was paired with shock. Presentation of shock in the Pavlovian situation is, by definition, independent of the subject's behaviour. There is no reason to assume, however, that the subject's behaviour at the time of shock is independent of the characteristics of a shock situation. The most common response exhibited by rats in a situation where shock has been presented is immobility (Blanchard & Blanchard, 1969). It follows then, that on the majority of trials when shock is presented, the rat will be immobile. According to Bolles' inherent contingency hypothesis, freezing, when followed by shock will decline in incidence and a concomitant increase in activity will result. The facilitative effect of prior shock may then be due to the suppression of freezing before the start of avoidance training.

Since the freezing-shock contingency in avoidance learning is, in fact, <u>inherent</u> to the avoidance task it is not possible to test Bolles' hypothesis by direct manipulation of response-shock contingencies within the avoidance situation. Such manipulations, while they may yield results consistent with the hypothesis, are of questionable value. Feldman & Bremner (1963) introduced a freezing-shock contingency into the inter-trial interval of a bar-press avoidance task. Bintz, Kellicutt, & Peacock (1970) made shock presentation during the usual UCS period in a locomotor avoidance task contingent on inactivity. Both these manipulations resulted in improved avoidance learning. In both these studies however, the experimental manipulations resulted in situations that were qualitatively different from the normal avoidance task; it is questionable therefore whether it is possible to derive valid generalizations about the normal avoidance process from these results.

Two studies may be interpreted as support for the inherent contingency hypothesis. Brenner & Goesling (1970) found that when shock presentation was contingent on non-activity, rats became more active. While these results were not obtained in an avoidance situation they do serve to demonstrate that level of activity may be modified by shock presentation. Secondly, Kurtz & Shafer (1966) compared the effect on locomotor avoidance performance of three pretraining procedures: (a) an avoidance procedure in which shock was withheld if the animal "began to respond," during the CS-UCS interval, (b) a procedure in which shock was presented if the animal "began to respond," during the CS-UCS interval and (c) a normal avoidance procedure. After 20 trials under these procedures, all subjects were given 30 normal avoidance trials. The shock-withheld group performed significantly better than the shock-presented group during the 30 normal trials but neither of these groups differed from the normal avoidance control. The shock-withheld and shock-presented groups in this experiment may, in a sense, be regarded as groups in which inactivity-shock and activity-shock contingencies were applied, with the inactivity-shock contingency resulting in superior avoidance learning. In that sense this study supports the inherent contingency hypothesis. If avoidance learning depends on the suppression of freezing by an inactivity-shock contingency within the avoidance task then it would be expected that prior exposure to such a contingency would facilitate later training compared to a group receiving exposure to an opposite contingency. This support is not unequivocal however, since neither of the two experimental groups differed from the normal avoidance control, although the trend was in the expected direction. The lack of these differences possibly may be attributed to two factors: (a) It is undoubtedly difficult to accurately observe when a rat "begins to respond". The lack of an objective criterion by which to administer shock may account for the high variability shown within experimental groups. (b) The avoidance learning phase of the procedure was perhaps too short for the effects of prior training to appear.

Notwithstanding these criticisms the Kurtz & Shafer experiment was an attempt to study the effects of inactivity-shock and activity-shock contingencies on avoidance learning that did not require a procedure substantially different from that used in normal avoidance training.

The present study is similar to the Kurtz & Shafer study in that inactivity-shock and activity-shock contingencies were applied prior to normal locomotor avoidance training. In contrast to the Kurtz & Shafer experiment, shock during pretraining was delivered automatically according to the measurement of activity by an electronic device. In further contrast, the avoidance training phase that followed pretraining lasted 100 trials. With these differences it was reasoned that the delivery of shock according to an objective criterion during pretraining would reduce the within group variability in later avoidance performance and that the longer avoidance training phase would permit differences due to pretraining treatment to be more strongly manifested.

Predictions

The three prior training treatments employed in this experiment were: (a) an inactivity-shock contingency, (b) an activity-shock contingency, (c) a control situation in which shock was not presented. It was predicted that subjects that received the inactivity-shock contingency would perform better in later avoidance than other groups since the inactivity-shock contingency is the prior training treatment most similar to the contingency proposed by the inherent contingency hypothesis to exist in avoidance training. Furthermore it was predicted that the activity-shock contingency would result in poorer avoidance than in the inactivity-shock or no-shock groups since the activity-shock treatment and the hypothesized avoidance process are opposites.

The basis of these predictions is the assumption that if a prior training situation is similar in some way to a later learning task then experience in prior training will facilitate later learning. Likewise, if the prior training situation is dissimilar or opposite then impairment of later learning will result. With this in mind a temporal variable was introduced into the prior training phase of this study. A prior training trial consisted of the presentation of a light for 20 seconds followed by a 40 second inter-trial interval. The light which formed part of the CS in later avoidance signalled the period when contingencies were effective. This period was divided into two halves each approximately as long as the CS-UCS interval in later avoidance. During each of these halves one of the three pretraining treatments was in effect. A subject then could undergo prior training under any combination of the three treatments. A single subject, however, only received one of the nine possible combinations during pretraining; that is, pretraining treatments were not varied within subjects.

It was predicted that the facilitation of later avoidance by the inactivity-shock contingency and the impairment by the activity-shock contingency would be more strongly or perhaps exclusively exhibited by those subjects receiving those treatments during the first half of the pretraining interval. The reasoning underlying this prediction stems from the self evident fact that only behaviour occurring within the CS-UCS interval in avoidance learning can affect level of recorded avoidance performance. The inherent contingency hypothesis holds that freezing behaviour occurring within the CS-UCS interval is suppressed by shock presentation. Since the first half of the pretraining interval in this study was designed to correspond temporally with the CS-UCS interval in later avoidance it was reasoned that modification of behaviour within this period would have the strongest influence on later avoidance performance.

Method

Design

The pretraining treatments studied in this experiment were: (a) an inactivity-shock contingency (IS), (b) an activity-shock contingency (AS), (c) a control situation in which shock was not presented (NO). In a single subject one of these three contingencies was effective during each of the two periods that composed the interval when treatments were in effect. Nine groups were formed from the factorial combination of the three possible first half situations with the three possible second half situations. These were: IS-IS, IS-NO, IS-AS, AS-IS, AS-AS, AS-NO, NO-IS, NO-AS, NO-NO. The design is illustrated in Figure 1.

Group Size

Although it was planned to include ten subjects in each of the nine experimental groups, apparatus failure late in the time alotted for the experiment limited group sizes to eight subjects in each of the IS-IS, IS-AS, IS-NO, AS-IS, AS-AS and NO-NO groups and to seven subjects in each of the AS-NO, NO-IS and NO-AS groups.

Subjects

Subjects were 69 male hooded rats, obtained from Canadian Breeding Farms Laboratories, with a mean weight of 367 gm. Subjects were housed five to a large plastic cage (35.5 x 30.5 x 16.5 cm) for at least a week, after receipt from the supplier, before experimental treatment. Subjects were maintained on an ad lib. feeding and watering schedule prior to the experiment.

Apparatus

The main piece of apparatus consisted of a shuttlebox with

Treatment – 2nd half

Treatment – 1st half	IS	NO	AS
AS	AS·IS	AS·NO	AS·AS
NO	NO·IS	NO·NO	NO·AS
IS	IS·IS	IS·NO	IS·AS

Figure 1. Groups resulting from the factorial combination of the three possible first half contingencies with the three possible second half contingencies

a tilting grid floor. The interior of the apparatus was 70.50 x 21.60 x 36.20 cm deep and painted flat black inside. The shock grid, consisting of .635 cm bronze rods, separated by 1.59 cm, was connected to a Grason Stadler E1064GS shock generator and mounted in a 76.20 x 27.40 cm frame built of 1.27 cm (½ in) plywood. The entire grid frame rested on a pivot such that it would tilt when weight was added to either end. Two microswitches, mounted on blocks, were placed beneath either end of the frame such that vertical movement of either end more than .32 cm from its horizontal position would result in closure of one of the microswitches.

The main body of the shuttlebox was fitted above this frame as illustrated in Figure 2. During the experiment, three adjoining plate glass squares were placed on top of the apparatus.

A GE #44 6-v. light bulb, within a translucent cover, was mounted on the centre line of one side of the shuttlebox 10.2 cm from the top. A 10.16 cm (4 in) speaker connected to a BRS-Foringer click generator (CL-201) and audio amplifier (AA-202) was placed, unmounted and facing upwards, 10.2 cm (from edge of apparatus to closest edge of speaker) from the side of the shuttlebox. The click generator was set at its maximum frequency. The amplitude control on the click generator was set at a point 2/3 of the distance clockwise from minimum to maximum amplitude. The combination produced a tone of moderate pitch and amplitude.

Movement detection was by means of a device manufactured by Alton Electronics, Box 398, Archer, Florida, U.S.A. This device employs two transducers, one a transmitter and one a receiver, to

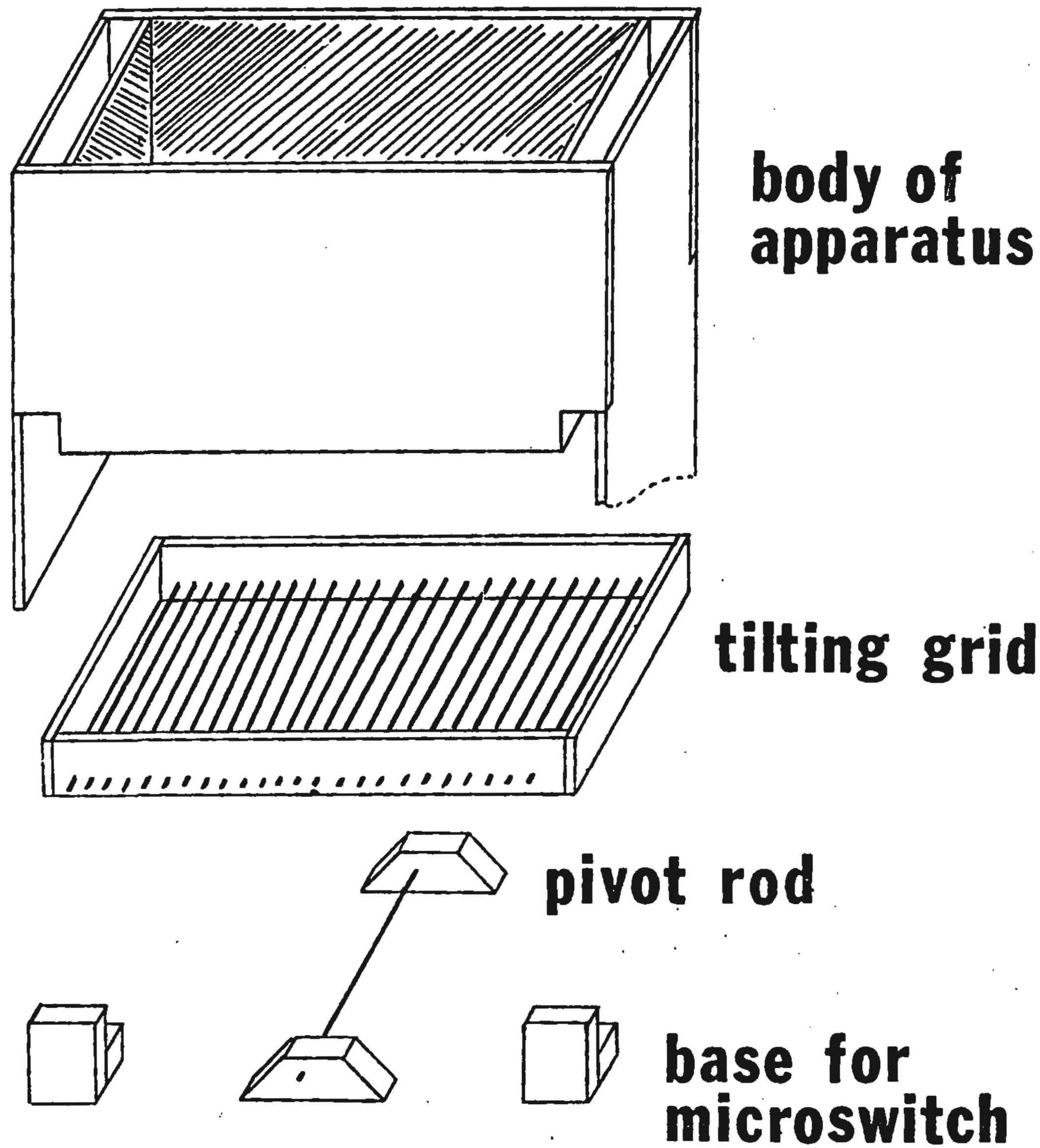

Figure 2. Exploded view of experimental apparatus

establish a pattern of ultrasonic air vibrations within a space. Movement within that space disturbs the pattern resulting in closure of a relay within the device. The two transducers used were mounted on the centre lines of both ends of the shuttlebox 15.25 cm from the top. Holes were drilled in the plywood of the apparatus and the transducers placed such that their protective grids were flush with the inside surface. The sensitivity dial of the movement detector remained set in the "4" position throughout the experiment. At this setting gross body movements appeared to be reliably detected but not head movements. The main body of the device was mounted on foam rubber to minimize the effects of vibration.

Procedure

The procedure followed was the same for all subjects and differed only in the contingencies employed during pretraining. Subjects were handled by the tail at all times during the experiment.

Pretraining The experimental room was darkened and subjects were placed in the apparatus and the glass tops put in place. At the end of a 5-min. 40-sec. period, the light mounted within the shuttlebox came on, signalling the beginning of the first period during which a response-shock contingency could be effective. The light remained on for 20 sec. Digital logic modules (BRS-Foringer) were wired and attached such that the number of closures of the relay within the motion detector occurring during each 2-sec. period within the 20-sec. could be temporarily stored. If, at the end of any 2-sec. period, five or more closures were recorded, a brief pulse signalling "activity" was generated within the controlling equipment.

Shock delivery under the three contingencies used in the experiment was determined as follows: (a) when the activity-shock (AS) contingency was effective, generation of the "activity" pulse resulted in the delivery of a 2-sec., 1 ma shock to the entire floor of the apparatus at the end of the 2-sec. period, (b) when the inactivity-shock (IS) contingency was in effect, a 2-sec. shock was delivered if the "activity" pulse was not generated at the end of the 2-sec. period, (c) under the no-shock (NO) condition, shock was withheld although activity measurement continued.

The CS interval during which contingencies were effective was, for all subjects, divided into two periods. During the first period one contingency was in effect while during the second period the same or another contingency was present. The transition between the two periods was effected by making the interval between the end of the eighth second to the beginning of the tenth second a contingency-free period in that the behaviour exhibited during this period could not result in subsequent shock. Shock could be delivered during this period, however, as a consequence of behaviour during the previous 2-sec. interval. Activity was not measured during shock administration so that an animal could not be shocked for activity or inactivity resulting directly from shock. Otherwise, activity was measured during the entire 20-sec. interval. Similar to the above "free" interval, shock was not administered as a consequence of behaviour during the last two seconds of the interval, since otherwise, shock presentation would be possible after the signal light had gone off. This procedure is illustrated in Figure 3.

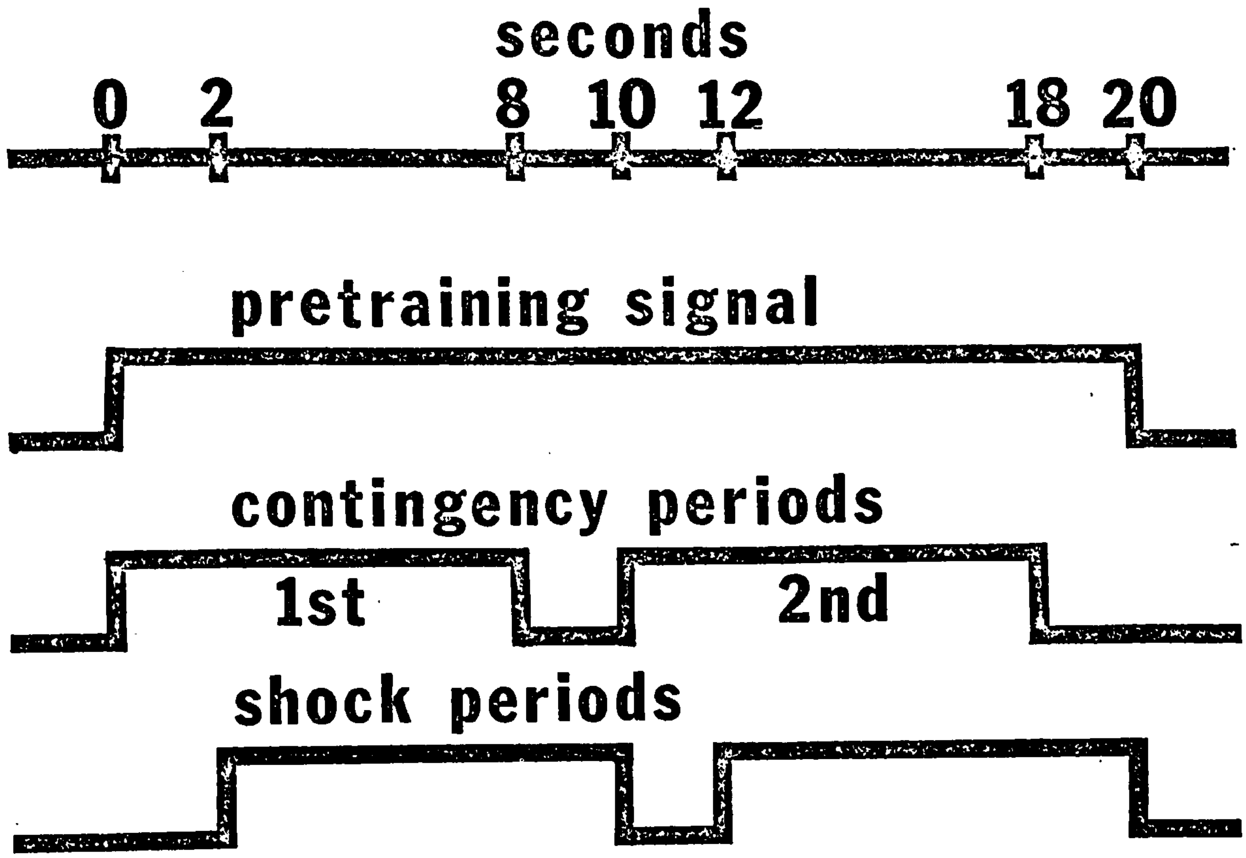

Figure 3. Temporal relationships between contingency periods and shock administration periods during pretraining

Light offset was followed by a 40-sec. interval after which the sequence was repeated with the same combination of contingencies in effect. In all, the sequence was repeated 30 times for each subject.

Avoidance Forty seconds after the end of the last pretraining contingency period, avoidance training began.

A warning signal, consisting of the light used in pretraining plus the tone was presented. Eight seconds after the onset of this signal, a 1-ma. shock was delivered to the entire floor of the shuttlebox. Both signal and shock remained on until the subject moved from one end of the apparatus to the other (the escape response). If this behaviour occurred prior to shock onset, the warning signal was terminated and shock withheld (the avoidance response). An avoidance or escape response was defined with reference to the two microswitches mounted beneath the balance grid floor. The presence of a subject in one end or the other of the shuttlebox was detected by the control equipment prior to the onset of the warning signal since the subject's weight was sufficient to **tip slightly** the shock grid and depress the microswitch beneath that end. The required avoidance response consisted of behaviour that would produce a 200-msec. closure of the microswitch opposite to the one that had been closed immediately prior to signal onset. It was found necessary to institute this minimum closure requirement while testing the apparatus prior to the experiment. The reactions of rats used in this testing would occasionally be so forceful that the shock grid would oscillate, alternately closing both microswitches for very brief periods and signalling an escape response. After inserting the minimum closure requirement into the control equipment, there were no instances observed (either in testing the equipment or during the experiment) where an escape or avoidance response was indicated when the animal did not actually move from one end of the shuttlebox to the other.

Each subject received 100 trials with an inter-trial interval of 40 secs.

Measures

The measures taken during pretraining were: (a) number of relay closures (moves) during the first half of the pretraining signal, (b) number of moves during the second half of the signal, (c) number of shocks administered during the first half of the signal, (d) number of shocks administered during the second half of the signal, (e) number of moves during the interval between signal presentations.

The measures taken during avoidance training were: (a) number of avoidances during each block of 10 trials, (b) number of moves during inter-trial interval during each block of 10 trials, (c) number of inter-trial responses; that is, the number of times a subject crossed from one side of the shuttlebox to the other.

It was not possible to measure activity during CS presentation in avoidance training since the tone part of the composite CS interfered with the reliable recording of movement, presumably because the movement detector employed sound waves for the measurement of activity.

Results

Avoidance

Avoidance scores were analysed using a 3 x 3 x 10 (contingency during first half of pretraining signal x contingency during second half of pretraining signal x block of 10 trials) analysis of variance, with repeated measures over blocks of 10 trials employing an unweighted means procedure to correct for the unequal number of observations in the groups (Winer, 1962; p. 374). This analysis indicated that avoidance performance was affected only by the contingency present during the first half of the contingency signal ($F = 3.35$, $df = 2/60$, $p < .05$) and that avoidance performance improved as trials progressed ($F = 36.72$, $df = 9/540$, $p < .01$). No other effects were significant. A summary of this analysis is shown in Table 1. The main effect and trials effect are illustrated in Figures 4 and 5.

As the direction of the differences between the means of the three contingency groups was predicted *a priori*, an individual comparisons technique was used in evaluating these differences (Winer, 1962; p. 378). One-tailed tests indicated that subjects receiving the IS contingency during the first half of the pretraining signal performed better than those receiving the NO treatment ($F = 3.86$, $df = 1/60$, $p < .05$). Animals receiving the NO treatment performed better than those receiving the AS contingency ($F = 36.27$, $df = 1/60$, $p < .005$).

Movement

Amount of movement during the avoidance ITI was analysed using

TABLE 1

Analysis of variance on number of avoidance responses per block of ten trials using a 3 x 3 x 10 repeated measures design (contingency during first half of pretraining interval x contingency during second half of pretraining interval x trial block)

Source	SS	df	MS	F
Contingency, 1st half (A)	458.94	2	229.47	3.35*
Contingency, 2nd half (B)	125.05	2	62.52	1
A x B	183.88	4	45.97	1
Subjects within groups	4104.07	60	68.40	
Trial block (C)	1345.47	9	149.49	36.72**
A x C	86.14	18	4.79	1.18
B x C	57.45	18	3.19	1
A x B x C	100.94	36	2.80	1
C x subjects within groups	2200.04	540	4.07	

* $p < .05$

** $p < .01$

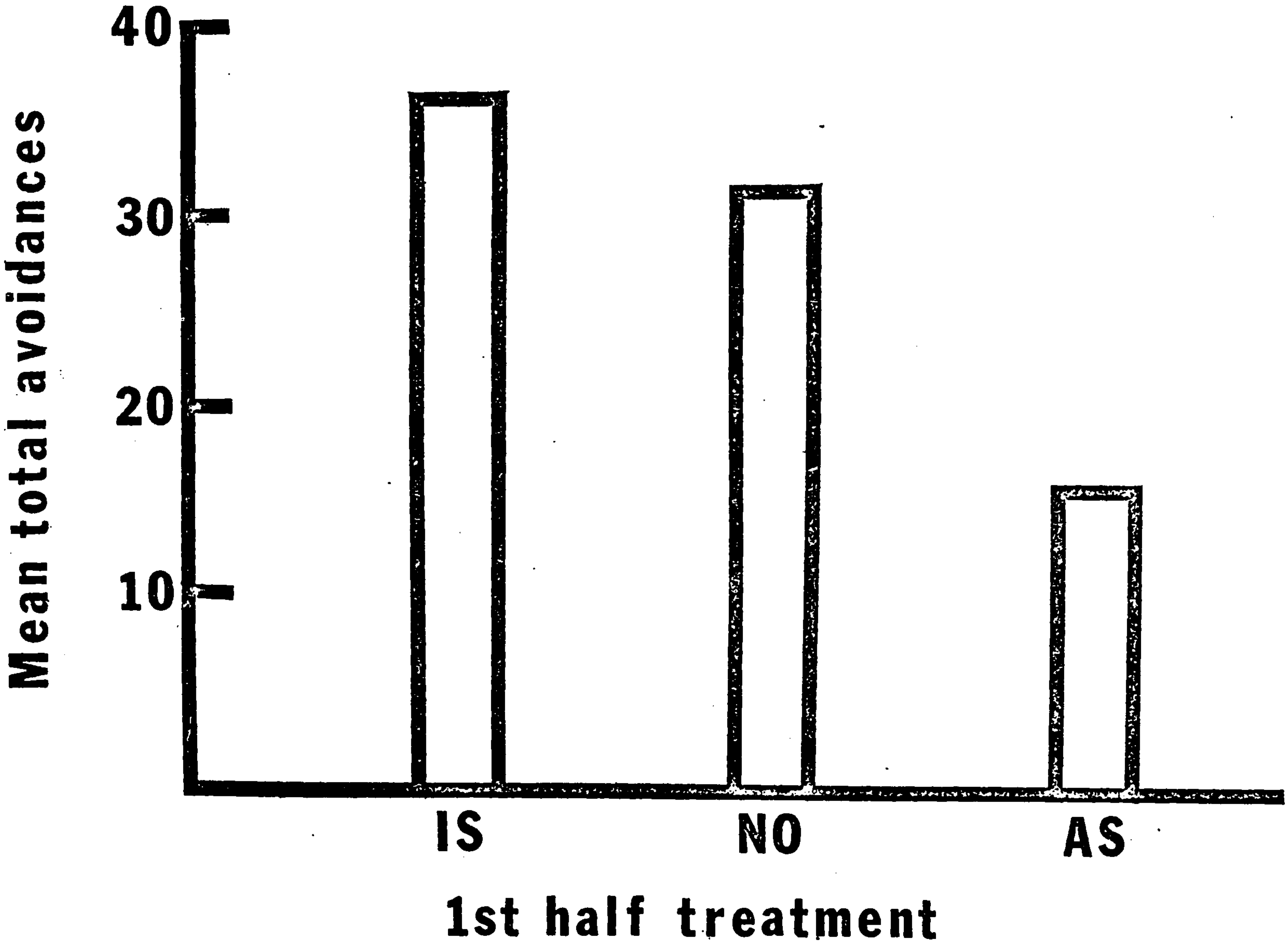

Figure 4. Mean number of avoidances as a function of the contingency in effect during the first half of the pretraining signal

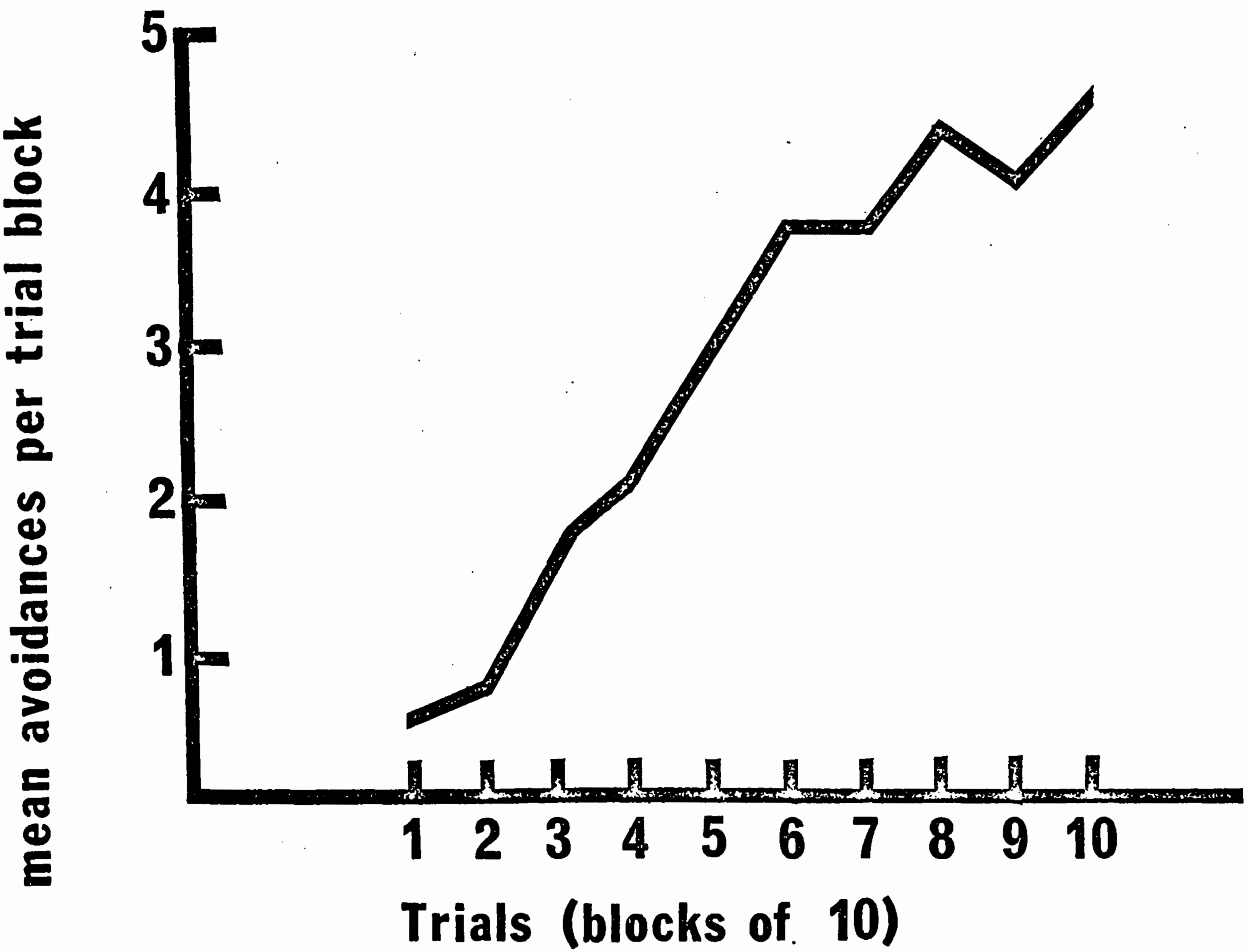

Figure 5. Mean number of avoidances as a function of trial block

a 3 x 3 x 10 (contingency during first half of pretraining signal x contingency during second half of pretraining signal x block of 10 trials) analysis of variance with repeated measures over blocks of trials employing an unweighted means procedure to correct for the unequal number of observations in the groups (Winer, 1962, p. 374). This analysis yielded a significant contingency during first half of pretraining signal x contingency during second half of pretraining signal interaction ($F = 3.51$, $df = 4/60$, $p < .05$) along with a significant contingency during first half of pretraining signal effect ($F = 4.06$, $df = 2/60$, $p < .05$). The analysis also indicated that amount of movement declined as trials progressed ($F = 5.48$, $df = 9/540$, $p < .01$). No other effects were significant. A summary of this analysis is given in Table 2, the interaction and trials effect are illustrated in Figures 6 and 7.

Multiple comparisons using Tukey's (a) procedure (Winer, 1962; p. 87) indicated that the IS-IS group moved more during the avoidance ITI than any other group ($p < .01$) and that within the remaining eight groups the AS-AS group moved more than the NO-AS group. No other comparisons were significant.

<u>Correlations</u>

Correlation coefficients were calculated for the relationship between several different pairs of variables. The values of these coefficients are given in Table 3. The Pearson product-moment correlation coefficients for the relationship between total amount of movement during the avoidance ITI and avoidances over 100 trials for

TABLE 2

Analysis of variance on total number of moves during the avoidance training inter-trial interval per block of ten trials using a 3 x 3 x 10 repeated measures design (contingency during first half of pretraining interval x contingency during second half of pretraining interval x trial block)

Source	SS	df	MS	F
Contingency, 1st half (A)	350654.76	2	175327.38	4.06*
Contingency, 2nd half (B)	192000.41	2	96000.21	2.22
A x B	607244.01	4	151811.00	3.51*
Subjects within groups	2593009.55	60	43216.83	
Trial block (C)	491360.88	9	54595.65	5.48**
A x C	127223.82	18	7067.99	1
B x C	138403.26	18	7689.07	1
A x B x C	235605.18	36	6544.59	1
C x subjects within groups	5382418.53	540	9967.44	

* $p < .05$

** $p < .01$

TABLE 3

Correlation coefficients calculated between selected variables and avoidance performance.

Variables	N pairs	test	coefficient	significance level
total movement during avoidance ITI x total avoidances. Calculated over all subjects.	69	Pearson product-moment	$r = +.008$	$p > .10$
total movement during avoidance ITI for each 10 trial block x total avoidances within that block. Calculated for each subject.	10	Pearson product-moment	range $r = -.95 - +.95$	$p < .01$ for extreme values
total movement during avoidance ITI x total avoidances. Calculated for each group	7 - 8	Spearman rank-order	range $\rho = -.25 - +.60$	all $p > .05$
total movement during 1st. half of pretraining signal x total avoidances. Calculated for each group.	7 - 8	Spearman rank-order	range $\rho = +.113 - +.68$	$\rho = +.68$ $p < .05$
total movement during 2nd. half of pretraining signal x total avoidances. Calculated for each group.	7 - 8	Spearman rank-order	range $\rho = -.04 - +.71$	$\rho = +.71$ $p < .05$
total movement during 1st. half of pretraining signal x total avoidances. Calculated over all subjects	69	Pearson product-moment	$r = +.5079$	$p < .01$
total movement during 2nd. half of pretraining signal x total avoidances. Calculated over all subjects.	69	Pearson product-moment	$r = +.4544$	$p < .01$

TABLE 3 (continued)

Variables	N pairs	test	coefficient	significance level
total number of shocks administered during 1st. half of pretraining x total avoidances. Calculated for each shocked group	7 - 8	Pearson product-moment	range $r = -.70 - +.21$	all $p > .05$
total number of shocks administered during 2nd. half of pretraining x total avoidances. Calculated for each shocked group	7 - 8	Pearson product-moment	range $r = -.32 - +.52$	all $p > .05$
total movement during pretraining ITI x total avoidances. Calculated over all subjects.	69	Pearson product-moment	$r = +.4003$	$p < .01$
total inter-trial responses during avoidance x total avoidances. Calculated over all subjects	69	Pearson product-moment	$r = +.1859$	$p < .10$

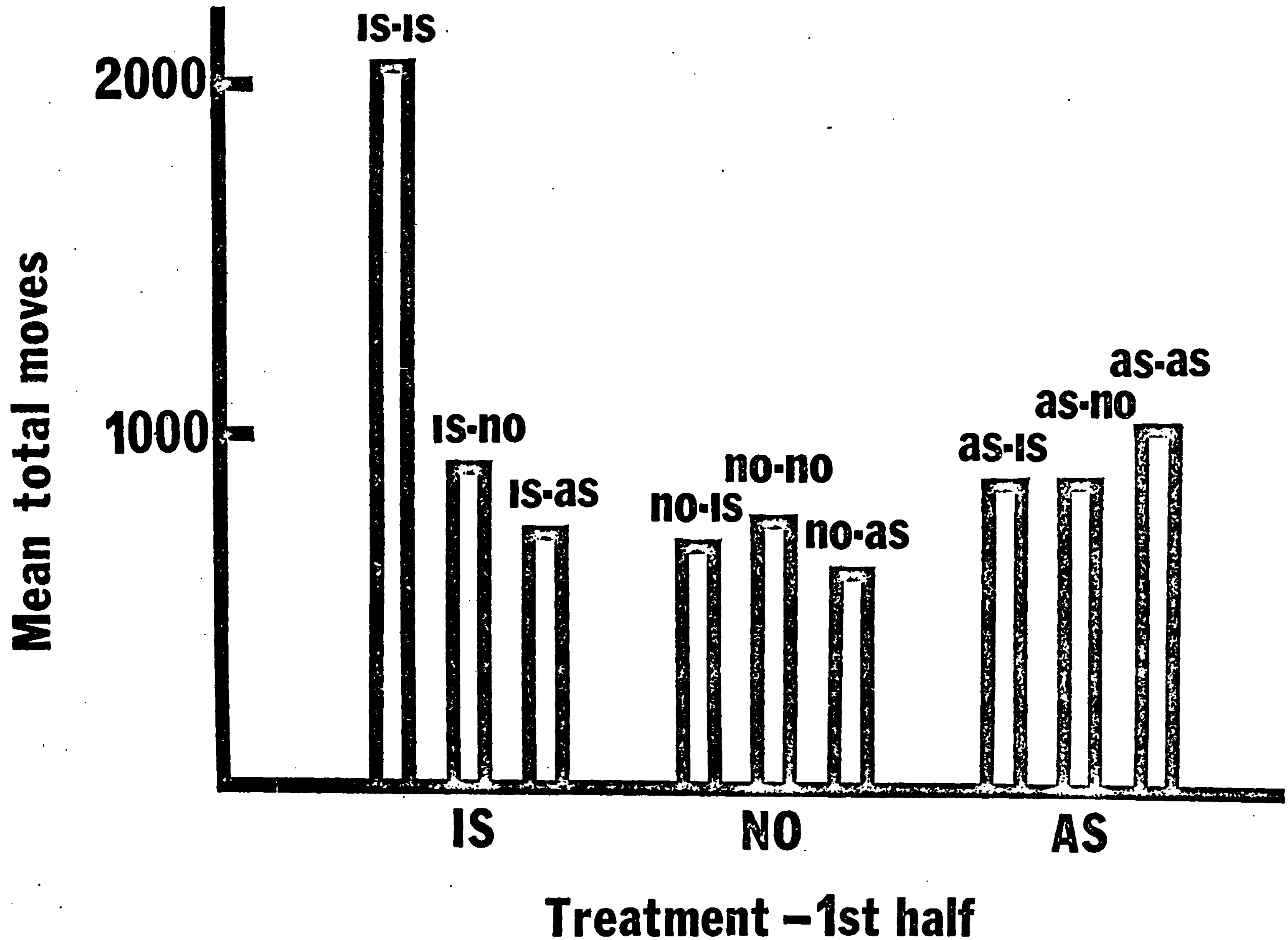

Figure 6. Mean number of moves during the avoidance training inter-trial interval as a function of experimental group

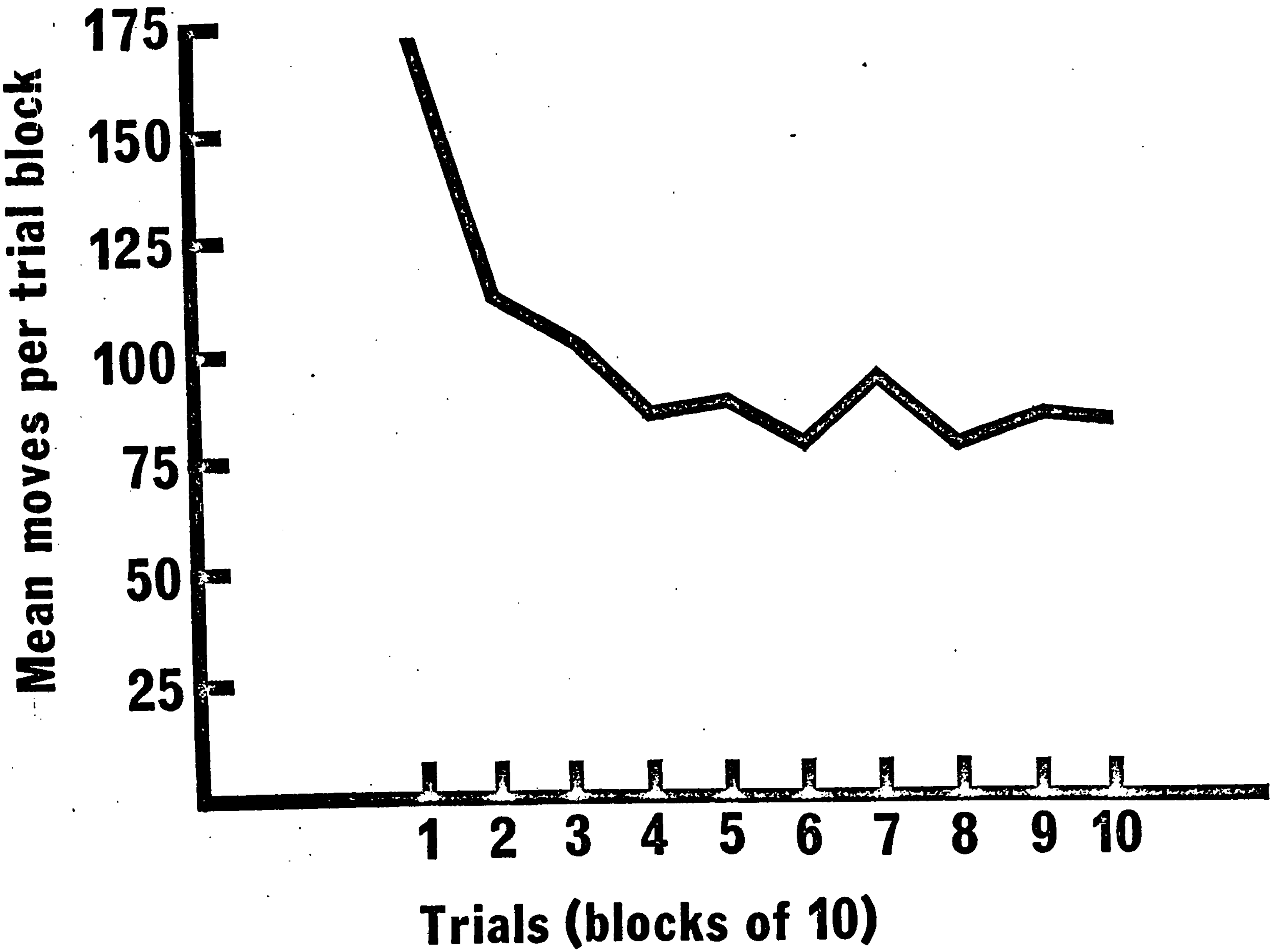

Figure 7. Mean number of moves during avoidance training inter-trial interval as a function of trial block

all subjects was calculated and found to be $r = +.008$, $p > .10$. Correlation coefficients were also calculated relating movement during the avoidance ITI within 10 trials to number of avoidances within that block of trials for each subject in each group. Eighteen of the 69 coefficients calculated were significantly different from zero. Significant correlations were not restricted to any particular group or groups ($\chi^2 = 11$, $df = 8$, $p > .20$).

When Spearman rank order correlation coefficients were calculated for each group relating total number of avoidances with total movement during avoidance ITI, none were significantly different from zero.

Spearman rank order correlation coefficients were also calculated for each group relating amount of movement during the first half of the pretraining signal with avoidances. Of nine calculated the only group where the coefficient was significantly different from zero was the IS-NO group ($N = 8$, $\rho = +.677$, $p < .05$). Rank order correlation coefficients calculated between amount of movement during the second half of the pretraining signal and avoidance yielded a significant value only in the IS-AS group ($N = 8$, $\rho = +.708$, $p < .05$). When Pearson product-moment correlation coefficients were calculated between these variables for all subjects however, the resulting values were: (a) movement during first half of signal x number of avoidances, ($r = +.5079$, $df = 67$, $p < .01$), (b) movement during second half of signal x number of avoidances, ($r = +.4544$, $df = 67$, $p < .01$).

Other Pearson product-moment correlation coefficients calculated were between: (a) total number of shocks administered during first half of pretraining to each shocked group and total avoidances. In no group was the correlation coefficient significantly different from zero, (b) total number of shocks administered during second half of pretraining for subjects in each shocked group and total avoidances. In no group was the calculated correlation coefficient significantly different from zero, (c) total movement during the pretraining ITI and total avoidances for all subjects (r = +.4003, df = 67, $p < .01$).

Intertrial responding

Inter-trial responding was analysed using a 3 x 3 x 10 (contingency during first half of pretraining signal x contingency during second half of pretraining signal x block of 10 trials) analysis of variance, with repeated measures over blocks of 10 trials employing an unweighted means procedure to correct for the unequal number of observations in the groups (Winer, 1962; p. 374). The only significant effect yielded by this analysis was the trials effect (F = 2.931, df = 9/540, $p < .01$) indicating that number of inter-trial responses increased as trials progressed. A summary of this analysis is presented in Table 4 and the trials effect is illustrated in Figure 8.

The Pearson product-moment correlation coefficient calculated between total inter-trial responses and total avoidances for all subjects was not significantly different from zero (r = +.1859, df = 67, $p > .10$).

TABLE 4

Analysis of variance on total number of inter-trial responses during avoidance training per block of ten trials using a 3 x 3 x 10 repeated measures design (contingency during first half of pretraining interval x contingency during second half of pretraining interval x trial block.)

Source	SS	df	MS	F
Contingency, 1st half (A)	69.32	2	34.66	1.805
Contingency, 2nd half (B)	28.80	2	14.40	1
A x B	35.35	4	8.837	1
Subjects within groups	1152.12	60	19.202	
Trial block (C)	64.65	9	7.183	2.921**
A x C	18.54	18	1.030	1
B x C	36.12	18	2.007	1
A x B x C	65.10	36	1.808	1
C x subjects within groups	1327.92	540	2.459	

** $p < .01$

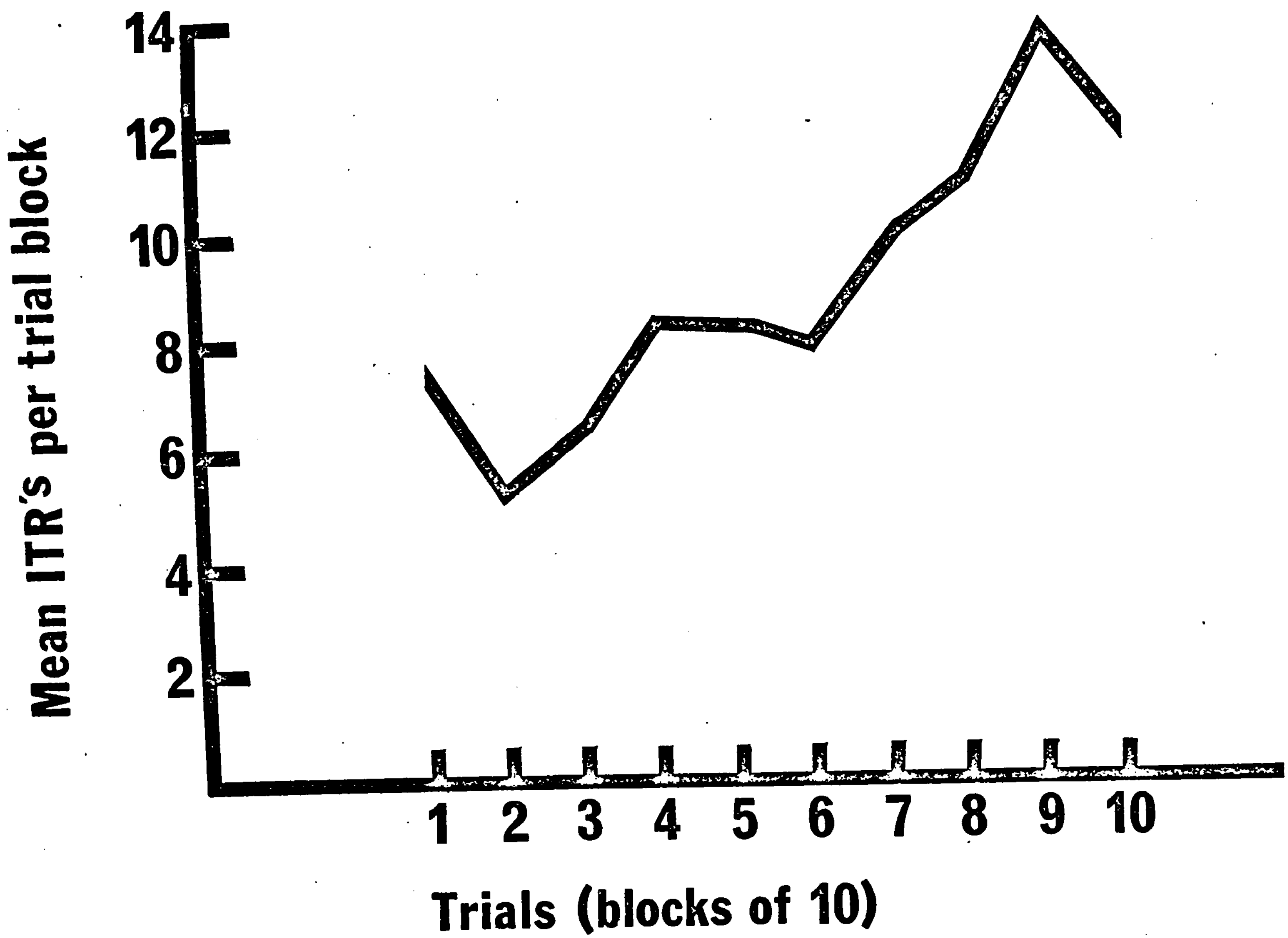

Figure 8. Mean number of inter-trial responses as a function of trial block

Discussion

This discussion consists of three parts. The first part consists of a discussion of the results of the various analyses taken separately. The second consists of an evaluation of the hypothesis that freezing in avoidance learning declines due to an inherent freezing-shock contingency in the light of these results. Lastly, an attempt is made to relate this hypothesis to some previous findings in the avoidance literature.

Discussion of Results

Avoidance Training The analysis of avoidance scores indicated that animals receiving the IS contingency during the first half of pretraining performed better than those receiving the NO treatment during the same period and that these animals, in turn, performed better than those receiving the AS contingency during this period. The analysis also indicated that it was only those contingencies applied during the first half of the pretraining period that affected later avoidance.

The conclusions to be drawn from these results are based on the assumption that if one learning situation facilitates learning in another then the two situations are in some way similar. If this assumption is accepted then it may be concluded that the IS contingency in pretraining was part of a situation that was more similar to the later avoidance task than the situations that included either the NO treatment or the AS contingency. Using the same reasoning, the NO treatment may be concluded to be part of a situation more similar to later avoidance than the situation which included the AS condition.

It is perhaps more correct though to refer to the AS situation as being dissimilar to the avoidance process since, relative to the presumably neutral no-shock NO treatment, the AS contingency caused retardation of later avoidance learning.

Movement scores The movement detector employed in this experiment did not permit measurement of movement during the CS-UCS interval in avoidance training. Since the facilitative effects of pretraining must be manifested within this period, the lack of such a movement measure is a serious shortcoming of this experiment.

The only movement measure taken during avoidance training was during the inter-trial interval. The analysis of variance on this variable yielded the result that the IS-IS group moved more than any other group including the AS-AS group which, in turn, moved more than the NO-AS group. Since movement during the avoidance ITI was not reliably correlated with avoidance performance these results will be cautiously interpreted. It is obvious that high ITI movement scores can accompany both high and low avoidance performance since the IS-IS and AS-AS group showed, respectively, the highest and lowest level avoidance scores. As the IS-IS animals were the best avoiders these animals would be the ones most likely to be moving after CS offset, since the locomotor response necessary for avoidance continues at least briefly after CS termination. As the recording of movement during the ITI began with CS offset, the high movement scores of the IS-IS group could reflect this movement. Conversely the AS-AS animals, which were the poorest avoiders, were the ones most likely to receive shock during avoidance training. Their relatively high ITI movement level could partly reflect the brief post-shock activity observed by Pinel (1971).

Inter-trial responding Although the significant trials effect obtained when inter-trial responding was analysed corresponds to similar effect obtained in the analysis of avoidance performance, the correlation coefficient calculated between total inter-trial responses and total avoidances for all subjects was not significantly different from zero. It is again necessary to conclude that the two measures are independent.

Correlations All correlation coefficients calculated in the analysis of the results of this experiment were between avoidance performance and some other variable. Of these all but one group of the significant coefficients obtained were calculated between avoidance performance and movement measures taken during pretraining. Of the coefficients calculated between avoidance scores and (a) total movement during the avoidance ITI for all subjects, (b) total movement during the avoidance ITI for all subjects within each group, and (c) total inter-trial responding for all subjects, none were significantly different from zero. Of the eighteen significant correlation coefficients obtained when movement during the avoidance ITI for each trial block was related to avoidances during that block, twelve were negative and six were positive. It is not likely that these significant values represent meaningful relationships since a test of independence showed that significant positive or negative values were not restricted to any group or groups. Furthermore, the large number of tests performed increases the probability of rejecting the null hypothesis

$\underline{r} = 0$ when it is true. Thus, although some significant values were obtained, none of the movement measures taken during avoidance training proved to be reliable predictors of avoidance performance.

Of the correlations calculated between measures taken during pretraining and avoidance several proved to be positive and significantly different from zero. Total number of moves during the first half of the pretraining interval, total number of moves during the second half of the interval and total number of moves during the pretraining ITI were all positively related to avoidance performance at the $\underline{p} < .01$ level of significance. When, however, coefficients were calculated between movement during the first half of the signal and avoidance <u>for each group</u> only one coefficient, that for the IS-NO group was significantly different from zero. Similarly the IS-AS group was the only group to yield a significant value when correlation coefficients were calculated for each group between movement during the second half of the pretraining signal and avoidance performance. The significant values in the IS-NO and IS-AS groups are two of eighteen calculated and are not meaningful when the possibility of statistical error with this number of tests is considered. In light of the lack of a large number of significant correlations when movement during pretraining and avoidance performance were related to each other, the validity of the significant values obtained when these measures were related for all subjects becomes questionable. It is possible to argue that the test of correlation within groups was insensitive since, in some cases, only seven paired scores were used. While this argument may be valid, it is necessary to conclude that the relationship between pretraining movement and avoidance performance is, in any event, low since the highest coefficient obtained indicated that variability in movement scores only predicted approximately 26% of the variability in avoidance performance.

Finally, the correlation coefficients calculated between number of shocks received during the first half of pretraining and avoidance performance along with number of shocks received during the second half of the pretraining signal and avoidance were all less than significant. These coefficients were calculated within each appropriate experimental group and permit the conclusion that, at least within individual groups, number of shocks was not related to avoidance performance.

General discussion

The results of this experiment are consistent with the hypothesis that, during normal locomotor avoidance training, freezing declines because of the freezing-shock contingency inherent in the avoidance procedure. The result lending strongest support to this hypothesis is the finding that, when applied during the first half of pretraining interval, the IS contingency facilitated later avoidance performance. It was hypothesized that avoidance learning only proceeds after freezing declines due to being followed by shock. If a similar freezing-shock contingency is applied prior to avoidance training then a facilitation of later avoidance would be expected since freezing would, by then, be partially suppressed. In other words it is suggested that the IS contingency facilitated avoidance performance because the IS pretraining procedure and later avoidance training were essentially similar situations.

Certain alternate explanations of this facilitation are not supported by the results of this experiment. A view that the facilitation was due to prior establishment of a fear response to the pretraining signal, which composed part of the avoidance CS, is not tenable. Groups receiving the AS contingency during the first half of the pretraining signal performed at a lower level in avoidance learning than groups receiving no shock at all during this interval. The fear interpretation would predict that the AS groups be superior, or, at least, equal to the NO groups in avoidance performance. A similar argument may be used to counter the suggestion that the IS facilitation was simply a result of prior exposure or habituation to shock. Further doubt is cast on these interpretations by the lack of a correlation between number of shocks received and avoidance scores.

The retardation produced by the AS contingency is also consistent with the hypothesis. If an inactivity-shock contingency in pretraining facilitates later avoidance because the two situations are similar it would be expected that the contingency opposite to inactivity-shock, namely the AS contingency would produce a retardation.

The result that only the contingencies applied during the first half of pretraining had an effect on later avoidance performance also supports the experimental hypothesis. If it had been found that contingencies applied during both halves affected avoidance training similarly then the interpretation that the IS contingency facilitated avoidance because of a similarity between the two situations would be questionable. In such an instance it would be difficult to maintain that IS during the second half of the pretraining signal facilitated avoidance because of a similarity between the two situations. The second half of the pretraining signal corresponded temporally with the UCS period in avoidance learning and behaviour during the UCS period cannot, under normal avoidance procedures, affect recorded level of avoidance learning. The lack of a contingency effect where the similarity interpretation could not account for it complements the finding that IS during the first half facilitates avoidance and lends support to the interpretation proposed to account for this facilitation.

To the extent that the correlation coefficients calculated between movement during pretraining and avoidance performance are meaningful they may be explained in a manner consistent with the inherent contingency hypothesis. These correlations may be simply interpreted as a result of the pretraining contingencies affecting movement during pretraining in the same way as they are suggested to affect activity during later avoidance training. For example, if avoidance learning proceeds due to increased activity resulting from an inherent inactivity-shock contingency and if the facilitative effect of the IS contingency is a result of a similarity between the two procedures then it is not surprising that amount of activity during pretraining was found to be positively related to avoidance performance. The IS contingency in pretraining, it is suggested, results in a decline in freezing; later avoidance is then facilitated since freezing is already partially suppressed. It is reasonable to assume that as freezing in pretraining declined, activity increased. Thus, since the IS contingency would be facilitative to the extent that it caused a decline in freezing, a positive correlation between pretaining movement and avoidance performance is to be expected.

The analyses of movement during pretraining do not yield results incompatible with the hypothesis. They may, if anything, be construed as weak support.

Relationship to other research

It is important to emphasize that the hypothesis that an inherent inactivity-shock contingency in shuttlebox avoidance learning leads to a decline in freezing was proposed to reconcile the contradiction contained mainly in the two facts that (a) locomotor avoidance learning occurs and (b) freezing is the common response in a situation where shock has been experienced. Support of the inherent contingency hypothesis permits formulation of the early avoidance process in this way: on the first training trial, if a fortuitous avoidance does not occur the subject is exposed to shock paired with the CS. On immediately succeeding trials CS onset leads to freezing and freezing invariably results in shock. This contingency results in a decrease in freezing with a concomitant increase in activity. When level of activity increases such that an avoidance response occurs the process has gone beyond the phase where the inherent contingency hypothesis is singularly relevant. The mode of reinforcement and maintenance of avoidance responding are not factors related to the problem under investigation. The necessity was to propose a mechanism accounting for the decline in freezing during the early stages of avoidance learning. If the hypothesis is able to account for a freezing decline to the point where an avoidance response is possible then an account such as two-factor theory (Mowrer, 1960) is compatible with behaviour thereafter.

This hypothesis does, however, permit interpretation of a number of observations of avoidance learning. Proceeding from a suggestion made by Meyer, Cho, & Weseman (1960) some of the differences found between rates of avoidance learning with different apparatuses may be explained. Avoidance learning proceeds very slowly when a rat is required to press a bar in order to avoid. Bolles (1970) has suggested that bar-press avoidance is slowly learned because the bar-press is not part of the animal's defensive response repertoire. A complementary explanation is that the response of bar-pressing is not sufficiently different from the punished freezing response for avoidance to be rapidly learned. The argument proposed by Meyer, et al. is that for an avoidance response to be rapidly learned it must be "antagonistic" to typical non-avoidance behaviour. They suggest that in bar-press avoidance the response topography of the bar-press is similar to that of the punished freezing response and thus is unlikely to occur. Conversely, this argument explains why locomotor avoidance is learned far more rapidly. The locomotor avoidance response is different, in almost every way, from the punished freezing response and does not then decline in probability due to the punishment of freezing. Indeed, according to the present hypothesis, the rate of activity and consequently the probability of locomotor avoidance initially increases solely due to the punishment and subsequent decline in freezing.

If the general statement is accepted that the avoidance process involves punishment of non-avoidance as well as reinforcement of avoidance behaviour then it becomes possible to also account, in some measure, for the difference between shuttlebox and one-way avoidance learning. Various investigators (Davis, Babbini, & Huneycutt, 1967; Stewart & Anisman, 1970) have reported that one-way avoidance proceeds more rapidly than shuttlebox learning. This difference may be interpreted as being due to increased freezing in a fear motivated conflict situation (Theios, Lynch, & Lowe, 1966; Wahlsten & Sharp, 1969). It is also possible that in shuttlebox learning there is a similarity between punished non-avoidance behaviour and the avoidance response that is not present in one-way learning. In shuttlebox learning as well as in one-way avoidance the subject is, along with being regularly punished for freezing, also shocked for running in the wrong direction. The animal is required to discriminate between the type of activity that will be punished and that which will not be punished. In one-way avoidance training this discrimination is simple since, relative to apparatus and extra-experimental cues, running in one direction is consistently punished while running in the other is, presumably, reinforced. This discrimination is far more complex in the shuttlebox situation since the subject is required to change direction on every trial. While running in one direction on a given trial would result in punishment, it is in that direction that a subject must run in order to avoid on the next trial. The subject then is not only required to discriminate between two directions but also to reverse that discrimination on each trial. This interpretation, while admittedly speculative, is easily testable using Anisman & Waller's (1972) apparatus which consists of a round alley divided into four compartments. If this interpretation is correct then subjects that could avoid by running in either direction should learn to avoid faster than animals in the one-way or shuttle situations since no direction discrimination would then be required.

The inherent contingency hypothesis easily accounts for the inverse relationship found between shock intensity and rate of avoidance learning (Moyer & Korn, 1964; Levine, 1966). Bolles & Moot (1971) reported that incidence of freezing increases with shock intensity. It is then reasonable to suggest that increased shock intensity in avoidance training would result in a greater incidence of freezing and that this freezing would require more trials to be suppressed.

Finally, the inherent contingency hypothesis permits an explanation of the results of an experiment performed by Kamin, Brimer, & Black (1963) that have been cited as contradictory to current avoidance theory (Marx, 1969). These experimenters found that when fear of an avoidance CS was measured using the capacity of the CS to suppress on-going operant responding as a fear index, the relationship between fear of the CS and number of avoidance trials experienced was not monotonic. Specifically, subjects receiving 27 avoidance trials showed less suppression of responding than those receiving only nine trials. If the suppression of on-going behaviour by presentation of a signal previously paired with shock depends on the elicitation of an interfering freezing response then the reported non-monotonic function is readily explained by the hypothesis that, in avoidance training, freezing, as a response to the CS, is suppressed as trials progress. If the hypothesis is true then presentation of the avoidance CS in an operant situation would result in less freezing, and less interference with on-going behaviour as the number of avoidance trials a subject received was increased.

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APPENDIX A - TABLE 1

Individual scores for avoidances, movement during the avoidance ITI and inter-trial responses for each block of 10 trials for the IS - IS group.

Subject number	Trial block										Total
	1	2	3	4	5	6	7	8	9	10	
					Avoidances						
1	0	0	3	1	3	4	6	9	9	8	43
2	0	0	0	1	2	3	9	7	7	7	36
3	0	0	0	0	1	1	2	1	0	1	6
4	1	0	1	0	2	1	9	2	1	2	19
5	0	0	1	1	0	1	2	2	3	2	12
6	5	6	5	5	9	8	7	7	8	6	66
7	4	10	10	9	8	7	1	10	9	8	76
8	1	2	6	4	9	9	10	9	10	10	70
					Movement during the avoidance ITI						
1	46	20	13	21	9	6	14	12	5	1	147
2	277	82	303	131	333	432	473	485	290	314	3120
3	87	84	80	135	113	116	136	90	91	76	1008
4	395	212	71	63	92	152	833	235	244	493	2790
5	260	217	142	95	121	92	105	146	334	197	1709
6	215	523	505	564	588	587	503	312	484	422	4703
7	282	228	150	315	275	315	167	367	245	258	2602
8	221	105	77	39	53	36	30	15	13	20	609
					Inter-trial responses						
1	0	0	0	0	0	0	0	0	1	0	1
2	0	0	0	0	2	3	3	6	5	7	26
3	1	0	0	0	2	3	5	6	7	7	31
4	0	0	0	0	2	3	15	3	3	4	30
5	3	1	0	0	0	2	1	1	4	1	13
6	2	10	5	4	0	1	2	2	4	2	32
7	4	4	2	4	1	3	1	1	1	5	26
8	2	1	2	5	3	1	1	0	1	1	17

APPENDIX A - TABLE 2

Individual scores for avoidances, movement during the avoidance ITI and inter-trial responses for each block of 10 trials for the IS - NO group.

Subject number	Trial block										Total
	1	2	3	4	5	6	7	8	9	10	
					Avoidances						
9	0	2	2	4	5	10	10	10	10	10	63
10	0	1	0	0	2	1	1	1	1	0	7
11	0	0	0	0	0	0	1	2	1	1	5
12	1	0	0	0	0	0	0	0	0	0	1
13	1	1	2	5	3	4	6	3	3	10	38
14	0	0	8	8	5	10	10	7	10	10	68
15	0	0	0	0	0	0	0	0	0	0	0
16	1	0	2	3	9	10	10	10	10	10	65
					Movement during the avoidance ITI						
9	195	235	30	59	84	27	19	13	25	44	731
10	52	33	79	61	96	79	60	61	104	32	657
11	56	13	21	7	12	15	12	12	7	6	161
12	777	322	223	148	145	156	158	233	138	140	2440
13	79	65	55	241	100	72	47	38	27	8	732
14	221	178	75	37	119	19	64	55	17	36	821
15	43	24	13	54	11	23	16	46	62	97	389
16	759	204	114	118	48	56	112	51	230	118	1810
					Inter-trial responses						
9	3	2	0	0	1	0	0	0	0	0	6
10	1	0	1	1	2	6	7	6	4	4	32
11	3	0	1	0	0	1	1	1	1	1	9
12	2	0	0	0	0	0	0	0	0	0	2
13	3	1	2	4	3	2	2	2	6	4	29
14	0	0	0	0	3	0	0	2	0	0	5
15	0	0	1	2	0	0	0	0	0	0	3
16	3	0	0	0	0	1	1	0	1	0	6

APPENDIX A - TABLE 3

Individual scores for avoidances, movement during the avoidance ITI and inter-trial responses for each block of 10 trials for the IS - AS group.

Subject number	Trial block										Total
	1	2	3	4	5	6	7	8	9	10	
					Avoidances						
17	0	1	1	2	1	3	6	10	10	10	44
18	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	1	0	1
20	2	5	4	7	6	4	4	9	10	9	60
21	1	0	4	8	7	10	10	9	10	10	69
22	0	1	2	1	4	10	9	6	3	8	44
23	2	0	1	1	2	1	2	0	2	0	11
24	0	0	1	6	10	10	10	10	10	10	67
					Movement during the avoidance ITI						
17	126	45	74	51	26	24	50	111	170	62	739
18	321	29	10	8	22	5	115	22	84	11	627
19	3	34	3	8	3	10	3	0	0	0	64
20	145	99	138	46	16	27	15	10	18	5	519
21	59	61	76	51	63	62	53	38	29	39	531
22	191	233	306	332	109	113	11	28	26	26	1375
23	105	189	239	206	221	177	166	162	110	49	1624
24	162	81	69	18	8	7	44	12	25	25	451
					Inter-trial responses						
17	1	0	1	1	1	0	3	3	8	1	19
18	0	0	0	0	0	0	0	0	0	0	0
19	0	1	0	0	0	0	0	0	0	0	1
20	1	2	0	1	0	0	0	0	1	0	5
21	0	0	0	0	0	0	0	1	2	1	4
22	3	6	7	10	6	3	0	4	5	5	49
23	1	0	1	1	0	1	0	1	1	5	11
24	0	0	1	0	0	0	0	0	0	0	1

APPENDIX A - TABLE 4

Individual scores for avoidances, movement during the avoidance ITI and inter-trial responses for each block of 10 trials for the NO - IS group.

Subject number	Trial block										Total
	1	2	3	4	5	6	7	8	9	10	
Avoidances											
25	6	10	5	7	9	10	10	10	8	10	85
26	0	0	0	3	0	1	1	6	10	10	31
27	0	0	1	2	4	7	4	7	1	4	30
28	0	2	5	7	10	9	8	9	7	10	67
29	1	0	1	3	6	9	10	9	8	8	55
30	0	1	0	0	0	0	3	1	1	0	6
31	0	0	0	1	1	0	0	1	1	3	7
Movement during the avoidance ITI											
25	33	38	26	5	10	4	15	4	11	11	157
26	124	81	176	67	64	49	24	28	49	32	694
27	65	49	20	59	10	49	41	101	73	21	488
28	29	75	108	48	69	43	42	45	59	69	587
29	100	404	271	163	93	29	19	51	42	43	1215
30	177	83	98	80	58	55	117	124	84	126	1002
31	34	70	29	27	33	17	21	29	71	117	448
Inter-trial responses											
25	2	2	3	0	1	0	2	0	1	1	12
26	0	0	0	0	1	2	0	1	2	1	7
27	1	0	0	0	0	2	0	2	0	0	5
28	1	3	4	2	2	0	2	1	3	5	23
29	0	6	2	6	5	1	1	5	8	8	42
30	1	0	0	0	0	0	0	0	0	0	1
31	1	0	0	0	0	0	0	0	0	0	1

APPENDIX A - TABLE 5

Individual scores for avoidances, movement during the avoidance ITI and inter-trial responses for each block of 10 trials for the NO - NO group

Subject number	Trial block 1	2	3	4	5	6	7	8	9	10	Total
Avoidances											
32	0	0	0	1	2	5	1	2	0	7	18
33	1	0	1	0	0	0	0	0	0	0	2
34	0	0	0	1	0	0	0	0	0	1	2
35	0	1	3	0	5	9	10	8	9	7	52
36	0	1	1	0	0	2	2	0	1	0	7
37	0	0	1	4	5	10	10	10	9	10	59
38	2	0	6	10	10	10	10	8	10	10	76
39	1	2	7	3	8	8	5	9	9	8	60
Movement during the avoidance ITI											
32	13	37	33	22	33	39	23	31	38	16	285
33	96	52	46	57	43	125	62	89	130	77	777
34	113	67	184	238	111	29	103	68	112	149	1174
35	277	137	80	111	86	51	105	125	78	157	1207
36	75	26	4	15	19	7	4	3	7	5	165
37	109	94	40	50	31	46	53	52	127	20	622
38	37	112	130	88	131	253	315	161	150	97	1474
39	86	17	21	17	32	13	33	60	18	21	318
Inter-trial responses											
32	0	0	1	1	0	1	0	2	2	0	7
33	4	0	1	0	0	0	0	0	1	0	6
34	1	0	0	1	0	0	0	1	0	0	3
35	0	0	0	1	0	0	0	2	0	2	5
36	1	0	0	1	1	0	0	0	0	0	3
37	1	0	0	1	0	0	0	0	0	0	2
38	1	0	1	6	5	10	8	10	10	5	56
39	2	0	0	0	1	1	0	0	0	0	4

APPENDIX A - TABLE 6

Individual scores for avoidances, movement during the avoidance ITI and inter-trial responses for each block of 10 trials for the NO - AS group.

Subject number	Trial block										Total
	1	2	3	4	5	6	7	8	9	10	
					Avoidances						
40	0	0	0	1	2	0	0	1	0	0	4
41	0	0	0	0	0	0	0	0	0	0	0
42	2	1	7	8	9	8	10	10	10	10	75
43	0	0	0	1	1	1	3	1	1	2	10
44	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	1	1	1	1	2	1	7
46	0	0	1	1	4	6	7	8	5	8	40
					Movement during the avoidance ITI						
40	67	11	24	28	98	59	20	5	7	2	321
41	67	124	21	45	14	22	53	58	27	126	557
42	153	120	129	104	137	175	248	115	59	59	1299
43	237	275	126	91	91	104	72	118	127	109	1350
44	73	11	7	12	28	39	16	15	25	25	251
45	65	34	43	65	77	227	92	88	89	97	877
46	121	45	30	19	21	12	19	40	71	52	430
					Inter-trial responses						
40	2	1	0	0	0	0	0	0	0	0	3
41	0	1	0	0	0	0	0	0	0	0	1
42	0	0	1	0	0	0	0	0	0	0	1
43	0	2	2	3	6	6	6	7	7	5	44
44	0	0	0	0	0	0	0	0	0	0	0
45	0	0	2	3	2	2	7	7	6	8	37
46	0	0	0	1	0	0	0	0	0	0	1

APPENDIX A - TABLE 7

Individual scores for avoidances, movement during the avoidance ITI and inter-trial responses for each block of 10 trials for the AS - IS group.

Subject number	Trial block 1	2	3	4	5	6	7	8	9	10	Total
					Avoidances						
47	0	0	0	2	2	5	1	4	0	1	15
48	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	1	0	0	1	0	0	0	2
50	1	0	1	1	1	2	1	2	1	1	11
51	1	1	3	2	7	8	6	7	5	3	43
52	0	0	4	0	3	8	2	9	7	10	43
53	0	0	0	0	1	0	1	1	0	0	3
54	0	0	0	1	1	0	1	0	0	0	3
					Movement during the avoidance ITI						
47	7	0	4	0	6	2	5	0	7	10	41
48	501	316	573	326	380	172	197	224	155	156	3000
49	21	5	5	6	61	31	17	14	8	11	179
50	78	94	112	72	86	80	92	260	160	184	1218
51	78	60	103	104	114	57	134	107	157	97	1011
52	227	92	55	15	20	33	28	71	43	19	603
53	194	119	59	28	42	49	24	63	11	18	607
54	16	21	76	5	25	5	42	47	55	45	337
					Inter-trial responses						
47	0	0	0	0	0	1	0	0	0	0	1
48	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	2	5	5	5	17
51	0	2	6	7	7	0	5	5	2	1	35
52	0	1	2	0	0	0	0	1	1	0	5
53	1	0	1	0	1	0	0	0	0	0	3
54	0	0	0	0	1	0	0	0	0	0	1

APPENDIX A - TABLE 8

Individual scores for avoidances, movement during the avoidance ITI and inter-trail response for each block of 10 trials for the AS - NO group.

Subject number	Trial block										Total
	1	2	3	4	5	6	7	8	9	10	
Avoidances											
55	0	0	0	1	0	4	0	3	2	6	16
56	0	0	4	8	10	9	10	10	10	10	71
57	1	1	0	2	2	5	3	8	6	10	38
58	0	0	0	0	0	0	2	1	1	0	4
59	0	0	0	0	0	1	0	0	0	0	1
60	0	0	3	2	2	6	4	6	10	7	40
61	0	0	0	0	1	2	2	1	2	2	10
Movement during the avoidance ITI											
55	20	4	4	0	4	10	0	0	7	75	124
56	207	19	11	32	5	19	0	1	9	4	298
57	524	338	165	92	192	103	212	217	158	31	2032
58	60	22	25	89	263	163	194	161	88	30	1095
59	543	79	59	20	19	19	20	18	22	18	817
60	102	103	125	68	103	42	81	25	26	30	715
61	230	308	110	101	61	37	33	40	33	102	1055
Inter-trial responses											
55	0	0	0	0	0	1	0	0	0	0	1
56	0	0	0	2	0	1	0	0	0	0	3
57	5	0	0	1	4	0	3	1	1	1	16
58	0	0	0	0	1	2	0	5	5	2	15
59	1	0	0	0	0	0	0	0	0	1	1
60	1	0	2	2	2	0	2	1	2	1	13
61	0	1	1	0	0	2	0	1	0	0	5

APPENDIX A - TABLE 9

Individual scores for avoidances, movement during the avoidance ITI and inter-trial responses for each block of 10 trials for the AS - AS group

Subject number	Trial block										Total
	1	2	3	4	5	6	7	8	9	10	
Avoidances											
62	0	0	1	3	2	2	0	3	5	3	19
63	0	0	1	1	2	3	1	3	0	1	12
64	0	0	3	1	5	1	1	1	2	2	16
65	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	1	1	2
67	0	0	2	0	1	0	2	4	5	6	20
68	0	0	0	0	0	0	0	0	0	0	0
69	0	2	1	0	0	0	1	6	3	1	14
Movement during the avoidance ITI											
62	64	46	2	3	10	9	18	10	3	31	196
63	1102	595	423	326	231	176	130	115	111	339	3548
64	261	49	261	165	112	65	37	23	27	13	1013
65	42	39	50	66	16	18	55	118	85	84	573
66	186	137	148	188	342	215	160	207	251	193	2027
67	67	30	20	2	42	23	132	12	15	12	355
68	77	5	6	4	1	9	32	32	14	22	202
69	53	9	11	14	12	14	12	11	57	148	341
Inter-trial responses											
62	1	0	0	0	0	0	1	0	0	2	4
63	0	0	0	0	3	1	0	0	0	0	4
64	2	0	1	1	1	1	0	0	0	1	7
65	0	0	0	0	0	0	0	0	0	0	0
66	3	0	4	0	1	3	4	3	4	5	27
67	0	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0	0	0
69	1	0	0	0	0	0	0	0	0	0	1

APPENDIX B - TABLE 1

Totals for individual subjects for movement during the pretraining ITI (Moves,ITI,pre), movement during the 1st. half of the pretraining interval (Moves,1st), movement during the 2nd half of the pretraining interval (Moves,2nd), movement during the entire pretraining interval (Moves, total), number of shocks administered during the 1st. half of the interval (Shocks, 1st), and number of shocks administered during the 2nd. half of the interval (Shocks, 2nd).

Subject number	Variable					
	Moves ITI pre	Moves 1st.	Moves 2nd.	Moves total	Shocks 1st.	Shocks 2nd.
			IS - IS Group			
1	120	205	349	554	30	28
2	1652	532	808	1340	22	15
3	481	339	394	743	29	28
4	264	113	160	273	32	29
5	1082	423	634	957	27	17
6	557	469	532	901	25	24
7	1141	492	827	1219	24	17
8	1556	695	684	1379	22	20
			IS - NO Group			
9	296	343	180	543	25	-
10	5	228	97	325	32	-
11	301	246	140	386	30	-
12	323	210	261	471	30	-
13	672	426	350	776	19	-
14	699	490	316	806	24	-
15	223	242	277	519	29	-
16	1121	638	589	1229	25	-
			IS - AS Group			
17	297	208	193	401	45	10
18	420	284	220	504	29	14
19	219	107	82	189	38	6
20	385	354	229	583	24	15
21	342	305	288	593	26	19
22	118	219	115	334	30	9
23	468	390	222	512	27	17
24	2006	583	794	1368	23	40

APPENDIX B - TABLE 2

Subject number	Variable					
	Moves ITI	Moves 1st.	Moves 2nd.	Moves total	Shocks 1st.	Shocks 2nd.
			NO - IS Group			
25	1353	152	485	637	-	27
26	1890	363	760	1123	-	20
27	388	95	417	512	-	29
28	2603	464	825	1289	-	18
29	623	71	337	408	-	27
30	1131	200	475	675	-	26
31	85	32	185	217	-	30
			NO - NO Group			
32	332	74	79	153	-	-
33	1126	167	347	514	-	-
34	882	148	265	413	-	-
35	4168	604	1096	1900	-	-
36	1382	248	430	678	-	-
37	1387	327	553	780	-	-
38	452	70	122	192	-	-
39	2008	418	638	856	-	-
			NO - AS			
40	83	6	27	33	-	2
41	111	19	33	52	-	2
42	462	88	126	214	-	10
43	115	31	46	77	-	3
44	147	14	38	52	-	2
45	793	105	130	235	-	7
46	97	5	40	45	-	2

APPENDIX B - TABLE 3

Subject number	Variable					
	Moves ITI	Moves 1st.	Moves 2nd.	Moves total	Shocks 1st.	Shocks 2nd.
AS - IS Group						
47	475	70	331	401	4	29
48	267	66	337	403	5	30
49	88	49	205	254	6	28
50	223	90	260	350	11	36
51	381	53	337	390	11	36
52	377	39	283	322	2	33
53	654	23	403	432	2	30
54	194	22	163	185	2	30
AS - NO						
55	181	30	63	93	4	-
56	227	23	40	63	2	-
57	586	116	181	297	8	-
58	55	19	21	40	3	-
59	199	36	47	83	3	-
60	297	41	17	58	2	-
61	176	25	32	57	1	-
AS - AS						
62	83	28	110	138	5	7
63	1256	213	389	602	12	18
64	410	79	64	143	6	5
65	82	13	1	14	2	0
66	253	30	35	65	2	2
67	272	61	43	104	4	4
68	187	76	24	100	6	2
69	145	26	17	43	2	2

APPENDIX C

Individual Pearson product-moment correlation coefficients relating number of moves during the avoidance inter-trial interval within a 10 trial block to number of avoidances within that block.

Contingency during 1st. half of pretraining interval	Contingency during 2nd. half of pretraining interval					
	IS		NO		AS	
	subj. no.	IS-IS	subj. no.	IS-NO	subj. no.	IS-AS
IS	1	-.68*	9	-.74*	17	+.45
	2	+.65*	10	+.47	18	.00
	3	+.44	11	-.34	19	-.22
	4	+.84**	12	+.95**	20	-.67*
	5	+.24	13	-.11	21	-.57
	6	+.39	14	-.95**	22	-.69*
	7	+.27	15	.00	23	+.09
	8	-.83**	16	-.52	24	-.82**
	subj. no.	NO-IS	subj. no	NO-NO	subj. no.	NO-AS
NO	25	-.35	32	-.16	40	+.50
	26	-.51	33	-.11	41	.00
	27	+.13	34	+.66*	42	-.08
	28	+.02	35	-.52	43	-.68*
	29	-.84**	36	-.35	44	.00
	30	+.13	37	-.30	45	+.45
	31	+.73*	38	+.47	46	-.30
			39	-.31		
	subj. no.	AS-IS	subj. no.	AS-NO	subj. no.	AS-AS
AS	47	-.44	55	+.70*	62	-.59
	48	.00	56	-.65*	63	-.55
	49	-.20	57	-.51	64	+.07
	50	+.40	58	+.38	65	.00
	51	+.26	59	-.13	66	+.17
	52	-.38	60	-.84**	67	-.21
	53	-.22	61	-.69*	68	.00
	54	-.29			69	-.07

**$p < .01$

*$p < .05$

APPENDIX D

Group Spearman rank-order correlation coefficients relating total movement during the avoidance ITI to total avoidances

Contingency during 1st. half of pretraining interval	Contingency during 2nd. half of pretraining interval		
	IS	NO	AS
	IS-IS	IS-NO	IS-AS
IS	+.05	+.11	-.20
	NO-IS	NO-NO	NO-AS
NO	-.25	+.23	+.60
	AS-IS	AS-NO	AS-AS
AS	-.13	-.36	+.10

APPENDIX E

Group Spearman rank-order correlation coefficients relating number of moves during the first half of the pretraining interval to total number of avoidances.

Contingency during 1st. half of pretraining interval	Contingency during 2nd. half of the pretraining interval		
	IS	NO	AS
	IS-IS	IS-NO	IS-AS
IS	+.57	+.68*	+.38
	NO-IS	NO-NO	NO-AS
NO	+.29	+.113	+.19
	AS-IS	AS-NO	AS-AS
AS	+.12	+.18	+.14

* $p < .05$

APPENDIX F

Group Spearman rank-order correlation coefficients relating number of moves during the second half of the pretraining interval to total number of avoidances

Contingency during 1st. half of pretraining interval	Contingency during 2nd. half of the pretraining interval		
	IS	NO	AS
	IS-IS	IS-NO	IS-AS
IS	+.52	+.43	+.71*
	NO-IS	NO-NO	NO-AS
NO	+.50	+.09	+.63
	AS-IS	AS-NO	AS-AS
AS	+.13	-.04	+.56

* $p < .05$

APPENDIX G

Group Pearson product-moment correlation coefficients relating number of shocks administered during the first half of the pretraining interval to total number of avoidances.

Contingency during 1st. half of pretraining interval	Contingency during 2nd. half of the pretraining interval		
	IS	NO	AS
	IS-IS	IS-NO	IS-AS
IS	-.62	-.70	-.35
	NO-IS	NO-NO	NO-AS
NO	-	-	-
	AS-IS	AS-NO	AS-AS
AS	-.20	+.07	+.21

APPENDIX H

Group Pearson product-moment correlation coefficients relating number of shocks administered during the second half of the pretraining interval to total number of avoidances.

Contingency during 1st. half of pretraining interval	Contingency during 2nd. half of the pretraining interval		
	IS	NO	AS
	IS-IS	IS-NO	IS-AS
IS	-.32	-	+.52
	NO-IS	NO-NO	NO-AS
NO	-.32	-	+.68
	AS-IS	AS-NO	AS-AS
AS	+.27	-	+.37

APPENDIX I

Individual comparison between mean avoidance scores of subjects under the three contingencies present during the first half of the pretraining interval. Procedure according to Winer (1962), p. 378.

Contingency during 1st. half of pretraining interval	Mean avoidance score	N_i
IS	36.29 ($\bar{A}_1$)	24
NO	31.50 ($\bar{A}_2$)	22
AS	a6.65 ($\bar{A}_3$)	23

$$F = \frac{\left[(\bar{A}_i) - (\bar{A}_{i'})\right]^2}{MS_{\text{subj w groups}}\,(1/n_i q + 1/n_{i'} q)}$$

N.B. the term $n_i q$ refers to the number of scores from which the mean was derived, in this case N_i

for comparison ($\bar{A}_1$) vs. ($\bar{A}_2$)

$$F = \frac{\left[(36.29)-(31.50)\right]^2}{68.40\ (.0871)} = \frac{22.94}{5.95} = 3.86,\ \underline{df} = 1/60,\ \underline{p} < .05$$ for one-tailed test

for comparison ($\bar{A}_1$) vs ($\bar{A}_2$)

$$F = \frac{\left[(31.50)-(16.65)\right]^2}{68.40\ (.0890)} = \frac{220.52}{6.08} = 36.27,\ \underline{df} = 1/60,\ \underline{p} < .005$$ for one-tailed test

APPENDIX J

Tukey (a) multiple comparisons procedure on movement during avoidance training inter-trial interval cell totals

cell and cell total		cell and cell total							
		NO-AS	NO-IS	IS-AS	NO-NO	AS-NO AS-IS	IS-NO	AS-AS	IS-IS
		5000	5545	5650	5735	6675	6990	7875	15190
NO-AS	5000	-						2875*	10910*
NO-IS	5545		-					2330	10465*
IS-AS	5640			-					10270*
NO-NO	5735				-				10175*
AS-NO AS-IS	6675					-			9235*
IS-NO	6990						-		8920*
AS-AS	7875							-	8035*
IS-IS	15190								-

$q_{.05}\ (8, 60)\ \sqrt{\tilde{n}\ MS_{error}} = 4.44 \times 574.2 = 2549.45$

N.B. calculation of the critical value employs the harmonic mean $\tilde{n}$ of the number of observations per cell. Cell totals tested are corrected from original using the formulae: corrected cell

total = $(X_{ij}/n_i)\ \tilde{n}$

* $p < .05$