RETENTION OF

THE INCOMPLETELY LEARNED AVOIDANCE RESPONSE

RETENTION OF THE INCOMPLETELY LEARNED AVOIDANCE RESPONSE:

THE EFFECTS OF

HANDLING AND LOCATION DURING THE INTERSESSION INTERVAL

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NANCY KAY ANDERSON, B.A.

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AUTHOR: Nancy Kay Anderson, B.A. (Western Reserve University)

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SCOPE AND CONTENTS:

The retention curve of an incompletely learned avoidance response was investigated, employing rats in a shuttlebox situation. Subjects were given a 15 trial relearning session 0, ½, 1 or 24 hours after original acquisition. Three treatment groups were tested at these intervals: a not-handled group which remained in the shuttlebox during the intersession interval, a handled group which remained in the shuttlebox during the intersession interval, and a group which was returned to a living cage. All treatment groups produced a monotonically decreasing curve as a function of intersession interval. Handling produced a decrement on performance at 0-hour intersession interval; location showed no effect. Results were interpreted in terms of the warm-up decrement and the effects of handling on the arousal of fear.

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CHAPTER I

INTRODUCTION AND HISTORY

The present experiment is concerned with the analysis of the peculiarly U-shaped retention curve of an incompletely learned avoidance response, first reported by Kamin (1957). With rats as subjects in a shuttlebox, Kamin showed that the retention curve for a partially learned avoidance response was not monotonic; rather, retention first declined with the passage of time, and then improved. Subsequently, a number of studies have been reported which have attempted to analyze this curve further. Several of these investigators have replicated the basic non-monotonic form of the curve, and some have reported experimental variations which seem to affect the point in time at which the curve reaches a minimum. For reasons which will become clearer after a review of the relevant literature, the present experiment attempts to separate the effects of two variables on the retention curve. The variables studied were: the effects of the experimenter "handling" the rat following its original learning of the avoidance response, and the effects of the place in which the rat spends the time between its original learning and the test for retention. We shall first review the relevant experimental literature, before describing our own experimental work.

The basic procedure of shuttlebox avoidance training was first employed by Warner (1932) in a parametric study of

CS-US interval, although it was not until later that Schlosberg (1934) clearly separated avoidance learning conceptually from classical conditioning with a noxious unconditioned stimulus. There has since been considerable interest in the parameters of avoidance training. The history of this work has been very thoroughly covered by Solomon and Brush (1956). The present experiment concerns itself specifically with the retention of an incompletely learned avoidance response. For this reason, most of the literature summarized by Solomon and Brush (as well as work subsequent to their Review) is largely irrelevant. We shall describe the distinguishing features of the avoidance training paradigm before proceeding to the directly relevant literature.

Two basic forms of avoidance training have been delineated. Mowrer (1960) calls them passive and active avoidance paradigms. The passive paradigm requires that the subject not perform some specific act, in order to avoid a noxious stimulus, which is presented if the act is performed. Active avoidance requires that the subject perform some specific response in order to avoid presentation of a noxious stimulus which would otherwise be delivered. We are concerned in this study with the active avoidance paradigm.

The technique most often used to study active avoidance is the shuttlebox, developed by Miller and Mowrer. This consists of a two-compartment box with a grid floor permitting presentation of an electric shock to the feet of the animal. The response which escapes (terminates) or avoids (prevents delivery of) this shock, is a running response from one compartment to the opposite compartment. The shock (US) is preceeded by a warning stimulus (CS) for a time interval sufficient to allow the animal to shuttle to the opposite compartment before the scheduled delivery of the US. The shuttlebox apparatus is used in the present experiment, as it has been in all previous experiments on the retention of an incompletely learned avoidance response.

The fact that we are studying retention of a response suggests that the voluminous psychological literature on retention and forgetting would be relevant. This is, however, not really the case. First, the great bulk of this literature involves the study of verbal learning in humans; nothing comparable to the classical Ebbinghaus retention curve has been reported for conditioned responses learned by animals. There are some scattered reports of the long-term retention of an avoidance response. Wendt (1937) and Liddell et al. (1934) carried out studies which test animals long after original learning, and which indicate that there is nearly complete retention of the response over a number of years. These studies however, differ from the present one in two fundamental ways. They are concerned with time intervals of a larger order of magnitude than those with which we are concerned, and the conditioned responses studied had been very thoroughly "overlearned". The retention curve of an overlearned response would presumably be much flatter than that of an incompletely learned response.

There is some hint that, when an aversively motivated response is considered, the retention curve may, for a period, actually rise, rather than decline. Two experiments on the notion of "incubation" of fear are particularly relevant. These studies both employed human subjects, and, in general, had similar outcomes. Diven (1937) demonstrated that a word (in a series of words) which had been paired with shock would elicit greater anxiety reactions, as measured by the galvanic skin response, at longer intersession intervals than at shorter ones. He tested four retention intervals: 5 minutes;.5 hours; 24 hours and 48 hours, and showed that the .5hour , 24 hour, and 48 hour groups had a greater galvanic skin response than the 5 minute group. Bindra and Cameron (1957) demonstrated a similar phenomenon measuring increases in galvanic skin responses over a ten minute time interval between original acquisition and a retest.

The galvanic skin response is considered to be an anxiety response. If avoidance responding can be considered to relate directly to anxiety level, then these incubation of fear experiments might suggest the possibility that the retention curve of an avoidance response may deviate from monotonicity.

We turn now to a detailed description of the eight previous studies which have dealt specifically with the retention of an incompletely learned avoidance response. It is difficult to get an "historical sense" of these studies, since they have all appeared quite recently, and there is no obvious development of one study from the results of another.

The original Kamin study (1957) laid down a basic experimental procedure which has been followed in some crucial aspects by all subsequent investigators. The animals were first trained in the shuttlebox for an arbitrary number of trials. They were then removed from the shuttlebox for different periods of time. The time periods (intersession intervals) varied, for different groups, between zero and 19 days. Retention was then assessed by giving each animal 25 further trials in a relearning session. Performance during this relearning session was used to indicate the amount of retention. The only differential treatment of groups, according to Kamin, was the length of the intersession interval. Differences between groups during the relearning session were attributed to the passage of different amounts of time since the original learning. The question asked by this experimental design is, basically, how much positive transfer is there from original learning to the relearning session, and how does this vary with the passage of time?

The apparatus employed by Kamin was a modified Miller-Mowrer shuttlebox, manually operated. The CS was a 74 db buzzer and the US was a 1.1 ma. electric shock. The procedure was standard avoidance training, delayed conditioning. The onset of the CS preceeded onset of the US by 5 seconds, and the CS continued to act until the US was terminated, or until the subject made an avoidance response. The subjects (hooded rats) could avoid the shock (and promptly terminate the CS) by running from one compartment to the other before the scheduled delivery of shock. When the subject failed to respond to the CS within 5 seconds, the CS and the US continued to act until the subject (usually very promptly) ran to the opposite compartment. This type of behaviour was termed an "escape". The intertrial interval in this study was one minute.

The original acquisition of the avoidance response consisted of 25 training trials for all subjects. The intersession intervals studied, in six different groups, were: 0 (1 minute), .5, 1, 6, 24 hours and 19 days. The zero hour animals, unlike all others, were not removed from the shuttlebox after the first 25 training trials. They began their "relearning session" after the normal one minute intertrial interval. In the other groups, the subjects were returned to their home cages for the intersession interval. The relearning session consisted of 25 trials which were identical procedurally to the acquisition trials.

Analysis of the number of avoidances made during the relearning session showed a significantly non-monotonic effect with the 1 hour intersession interval group making significantly fewer avoidances than the 0 hour, the 24 hour, and 19 day groups.

In fact, analysis of covariance indicated that after a

1 hour intersession interval, the subjects made no more avoidances in 25 relearning trials than they had made in the original 25 training trials.

Kamin (1963) reported some further analyses of this finding in subsequent experiments. Two changes in his previous procedure were made: all the subjects were run to an acquisition criterion of three consecutive avoidances in original learning, and the zero-interval subjects were removed from the shuttlebox and "handled" by the experimenter briefly at the conclusion of original acquisition. This treatment was intended to equate the zero-interval group with all others in respect to "handling" by the experimenter. The experiment under these conditions basically replicated the previously reported U-shaped curve.

A more detailed analysis of the data, however, suggested that the results of this experiment were more complex than appeared at first. The subjects in each group, were divided into two equal-sized groups: those which had had the greatest and those which had had the least number of escape trials during the original learning. The "fast learners" (least number of shocks during original acquisition) performed better during relearning; but of more interest, an analysis of the number of avoidances during the relearning as a function of the speed of original acquisition, indicated that the slower learning half of the animals showed poorest retention at 6 hours after acquisition, whereas the curve for the faster learning subjects reached its minimum one hour after original acquisition. The interaction between speed of original learning and intersession interval fell barely short of significance.

The analysis of performance during the first five, as opposed to the last five, relearning trials suggested a further complication. There was a significant interaction between Trial Block and Intersession Interval. This reflected a tendency for performance during the early trials to decline relatively monotonically with retention interval; only in the last five relearning trials was there a clear U shaped function. This led Kamin to suggest that performance during very early relearning trials reflected monotonic "warm-up decrement", which blended with a U-shaped characteristic specifically impeding performance after an intersession interval of one hour.

A separate study in the same report provided evidence compatible with this view. Four groups of subjects were given 150 trials of avoidance training, in sessions of 30 trials each. The intervals between sessions were 0, 1, 24, or 192 hours. During early trials of the sessions (after the first), there was a clear decline in performance (from the terminal level of the preceeding session) for all groups except the 0 intersession interval group. During sessions 2 and 3, the 1-hour group alone showed a persisting decrement, lasting through all 30 trials. By session 5, the only decrement observed was in the early trials of the session for all groups; the magnitude of the decrement was inversely related to the length of the intersession interval.

Thus Kamin concluded that, although a monotonic warm-up decrement might complicate results during early relearning trials, "some other factor" was involved in adversely affecting performance at one hour.

With a final experiment in the same paper Kamin attempted to discover whether the curvilinear retention curve applied to the classically conditioned fear of the CS, to the instrumentally learned escape response, or to both. The attempt to separate these alternatives was made by giving three different types of pre-training to the three major groups each of which was divided into subgroups given avoidance training 0, 1, or 24 hours after pretraining intervals. Three major groups of animals were given 15 pretraining trials consisting of either: (1) escape response training, where only the US was presented, and terminated by the shuttling response, or (2) CS-US pairings, with the subject penned on one side of the shuttlebox (CS was 6 seconds, the last 1 second coinciding with a fixed duration 1 second US), or (3) US treatment, which was identical to the CS-US pairings treatment, except that the CS was omitted. The subsequent acquisition of avoidance was not differentially affected by these pre-training treatments at any of the intervals tested.

Two groups of workers other than Kamin have been interested in the U-shaped retention curve and have reported a number of studies on it, all employing rats as subjects. Since the procedural details are similar within each laboratory, it will be simpler to describe first the work of Denny and his associates, and then the work of Brush and his associates, disregarding the chronological order of the reports.

Denny (1958) first replicated Kamin's results, using a procedure very similar to that reported in Kamin's 1957 paper, but with a slightly smaller shuttlebox. He also found that a group of 24-hour intersession interval subjects who were given a number of unavoidable shocks one hour before the relearning session showed a decrement in retention similar to the effect seen at the one hour intersession interval. The untreated 24-hour controls showed no decrement in relearning performance. The exact procedural details are not available in the published abstract of this work.

Differences in the absolute number of avoidance response made by Kamin's and Denny's subjects led Denny and Thomas (1960) into an examination of the effects of shuttlebox dimensions on the retention of an incompletely learned response. Kamin's studies were performed in a shuttlebox 36 inches long, 5 inches wide, and 4$\frac{3}{4}$ inches high. Denny and Thomas tested six groups of subjects at the 1 hour intersession interval, in shuttleboxes either 16, 26, or 36 inches long, and 5 or 14 inches high. The rest of the procedure was similar to Kamin's first study: a standard 5-second CS-US delayed conditioning procedure was used, with a 70-db. buzzer as the CS and a 1.7 ma. shock as the US. Twenty-five acquisition and 25 retraining trials, with a 1-minute fixed intertrial interval, were given, with all subjects spending the 1-hour intersession interval in the home cage.[1]

The results of the experiment were complicated. The basic finding was that the height of the shuttlebox significantly affected the number of avoidances made in the 25 trials of original acquisition: rats trained in a high-ceiling box made more avoidances than did rats trained in a low-ceiling box. This, of course, means that the degree of learning which the subject had reached after 25 training trials was not equal across experimental groups, although all groups were tested after a 1-hour intersession interval. Whether or not the subject showed a decrement after the 1-hour interval depended upon shuttlebox height (amount of original learning). The Denny study indicated that only rats trained in the high-ceiling box showed a significant decrement. These data thus indicate that the shape of the retention curve will be influenced by such factors as shuttlebox dimensions; although it may well be the case that shuttlebox dimensions affected retention only because of its effect on the level of acquisition achieved after 25 trials. The effect of such a

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[1] Because there is no explicit statement concerning an automated procedure, it seems certain that the animals were run in manually operated shuttleboxes in all of Denny's experiments.

variable as shuttlebox dimensions might be circumvented by training all animals in such retention studies to a criterion of suitably "incomplete" acquisition, instead of training for an arbitrary number of trials.

That the study of retention of avoidance is fraught with pitfalls, however, is indicated by Denny and Thomas's findings that the interaction of the subject's sex and box height significantly affected performance, such that females make more avoidances in high-ceiling shuttleboxes whereas males make a few more avoidances in low-ceiling boxes.

Denny and Ditchman (1962) next reported a study attempting to pinpoint the locus of "maximal Kamin effect". They used this term to refer to the minimum point in the curvilinear retention function. The procedural details corresponded to those of the Kamin study (1957), and the Denny and Thomas (1960) study, but the shuttlebox was the one earlier demonstrated to produce the best "Kamin effect": 4 inches in width, 36 inches in length and 14 inches in height. The subjects were given 25 original learning trials, then given relearning trials, after intersession intervals of 0, .5, .75, 1, 1.25 or 1.5 hours. The subjects (with the exception of the zero-interval group) spent the intersession interval in the home cage. The retention function was found to be significantly curvilinear; furthermore, the minimum was fairly precisely localised at 1 hour, since this group was significantly worse than both the .75 and the 1.5 hour groups.

This apparently clear-cut result, however, must be speedily modified, for Denny and Fisher (1960) reported a study showing that the locus of greatest decrement in relearning was affected by the intertrial interval used. Different groups of rats were given 25 acquisition and 25 relearning trials, using either a ½-minute or a 1-minute fixed intertrial interval. Within each intertrial interval group, 0, 1, 4 and 24 hour intersession intervals were tested. The original acquisition was poorer with a ½-minute than with a 1-minute intertrial interval. The retention curve for groups trained with a ½-minute intertrial interval showed a maximal decrement in performance at the 4-hour, rather than the 1-hour intersession interval. Thus, though the familiar U-shaped curve appeared, the 1-hour minimum demonstrated with a 1-minute intertrial interval was displaced when intertrial interval was reduced.

We now turn to a series of studies by Brush and his associates. Segal and Brush (1959) reported a U-shaped retention curve under somewhat different procedural conditions. The shuttlebox used was 19 inches long, 6 inches wide, and 12 inches high, and completely automatic. A swinging door separated the two compartments. A standard 5 inch CS-US interval delayed conditinning procedure was used. The US was a .15 ma. shock,[2]

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[2] The nature of the CS is not reported in the abstract available to us.

The study examined the intersession intervals of 0, 1 hour, 1, 5, 10 and 20 days. However, rather than a single acquisition session, followed by a relearning session, five training sessions were given, each consisting of 20 trials, and each separated by the appropriate intersession interval. The zero intersession interval group continued through the 100 trials undisturbed, and the other subjects spent their intersession intervals in their home cages.

The Segal and Brush data were less than clear-cut. They reported that this procedure led to very rapid and efficient learning of avoidance, imposing a "ceiling effect" which made it difficult to show differences between groups; essentially, all groups learned avoidance well, and rapidly.

However, when attention was restricted only to animals which made fewer than 10 avoidances during the first session of avoidance training, a significant effect of intersession interval on performance during the second session could be demonstrated. Further, when all subjects were given an "improvement score", consisting of the difference in the subject's performance between sessions 1 and 2, analysis of variance of the improvement scores showed a significant effect of intersession interval. Though no differences between individual pairs of groups were tested for significance, the least improvement was shown by subjects with intersession intervals of 1 hour, 1, 5, and 10 days. More improvement was shown by subjects with zero and with 20-day intersession intervals. Thus, the curve reported by Brush and Segal was basically U-shaped, although no clear-cut difference was shown across the range 1 hour to 10 days.

Brush, Myer, and Palmer (1963a, 1963b) have reported further work on the U-shaped retention curve. Their shuttle-box was the same automated shuttlebox described by Segal and Brush. A standard 5" CS-US interval delayed conditioning procedure was used. The CS was a flashing light and a clicking sound; the US was a .26 ma. electric shock. The intertrial interval was fixed at 1 minute. The subjects were trained to an original acquisition criterion of three (not necessarily consecutive) avoidances.

Relearning trials were given to different groups after one of five intersession intervals: .08 (5 minutes), 1, 4, and 24 hours, and 7 days. There was another group, outside the main experimental design, given retraining trials after 1 hour, which spent the intersession interval in the shuttlebox. All other groups, apparently including the 5-minute group, were returned to the home cage for the intersession interval. Forty relearning trials were given after the intersession intervals.

Brush et al (1963a) found, as did Kamin, a curvilinear retention function. They indicated, however, that an analysis of the retraining trials in blocks of ten showed that during trials 1-10, the low point of the curve was at four hours.

After the first 10 trials, the low point shifted to 1 hour. The authors, however, do not indicate that this shift was statistically significant. There was a significant effect of intertrial interval, but no significant tests between individual pairs of groups were reported. The "extra" group, detained in the shuttlebox for the intersession interval performed significantly better than did the group spending the 1 hour in its home cage. The authors do not indicate whether this group performed significantly better than the .08-hour group; the published figures indicate that this might be the case.

Within the same study, Brush et al next experimented with three different "pre-training" conditions, in an attempt to discover what part of the avoidance training experience was responsible for the U-shaped curve. One major group was given escape-response training trials, during which only the US was presented; the US was terminated by shuttling. The subjects were given the same number and temporal distribution of shocks received by the average subject in the first experiment. The major group was sub-divided into four sub-groups, given 40 avoidance learning trials after the same intersession intervals employed in the first experiment. The avoidance learning following this pre-training was unstable, and showed no systematic relationship to length of intersession interval. Another major group was given CS-US pairings, with a .5 second

CS-US interval. The US terminated with the shuttling responses, but the CS-US interval was so short that the subject could not avoid shock. (This procedure differed from Kamin's (1963) procedure of CS-US pairings, already described, where the subject was penned in one compartment and could not escape a brief, fixed-duration shock) The subsequent avoidance learning after various intersession intervals showed the same kind of effect observed in the first experiment. The acquisition of avoidance was curvilinearly related to the interval between CS-US pre-training and acquisition, with the poorest acquisition occuring 1 hour after pre-training. Finally, a third major group provided a control for pseudo-conditioning. These animals, run at .08, 4, and 24 hour intersession intervals, were given escape-response training, with random presentations of the CS interspersed during the intertrial intervals. There was no significant relation between avoidance performance and intersession interval. Thus, Brush et al concluded, fear conditioned to the CS (during CS-US pairings), is a necessary condition for the appearance of the Kamin effect; shock stress, or escape-response training alone, is not sufficient.

A later series of studies by Brush, Myer, and Palmer (1963b) indicated that the intersession interval interacts with the intertrial interval in determining the shape of the retention curve. With the same basic procedure used in the previously described study, three intertrial intervals were used: $\frac{1}{2}$, 1, and 2 minutes. Five intersession intervals were examined: 5 minutes, 1, 4, 24 hours, and 7 days. This study was thus a 3 x 5 factorial design.

The authors reported that intertrial interval greatly affected the rate of original acquisition. The 2-minute intertrial interval groups acquired the response most quickly, then the 1-minute groups, and then the $\frac{1}{2}$ minute groups. Whatever intertrial interval was employed, a significant curvilinear retention function was found. The intertrial interval, however, affected the location of the minimum point of the curve. During relearning trials 10-40 <u>all</u> intertrial interval groups showed the locus of most severe decrement at 1 hour. However, during trials 1-10, the lowest retention point for $\frac{1}{2}$ minute intertrial interval groups was 24 hours, and for the 1- and 2-minute intertrial interval groups, it was 4 hours. Again, the authors did not indicate whether the effects observed during trials 1-10 were statistically significant. To demonstrate significance, a significant interaction between intersession and intertrial intervals would have to be shown. The authors, however, analyze the effects by median tests on pooled groups within each block of trials. These tests can not show difference between any particular pairs of groups. Examination of their data suggests that it is very unlikely that a signigicant deviation from monotonicity can be demonstrated for any of the three retention curves plotted for trials 1-10.

However, it should be remembered that Denny and Fisher (1962) also reported an apparent shift in the locus of maximal Kamin effect, attributable to changing the intertrial interval.

This review of the literature reveals that all studies on the retention of an incompletely learned avoidance response agree on the U-shaped nature of the retention curve. Furthermore, the intersession interval of greatest decrement in performance (1 hour), first shown in Kamin's 1957 report; has been replicated by Denny (1958), Denny and Ditchman (1962), and Brush, Myer, and Palmer (1963a, 1963b). Table I lists all the experiments for which the data are available. The number of avoidances during relearning for at least two of the following three intersession intervals: 0 (5 minutes), 1 hour, 24 hours is shown. With the exception of one study, (Segal and Brush 1959) the retention curve is U-shaped for these data.

Insert TABLE I

However, certain factors seem to alter the time interval of greatest decrement in relearning performance. Thus, there are two problems of theoretical concern which arise from these data: (1) the U-shaped form of the retention curve, and (2) the way in which various factors interact with the effects of time to determine the point at which the most severe decrement occurs. We will first consider the theories devised to ex-

TABLE I

Mean[3] Number of Avoidances on the Retest at Three Intersession Intervals

Number of relearning trials	Source	Measure 0	1	24
25	Kamin (1957)	14.6	6.5	13.4
25	Kamin (1963, experiment 1)	20.1	11.8	18.0
30	Kamin (1963, experiment 2, 2nd. session)	23.6	13.2	20.1
25	Denny (1958)	17.8	10.1	18.4
25	Denny and Ditchman (1962)	21.0	10.0	----
40	Brush, Myer, Palmer (1963b) Intertrial Interval			
	½	25[4]	12	19.5
	1	31.5	13.5	23.5
	2	31.5	19.5	34.0
20	Brush and Segal[5] (1959)	7.5	5.8	5.8

[3] Brush, Myer, and Palmer report medians which are given in this table.

[4] This interval was 5 minutes and the animals were returned to the home cage.

[5] These figures are the mean number of avoidances on relearning session 2 minus the avoidances on relearning session 1.

plain the general form of the retention curve, and then consider the factors which shift the point at which the poorest retention occurs in terms of these theories.

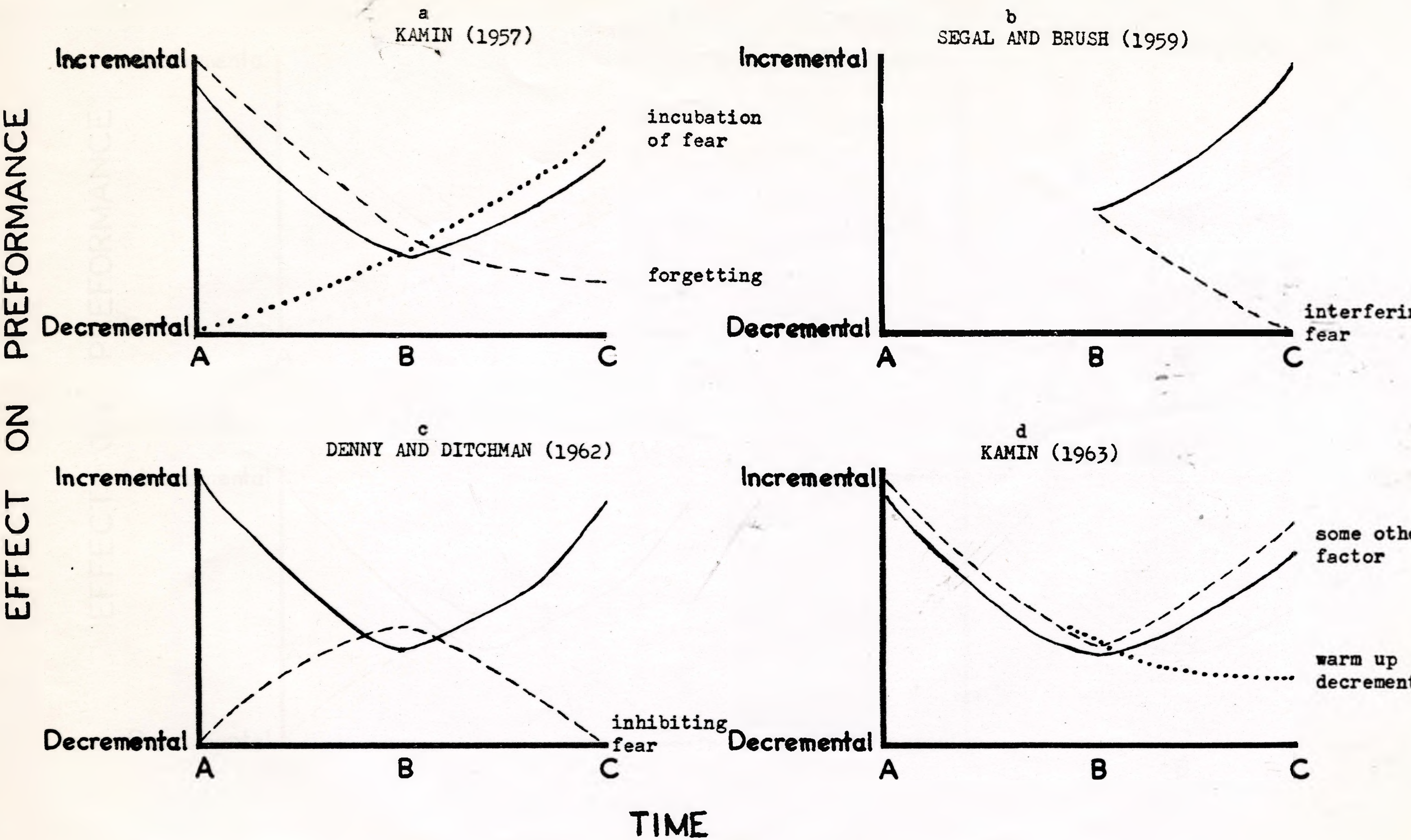
There have been two basic types of theories proposed to explain the U-shaped retention curve. Both of them have been deliberately framed to fit the data presented in Table I (page 20). The theories can be classified generally as either one-process or two-process theories.

A one-process theory must imply that the underlying process which "causes" the U-shaped curve changes through time in some curvilinear fashion. Also, in a one-process theory, the empirical curve is considered to be a direct expression of the activity of this one process. Thus, the point of maximum decrement in relearning performance is the point of either maximum or minimum effect of this underlying process (depending on whether the postulated process is detrimental or facilitative to avoidance behaviour). Of course, if a one-process theory is possible, it is much more parsimonious than a multi-process theory, and, therefore, more desirable.

Two-process theories imply that the interaction of two underlying processes are producing the U-shaped curve. These two processes may be both monotonic, with one operating to facilitate performance and the other operating to depress performance, or they may be more complex; one or both processes may be curvilinear in character and interact in various ways at various time intervals. The assumption of two processes

FIGURE I

PROPOSED THEORETICAL PROCESSES



underlying a single response results in problems of interpretation. The main one is that without independent measures of at least one process the theory may be untestable, ie. it may explain too much. If there is only one behaviour being measured, the differences between empirical results under various experimental treatments, may be functions of changes in one process, the other process, or their interaction, and there is no way of knowing which is the case.

Kamin (1957) suggested a two-process theory as one of many possible explanations of his findings. Figure la illustrates the theoretical processes which Kamin suggested. In this figure and in the subsequent figures plotting theoretical processes, the proposed processes and resultant behaviour will be plotted according to their effect on performance during the relearning sessions as a function of three intersession intervals. Because of certain disagreements on the exact shape of the retention curve, a short interval (tentatively called 0 minutes), the point of maximum decrement (1 hour), and a point of subsequent improvement in performance (24 hours), will be listed ordinally as A, B, and C. The theoretical processes will be plotted as dotted lines, and the resultant behaviour will be plotted as a solid line.

Insert FIGURE 1

Kamin proposed that the U-shaped curve was a function of two monotonic processes. The forgetting process acts to decrease performance particularly from A to B. Since the classical retention curves are negatively accelerated, it is assumed that sometime after B forgetting reaches an asympototically maximum level and exerts relatively little differential influence at longer time intervals. The other process is a monotonically increasing one which facilitates performance and "reaches a substantial level" some time after B. This process, it is suggested, is an incubation process. It is implied further, that the forgetting process affects the instrumental aspects of the response and the incubation affects the emotional aspects of the response. This theory can predict that performance will be worse at B than at A, because of the monotonic forgetting process. It will also predict that at C, performance will be better than at B, since forgetting is now asymptotic, and incubation of fear (which is facilitative) is increasing with time. It cannot, however, predict whether performance would be better at C (24 hours) than at A (0 hours) since the slope of the incubation of fear curve is unknown.

Because of the problems involved in two-process theories previously discussed, both Denny and Brush suggested one-process theories. Segal and Brush (1959) suggested that the process leading to the curve found in the retention of the incompletely learned response was a function of an interfering fear which led to inhibition of the avoidance response, and produced instead, crouching and freezing behaviour. Segal and Brush propose that fear inhibits performance while Kamin (1957) proposes that fear facilitates performance. This fear dissipated with time and by 24 hours had sufficiently dissipated to permit the avoidance response to reappear. Figure 1b (page 22) represents this theoretical curve. In this figure, fear dissipates with time, and this is increasingly facilitative to avoidance performance.

Although Segal and Brush say nothing of the behaviour of the process from A to B, it is implied that this inhibiting fear is a monotonically decreasing function. Thus, although it can predict that performance will be <u>better</u> at C than at B, it cannot predict the empirical performance decrement from A to B. In fact, logically, fear should be greater at intervals shorter than B than it is <u>at</u> B and performance should be <u>worse</u> at intervals shorter than B. Since this does not agree with empirical findings, it casts serious doubts upon its adequacy as a theory.

As Figure 1b indicates, Segal and Brush do not consider forgetting of the avoidance response to be a significant process in the retention of the incompletely learned avoudance response. They feel that it is unlikely that the avoidance response is forgotten over 1 hour, when their data show excellent retention over 20 days. Thus, they state, "The fact that the 20-day incubation animals show an improvement in performance over their preceeding session, even for small blocks of trials seems to eliminate an explanation of the decrease in performance over smaller intervals by "forgetting". We do not understand the postulated process of forgetting of the instrumental response over short intervals of one hour to 5 days, but remembering, and even reminiscence of the emotional response over longer intervals of 10 to 20 days". (Segal and Brush, 1959, p.6)

This statement questions the possibility of the forgetting of the instrumental response at short intervals while the memory of the emotional response is increasing at later intervals. However, unlikely as it may seem, it is not logically impossible for the emotional response to be incubating and increasing while there is partial loss of the instrumental response. Furthermore, their data are not completely relevant since their subjects had much more training on the avoidance response. Thus, it is not surprising that there is improvement even in the 20 day animals, during later <u>relearning</u> sessions. (Segal and Brush gave 5 relearning sessions, each separated by the various time intervals tested) By this time, the avoidance response is well-learned, and it has been shown that well-learned avoidance responses are retained well. However, the main point, aside from their inadequate criticism of two-factor theories, is that their own one-factor theory cannot adequately explain the decrement in performance from 0 to 1 hour.

Denny and Ditchman (1962) also propose a one-process theory. In this theory the incubation of anxiety is a curvilinear function. Fear increases to one hour interfering with the avoidance response and leading to freezing or crouching behaviour, after one hour, this inhibiting fear begins to dissipate and avoidance responding improves. Figure 1c (page 22) is a graphical representation of this notion.

The empirical curve is a direct representation of the character of this incubation of anxiety process, so it would predict that performance is better at both A and C than it is at B. A group of subjects run by Denny (1958) would seem to support this theory. This group was given a series of shocks 23 hours after acquisition of the avoidance response. They were tested one hour later and showed a severe decrement in performance compared to a group which had no shocks during the 24 hours. Denny and Ditchman suggest that this incubation of anxiety is a function of reticular recruitment. Since the mechanisms of reticular activity are not yet well understood, this suggestion seems a bit premature.

It is interesting to note here that all the theories presented involve as a basic concept changes in the level of fear. Segal and Brush, and Denny and Ditchman suggest that fear is inhibitory, that at one hour the animals are <u>too</u> afraid to perform the avoidance response, whereas Kamin suggests that they are not afraid enough and that fear (through incubation) is the facilitating factor in avoidance behaviour. The final two theories to be discussed do not emphasize the nature of the emotional activity leading to the U-shaped retention curve.

Brush, Myer, and Palmer (1963a) suggest another single factor theory similar to that of Denny and Ditchman. The curvilinear function they propose is called "parasympathetic overeaction". This parasympathetic overeaction reaches a peak at one hour and then begins to dissipate. At its maximum level, it leaves the animal "unable to cope with the avoidance procedure. It is not clear whether this process leads to too much fear or too little fear at one hour to permit the animal to perform well. However, since the empirical curve is a direct representation of the underlying "parasympathetic overeaction", it would predict that performance at 1 hour would be worse than at 0 or 24 hours.

Despite its disadvantages, Kamin (1963) still finds it necessary to postulate the operation of two processes in the U-shaped retention curve. However, in his more recent work, the nature of the two processes are somewhat different from the earlier ones. Figure 1d (page 22) illustrates these processes.

The monotonic "warm up" effect manifests itself particularly during the interval from A to B. The other process, which Kamin calls simply "some other factor", is unclearly defined. Its point of maximum decremental effect is at 1 hour; after that, presumably, this other factor operates facilitatively, or at least not decrementally, to performance. However, another time factor other than intersession interval seems to be operating. In early retraining trials (trials one to ten), the "warm up effect" seems to be exerting relatively greater influence than the "other factor" resulting in a monotonic decrement in performance as a function of intersession interval. During the later trials, however, the 1-hour group continues to perform badly while the other groups improve, and this seems to be an effect of "some other factor". This implies that without this "other factor" performance in early relearning trials would be monotonically decreasing in time, and that later relearning trials would show an essentially flat curve over time, since all groups would presumably reach the same asymptotic level of performance. Thus, in later relearning <u>sessions</u>, when the response is more completely learned, only the initial warm up decrement would be apparent.

Since nothing is known of the character of the two factors, any prediction can be made concerning their interaction in producing the retention curve. However, it may be assumed that warm up, like the classical retention curves, is negatively accelerated and reaches an asymptote after a fairly short intersession interval. This would produce a decrement which

which is undifferentiated at longer intersession intervals. The nature of the process which affects performance at one hour is more mysterious. Does this factor operate merely to depress performance at one hour, or rather does it operate to depress performance at early intersession intervals, and then facilitate performance at later intersession intervals?

In summary, five theories have been outlined which have been derived to explain the U-shaped character of the retention curve. The one process theories, with the exception of that of Segal and Brush, can explain the basic form of the U-shaped curve. The two-factor theories have greater problems in prediction. However, Kamin's 1963 two-factor theory suggests that the "warm-up decrement" is an empirical finding which must be accounted for in the postulation of a theory. Thus, it would seem that if the warm up effect is a replicatable phenomenon, a two-process theory must be adopted to explain all the data.

The implications for any shift in the point of maximum decrement are different for one- and two- process theories. Any factor which affects the point of maximum decrement in relearning obviously affects directly the underlying process involved in the one-process theory. However, in a two-process theory, a shift is difficult to interpret. Any shift can be a function of change in either or both processes and, with one measurable response, there is no way of knowing which is the case.

Several factors have been found which seem to alter the shape of the relearning curve. First, Kamin has demonstrated that speed of acquisition alters the low point in relearning such that slower learners displace the locus of maximum decrement to intersession intervals greater than one hour. Since there have been few comparisons in the literature between rates of original acquisition and since several different acquisition criteria have been used (25 trials, 3 avoidances, or 3 consecutive avoidances), this may account for discrepancies in the low point of performance in the various experiments which have been reported.

Intertrial interval seems to be another factor which alters the point of lowest performance in relearning. A fixed one-minute intertrial interval has been used in the previous studies not concerned with intertrial effects. Denny (1958) reports that the use of a ½minute intertrial interval produces the lowest point of relearning at 4 hours. However, this is also confounded with speed of acquisition, since the ½minute intertrial interval groups showed poorer acquisition after 24 trials than the 1 minute intertrial interval groups. Brush et al (1963b) also reported that the low point in early retraining trials is altered by the intertrial interval used. With a ½-minute intertrial interval, the low point is 24 hours in the early relearning trials. The 2 minute and 1 minute intertrial interval groups show the maximum decrement at 4 hours in trials 1 to 10. Here, again, the speed of acquisition seems to be a confounding factor, for the 2-minute groups show the fastest acquisition to a 3 avoidance criterion, then 1-minute, and finally the ½-minute groups show poorest acquisition. Brush et al also report that in the later relearning trials, the low point shifts to 1 hour for all intertrial interval groups. Thus, the factors of speed of acquisition and intertrial interval appear to be confounded in their effect of shifting the point of maximum decrement.

A third factor was pointed out by Kamin, in his 1963 study, and Brush et al (1963b) that U-shape of the curve changes during the relearning session. The point of maximum effect seems to be different during the first few trials as opposed to the later trials. Kamin demonstrated a monotonic "warm-up effect" which is directly related to the intersession interval and is present during the first 10 retraining trials. Brush et al demonstrate that the low point in early retraining trials varies from 4 to 24 hours under various intertrial intervals; however, this curve also seems to be a monotonic one. Denny and Ditchman (1962) show the effect in the first 10 retraining trials of their study; however, they are using intervals from 0 to 2 hours and these shorter intervals may not show differential warm-up effects and thus permit the 1-hour effect to be seen in the early trials. Therefore, there seems to be evidence for a monotonic effect in early trials that may be somewhat masked by the "other factor" leading to the

U-shaped curve.

In summary, it seems that there are three[6] factors that have been demonstrated to have an effect on the locus of maximum decrement in retention. They are (1) the rate of acquisition, which is in direct relation to the time interval of greatest effect; (2) the intertrial interval, which is closely related to the rate of acquisition; and (3) the problems of the early vs. late relearning trials, where there is one factor leading to a monotonic warm-up decrement relating directly to the intersession interval and "some other factor" particularly leading to the decrement at 1 hour. It is very difficult to know how all these factors are interacting to produce the retention curve reported for the incompletely learned avoidance response.

Further data which should be of theoretical concern but which have not been integrated into any of the theories presented so far should be mentioned here. Certain pre-training treatments have shown either no systematic relation

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[6] Segal and Brush (1959) indicate that an average of four relearning sessions shows that the locus of maximal decrement is 24 hours and suggest that this may be a function of the lower intensity US used. However, analysis of the first session shows the normal decrement at one hour and this 1-hour effect has been replicated by Brush et al (1963a) using low US intensity. This suggests that the 24-hour effect may be an artifact of the method of analysis in which data for the scores during the relearning session have been used in a somewhat involved analysis.

to intersession intervals or they have replicated the 1-hour decrement in relearning. These treatments involved some form of pretraining procedure which deviated from the standard delayed conditioning procedure. Both Kamin and Brush et al demonstrated that response training without the CS will not produce any systematic performance during the acquisition trials after various intersession intervals. Brush et al (1963a) have also shown that presentation of the CS unrelated to the US is not sufficient to produce any systematic conditioning. Kamin (1963) reports that CS-US pairings with an inescapable US produces learning that has no systematic relationship to the intersession intervals tested; however, Brush et al (1963a) have shown that CS-US pairings, (with a CS-US interval too short to permit avoidance) when the US was response terminated, produces a U-shaped effect on subsequent learning which is identical to the one shown with the standard delayed conditioning procedure. Thus, as long as response training is also possible, _fear_ of the CS seems to be a necessary condition for the appearance of the U-shaped curve. This implies the U-shaped curve may be at least a partial function of changes in fear over time. However, it does not indicate whether the changes in fear are detrimental or facilitative of avoidance performance. Furthermore, since response training is necessary, there may also be changes in the "remembering" of the instrumental response which affect the final retention curve.

A second group of treatments which have not been related to the various theories are those which seem to eliminate the U-shaped character of the retention curve. These factors appear to affect the process or processes leading to the 1-hour decrement. Denny and Thomas (1960) report that subjects trained in a low ceiling shuttlebox show improvement, rather than a decrement, in performance after an intersession interval of 1 hour. This is very odd, since Kamin has demonstrated a significant decrement at 1 hour using a low ceiling shuttlebox.

Denny (1958) also reports, using a US of 1.7 ma., that females do not show the 1-hour decrement until the shock level is raised slightly. Denny and Thomas (1960) report, further, that females are more likely to show freezing behaviour in a low-ceiling shuttlebox than males. Kamin does not report the sex of the rats used in his studies, and Brush et al (1963a,b) have used only male rats, thus there have been no replications of these findings. They may, however, be relevant to the present experiment which used only females.

Denny (1958) and Brush et al (1963a) have both demonstrated that subjects left in the shuttlebox during the 1-hour intersession interval have not shown the decrement in relearning that is seen in subjects returned to the home cage for the 1-hour intersession interval.[7] This suggests that some factors which

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[7] Although this group was not reported in the abstract of Denny's study, there is reference to it in Brush et al (1963a).

have not been previously studied greatly affect the character of this retention curve. Although it has been assumed that this phenomenon is a function of the subject remaining in the situation for the intersession interval, it must also be recognized that these subjects have not been handled during this interval. The standard procedure for all the experiments reported has been to place the subjects in the home cage for all intersession intervals except the zero interval groups. In Kamin's first study and the studies by Denny and his associates, the control group (1 minute intersession interval) were not handled at all. Although in Kamin's second study and the Brush et al studies, the control groups were also handled, no mention is made that this treatment may in itself be significant.

Thus, of the three factors discovered which seem to eliminate the U-shaped decrement, the most theoretically interesting one seems to be the function of location of the subject during the intersession interval. This variable is completely confounded with possible handling effects. Therefore, one of the aims of the present study will be to partially deconfound the variables of location of the subject during the intersession interval and the effects of handling the subject during the intertrial intervals.

Unfortunately it is not possible to completely deconfound these two variables. Although it is possible to leave subjects in the shuttlebox for the intersession interval and either "handle" them or not, it is not possible, of course, to return them to the home cage without handling them. However, any differences in performance between "handled" subjects which remained in the shuttlebox and "handled" subjects which are returned to the home cage for the intersession interval could be attributed to the location effect. Thus, we will have three treatment groups in this experiment and each group will be tested at 4 intersession intervals. The three treatment groups will be: (1) a group which remains in the shuttlebox during the intersession interval and is not "handled", (2) a group which remains in the shuttlebox, but is "handled", and (3) a group which is returned to the home cage during the intersession interval.

Although there is an extensive literature on the effect of "handling" procedures on subjects in anxiety producing situations, most of it is irrelevant to the present study. These gentling procedures, as they are generally called, have involved daily contact over a period of at least several days. The handling involved in taking the animal from the shuttlebox to the home cage can hardly be considered gentling. In general these gentling studies, such as that of Spence and Maher (1962) indicate that gentled animals show less emotionality in fear producing situations than non-gentled controls. The rats in the present experiment which have not been previously gentled and which are casually handled in the manner employed in this experiment show signs of high anxiety, ie. biting, squealing, struggling, urination, and defecation on being picked up. How this arousal of anxiety would interact with the fear aroused in the avoidance situation is very difficult to predict. Thus two groups will be run in this experiment which will consider the handling effect. Both groups of subjects will remain in the shuttlebox for the intersession interval, but one group will be "handled" before and after the intersession interval, and the other group will not be handled.

The only studies concerned with the effects of location on retention of incompletely conditioned responses are the Brush et al (1963a) and Denny (1958) studies previously mentioned. Studies concerned with the extinction of responses have shown that the similarity or dissimilarity of the retaining box, in terms of secondary cues, affects the rate of extinction in the original training situation. Generally, animals retained in boxes similar to the training boxes extinguish more quickly than controls retained in dissimilar environments. Kurtz and Pearl (1960) demonstrated that being placed during a 1½ hour retention period in a box where the subjects had previously been shocked extinguished fear responses associated with the box. Thus, if one can assume that the retention of an avoidance response is some function of the fear of the CS and other cues associated with the shock, there may be changes in performance, particularly at longer intervals, when subjects have an opportunity to extinguish fear of the apparatus cues. In this experiment, we will compare animals which remain in the situation and those which are removed from the situation at all intersession intervals. The handling variable will be kept constant for these groups.

The second aim of this experiment will be to examine the early trials of the relearning session in order to determine whether or not the warm-up decrement can be replicated. If a monotonic effect can be shown during the early relearning trials, then it will be necessary to abandon the possibility of a one-process theory. This study will be particularly interested in the first 15 trials after the intersession intervals of 0, $\frac{1}{2}$, 1, and 24 hours. If a monotonic warm-up effect is seen in this study, we will then be able to determine the effect of the handling and location effects on this effect.

To summarize, the present study is concerned with two aspects of the retention of the incompletely learned avoidance response. First, it is interested in confirming the existence and character of the "warm-up" decrement. Also, it will attempt to deconfound the variables of "handling" and location of the rat during the intersession interval as a function of length of intersession interval.

CHAPTER TWO

METHOD

Subjects

The subjects were 199 experimentally naive female hooded rats from the colony maintained at the McMaster University psychology laboratories. They averaged about three months of age and about 175 grams in weight. There were 120 subjects which survived various criteria for inclusion in the experiment. The other 79 subjects were discarded for the following reasons: 47 did not reach the acquisition criterion for original learning of avoidance within 70 trials; 15 were discarded due to procedural errors; 17 were rejected due to apparatus failures or excessive failures to respond to the US. The surviving subjects were randomly assigned to 12 experimental groups.

Apparatus

The apparatus used was a modified, automated, two-compartment, Miller-Mowrer shuttlebox. There were three such shuttleboxes employed in the experiment, each identically built. The dimensions of a single shuttlebox were: length, $23\frac{1}{4}$ inches; height, $4\frac{1}{2}$ inches; width, 5 inches. The sides and ceiling were wood painted flat black. The two compartments of each box were identical, with no barriers between them.

The compartments had individual grid floors. The two floors were mounted on microswitches associated with relay circuitry so that the rat's passage from one compartment to the other could be recorded, and could control appropriately the programming of stimulus presentations. Each floor was built of 1/16 inch steel rods placed in parallel ½ inch apart. Alternate bars comprised one pole of the shocking circuit. Thus, the subject completed the circuit when standing on alternate bars. A high voltage, igh resistance 60 cps. Ashman shock generator was used to deliver shock, the unconditioned stimulus (US). A milliameter in series with the rat indicated the delivery of a shock of about 1 ma.

The conditioned stimulus (CS) was a 73 db., 1200-cycle tone, interrupted 10 times per second. The tone was generated by an Ashman tone generator, the output of which was fed into an Ashman audio splitter, which in turn fed to the loudspeakers of the three shuttleboxes. This arrangement assured that tone volume would not vary in one box as a result of tone termination or onset in another box.

The three shuttleboxes were contained in individual sound-attenuating chests, in each of which was a 3 watt frosted light bulb to provide background illumination during the experimental session. The chests also contained ventilating fans, and loudspeakers for the delivery of the CS. These chests were kept in rooms separate from the programming and recording equipment.

Procedure

The experiment consisted of two separate phases: original acquisition of avoidance, and a subsequent relearning session. The experimental groups differed only with respect to treatment between the two sessions of avoidance training. The variables investigated were: amount of time elapsing between the two sessions, place where the rat spent the time between sessions, and whether or not the experimenter "handled" the subject between the two sessions.

Original Acquisition of Avoidance

The procedure for original acquisition of avoidance was identical for all subjects. The subject was given a 5 minute adaptation period in the shuttlebox before acquisition trials began. The procedure was standard delayed avoidance conditioning, with a 5 second CS-US interval. The US was delivered to the side of the shuttlebox in which the rat stood 5 seconds after onset of the CS unless the rat had, during the CS-US interval, responded by crossing to the opposite compartment.

A response was recorded whenever the subject crossed from one compartment of the shuttlebox to the other. Three types of responses were possible. An avoidance response was a crossing in the presence of the CS before the scheduled delivery of the US. Such a response prevented occurrence of the US on that trial, and immediately terminated the CS. An escape was a response in the presence of both the US and CS. Such a response immediately terminated both the US and the CS. A "spontaneous" response was a crossing during the intertrial interval, when neither CS nor US was present. If, on a given trial, the subject failed to respond within 10 seconds after onset of the US, both US and CS were terminated, and a "no response" was recorded.[8] Subjects with more than 5 "no responses" during both acquisition and relearning were rejected from the experiment.

The intertrial interval followed a variable interval schedule, averaging one minute. The length of the intertrial interval varied in a range from 30 to 107 seconds. The programming of all stimuli and recording of all responses were automated. The acquisition criterion was three consecutive avoidances. Animals which did not meet this criterion within 70 acquisition trials were discarded.

Experimental Treatments and Design

The experimental treatment was interpolated between original acquisition and a later relearning of avoidance. There were 12 randomly constituted groups of 10 subjects each. Two of the variables investigated constituted a 2 x 4 factorial design. These were: intersession interval (varied at four levels) and "handling" by the experimenter (varied at two levels). Within this portion of the experimental design, all subjects spent the interval between original acquisition and relearning in the shuttlebox. The four intersession intervals studied were: 0, ½, 1, and 24 hours. At each of these intersession intervals, one group was handled

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[8] The "no response" was generally attributable to an apparatus failure, or to shorting of the circuit by a bolus. Occasionally, a subject may have avoided contact with alternate grid bars or may simply have "frozen" in response to shock.

by the experimenter, and another group was not.

The third variable investigated was the location in which the intersession interval was spent. Three groups of rats, with intersession intervals of ½, 1, and 24 hours, spent the intersession interval in a living cage in the colony room, rather than in the shuttlebox. This treatment, of course, necessarily involved handling by the experimenter, and could not be studied with a zero intersession interval. Thus, viewed from another angle, a 2 x 3 factorial design can be constituted. At each of three intersession intervals (½, 1, and 24 hours) groups are studied which have (a) been handled, and have spent the interval in the shuttlebox; or, (b) been handled and have spent the interval in a living cage. The animals described in category "b" above have already been utilized in the 2 x 4 factorial design previously described. Unfortunately, it is physically impossible to deconfound completely the factors of "handling" vs. "not handling" by the experimenter, and "remaining in shuttlebox" vs. "not remaining in shuttlebox". Animals which spend the intersession interval in the shuttlebox can be briefly handled by the experimenter, or can not be handled; but animals removed to any other location from the shuttlebox must be handled by the experimenter. Thus the effect of handling can only be studied in conjunction with remaining in the shuttlebox. The twelfth group was a control for the 24-hour groups which remained in the shuttlebox and will be discussed below.

The various experimental treatments involved the following procedures for different groups of subjects. For the not-handled groups, treatment consisted only of a time interval between original acquisition and the beginning of relearning. This time interval was either 0, ½, 1, or 24 hours, during which time the subject remained undisturbed in the shuttlebox, with no stimuli presented.

For the handled groups, one minute handling was administered both at the conclusion of original acquisition and immediately before the relearning session. "Handling" consisted of the following: the shuttlebox was opened, and the subject was picked up in the experimenter's gloved hand, and removed from the experimental room. If the subject was to spend its retention interval in the shuttlebox, it was replaced into the shuttlebox after one minute. If it was to spend its retention interval in a living cage, it was placed into the living cage after one minute. Following passage of the appropriate intersession interval, the subject was rehandled and then placed in the shuttlebox for the relearning session. For the handled group with a zero intersession interval, there was only one 1-minute handling period, occurring between conclusion of original acquisition and the beginning of relearning.

The twelfth experimental group was added to check for possible effects of deprivation of food and water on performance during the relearning session. Since there was never food and water available in the shuttlebox, groups which spent the intersession interval in the shuttlebox were deprived during this interval. There was food and water available to subjects spending the retention interval in the living cage. Thus, the comparison between spending the intersession interval in the living cage and in the shuttlebox is confounded with the deprivation variable. For this reason, an extra group was trained which spent a 24-hour retention interval in the living cage, without food and water. This group, it may be noted, did not in fact perform differently from the similarly treated group which had food and water available.

The subjects within each experimental group were, as much as possible, equally divided among the three shuttleboxes used. Analysis of the data did not indicate any differential effect attributable to the box in which the subject was trained.

Relearning of Avoidance

Following the intersession interval, a relearning avoidance training session of 15 trials was given. The procedure, for all subjects, was identical to that employed during original acquisition. The basic data of the experiment consisted of the number of avoidances made during the relearning sessions by the various experimental groups. Thus, the effect of experimental treatment was manifested by amount of positive transfer from original acquisition to relearning.

The experimental design is schematized in the following table:

TREATMENT	INTERSESSION INTERVAL (IN HOURS)			
	0	$\frac{1}{2}$	1	24
Not handled, shuttlebox	$\bar{H}$S,0	$\bar{H}$S,$\frac{1}{2}$	$\bar{H}$S,1	$\bar{H}$S,24
Handled, shuttlebox	HS,0	HS,$\frac{1}{2}$	HS,1	HS,24
Handled, living cage		HC,$\frac{1}{2}$	HC,1	HC,24
Handled, living cage, deprived				HCD,24

The columns refer to length of intersession interval, and the rows to the various studied combinations of handling and location variables. The notation in each cell will be used in the future to refer to individual experimental groups, each of which contained ten animals.

CHAPTER THREE

RESULTS

Original Acquisition

There were no significant differences among the 12 experimental groups during the original acquisition of the avoidance response. The grand mean number of trials required to reach the criterion of three consecutive avoidances was 29.6. (F=1.26, with 11 and 108 df.). An analysis of variance shows no significant difference between the 12 groups. An analysis of variance shows also that the number of spontaneous responses made during the initial 5-minute adaptation period did not differ among groups; F=.24, 11 and 108 df. This equivalence of groups during original acquisition indicates that the subjects were, indeed, randomly assigned to groups. Various indices of performance during original acquisition are summarized in the Appendix; with all indices, all groups behaved similarly during acquisition.

Relearning of Avoidance

Figure 2 presents the mean number of avoidances made during the relearning session of 15 trials, as a function of length of intersession interval. The three separate functions in Figure 2 are for the $\overline{HS}$, the HS, and HC experimental treatments. There is, of course, no point plotted for the HC curve at the zero intersession interval. The detached point plotted at the 24-hour retention interval represents the HCD control group.

Insert FIGURE 2

Table II provides summary data for number of avoidances for all groups.

TABLE II

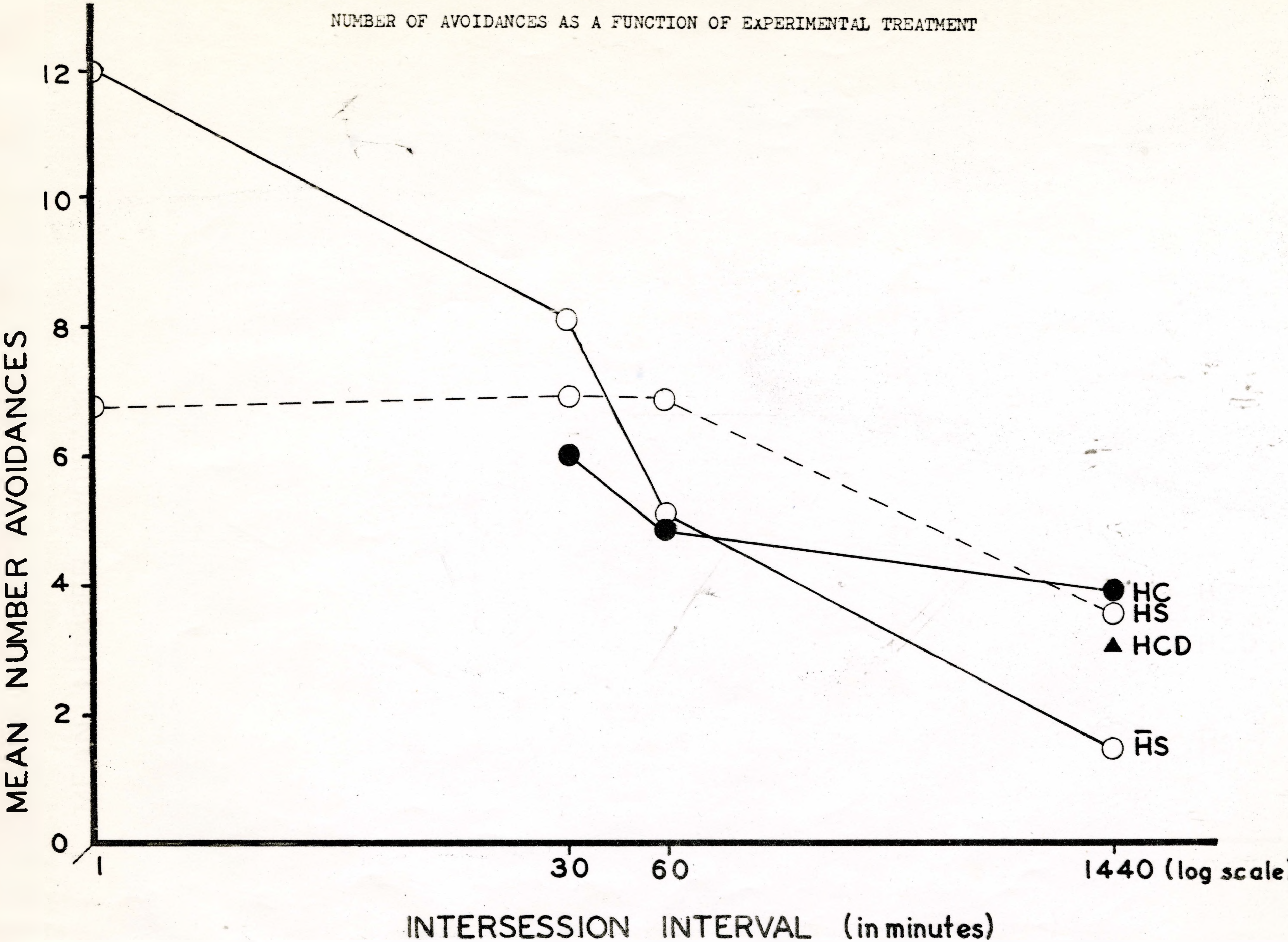
Summary Data for Number of Avoidances during Relearning Session

Treatment		Intersession Interval (Hours)			
		0	½	1	24
$\overline{HS}$	Mean	12.00	8.10	5.10	1.40
	Median	13.00	9.00	4.50	1.50
	Range	7-15	2-12	0-10	0-3
HS	Mean	6.80	6.90	6.90	3.60
	Median	7.00	8.00	5.50	3.50
	Range	1-12	0-12	1-15	0-8
HC	Mean		6.00	4.80	3.90
	Median		6.00	2.50	2.50
	Range		0-14	0-12	0-8
HCD	Mean				3.10
	Median				3.00
	Range				0-9

From inspection of Figure 2, it is obvious that none of the three functions depicted deviates from monotonicity. There appears to be a clear downward trend in the $\overline{HS}$ groups as the intersession interval increases. The HS, HC functions are essentially flat at

FIGURE 2

NUMBER OF AVOIDANCES AS A FUNCTION OF EXPERIMENTAL TREATMENT



the various intersession intervals.

The raw count of number of avoidances showed considerable heterogeneity of variance. Therefore, all statistical tests were performed after these counts had been transformed with a Tukey-Freeman $\sqrt{X} + \sqrt{X+1}$ transformation (cf. Bush and Mosteller, 1954).

When the $\overline{HS}$ and the HS treatments alone are considered, eight experimental groups form a 2 x 4 factorial design; the four intersession intervals constitute one factor, and handling versus not handling the other. The location in which the intersession interval is spent does not enter into this analysis, since all groups spent the interval in the shuttlebox. The summary of the analysis of variance of the transformed number of avoidances for this 2 x 4 design is presented in Table III.

TABLE III

Summary of Analysis of Variance of Transformed Number of Avoidances (Four Intersession Intervals, Two Levels of Handling)

Source	d.f.	M.S.	F	p
Handling	1	1.00	.33	-
Intersession Interval	3	29.67	9.72	<.005
Interaction	3	13.00	4.62	.005
Error	72	3.05		

The main effect of intersession interval was significant, reflecting the tendency for performance to decline with increasing intersession interval. There was no main effect of the handling factor, but the interaction between this factor and intersession interval was highly significant. The nature of this interaction is clarified by examination of Figure 2; at the short (zero and $\frac{1}{2}$ hour) intersession intervals, the handled subjects made <u>fewer</u> responses than the not handled subjects, but at the long (1 hour and 24 hour) intervals, the reverse was true. Supplementary t-tests revealed that: the unhandled group made significantly more responses than the handled group at the 0-intersession interval (t=2.37, d.f.9, $<.01$). There was no significant difference attributable to any other intersession interval. (t=.88, d.f.9; t=.91, d.f.9; t=1.51, d.f.9) Figure 2 and the supplementary t-tests suggest that the major contributor to the significant interaction between treatment and intersession interval is the detrimental effect of handling at the zero intersession interval.

When the HS and HC groups alone are considered, a 2 x 3 factorial design is formed by six experimental groups; only three values of intersession interval can be studied, in conjunction with two levels of location. The zero retention interval must be omitted. The effect of handling does not enter into this analysis, summarized in Table IV, since all groups in this design have been handled.

TABLE IV

Summary of Analysis of Variance of Transformed Number of Avoidances

(Three intersession intervals, two levels of locations)

Source	d.f.	M.S.	*F*	*p*
Location	1	4.00	1.14	$<.30$
Intersession Interval	2	8.50	2.42	$<.10$
Interaction	2	.50	.14	–
Error	54	3.50		

This 2 x 3 analysis of variance shows no significant results, although the main effect of intersession interval approaches significance. The factor of location (home cage versus shuttlebox) is not significant, nor is the interaction.

The failure of the foregoing analysis to show a significant effect of intersession interval is clearly attributable to the omission from this analysis of the $\overline{HS}$-0 group, which was included in the analysis in Table III. It should be pointed out that a significant effect of intersession interval *can* be demonstrated over the range of ½ hour to 24 hours; when the nine experimental groups tested at ½, 1, or 24 hour intersession intervals were cast into a single 3 x 3 analysis of variance, the only significant effect was that of intersession interval.(F=7.09, with 2 and 81 d.f., p .005)

Spontaneous Responses

Spontaneous responses made during the relearning session during the intertrial intervals were also analysed. Figure 3 presents the mean number of spontaneous responses made during the relearning session as a function of the length of intersession interval. As in Figure 2, three separate functions are plotted for the $\overline{HS}$, HS, and HC experimental treatments. The detached point plotted at the 24-hour intersession interval represents the HCD control group.

Insert FIGURE 3

Figure 3 suggests a very prominent interaction between the handled and not-handled shuttlebox groups. Analysis of variance on the transformed scores (Tukey-Freeman transformation) confirms the significance of this interaction. Comparison of the $\overline{HS}$ and HS treatments at the four intersession intervals forms a 2 x 4 factorial design, with the 4 intersession intervals constituting one factor, and handling conditions constituting the other factor. Table V is a summary table of this analysis.

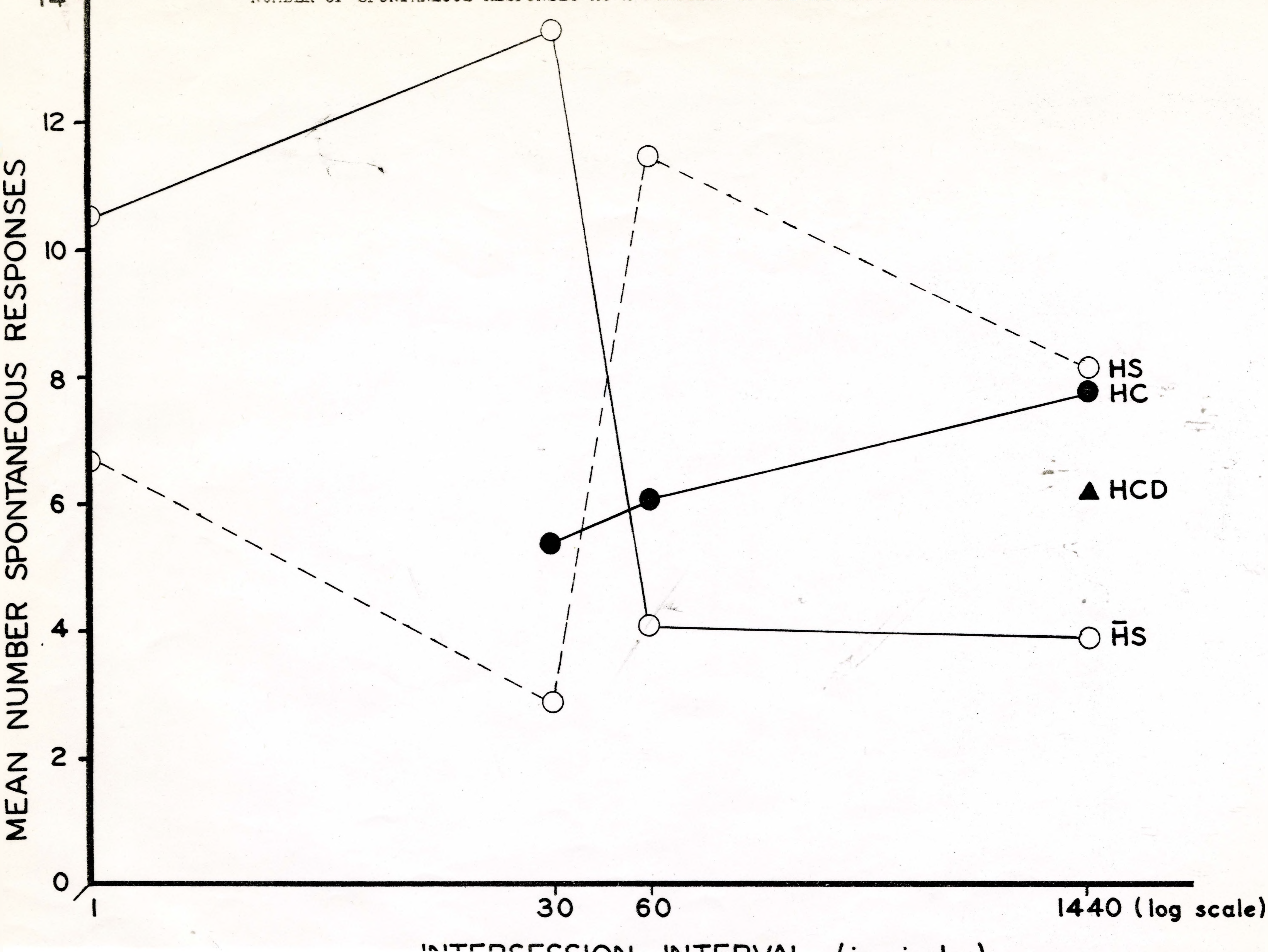
TABLE V

Summary of Analysis of Variance of Transformed Numbers of Spontaneous Responses (Four intersession intervals, two levels of handling)

Source	d.f.	M.S.	*F*	*p*
Handling	1	1	.15	-
Intersession Interval	3	2	.29	-
Interaction	3	33	4.92	.005
Error	72	6.7		

FIGURE 3

NUMBER OF SPONTANEOUS RESPONSES AS A FUNCTION OF EXPERIMENTAL TREATMENT



This Table indicates that neither the main effects of intersession interval nor handling are significant, but that the interaction of these effects is highly significant.

Inspection of Figure 3 suggests that this interaction can be verbalized: handling tends to decrease the number of spontaneous responses at the early intersession intervals, and increase the number of spontaneous responses at later intersession intervals. Not-handled animals, on the other hand, make relatively more spontaneous responses at the short intersession intervals and relatively few at later intersession intervals. Thus, handling seems to affect the number of spontaneous responses in opposite directions from the not-handling at the various time intervals.

It should be remembered here that the interaction is also significant for the handled and not-handled groups on the number of avoidances made during retest. In fact, there is a tendency for the spontaneous responses and avoidances to interact in the same way with two measures. The not-handled groups make many avoidances and many spontaneous responses at the short intersession intervals, whereas, the handled groups make significantly fewer avoidances and spontaneous responses. At long intersession intervals the $\overline{H}S$ groups tend to make few avoidances and spontaneous responses, whereas, the HS groups tend to make more avoidances and spontaneous responses.

A 2 x 3 factorial design of the HS groups and the HC groups at the three intersession intervals show no significant results. This analysis is comparing the two handled groups, which differ only in the location of the intersession intervals. Since no HC-0 group could be run these groups can only be compared at the intersession intervals $\frac{1}{2}$, 1, and 24 hours. Table VI summarizes this analysis.

TABLE VI

Summary of Analysis of Variance of Transformed Number of Spontaneous Responses

(Three intersession intervals, two levels of location)

Source	d.f.	M.S.	*F*	*p*
Location	1	5	1.06	-
Intersession Interval	2	10.5	2.23	.25
Interaction	2	7.5	1.59	-
Error	54	4.7		

This analysis indicates that location of intersession interval has no significant effects on the number of spontaneous responses during retest at any of the intersession intervals. Again, this is similar to the results seen with the HS and HC groups on number of avoidances. Thus, the subjects which remain in the shuttlebox and those which are returned to the home cage do not make significantly different numbers of avoidances and spontaneous responses at the various intersession intervals.

The interaction of the handled and not-handled groups can still be shown to be significant when the three treatment groups, $\overline{HS}$, HS, and HC, are put into a 3 x 3 factorial design. These groups can only be compared at the three intersession intervals $\frac{1}{2}$, 1, and 24 hours. Analysis of variance shows the only significant effect to be the interaction. ($F=5.67$, with 2 and 81 d.f., $p<.005$). Here again the analysis of spontaneous responses parallels the 3 x 3 analysis of avoidance responses.

Thus, the effects of both the variables, location and handling, on the spontaneous responses is the same as it was on avoidance responses.

A supplementary analysis was performed with t-tests between the $\overline{HS}$ and HS groups at each intersession interval. The t-tests revealed that the handled groups make significantly more responses at the $\frac{1}{2}$-hour intersession interval than the not-handled groups, ($t=2.8$, d.f.9, p .005) and the not-handled groups make significantly more spontaneous responses at the 1-hour intersession interval.($t=2.34$, d.f.9, $p<.05$) There were no significant differences between the groups at the extreme intersession intervals of 0 and 24 hours ($t=.12$, d.f.9; $t=1.3$, d.f.9). These t-tests reveal that spontaneous responses differ more significantly in the handled and not-handled groups at the middle intersession intervals, whereas the number of avoidances between handling conditions differ most greatly at the extreme intersession intervals of 0, and 24 hours.

CHAPTER FOUR

DISCUSSION

It is obvious from Figure 2 and analysis of the results, that the curves in this experiment do not deviate from monotonicity. This is very unusual in view of the past studies on this phenomenon. All the previous studies report U-shaped retention curves. There are two possible explanations which might explain why the curves in the present experiment are monotonic. One possibility is that 15 trials is not a sufficiently long relearning interval to produce a curvilinear effect. The other suggests that certain procedural details in this experiment have minimized the curvilinear effect.

Considering the first of these possibilities, if the monotonic effect is simply a function of the short 15 trial relearning session, then the data demonstrates the monotonic warm-up decrement which Kamin reports, with the subsequent effect of the"other factor" appearing at later relearning trials. If this conjecture is correct then examination of the other studies on the retention curve should also demonstrate a similar monotonic decrement in the early relearning trials. Table VII lists all the studies for which data are available on the relearning session in blocks of trials.

TABLE VII

Mean number of avoidances on relearning session in blocks of 5 or 10

Source	Trials	Measure (Hours) 0	1	24	Difference 24-1
Kamin (1957)	1-10	5.0	1.6	3.8	2.2
	16-25	6.2	3.4	6.6	3.2
Kamin (1963-experiment	1-5	4.3	1.1	.9	-.2
1)	21-25	4.3	3.5	4.4	1.1
Kamin (1963-experiment	1-10	7.3	2.6	4.2	1.6
2, 1st. session)	11-20	7.2	5.0	7.5	2.5
	21-30	8.1	5.6	8.4	2.8
Denny & Ditchman(1962)	1-10	10.0	3.0	-	-
Brush, Myer, Palmer[9](1963b) Intertrial Interval					
½ minute	1-10	3.0	2.0	.5	-1.5
	11-20	6.0	1.0	4.5	3.5
	21-30	7.5	4.0	6.0	2.0
	31-40	9.5	5.0	7.0	2.0
1 minute	1-10	4.5	1.0	1.0	0.0
	11-20	8.5	2.0	3.5	1.5
	21-30	9.5	5.0	7.0	2.0
	31-40	10.0	5.0	10.0	5.0
2 minute	1-10	5.0	3.0	6.0	3.0
	11-20	8.5	4.0	8.5	4.5
	21-30	10.0	6.0	9.0	3.0
	31-40	9.0	5.5	9.5	4.0
Brush, Myer, Palmer	1-10	4.5	1.0	1.0	0.0
(Expt. 1, 1963)	11-20	8.5	2.0	3.5	1.5
	21-30	9.5	4.5	7.0	2.5
	31-40	10.0	5.0	10.0	5.0
Present experiment $\overline{H}S$	1-5	4.1	1.1	0.2	-0.9
	5-10	3.8	1.7	0.5	-1.2
	11-15	4.1	2.3	0.7	-1.6
HS	1-5	2.0	1.6	0.4	-1.2
	5-10	2.0	2.4	1.5	-0.9
	11-15	2.8	2.9	1.7	-1.2
HC	1-5		0.9	0.4	-0.5
	6-10		1.8	1.3	-0.5
	11-15		2.1		-0.1

[9] These are recorded as medians.

The numbers represent the mean[10] number of avoidances during relearning at the 0, 1, and 24 hour intersession intervals. The last column is the difference between the number of avoidances for that trial block at 24 and at 1 hour intersession intervals. This difference gives some indication of the changes in performance from 1 to 24 hours at different trial blocks throughout the relearning session. No data are available for the studies by Denny and his associates, with the exception of Denny and Ditchman (1962).

Examination of this Table indicates that, with one exception[11], the differences in number of avoidances between 1 hour and 24 hour groups is smaller in the first trial block than in any of the later trial blocks. In three studies, Kamin (1963, experiment 1), Brush et al (1963,b), ½ minute intertrial interval, and the data of the present experiment, the number of avoidances is fewer at the 24 hour intersession interval than at 1 hour. In the other cases, it has not been demonstrated that the number of avoidances in the first trial block deviates significantly from monotonicity. Thus, it is not so surprising that the present study demonstrates a monotonic relearning curve. In fact, an essentially monotonic relearning curve might have been expected.

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[10]Brush, Myer, and Palmer reported medians which are recorded in this Table.

[11]Brush et al (1963b), 2-minute intertrial interval.

This function, in conjunction with the 1 hour decrement seen in the other studies, would seem to necessitate the acceptance of a two-process theory to adequately explain the present results; for in order to fit these phenomena into a one-process theory, it would be necessary to postulate a process that operates somehow monotonically during early relearning trials and curvilinearly at later trials. Certainly a simple "forgetting" function could not sufficiently explain the rise in performance at longer intervals than 1 hour. On the other hand, incubation of fear or loss of inhibiting fear could not easily explain the monotonic effect in early trials. Thus, despite its disadvantages, it seems necessary to postulate a two-process theory in which both a "forgetting" process and "some other" process are acting to produce an essentially curvilinear function. In the later trials of the relearning session at all intersession intervals, a warm-up effect appears to be operating, probably as some form of interaction with the "other factor". At the later relearning trials, this "other factor" seems to be operating to produce a decrement in performance at 1 hour.

Turning to the second possibility, although it seems likely that the curves in this experiment represent a warm-up decrement seen in the early trials of all studies on the incompletely retention response, on the other hand it is also possible that even with a longer relearning session, the

"Kamin effect" would not have been replicated in the study. Consideration of several procedural details of this experiment suggest that the particular conditions of this experiment have acted to minimize the "other factor" and maximize the "warm-up effect".

Kamin (1963) reported that subjects which showed slower rates of acquisition tended to perform worse at 6-hour rather than at 1-hour intersession intervals. Thus, if the subjects in the conditions of the present experiment have produced considerably slower acquisition, it is possible that the low point of performance has been displaced beyond one hour to 24 hours, and a group run at a longer intersession interval, i.e. 2 or 5 days, would show the characteristic rise in performance.

There have been several factors in this experiment which may have led to slower acquisition of the avoidance response than in other studies on the "Kamin effect". First of all, the CS in the present study was an interrupted tone rather than a buzzer (as used by Kamin and Denny) or a clicking sound and light (Brush et al). Myers (1962) demonstrated that acquisition of avoidance is slower with a tone than a buzzer as a CS. Secondly, a 1-minute variable intertrial interval, rather than a fixed intertrial interval, was employed and it has been demonstrated that acquisition of avoidance is poorer with a variable than with a fixed intertrial interval.(Levine and England, 1960). Thirdly, Black (1963) showed that with the particular automated shuttleboxes being used, acquisition is better with a 10" CS-US interval, than with the 5" CS-US interval used. Finally, the use of females, in combination with the low ceiling shuttlebox has been shown to produce slower acquisition and less decrement at 1 hour (Denny and Thomas, (1960).

There is certainly evidence that some factors such as these are operating to produce less efficient acquisition of the avoidance response in this experiment than in previous ones. Nearly one-quarter (47) of all the subjects run were rejected for not reaching the acquisition criterion of three consecutive avoidances. Although this is a more difficult criterion than used by Brush and Denny, the 70 trials as a maximum number of trials before rejection is also considerably higher than in other studies, where subjects were rejected after 30 or 40 acquisition trials. (Brush et al 1963a; Kamin 1963) Thus, it may well be that the particular procedural conditions of this experiment have been functioning to displace the point of maximum decrement in performance to 24 hours or beyond that, and the "Kamin effect" would only show up, under these conditions, at intersession intervals of 2 or 5 days; or it is also possible that these procedural conditions so minimize the process leading to the "Kamin effect" that it would not be seen even with longer relearning sessions or longer intersession intervals. Of course, as has already been discussed, these curves might represent a clear warm-up decrement, and relearning sessions of 25 or 40 trials would show the curvilinear function.

Obviously, the possibilities just mentioned can only be explored by running groups of subjects, under this procedure, for longer relearning sessions and at longer intersession intervals. However, if we can assume that the curves in this experiment represent a relatively pure warm-up effect, then this procedure would be valuable in determining how certain experimental procedures affect one of the two processes operating. (This assumption may be a dangerous one to make, for the real warm-up decrement may be steeper than the one shown here, and this curve would then be a function of some interaction of both processes) Kamin has indicated the difficulties with a two-process theory in determining just which process is being affected by the experimental treatments. If we assume that this is a relatively pure warm-up effect, then we have succeeded in isolating one of the processes by procedural conditions. Thus, changes in the curve due to the experimental treatments examined in this experiment can be attributed to changes in the process underlying the warm-up effect. Studies under procedural conditions which maximize the Kamin effect could thus test these variables and know how the warm-up component of this effect should be affected. In this way, knowledge of the behaviour of the "other factor" separated from the warm-up effect could be gathered. Of course, this assumption can only be tested by more experimentation.

Up to this point in this discussion, we have only discussed the general shape of the retention curve seen in this experiment. We will now consider how this curve is affected by the variables of handling and location of the subject during the intersession interval.

The effect of handling on the warm-up effect is obvious from Figure 2 and analyses of the number of avoidances on the relearning sessions. Handling the subject at early intersession intervals (0 minutes) is profoundly disruptive to relearning performance. Although there is no significant difference between the handled and not-handled subjects at other intersession intervals, there is a nearly significant trend for the handled 24-hour group to perform better than the not-handled group. Another way of saying this is that handling tends to flatten the curve, eliminating the warm-up effect; the handled subjects with an intersession interval of 1 minute do not perform significantly better than handled subjects with a 24-hour intersession interval.

Examination of the zero intersession interval for the first block of relearning trials in past experiments may also show the handling decrement. However, there are at least two factors which would tend to mask any decrement attributable to handling. If the level of original acquisition is too low, the performance on the early trials of the 0 interval would also be low regardless of handling, i.e. handling could not show any decrement on already poor performance. Secondly, if a manual shuttlebox is used, this would tend to eliminate any effect of handling, since the subjects would be more accustomed to the presence and handling of the experimenter.

In the two experiments where the 0-interval group was not handled, Denny and Ditchman show perfect retention for the first 10 relearning trials. However, Kamin (1957) shows only 5 mean avoidances out of the first 10 trials. This may be a function of poor acquisition after the arbitrary 25 acquisition trials. Kamin, 1963, with handling at the 0 interval, does not show any handling decrement. However, this experiment was run in a manually operated shuttlebox. In the two experiments by Brush et al (1963) with the handled control, all four experimental groups show 5 or fewer median avoidances in the first 10 trials. This is similar to the present results where the not-handled group made a mean of 12 avoidances out of 15 relearning trials, whereas the handled group made only 6.8 avoidances. It is also important that in both these experiments the acquisition criterion was experimentally controlled, and the shuttleboxes were fully automated. Thus, although the handling decrement is closely dependent on procedural details, it can be shown to greatly effect the absolute number of avoidances on the early relearning trials; since it doesn't seem to alter the U-shaped character of the relearning curve at later relearning trials, it seems to influence directly the warm-up effect.

A variable such as handling is difficult to compare from laboratory to laboratory. The prior handling experience of the subjects is rarely reported in studies and probably veries greatly from one laboratory to another. The colony at McMaster University is maintained with a minimum of handling; at other laboratories it is possible that handling for weighing, cleaning and cage transfer purposes may be considered gentling. The gentling literature definitely suggests that gentled animals show less emotional reactivity than not-gentled controls. This suggests two ideas: (1) that animals which have been previously handled, or gentled, would not show the handling decrement in relearning trials, and (2) that casual handling operates to increase anxiety to a disruptive level at short intervals after acquisition of an incompletely learned response.

Examination of the effects of handling on spontaneous responses sheds some light on how handling affects performance. As has already been pointed out in the description of results, the handling variable affects number of spontaneous responses and number of avoidances similarly during the relearning session. In comparison to the not-handled subjects, handled subjects make fewer spontaneous responses and avoidances at the early intersession intervals, but the handled subjects tend to make more spontaneous responses, at the later intersession intervals.

Spontaneous responding can really only be considered a measure of the general activity of the animal. The number of avoidances, however, would seem to measure the ability of the animal to know or remember what to do to avoid shock. That these two factors are so closely related suggests three possibilities:

(1) avoidances at this level of acquisition are "spurious avoidances" caused by the level of activity, or (2) avoidances at this point of acquisition are at least partially a function of knowledge of the avoidance response and that knowledge of the response leads to an increase in spontaneous activity, or (3) the two measures are effected in similar ways by some other factor. Since handling seems to be a factor which decreases both measures at early intersession intervals and tends to increase them at later intersession intervals, it could be that handling at early intersession intervals increases anxiety to a disruptively high level where more innate responses to fear are seen. Thus the subject freezes rather than runs during the relearning session at short intervals, decreasing both the number of avoidances and the number of spontaneous responses. At later intersession intervals, when fear of the situation has dissipated somewhat, handling may be increasing the general level of fear, less than before, but sufficient to motivate the subject, and either increases activity leading to spurious avoiding, or increases sensitivity to the CS and increases the tendency to avoid. Obviously more experimentation is needed on this notion; however, it is interesting to note the close relationship between the general activity level and avoidance responding.

Another problem of interpretation exists at later intersession intervals because subjects were handled both immediately _after_ acquisition of the avoidance response, and immediately _before_ the relearning session. It is possible that handling immediately _after_ learning interferes somehow with the "consolidation" process of the avoidance response. However, handling just before the relearning session may affect more directly the emotional state of the subject. Although it is theoretically interesting to deconfound the effects of these two handling sessions, the within-group variability of performance in the shuttlebox situation makes it methodologically difficult.

Finally, as Figures 2 and 3 indicate, the curve of the home cage groups, in terms of both spontaneous responses and avoidance responses, closely resembles those of the handled shuttlebox groups. This seems to indicate that the location variable does not have any effect on the shape of the "warm-up effect". This similarity casts some doubt upon theories (Brush et al, 1963a), which suggest that remaining in the shuttlebox during the intersession interval is an important variable in changing the retention function. Handling alone appears to account for the changes in the curve. However, there are two other possible explanations for failure to produce any effect of location of the subject in this experiment. It is logically possible that any location effect is masked by the handling effects. Unfortunately, it seems technically impossible to completely deconfound the handling and location variables. Secondly, it is possible that the lack of decrement in the shuttlebox group at one hour shown by Brush, is the effect of location on the "other factor" leading to the Kamin effect. Thus, the effect of location would not necessarily be seen in a curve of the "warm-up effect".

SUMMARY

In summary, the present experiment studied two aspects of the retention of an incompletely learned avoidance response during the first 15 relearning trials. The first aspect considered the general shape of the retention curve. Previous studies on this retention function demonstrated U-shaped curves as a function of length of intersession interval. The general shape of the curves in the present study was monotonic. Two possible explanations were offered to account for the difference in findings between the present study and earlier ones. One explanation is that the early relearning trials represent the monotonic warm-up function suggested by Kamin (1963). It was shown that the early relearning trials of other studies support this notion. Thus, it is necessary to adopt a two-process theory in order to explain both the monotonic curve in early relearning trials and the U-shaped curve in later relearning trials. The second possible explanation is that certain procedural details of this experiment have minimized the processes underlying the U-shaped "Kamin effect".

A second aspect of this experiment considered the effects of two variables on the warm-up decrement. Handling the subjects during the intersession interval was shown to have a detrimental effect on performance at the zero intersession interval and a tendency to have a facilitative effect at later intersession

intervals. This trend was seen in both the number of avoidances and the number of spontareous responses during the relearning session. The location variable appeared to have no differential effects on the retention curve. The handling effects were discussed in terms of the arousal of innate fear interacting with learned fear.

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APPENDIX

Summary Data for Various Indices of

Original Acquisition

Index	Measure		
	Grand Mean	Grand Median	Range
Spontaneous responses during adaptation	18.10	18.00	1-40
Trials to criterion	29.60	27.50	4-70
Number of avoidances	9.18	7.00	3-19
Number of escapes	22.10	21.00	1-60
Spontaneous responses during acquisition	14.60	12.00	0-75

RAW DATA

0 $\bar{H}$SB Subject	Trials to acquisition	Number of avoidances Trials 1-5	Trials 6-10	Trials 11-15
1	28	4	5	5
2	30	5	4	4
3	17	5	3	4
4	30	3	4	4
5	35	5	3	3
6	4	4	5	5
7	45	3	1	3
8	39	3	2	3
9	37	4	4	5
10	30	5	5	5
$\frac{1}{2}$ HSB				
31	21	3	3	5
32	9	1	4	5
33	19	1	0	0
34	27	0	3	4
35	35	0	0	0
36	30	4	4	4
37	44	2	2	5
38	40	0	0	4
39	51	0	0	1
40	20	4	5	5
0 HSB				
11	40	4	3	5
12	24	1	0	0
13	47	2	0	0
14	70	2	2	0
15	17	1	3	2
16	64	1	1	2
17	44	1	3	4
18	15	3	1	5
19	39	2	4	5
20	24	3	3	5
$\frac{1}{2}$ HC				
41	7	2	1	0
42	7	4	5	5
43	48	2	3	1
44	24	0	0	0
45	28	0	2	4
46	37	0	0	1
47	20	1	4	5
48	23	0	0	0
49	12	2	5	5
50	43	0	3	5

RAW DATA

½ $\overline{\text{HSB}}$ Subject	Trials to acquisition	Number of avoidances Trials 1-5	Trials 6-10	Trials 11-15
21	19	4	2	4
22	30	4	5	3
23	46	0	1	1
24	59	0	4	5
25	19	3	3	3
26	67	4	3	5
27	12	0	0	3
28	38	5	3	5
29	21	1	0	1
30	34	3	3	3
1 $\overline{\text{HSB}}$				
51	17	2	3	5
52	29	2	3	4
53	48	2	4	3
54	70	1	1	0
55	31	0	0	1
56	46	1	1	2
57	32	3	2	5
58	23	0	0	0
59	21	0	3	2
60	48	0	0	1
1 HSB				
61	23	4	4	5
62	11	0	1	0
63	23	5	5	5
64	11	1	3	2
65	41	4	4	5
66	11	0	0	1
67	28	0	0	2
68	14	2	4	5
69	45	0	1	1
70	26	0	2	3
1 HC				
71	22	2	2	3
72	63	1	1	0
73	55	0	0	2
74	59	0	1	1
75	13	2	5	5
76	9	2	5	4
77	22	0	0	0
78	27	1	1	1
79	23	1	3	5
80	46	0	0	0

24 HSB Subject	Trials to acquisition	Number of avoidances Trials 1-5	Trials 6-10	Trials 11-15
81	14	0	1	0
82	9	0	0	0
83	27	0	0	0
84	41	1	1	0
85	15	0	1	2
86	29	0	1	2
87	5	0	0	0
88	36	0	0	1
89	36	1	1	0
90	34	0	0	2
24 HSB				
91	52	0	0	0
92	9	0	1	1
93	17	0	2	3
94	19	0	0	2
95	44	0	0	0
96	18	2	3	1
97	36	1	2	3
98	31	1	4	1
99	9	0	3	5
100	24	0	0	1
24 HCD				
101	56	0	0	0
102	22	0	2	1
103	18	0	1	3
104	26	0	2	0
105	20	0	2	3
106	30	0	2	0
107	36	0	3	0
108	44	0	0	0
109	22	1	3	4
110	34	0	0	2
24 HC				
111	22	0	3	5
112	9	0	0	0
113	31	0	0	3
114	6	2	3	4
115	18	2	1	4
116	38	0	2	1
117	26	0	4	5
118	26	0	0	0
119	38	0	0	0
120	20	0	0	0