THE EFFECTS OF ESCAPABLE AND INESCAPABLE SHOCK ADMINISTERED IN INFANCY UPON ADULT AVOIDANCE CONDITIONING

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ABSTRACT

The present research was conducted to test the hypothesis stimulation in infancy acts to reduce adult emotional reactivity in a decreasing monotonic fashion and secondly, to determine if the effects of escapable stimulation administered in infancy were greater than the effects of inescapable stimulation administered in infancy.

Four groups of animals were used. One group received little stimulation in infancy, a second group received handling daily in infancy, a third group received handling and inescapable shock daily in infancy, and a fourth group received handling and escapable shock daily during infancy. Adult emotional reactivity was inferred from adult avoidance conditioning performance and heart rate change in response to a conditioned aversive stimulus.

The results did not support the hypothesis that adult emotional reactivity resulting from escapable infantile stimulation is greater than adult emotional reactivity resulting from inescapable infantile stimulation, but did support the hypothesis that adult emotional reactivity was inversely related to the amount of infantile stimulation.

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CHAPTER I

INTRODUCTION

Statement of Problem

Few studies concerned with the effects of stressful infantile stimulation have involved escapable stressors. It is the purpose of this thesis to vary escapable and inescapable stress in infancy and to determine its effect on adult emotional reactivity in the guinea pig.

Stanley and Monkman (1956) and Gauron (1964) have both varied escapable and inescapable shock in infancy. Stanley and Monkman, using mice, reported no differences in adult emotionality. However, their control group had received handling daily during infancy as did the two experimental groups, and it is possible that the effect of handling masked the effects of the experimental treatments. The handling of infant rodents, such as placing them in a box for as little as three minutes daily, has been demonstrated by a number of investigators such as Levine (1956), and Levine, Chevalier, and Korchin (1956) to affect adult emotionality.

Gauron exposed infant rats of two strains to two types of infantile stimulation, either escapable or inescapable shock. The control animals were left undisturbed in infancy. He found a significant interaction of strain and type of stimulation on adult avoidance conditioning. This study may be criticized on two methodological points: first, the two shock groups received differing amounts of infantile shock, and secondly, both groups receiving shock were handled in infancy while the control group was not, making it difficult to say whether differences between shocked and control animals were due to shock or handling.

Historical Background

The effect of early experience (EE) on adult behavior is a recent area of experimental investigation in psychology. Intensive experimental investigations in this area have been conducted only within the last fifteen years. The importance of EE as a determinant of adult behavior was recognized by Freud (1935), who emphasized the possibility of neuroses stemming from traumatic experiences early in life. However, it was not until the publication of D. O. Hebb's Organization of Behavior in 1949, that the effects of EE came under intensive experimental investigation.

The term "early experience" has commonly been used to denote a wide variety of experimental treatments administered before or shortly after weaning. Treatments administered prior to weaning have commonly been termed "infantile" stimulation. The types of stimulation used in this area of research have been classed as either physical (mechanical) or environmental (non-mechanical). Physical treatments would include electric shock, handling, and temperature variation. Environmental treatments would include varying litter size, exposure to enriched and deprived environments, and separation from the mother. A more extensive discussion of this classification system and the treatments involved may be found elsewhere (Levine, 1962a; P.141). The dependent variables have included indices of learning, social behavior, and physiological and behavioral measures of emotionality.

In 1951, Hall and Whiteman carried out a study to investigate Freud's contention that early traumatic stimulation would result in increased emotional instability in later life. They exposed one group of infant mice to the sound of a loud buzzer for two minutes daily for the first seven days of life. A control group received the same handling, but were not exposed to the sound of the buzzer. When compared with the control group in an open-field test at thirty days of age, the experimental group had a higher defecation rate and less locomotor activity. The authors concluded that infantile stimulation resulted in increased emotional instability in later life. Griffiths and Stringer (1952) exposed groups of rats, during the first twenty-one days of life, to either intense sound, electrical shock, extreme temperatures, or rotation. When compared with a control group (treated in an unspecified manner) they reported no differences in defecation in an open-field test and concluded that infantile stimulation did not increase emotional instability. It should be noted, however, that neither of these studies included a non-treated control group. Another possible cause of the conflicting reports may be the presence of species differences, since one study used mice and the other rats.

Levine, Chevalier, and Korchin (1956) carried out a study in which they either shocked, handled, or ignored infant rats during the first twenty days of life. When later tested in an avoidance conditioning apparatus, the non-treated control animals performed significantly poorer than the two groups which had received stimulation in infancy. This finding was interpreted as indicating that the non-stimulated animals were more susceptible to emotional disturbance which interfered with performance, or conversely, that the animals stressed in infancy were less emotionally reactive. The hypothesis that adult emotional reactivity is inversely related to increasing infantile stimulation has since gained support.

Denenberg and his co-workers have found evidence of decreased emotionality as a result of intense stimulation in infancy on a number of behavioral measures such as conditioned emotional responses in mice (Denenberg, 1958), avoidance conditioning (Denenberg, 1962), and open-field tests (Denenberg and Smith, 1963). Evidence of decreased reaction to stress as a function of infantile stimulation has also been found in a number of physiologically related measures such as weight gain (Denenberg and Karas, 1959), and mortality (Denenberg and Karas, 1961; Levine and Otis, 1958).

The finding of decreased emotionality as a result of stressful infantile stimulation has not gone unchallenged, however. A study by Levine (1962b) has indicated that rats and mice stimulated in infancy may have a greater, more immediate, physiological response to acute stress. It should be noted that the studies mentioned previously, involving physiologically related measures, dealt with reactions to chronic stress such as food deprivation or immobilization as adults. Lindzey, Lykken, and Winston (1960) reported measures of increased emotionality in mice that were stimulated in infancy. However, this study and others not using an appropriate non-treated control group have come under severe criticism (Denenberg, 1961; Levine, 1961). Yet other studies have noted increases in emotionality as a result of stimulation during infancy (King and Eleftheriou, 1959; Gauron, 1964).

The lack of parametric studies varying noxious stimulation in infancy may be responsible, in part, for many of the conflicting reports in the literature. There are several studies (King and Eleftheriou, 1959; Levine and Wetzel, 1963; and Gauron, 1964) which suggest that there may be an important genetic factor in determining the effect of stressful infantile stimulation.

The intensity of the stimulation in infancy may be another important parameter. Denenberg (1959) exposed groups of twenty-five day old mice to several levels of shock intensity, then tested them by conditioning an emotional response to a buzzer at fifty days of age. Several levels of shock were used in adult conditioning. He reported an interaction of early shock levels and shock levels in adult conditioning. There was a curvilinear relationship in which animals receiving low intensity early shock were still too emotionally reactive to perform well. The presence of such an inverted U-shaped relationship between intensity of infantile stimulation and adult performance may possibly account for some of the conflicting reports in the literature.

The context in which the animal encounters the stressor may be another factor. Stanley and Monkman (1956) hypothesized that the anxiety or emotional reaction of an animal to electric shock would be greater under conditions of arbitrary shock than under conditions which allowed the animal to terminate the shock by making an operant response. Every day, for the first 11 days of life, one group of infant mice were exposed to shock in an apparatus in which termination of the shock was contingent upon the animal moving to the safe side of the box. Animals in a second group were paired with animals in the first group and received, on each trial, the same amount of shock as animals in the response-contingent group. However, cessation of shock was not contingent upon a specific response for this second (yoked-control) group. A third group of animals were placed in the shock apparatus for an equal amount of time, thus receiving handling but no shock. A non-handled control group was not used. The animals were tested in an open-field test at 45 days of age and later avoidance conditioned. No significant differences were noted between the groups in amount of defecation. Activity in the open-field test was not scored. The only significant difference in avoidance conditioning was faster running time by the response-contingent animals, which the authors attributed to infantile learning and concluded there were no differences in emotionality. As pointed out earlier, the study lacked a non-handled control group which could possibly have differed in emotionality from animals receiving shock and/or handling in infancy.

A study by Brady (1958) suggests, contrary to Stanley and Monkman's hypothesis, that avoidance training may increase the amount of stress for the animal required to make an operant response to terminate or avoid shock. Brady found a much higher incidence of gastro-intestinal lesions in monkeys required to push a lever to avoid shock, than in control monkeys receiving the same shock but unable to avoid it. This group difference was also found to be a function of the schedule of experimental and rest periods and has yet to be replicated. However, the study does suggest that the requirement of having to interact with the environment to avoid the stressor increases the resulting stress. A study by Denenberg (1964b), in which rats were used as subjects, supports this hypothesis. One group of rats received avoidance training daily from 60 to 69 days of age. A second group of animals received an equivalent amount of shock, but were unable to avoid it, while a third group of animals were neither shocked or handled. Under conditions of terminal deprivation animals that had received avoidance training died significantly sooner than animals in the other two groups. The inescapable shock group survived approximately as long as the control group. Thus, the context in which the shock was encountered, not the shock itself, would seem responsible for the differences in survival time.

Gauron (1964) not only varied escapable and inescapable shock in infancy but the strain of the animal as well. The rats were tested as adults in an open-field test, water escape maze, and avoidance conditioned. In avoidance conditioning there was a significant interaction of strain and type of trauma. Escapable shock animals made the most errors and non-shocked animals the least in the Sprague-Dawley strain, while the opposite was true for the Long-Evans hooded rats. This attempt to resolve some of the conflicting results reported in the literature may be criticized on a number of points. As mentioned earlier, both shocked groups received handling and shock in infancy, while the control group received neither treatment. In the absence of a handled control group, it is difficult to say whether the differences between the shocked groups and the control group are due to shock in infancy, handling in infancy, or both. The two shocked groups also received differing amounts of shock in infancy. The escapable shock group received a total of 15 seconds of non-continuous shock daily for 15 days for a total of 225 seconds of infantile shock. The inescapable shock group received three minutes of uninterrupted shock daily for 15 days for a total of 2700 seconds of infantile shock. This difference in amount of infantile shock between the two groups may, in part, be responsible for differences in adult performance. The difficulty in obtaining escape responses from infant rats and mice results in a methodological difficulty evident in the two studies involving escapable shock in infancy (Stanley and Monkman, 1956; Gauron, 1964). Prior to the tenth day of life, neither of the species of rodent is capable of well co-ordinated movement.

Two hypotheses have been drawn from the literature. The evidence presented by Brady (1958), Denenberg (1964b), and Gauron (1964) suggests that animals receiving shock terminable by an operant response would be stressed more than animals receiving an equivalent amount of shock and unable to influence its termination. To test this hypothesis, two groups of guinea pigs, capable of well co-ordinated movement within several hours of birth, were used. The guinea pigs in the inescapable shock group were paired, or "yoked", with a corresponding animal in the escapable shock group, in a manner similar to that used by Brady (1958). This method of yoked control assured equivalence of duration and temporal distribution of infantile shock. In order to control for the effects of handling these animals daily during infancy, a third group of animals were handled the same amount as animals in the two shocked groups. Each animal in this handled control group was yoked to a corresponding pair of shocked animals. These handled animals were removed from the home cage and placed in an apparatus similar to the shock apparatus, while the other two animals were being run. Animals in this control group were not shocked. A fourth group of animals made up the non-treated control group and were left in the home cage during infancy.

The second hypothesis was derived from Denenberg's (1964a) paper which states that stimulus input in infancy acts to reduce emotional reactivity in a monotonic fashion. He further states that from this it follows that an inverted U-shaped function should be obtained between the amount of infantile stimulation and adult performance on tasks involving some form of noxious stimulation such as avoidance conditioning. Since there is evidence to suggest that "handling" the infant animals produces less intense stimulation than electric shock (Denenberg and Smith, 1963), the four groups in this experiment may be ordered in terms of the degree of infantile stimulation, ranging from least to greatest, as follows: the non-handled control group, the handled control group, the inescapable shock group, and the escapable shock group. If Denenberg's hypothesis of an inverted U-shaped function between stimulus input in infancy and adult avoidance conditioning is correct, and if escapable shock is more stressful than inescapable shock, predictions may be made about relative performance on adult avoidance conditioning. The non-handled control animals should perform poorly due to excessive emotional reactivity reducing the probability of an appropriate response. The escapable shock animals should also perform poorly due to low emotional reactivity, while the groups receiving intermediate amounts of infantile stimulation, the handled control and inescapable shock animals, should perform much better. In other words, an inverted U-shaped function should be obtained between the amount of infantile stimulation and the adult avoidance conditioning performance.

CHAPTER II

METHOD

Subjects

The subjects were 34 guinea pigs of the Abbysinian strain, bred in the animal colony at the University of Manitoba. The initial stock had been obtained in 1964 from the Lemberger Company, Oshkosh, Wisconsin.

The Ss remained with the mother for the first 15 days of life, housed in cages of sheet metal (15 1/2 by 9 1/2 by 8 in.) with a wire mesh front and floor. On the 16th day the animals were caged individually in smaller cages (8 1/2 by 9 1/2 by 8 in.) of similar construction. On the 70th day, at the beginning of avoidance conditioning, each animal was returned to one of the original larger cages. Each cage contained a food box and water bottle. Both food and water were available at all times. The animals were left undisturbed except for experimental treatment, filling of the water bottles and food boxes when needed, and changing of the dropping pan sawdust.

Apparatus

The apparatus consisted of three early experience runways, an avoidance conditioning shuttle-box for adult training, and a Grass model 5D Polygraph used to record heart rate.

The early experience runways were three wooden boxes of similar size and construction. The internal dimensions of the runways were 36 by 4 1/4 by 5 inches. The length of the runways could be varied by use of a cardboard liner insert. The end zones of each liner were covered with 1/2 inch diagonal black stripes (see Figure 1). All runways had grid floors made of 1/8th inch bronze rod, spaced parallel every 3/8th inches apart. In two of the runways, the grid floor could be electrified by a Grason Stadler Shock Generator E1064GS Operant Conditioning Apparatus which supplied eight output leads to the escapable shock runway and eight to the inescapable shock runway. Onset, as well as termination, of shock was simultaneous in both runways. The third runway, which received no shock, was used for the handled control animals. A random program punched in 16mm. film, with an average intertrial interval of ten seconds and a range of 14 seconds, turned on a light in front of the experimenter to signal the start of a trial. Manual initiation of shock by the experimenter also activated a Hunter Klock Kounter which measured the duration of shock to the nearest .01 second.

The shuttle-box used for avoidance conditioning was fully automatic. It consisted of a large plywood box (36 by 12 by 12 inches) on legs. The box was divided in two equal compartments by a four inch high hurdle. Each compartment of the box had an independently hinged grid floor made of 1/8th inch bronze rod spaced parallel every 1/2 inch. Each section of the floor was supplied with shock from eight scrambled output leads from the shock generator described previously.

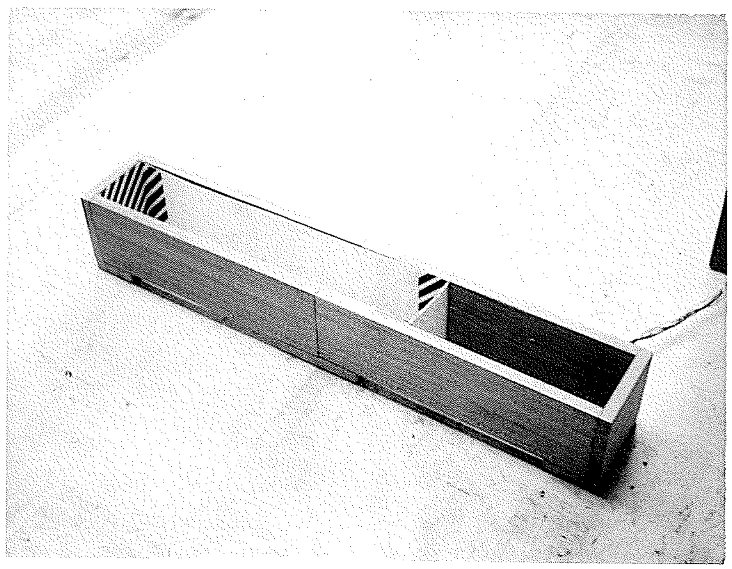

Figure #1

Early Experience Runway

Each of the two sections of the floor could be electrified independently. The floor sections were hinged at the centre of the box beneath the hurdle and dropped approximately 1/2 inch at the end of the box when the animal's weight depressed the floor (see Figure 2). A micro switch, one at each end of the box, was closed when the floor section dropped. A small coil spring kept that section of the floor raised and the micro switch open when that compartment was empty. A Standard Clock Timer, activated by the onset of the buzzer, recorded the response latency to the nearest .01 second.

The apparatus used in obtaining records of heart rate change consisted basically of three parts: a Grass polygraph, an immobilization platform, and a 110 volt house buzzer. The EKG circuit (type II limb lead) of the polygraph was used to record the heart rate of the animal. The recording electrodes consisted of 1/2 inch long strips of bare copper wire. The immobilization apparatus consisted of a wooden platform, one foot wide and eighteen inches long, with one inch long steel studs placed at each corner (see Figure 3). Wide cloth straps, tied around the animal's limbs, were fastened to the steel studs. Small wooden guides, two inches by three inches, were placed on either side of the animal's head and body, and one was used to prevent the animal from backing out of the apparatus. Three 1/8th inch bronze rods were run through the tops of the guides, from one side to the other, to prevent the animal from raising its body. One was placed across the neck, just behind the skull, and the other

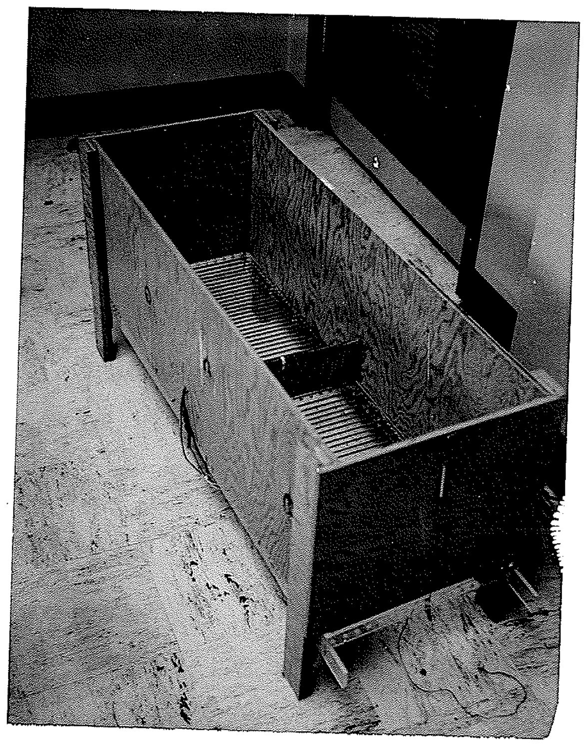

Figure #2

Avoidance Conditioning Shuttle-box

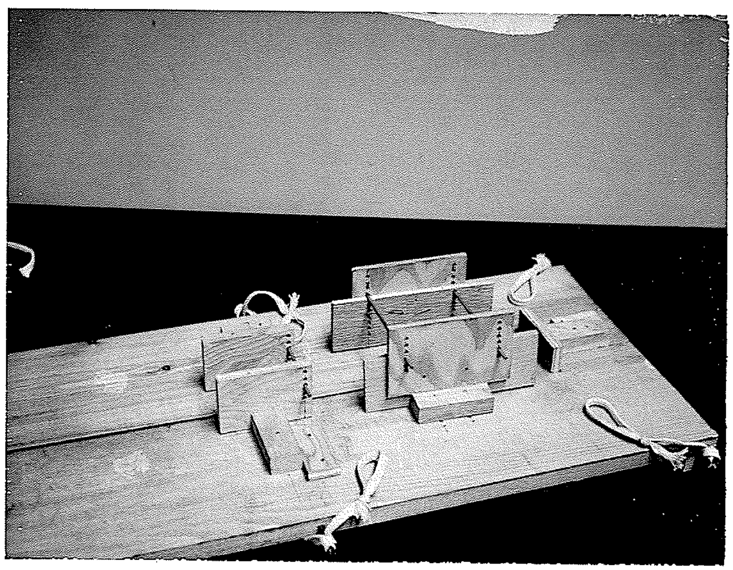

Figure #3

Immobilization Apparatus

two across the back. All rods were adjustable in height, and the distance between the guides could be varied.

Procedure

Early experience. Within twelve hours of birth all animals were earpunched for identification and assigned to either group NHC (non-handled control), HC (handled control), IS (inescapable shock), or ES (escapable shock). Since the usual litter size was three, one animal from each litter was assigned to each of the three groups: HC, IS, and ES. Not enough animals were born to supply nine animals for each of the four groups. As a result, additional animals were bred and nine infants were used for the NHC group subjects and two for the HC group. This control group, along with the two animals in the HC group, were born in August, approximately three months later than the other animals and therefore were tested approximately three months later.

Ss from the HC, IS and ES groups were placed in the EE runways each evening for the first 15 days of life. Ss in the NHC group were left undisturbed in the home cage during this period. In a given session, one S from the ES group and the two yoked control animals, from the IS and HC groups, were run simultaneously. The Ss were placed in the EE runways and a stopwatch was started to record the total time in the EE situation. The two HC Ss run at a later time were placed in the EE runways daily for a period corresponding to the total daily testing time of the IS and ES animals with which they were yoked. The experimenter pushed a button to initiate shock when the interval light, described previously, came on. Shock was supplied to the ES and IS animals. The shock was terminated by the experimenter when the ES animal reached the opposite end zone of the runway. This response completed one trial. The experimenter then recorded the duration of shock indicated on the Klock Kounter. There were 15 trials daily for each animal. The length of the runways was varied by the use of cardboard liners. On day 1, the runways were 12 inches long. They were increased to 18 inches on days 2 through 7, and were full length (36 inches) on days 8 through 15. The shock intensity was 1.2 ma. on days 1 through 10, but was increased to 1.6 ma. for the last five days.

Avoidance conditioning. Beginning on day 70, all animals received 15 avoidance conditioning trials per day for ten consecutive days. The animal was removed from its cage and placed in one compartment of the shuttle-box. The side in which it was first placed was alternated each session. Trials were initiated by a program of random intervals, with an average intertrial interval of ten seconds and a range of 14 seconds. A trial consisted of a ten-second presentation of a buzzer (CS), the last five seconds of which it was paired with 2 ma. of shock (UCS) delivered to the grid floor. When the animal crossed the hurdle into the opposite compartment, the micro switch on that side was closed, turning off the shock and/or buzzer. Shock was present during the intertrial interval on the side of the hurdle opposite the animal, to discourage intertrial crossings and the possibility of pseudo-conditioning. The animal could "escape" the shock by crossing the hurdle into the opposite compartment, or "avoid" the shock by crossing the hurdle during the five seconds following the onset of the buzzer. The time that elapsed between the initiation of the buzzer and the animal's response of crossing into the alternate compartment was used as a measure of latency. On each trial, the experimenter recorded the latency of response, instances of vocalization present during the UCS and also the number of intertrial hurdle crossings.

Cardiac recording. On the 87th day, heart rate recordings were obtained for each animal. The animal was first immobilized in the apparatus described previously. The animal's right front foreleg and left hind leg were then shaved, electrode jelly applied, and the recording electrodes taped on. Since the experience of immobilization seemed stressful to the animals, they were left for a six minute adaptation period before recording was begun in order to obtain a stable basal heart rate. After the adaptation period, the experimenter recorded heart rate for a minute and a half. At this time the experimenter sounded a 110 volt house buzzer, similar to the one used in avoidance conditioning, for three seconds. After 27 seconds, the buzzer was sounded again for three seconds. A full minute of record was obtained following the onset of the second buzzer. The animal was then removed from the apparatus. The average number of beats per minute was computed for the minute and a half period preceding the presentation of the first buzzer (basal rate), and for the minute and a half following the first presentation (post stimulus rate). These two average rates were then subtracted to give the number of beats per minute increase or decrease between the two periods. This difference score was used as the index of heart rate change.

CHAPTER III

RESULTS

The mean and variance of each group was calculated for the following data: response latency, trials to successive criteria, total number of avoidance responses, number of vocalizations to the UCS, heart rate change, and the number of intertrial crossings. The mean was plotted against the variance for each group on each measure, in order to determine if transformations were appropriate (Winer, 1962). The variance was found to be proportional to the mean for all measures with the exception of response latency. The data for all measures, with the exception of response latency, were transformed using the formula $x^1 = \sqrt{X} + \sqrt{X + 1}$.

The transformed data for number of trials to successive criteria, total number of avoidance responses, number of vocalizations, number of intertrial crossings, and heart rate change were analyzed by a one-way analysis of variance (Lindquist, 1953; Pp. 47-100). In all measures where a significant treatment effect was found, a Duncan's Multiple Range test for unequal N's (Kramer, 1956) was applied to determine which groups differed significantly. The data for response latency were analyzed by a Lindquist Type I analysis of variance (Lindquist, 1953; Pp. 267-273).

The results of the analysis of: the number of trials to the first avoidance, the number of trials to the first two successive avoidances, and the number of trials to the first five successive avoidances per animal are shown in Table I.

Table I

Analysis of Variance of the Number of Trials Required to Reach Successive Criteria

Criteria	Source	df	Mean Square	F
trials to first avoidance	treatment	3	48.77	2.93*
	within	30	16.64	
trials to first two successive avoidances	treatment	3	122.38	5.14**
	within	30	23.83	
trials to first five successive avoidances	treatment	3	62.08	3.58*
	within	30	17.34	

* significant at .05 level

** significant at .01 level

The results of the Duncan's Range Test for the group means of all three measures are shown in Table II, with the means that do not differ significantly (p greater than .05) underlined with a common line. In each case the non-handled (NHC) differed significantly from both of the shocked groups but not from the handled control group. The handled control group did not differ significantly from either the shocked groups or the non-handled control group. The escapable and inescapable shock groups did not differ significantly. The non-handled control animals required the greatest number of trials to reach the criteria considered, while the escapable

Table II

Results of Duncan's Range Test for the Mean Number of Trials per Group Required to Reach Successive Criteria

Criteria	ES group	IS group	HC group	NHC group
trials to first avoidance	10.95	10.44	13.60	15.44
trials to first two successive avoidances	10.63	12.33	15.64	18.98
trials to first five successive avoidances	15.50	15.98	18.69	21.19

shock animals required the least number of trials (see Figure 4).

Table III shows the results of the analysis of variance of the total number of avoidance responses out of a possible 150. A Duncan's Range Test showed that the non-handled control group differed significantly from the two shocked groups. The handled control group, as in the number of trials to successive criteria, did not differ significantly for either the shocked groups or the non-handled control group. The two shocked groups did not differ significantly. The inescapable shock animals made the greatest number of avoidances (see Figure 5) and the non-handled control animals the least number of avoidances.

The results for the analysis of the data for the total number of vocalizations to the unconditioned stimulus are

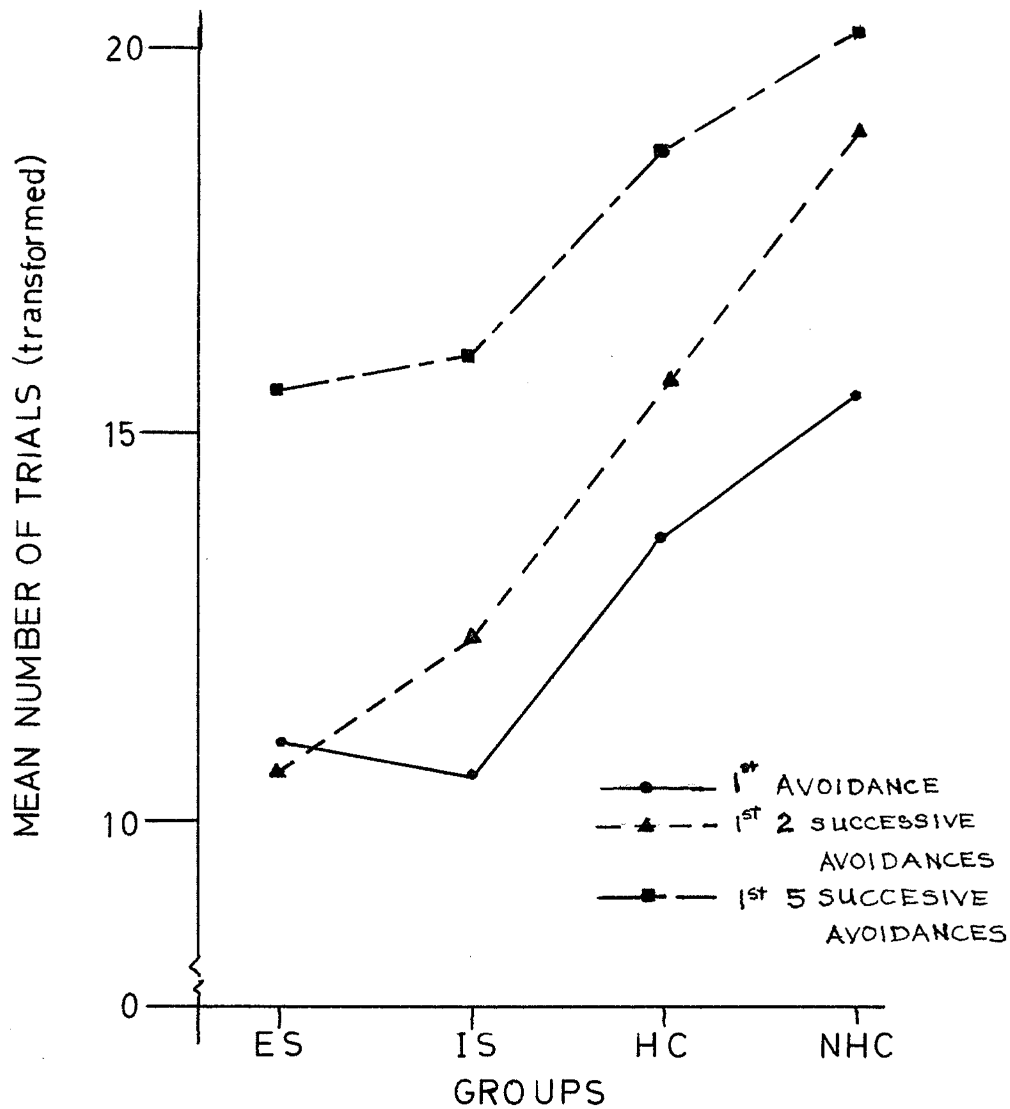

FIGURE 4

TRIALS TO SUCCESSIVE AVOIDANCE CRITERIA

Table III

Analysis of Variance of the Total Number of Avoidance Responses Per Animal Made Out of 150

Source	df	Mean Square	F
treatment	3	85.22	4.085*
within	30	20.86	

* significant at .05 level

shown in Table IV. A Duncan's Range Test showed that the non-handled control group differed significantly ($p = .01$) from the other three groups, which did not differ amongst themselves. The non-handled control animals made the greatest number of vocalizations while the inescapable shock animals made the least number of vocalizations (see Figure 6).

The untransformed data for the mean, daily latency of the hurdle crossing response were analyzed by a Lindquist Type I analysis of variance (see Table V). There was a significant groups effect, days effect, and a significant groups by days interaction. The non-handled control animals had the greatest latency of response while the escapable shock animals had the lowest response latencies (see Figure 7).

The transformed data for the number of intertrial crossings and heart rate change were analyzed by a one-way analysis of variance. Neither analysis resulted in a significant treatment effect. The means and variance for the

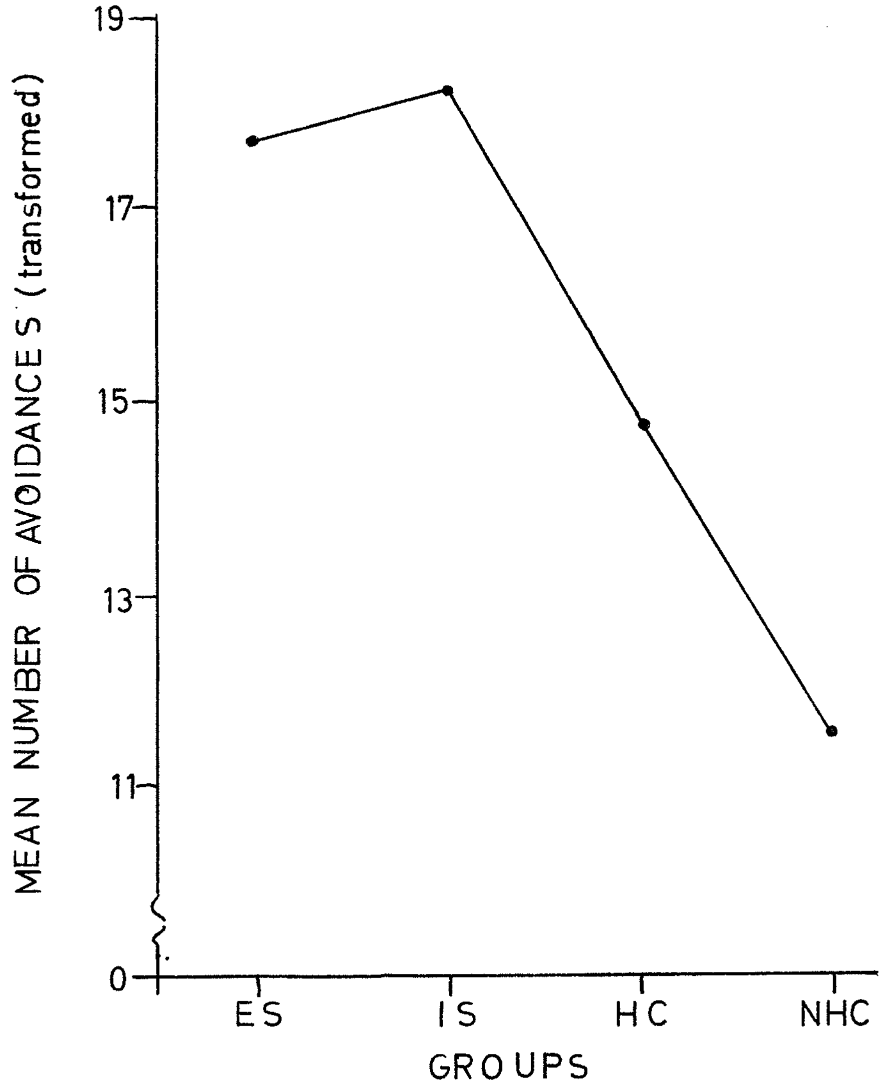

FIGURE 5

TOTAL NUMBER OF AVOIDANCES

Table IV

Analysis of Variance of the Total Number of Vocalizations Made per Animal to the Unconditioned Stimulus

Source	df	Mean Square	F
treatment	3	147.99	22.59**
within	30	6.55	

** significant at .01 level

Table V

Analysis of Variance of Mean Daily Latency of Hurdle Crossing Responses

Source	df	Mean Square	F
Groups	3	22.48	3.26*
Subjects within groups	30	6.89	
Days	9	50.91	127.28**
Groups x Days	27	1.42	3.55*
Subjects within groups x Days x Groups	270	.40	

* significant at .05 level

** significant at .01 level

untransformed data on both measures may be found in Appendix A.

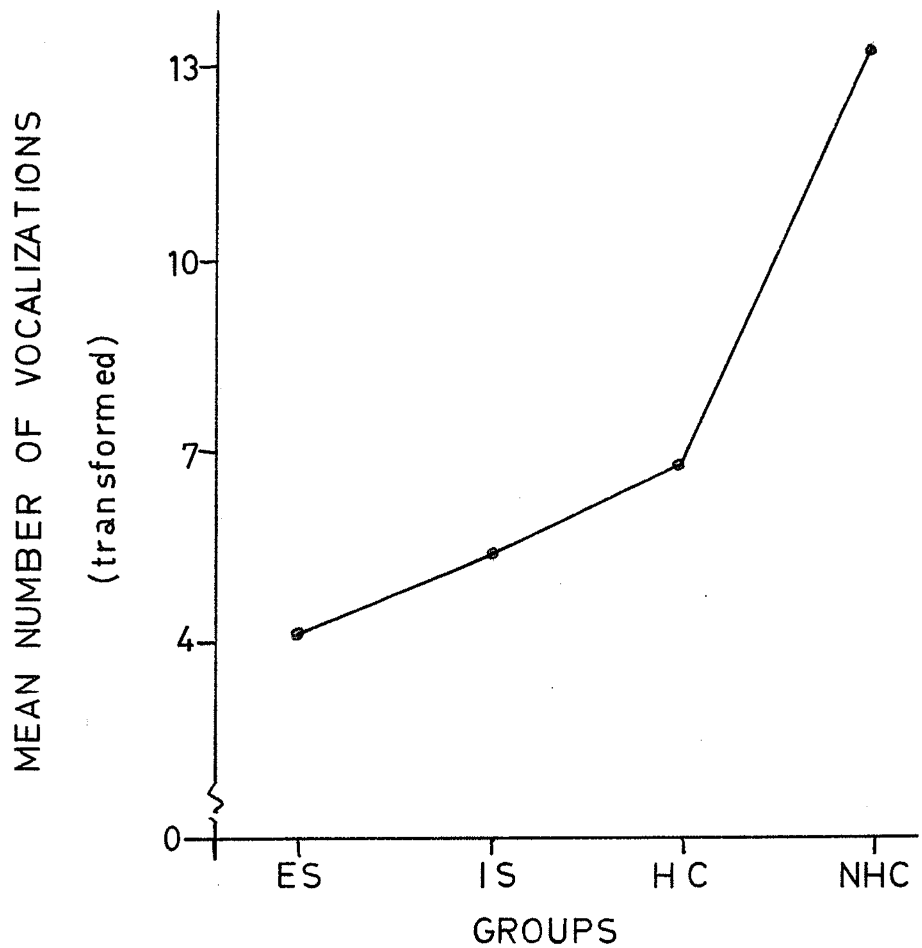

FIGURE 6

NUMBER OF VOCALIZATIONS

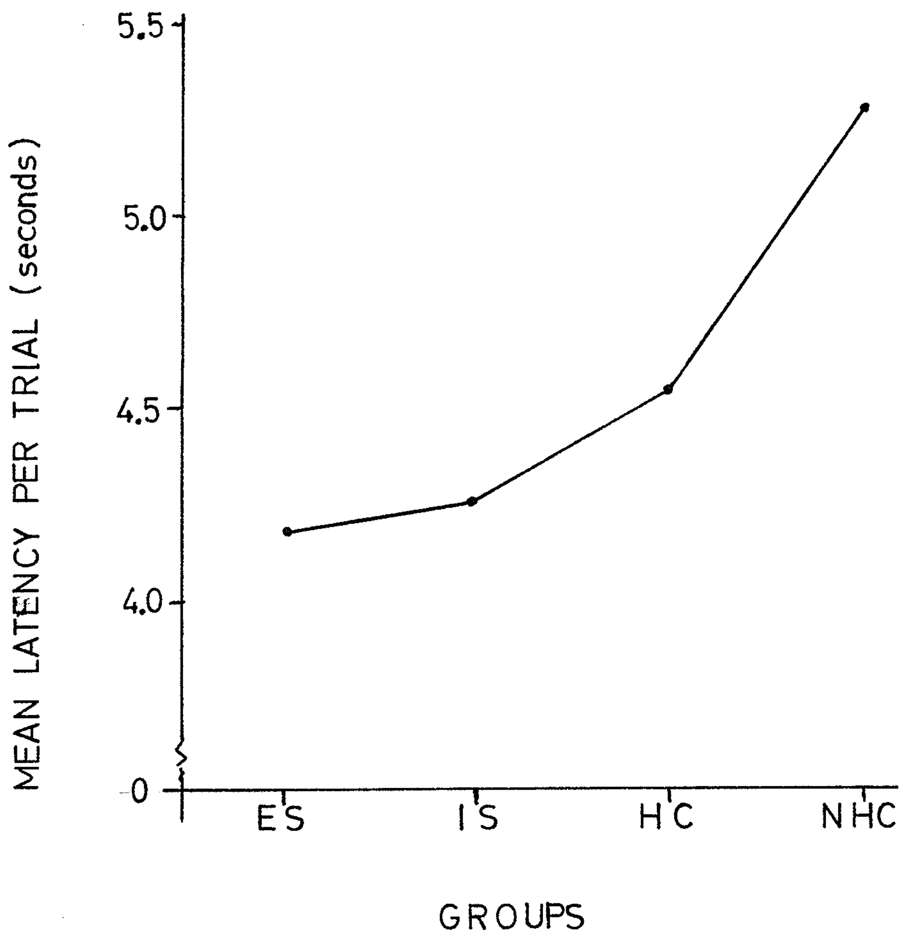

FIGURE 7

MEAN LATENCY OF HURDLE

CROSSING RESPONSE

CHAPTER IV

DISCUSSION

The obtained results do not support the hypothesis that animals exposed to stress terminable by an operant response in infancy are rendered less reactive to stresses in adulthood than animals exposed in infancy to an equivalent amount of inescapable stress. Differences in emotional reactivity between the two groups (IS and ES) as a result of differential infantile treatments should be evidenced in avoidance conditioning performance. No significant differences were found between the two shocked groups on any of the measures of avoidance learning in this study.

The model presented by Denenberg (1964a) would predict that the effect of increased stress in infancy would impair the avoidance conditioning performance of the escapable shock animals. It is possible that, as a result of infantile learning in the escapable shock animals, performance on avoidance conditioning would be facilitated and would result in better performance than that predicted. This explanation for the fact that no difference was found between the ES and IS groups assumes that there was a real difference in emotional reactivity between the two groups but that it was not evidenced in performance due to the facilitating effect of infantile escape learning. For the escapable shock animals, the response to shock reinforced in infancy was that of locomoter activity. This learning, if present and transferred to the adult avoidance conditioning situation, would increase the probability of an appropriate response in the escapable shock animals and therefore reduce response latency. Thus, it would tend to improve the low predicted performance of the ES animals and reduce the predicted difference between the two shocked groups.

In order to evaluate this possibility a second, physiological measure of emotional reactivity, heart rate change, was included. Neither the results of the behavioral measures of emotional reactivity (avoidance conditioning), nor the physiological measure (heart rate change) which was free of the effects of infantile learning, showed any statistically significant difference between the two shocked groups.

The second hypothesis, that an inverted U-shaped function would be obtained on measures of avoidance conditioning, with non-handled control animals and escapable shock animals performing poorly and handled control and inescapable shock animals performing best, was only partially supported. The escapable shock animals failed to show the predicted drop in performance that would have resulted in a U-shaped performance curve.

The prediction of an inverted U-shaped performance curve in this study was derived from a theory described by Denenberg (1964a). Denenberg states that when stimulus input in infancy is low, performance on a task involving a noxious stimulus and of moderate difficulty (such as avoidance conditioning) is also low. The animal is too emotionally reactive to perform well, and usually exhibits freezing and other behavior incompatible with an appropriate avoidance response. If stimulus input in infancy is increased to a moderate level, the animal is not as emotionally reactive in adulthood and conditioning performance reaches an optimum. However, when stimulus input is increased to a high level, emotional reactivity drops to a point at which avoidance conditioning performance is impaired. The animal is not sufficiently motivated by the noxious stimulation to avoid at an optimum level. Thus Denenberg's theory suggests an inverted U-shaped performance curve for avoidance conditioning would be obtained when stimulus input in infancy ranges from low to high levels.

It should be noted that in order to test Denenberg's theory, a number of basic assumptions must be met. The amount of stimulus input in infancy must range from low, through moderate, to a high level of input. In this experiment the amount of stimulus input was determined by the four treatments administered the animals during infancy. The non-handled control group received little stimulus input in infancy relative to the other three groups. The handled control group received moderate input, and the two shocked groups received a high level of stimulus input in infancy. The assignment of these levels of stimulus input is reasonably justified in that this is the procedure used by Denenberg and others (Denenberg, 1964a) to vary the amount of infantile stimulation, i.e. shock (high level of input), handling (moderate input), and non-handled, non-shocked (low input). In this study two types of infantile shock were used; escapable and in-inescapable shock. It was hypothesized that escapable shock would induce a greater stress response in the animal and therefore constitute a greater stimulus input in infancy. If inescapable shock, used in most previous studies, results in high levels of stimulus input, then it was predicted that escapable shock would result in "extreme" input. As noted earlier, there were no significant differences between the two shocked groups, suggesting that the <u>type</u> of shock is not an important parameter. With one exception, the results of conditioning performance obtained may be considered as supporting Denenberg's theory. The group receiving low stimulus input (NHC) performed significantly poorer than groups receiving high stimulus input in infancy (ES and IS). The group that received moderate stimulus input (HC), though it did not differ significantly from groups receiving either low or high amounts of stimulation, consistently obtained scores between these two extremes. (see Figures 4,5,6 and 7). However, animals receiving high levels of stimulation failed to show the decrement in performance suggested by Denenberg's theory. Thus the obtained results support the general statement that adult avoidance conditioning performance is directly related to the amount of infantile stimulation.

The failure of the shocked groups to perform as would be predicted from Denenberg's theory may be due to one, or both, of two possible causes. It was assumed, in order to test the theory, that the avoidance conditioning task used was of moderate difficulty for guinea pigs, as it is with rats. This implies that guinea pigs would perform as well as rats on an avoidance conditioning task. In his discussion of the role of task difficulty and its relation to performance obtained under varying levels of infantile stimulation, Denenberg (1964a) points out that if the task is of greater than moderate difficulty, an increasing monotonic performance curve is obtained rather than a U-shaped performance curve. Animals receiving high levels of infantile stimulation show optimum performance, and a curve is obtained similar to that shown in Figure 7. Thus, if the task used in this study were of greater than moderate difficulty for guinea pigs, the obtained results would fit Denenberg's theory. The results of a recent study, Mogenson and Lin (1965), suggest that rats perform better than guinea pigs in shuttle-box avoidance conditioning. It is therefore reasonable to conclude that the task is more difficult for guinea pigs than for rats. Mogenson and Lin compared avoidance conditioning in rats, guinea pigs, and hamsters using a shuttle-box and a lever-press avoidance situation. Guinea pigs took significantly longer than rats to make the first avoidance response and made fewer avoidances in 150 trials. Thus, the results of this study support Denenberg's theory as it applies to tasks of greater than moderate difficulty and there is evidence to suggest the task used in this study was of greater than moderate difficulty for guinea pigs. The plotted results of response latencies obtained in this study closely resemble the theoretical performance curve described by Denenberg (1964a) for tasks of greater than moderate difficulty.

A second, equally plausible explanation, is that shocking infant guinea pigs does not result in as great an amount of stimulus input as it does with infant rats. The infant rat at birth is at an earlier stage of physical development than a new-born guinea pig. The rat, physiologically, is much more immature at birth and is incapable of well-co-ordinated movement, as well as being relatively insensitive to visual and auditory stimulation. The infant guinea pig, however, has none of these handicaps and is capable of well-co-ordinated movement within a few hours of birth. There is evidence to suggest that the effect of infantile stimulation decreases with increasing age (Denenberg, 1964a). Since physiological development is closely linked with chronological age, the effect of infantile stimulation is also a function of physiological development. The younger and more immature the organism, the greater the effects of infantile stimulation will be. One would expect, since the rat is less mature physiologically at birth, that shocking a one day old rat would result in greater stimulus input than shocking a one day old guinea pig. Thus, shock in infancy would have less effect on the emotional reactivity of adult guinea pigs than it would on rats, and consequently, guinea pigs would exhibit less of a performance deficit as a function of infantile shock than would rats. As can be seen from Figure 7, the guinea pigs in this study did fail to show the performance deficit that was predicted. The prediction of a deficit in performance was derived from Denenberg's theory, a theory based primarily on experiments with rats.

Two possible explanations have been considered to account for the fact that shocked animals in this experiment failed to show the poor avoidance conditioning performance suggested by Denenberg's theory. Both explanations are based on the presence of species differences between rats and guinea pigs. In the first case, guinea pigs may find the avoidance conditioning task more difficult than it is for rats. Secondly, guinea pigs, because they are more mature at birth than rats, may not have received sufficient stimulus input in infancy to produce the same performance deficit as that produced in rats receiving shock at birth. Either explanation would adequately account for the difference in obtained and predicted results for the animals receiving shock in infancy.

The number of vocalizations to the unconditioned stimulus also appears to support the hypothesis suggested by Denenberg that stimulation in infancy acts to reduce adult emotional reactivity. Vocalization in the guinea pig is one of the typical responses to a fear producing stimulus. In this study, animals in the non-handled control group which received little stimulation in infancy, produced significantly more vocalizations in response to shock than did any of the other three groups. These results, however, cannot be considered as definitely supporting the hypothesis since the non-handled control group also received more shock during conditioning due to greater response latencies.

As noted previously, the results of measurement of heart rate change failed to show any significant differences between the groups used in this study. This measurement was intended as an index of adult emotional reactivity, free from the possible effects of infantile learning which could possibly have affected the performance data. Since an increase in heart rate is a common physiological response to stress and to noxious stimulation, it was expected that the animals with reduced emotional reactivity, due to intense infantile stimulation, would exhibit less heart rate change in response to the conditioned aversive stimulus than animals that had received little stimulus input in infancy and were, therefore, emotionally reactive. The measurement of heart rate change failed to show any differences between the groups. This was possibly due to a difficulty encountered in the technique used to obtain the measures. In order to note any consistent increases in heart rate, it was first necessary to obtain a normal or basal heart rate for the animal. This normal rate could then be compared with the mean rate obtained after exposure to the conditioned aversive stimulus. However, in order to obtain measures of heart rate in this experiment it was necessary to immobilize the animal. This immobilization in itself seemed stressful and the typical response was extreme tachycardia. Pre-stimulation rates, supposedly normal or basal, of 300 to 340 beats per minute were not uncommon. It is believed, although there is no definite evidence, that these extremely rapid rates were close to the maximum possible and as a result, the only way heart rate could change would be to decrease. Since a valid measure of resting or basal heart rate could not be obtained in this study, it is not surprising that the measures of heart rate change showed no significant differences. It is possible that recording heart rate using a technique that doesn't require immobilization of the animal could obtain valid basal rates and comparison of these rates with those obtained after noxious stimulation would be sensitive to group differences in the amount of heart rate change.

CHAPTER V

SUMMARY AND CONCLUSIONS

Thirty-four infant guinea pigs were assigned randomly to one of four groups shortly after birth. For the first 15 days of life, animals in one group received escapable shock daily while a second group received inescapable shock. A third group was merely placed in the apparatus daily but not shocked, and a fourth group remained undisturbed in the home cage during this time. Beginning on the 70th day of life, all animals were avoidance conditioned for ten days and a measure of heart rate change in response to a buzzer was obtained on the 87th day.

On all indices of learning, the escapable and inescapable shock animals performed better than the non-handled control animals, with the scores for the handled control group lying consistently between the two extreme group scores. The non-handled control group responded to the unconditioned stimulus with significantly more vocalizations during conditioning than the other three groups. The escapable and inescapable shock groups did not differ significantly on any of the measures recorded, nor did the non-handled and handled control groups differ significantly on any of the measures, with the exception of vocalization. The handled control group did not differ significantly from either of the shocked groups or the non-handled control group on any of the measures recorded.

No significant differences were found between groups on measures of heart rate change or the number of intertrial crossings.

The results were interpreted as supporting Denenberg's (1964a) hypothesis of decreased reactance to stress as a function of increased stimulation in infancy. The results did not support the hypothesis that animals receiving escapable shock in infancy would perform significantly poorer on avoidance conditioning than animals receiving an equivalent amount of inescapable shock.

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APPENDIX

APPENDIX A

The Means and Variance of the Untransformed Data for Each Measure

MEASURE	MEAN and VARIANCE	GROUP			
		ES	IS	HC	NHC
TRIAL TO SUCCESSIVE CRITERIA					
1st Avoidance	mean	33.3	29.55	48.4	64
	variance	621.0	364.28	818.29	1523.50
1st 2 successive Avoidances	mean	40.8	45.6	66.1	93.6
	variance	416.63	419.75	1917.17	1581.25
1st 5 successive Avoidances	mean	64.1	67.2	92.4	113.3
	variance	1434.86	1375.46	2208.95	853.0
HEART RATE CHANGE (+50)	mean	86.88	49.63	71.33	47.13
	variance	3873.84	473.12	1339.87	546.12
TOTAL NUMBER OF AVOIDANCES	mean	79	84.56	62.43	38.78
	variance	950.75	737.53	1520.62	577.20
LATENCY OF RESPONSE	mean	4.157	4.240	4.505	5.256
	variance	2.708	3.391	2.412	1.572
NUMBER OF VOCALIZATIONS	mean	4.66	8.50	13.3	43.2
	variance	16.75	69.00	160.00	533.00
NUMBER OF INTERTRIAL CROSSINGS	mean	10.	14.4	10.7	6.3
	variance	42.8	122.5	101.5	24.7