BIMODAL EFFECTS OF SENSORY DEPRIVATION

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This is to certify that the

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By

Mary Jane Keller

A THESIS

Submitted to the School for Advanced Graduate Studies
of Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

DOCTOR OF PHILOSOPHY

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Dedication

To Wally

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AN ABSTRACT

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Approved M. Ray Denny

ABSTRACT

The present study was designed to investigate certain behavioral and physiological characteristics of albino rats which had been exposed to a restricted environment (darkness, masked sound, restricted opportunity for movement, and isolation from other rats) during various periods of their life cycle and tested for effects at varying intervals following release from perceptual deprivation.

These effects were studied in 110 experimentally naive rats divided into nine experimental and two control groups, each group consisting of 10 animals. Four experimental groups were composed of 55-day-old[1] Ss while five other experimental groups consisted of 85-days-old[2] animals; there was one 55-days-old[3] and one 85-days-old[4] control group. Experimental manipulation consisted of placing the experimental animals in a highly limited sensory environment either at birth for a period of 25 days (in this instance a mothering rat and litter mates were present), or at 25-days-old or at 55-days-old for a 30 day period (onset variable). Testing for effects by means of avoidance conditioning took place either immediately following release from restraint or 30 days later (duration variable). Body weight was determined before avoidance conditioning began whereas adrenal gland size was determined directly following conditioning.

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[1]Age of the animal at the time of testing.
[2]*Ibid.*
[3]*Ibid.*
[4]*Ibid.*

As a result of this study, the following conclusions would appear warranted:

1. An environment lacking in stimuli increases the variability of performance in an avoidance learning task. A plotting of the scores resulted in a bimodal distribution. Furthermore, there is some evidence to suggest, at least as far as 55-days-old Ss are concerned, that the amount of variability is related directly to the degree of sensory deprivation. The effects of sensory deprivation as measured by avoidance conditioning also seem to be related to:

   a) age of the animal at the time restriction was imposed as indicated by the fact that animals older when first deprived seemed to be more anomalous in almost every possible way;

   b) amount of time elapsing between release from deprivation and testing for effects in that there was evidence to suggest that the strength of the effect might abate with time.

2. Sensory deprivation also had a differential effect on body size and adrenal gland weight of animals of different ages. Fifty-five-days-old Ss did not differ from the controls in body weight but had smaller adrenal gland weights. Eighty-five-days-old Ss, on the other hand, differed significantly in variability (the distribution again being bimodal) from their controls on both measures. When combined with the fact that 85-days-old experimental Ss had large variability differences on the avoidance conditioning

task, this finding of significant variability differences on physiological measures seems to suggest that the older an animal is, the more different his response to sensory deprivation is likely to be.

3. Correlations between a) adrenal gland size and avoidance learning performance; b) body weight and avoidance learning performance, and c) body weight and adrenal gland size were not, for the most part, significant. This finding makes it difficult to attribute the variant avoidance conditioning responses to obvious physiological variables.

4. In general, frequency of elimination did not prove to be a discriminative measure of the effects of sensory deprivation. The group which was oldest when exposed to sensory deprivation was the only one to differ (more instances of elimination) from both control and experimental groups on this measure.

The main experimental findings of the study are clear-cut, though their full interpretation at the present state of knowledge appears to be an insurmountable task. However, the findings seem to merit careful consideration especially for those interested in the human being's need for a normal sensory environment. If relatively simple organisms such as a rat, animals whose personality is seldom, if ever, referred to, can become disturbed when placed in a sensory deprivation condition, it would seem likely that man, with his multiplicity and complexity of temperament—would also be markedly influenced by such deprivation. Certainly further study of the parameters of this problem area seems warranted.

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THE PROBLEM

Recent experimentation has shown that drastic curtailment of an individual's perceptual environment results in a wide variety of behavioral anomalies (Hebb, 1958). Unfortunately, there is a dearth of controlled studies dealing with the parameters concerned with this problem of an organism's relationship to his sensory world. The present study was designed to explore systematically two of these parameters, namely, the onset and duration variables. More specifically, the present study was concerned with the effects of sensory deprivation on certain characteristics of albino rats. These rats were exposed at various periods in their life spans (onset variable) to a highly restricted sensory environment, that is, to an environment in which sound was masked, light was absent, opportunity for movement was curtailed, and contact with other rats was nonexistent. Testing for effects by means of avoidance conditioning performance, frequency of elimination during avoidance conditioning, body weights, and adrenal gland size took place at varying intervals following release from the abnormally limited sensory environment (duration variable). Comparison of effects then were made between: 1) animals exposed to restriction when young and those exposed when older, and 2) animals who had an opportunity to recover from the restricted environment before testing occurred and those who were tested immediately following release from the deprivation chamber.

It is hoped that the findings of the present study will not only contribute to the fund of knowledge already existing in this area but also will offer some explanations for the controversial results reported by those persons who have been studying some of the many possible effects of sensory deprivation on the behavior and physiology of organisms.

REVIEW OF THE LITERATURE

A. Sensory Deprivation

When an organism is placed in a situation designed to reduce stimulation, a series of behavioral abnormalities usually ensues, the severity of which is correlated positively with length of time in the sensory deprivation condition. According to Wexler *et al.* (1958), techniques thus far used to produce sensory deprivation experimentally include:

1. Reduction of the absolute level of intensity of all physical stimulation. Lilly's (1956) study of his own psychotic-like responses to submergence in a swimming pool which curbed his usual modes of responding serves as the best example of this type of sensory deprivation.

2. Reduction of the patterning of stimuli. The work of Hebb (1958) and associates (Bexton, Heron and Scott, 1953; Melzank, 1954; Melzank and Scott, 1957; Melzank and Thompson, 1956a,b; Thompson and Heron, 1954; and Thompson, Melxank and Scott, 1956)[1] exemplifies this approach. These men raised dogs in isolation and found that the organisms were atypical in response to pain stimulation, social responsiveness, activity measures, exploratory behavior, and formal problem solving behavior.

3. Imposing structure on stimuli. Wexler *et al.* (1958)[2] have reported work with men forced to remain in poliomyelitis

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[1]In subsequent references to this large group of men, the term "Hebb and McGill Associates" will be used frequently.

[2]There is some justification for not discussing the results of these studies in a collective fashion because of the fact that, in some cases, the experimental subjects were exposed to prolonged sensory deprivation from infancy (e.g., Hebb and McGill Associates) while in other instances the subjects experienced a curtailment of sensory input

> respirators. Increased suggestibility, impairment of thought processes, oppression, depression, desire for bodily motion, and sensory stimulation were the common responses to this situation. Extreme responses included hallucinations, delusions, and confusion.

A wide variety of subjects have been used in sensory deprivation studies and include the dove (Craig, 1914), chickens (Pattie, 1936), chimpanzees (Riesen, 1947; McCulloch and Haslerud, 1939), rats (Hymovitch, 1952; Montgomery and Zimbardo, 1957; Forgays and Forgays, 1952), dogs (Hebb and McGill Associates), and humans (Davis, 1940; Boag, 1952; Burney, 1952; Lilly, 1956; Heron _et al._, 1956). It probably is not surprising that these experimenters offer different explanations for the aberrant behaviors resulting from restriction or curtailment of perceptual experience. Lilly (1956) simply questions whether the brain becomes comatose when freed of normal afferent and efferent activities. Wexler _et al._ (1958) posit that deprivation of sensory experience creates abnormalities because it jeopardizes the individual's hold on reality. Obviously this is far from being an explanation for the question still remains as to how and why it jeopardizes the subject's reality testing capacities or, more basically, why organisms seem to need a constant flow of sensations in order to remain intact and fully functioning.

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for a limited period during adult life only (e.g., Lilly). Obviously one would expect differences and especially as far as irreversibility/permanency of effects is concerned (and this is exactly what has been found). Accordingly, for the present, the reader is asked to focus his interest on the kinds of aberrant responses which occur—without exception—when an organism, human or animal, is placed in a deprived stimulus situation.

Hebb (1958) attempts to place this problem within a learning theory framework. He hypothesizes that after expectancy cues have been established, unfavorable perceptual and motoric experiences influence motivation. The motivational differences, in turn, lead to misapperceptions of the experimental situation in which the subject is expected to perform. Riesen (1950), however, contradicts Hebb's theorizing in his discussion of chimpanzees raised in darkness. Riesen believes that his Ss were well motivated so their poor performances were due to lack of opportunity to develop organized perceptual processes.

Thompson (1955) attempts to utilize physiological and anatomical characteristics of organisms to explain why varied sensory stimulation is essential:

> The massive stimulation supplied by handling (or "mothering," for example) may serve not only to build up patterns of central neural firing, but may also contribute to the general physiological well-being of the infant through some kind of priming action via the reticular activating system.
>
> Thus, early restriction, besides limiting the growth of organization in the brain, may also have the effect of dampening the arousal function. It is important to note in this connection that stimulation, in order to maintain arousal, must be varied. The reticular activating mechanism apparently adapts quickly to repetitive stimulation and loses its arousing properties (p. 137).

One quickly recognizes Hebb's (1949) influence on Thompson's theorizing, that is, the familiar cell assemblies-phase sequence construct. Thus, it can be seen that even the most thoroughgoing of explanations concerning the need for a stimulating environment rests upon unproven, somewhat unsophisticated physiological theorizing. However, this does not discount the value of the aforementioned studies for there seems to be little doubt but what organisms need varied stimulation in order to interact meaningfully and appropriately with their environments. Furthermore, evidence suggests that the amount of stimulation may be just as important as the kind of stimulation (Levine and Lewis, 1959).

Partial Deprivation as seen in restriction of movement is also believed to have serious effects in that it represents a massive blocking of a system of discharge which usually serves as a means of expression. When, for example, restraint of children is sudden and unexpected, the reaction is characterized by increased attempts at motor discharge (Bergman, 1945; Pratt *et al.*, 1930; Taylor, 1934; and Levy, 1943). Persistent restraint leads to apathy, listlessness, and dullness (Dennis, 1935). Hill (1958) found that extensive confinement of animals leads to increased activity while Montgomery (1953) found long periods of such restriction resulting in reduced activity. Hill theorizes that the reported differences were due to the kind of activity measures utilized, that is, long confinement may influence gross activities while other periods may affect small movements. Another important contribution by Hill was his finding that effects of confinement were not permanent.

Hymovitch (1952) and Forgays and Forgays (1952) found motor restraint not to be as deleterious as perceptual restriction as far as learning ability was concerned. This led Thompson (1955) to conclude, ". . . varied sensory stimulation of all kinds is essential to the growing organism. This may be provided through any one of the sense modalities though the visual and cutaneous are probably the most important" (p. 183).

Although the present study does not address itself to the problem of maternal deprivation, it seems important to survey briefly some of the findings resulting from studies in this area because of this writer's belief that maternal deprivation is really a form of sensory deprivation, that is, lack of cuddling, rocking, and attempts at verbal communication appear to constitute a partial restriction of the infant's environment.

According to Scott (1958), a form of care-dependency is characteristic of all highly developed animal societies. Clinicians are well aware of dictums concerning the human infant's need for warm, consistent mothering, the lack of which is believed to result in one of the many psychopathologies (Benedick, 1953; Fenichel, 1945). Spitz and Wolf (1946), two of the most provocative researchers in this area, assert that lack of stimulation and absence of the mother are the two principle etiological factors in childhood psychopathologies. This study of institutional children, although arousing severe criticism because of an obvious lack of rigorous scientific methodology (Orlansky, 1949), cannot be discounted in that very interesting hypotheses are to be found in their work, for example, they purport that pathological processes resulting from separation from the mother are irreversible if they last longer than five months. In this situation the stressor agent causing anorexia, weight loss, facial rigidity, infection liability and even death is believed by Spitz and Wolf to be emotional deprivation.

Ribble (1944), also criticized for naive physiology and methodology (Kubie, 1945; Pinneau, 1950), presents case studies intended to support the same propositions to which Spitz and Wolf's work is addressed, namely, lack of mothering invariably leads to psychic illness and physical debilitation. She reports that infants receiving little personal attention fail to grow adequately due to inability to assimilate their food. Her theoretical position is concerned with the belief that only the mother can provide the kinds of physical attentions, e.g., rocking, fondling, and caressing, which stimulate the various physiological mechanisms. Thus, she carries Spitz and Wolf's (1946) position a bit further by attempting to evoke a physiological rationale for the infant's need for a mother. Further evidence accrued to show that there are permanent adverse effects of separating the child from its mother can be found in the work of Bakwin (1942), Beres and Obers (1950), Prugh *et al.* (1953), Edelson (1943), and Bowlby (1951). They all indicate that the institutional child under six months of age will most likely be listless, show pallor, be relatively immobile, and fail to gain weight despite the ingestion of diets believed to be adequate.

One cannot help but raise the question as to whether the infant's health depends on care by one female adult (mother) or whether the young organism needs stimulation regardless of who provides this. Harlow's (1958) discussion of the nature of love and affection is particularly relevant. In contrast with the behavior of monkeys raised by a wire mother surrogate, monkeys reared with a cloth mother surrogate seemed to show no deleterious effects from the experience. Apparently this type of mother gave the infant what Harlow posits to be the essential variable in love, namely, contact comfort. In his words:

> Love for the real mother and love for the surrogate mother appear to be very similar. . . . As far as we can observe, the infant monkey's affection for the real mother is strong, but no stronger than that of the experimental monkey for the surrogate cloth mother, and security that the infant gains from the real mother is no greater than the security it gains from a cloth surrogate (p. 684).

Thus, an infant monkey does not appear to need an object relationship with an organism having primarily mammalian capabilities; rather it seems to need someone or something on which it can depend for tactual and kinesthetic stimulation.

Orlansky (1940) probably sets psychology in the right direction when he emphasizes the need for further experimental study based primarily on the observation that Spitz and Ribble are overly concerned with the requisites of Western family life rather than actual necessities of sound personality formation. At this point, however, the bulk of evidence reviewed does seem to suggest that distortions of personality development can result from separation of the infant from a person who would have provided a wide variety of stimulation to the infant.

B. <u>Perceptual Experience and Emotionality</u>

A great body of literature concerned with the effects of "gentling" (that is, specific sensory stimulation by means of stroking which affects kinesthetic, proprioceptive, and tactile sensory receptors) on lower animals has slowly been accruing. This area is especially important in that, for the purposes of making generalizations, one could liken the nongentled animals in the studies to be mentioned to the restricted/isolated animals used in the present study. Studies by Hunt and Otis (1953), Levine and Otis (1958), Levine (1956), Weininger (1954) and Bovard (1954) indicate that gentling decreases emotional reactivity while increasing activity and curiosity. Scott (1955) and Gertz (1957), however, found no differences in their measures of emotionality between gentled, shocked, and control groups. They conclude that gentling does not lead to a permanent rise in the animals' threshold for emotional reactivity.

While it is not the present author's intention to explain these contradictory findings, it seems important to consider some variables which conceivably could be responsible. The recent work of King and Eleftherious (1959), for example, suggests that genetic differences between mice contribute to the effects of such handling. Ader (1959), however, presents a more complete analysis of the situation; his major point is concerned with the lack of appropriate controls.

> . . . unless one manipulates both young and old individuals in the same manner, one is not investigating <u>early</u> experience but only the effects of <u>previous</u> experience. That an individual's past experience influences his present behaviors is well documented. That early experience is particularly influential remains to be conclusively documented (p. 1).

Thus, it can be concluded that the lack of appropriate control groups prohibits any definite statement concerning the effect of excessive perceptual experience on emotional responsivity.

C. Perceptual Experience and Learning

Forgays and Forgays (1952) and Bingham and Griffiths (1952) showed that rats reared in richer "environments" were superior in maze learning ability to animals raised in laboratory cages. Cooper and Zubek (1958) also found this to be true for their rats and attempted to explain the differences by hypothesizing that normal or enriched environments lead to the creation of more cell assemblies. Kahn (1954) reared rats in isolation and found them to be more aggressive but also less investigative. Such subjects would tend toward performing poorly in a maze learning task. Bernstein (1957) found handled rats to be better learners and concluded that reduced emotional reactivity is the causal variable rather than increased perceptual experience. Thus, when the handled rats were placed in an experimental situation, they were less emotional and could deal more constructively with the problem at hand, that is, to explore the maze more actively.

Hebb (1949) and Thompson (1955) assert that organisms having a vast amount of perceptual experience early in life will prove to be the better learners than others denied such experience. Harlow (1949) also reports that learning performance may be facilitated by prolonged experience with various aspects of the problem. According to Thompson (1955), "Inadequate environmental stimulation early in life can produce serious deficiencies" (p. 125). The rationale for this occurrence is given as follows:

> For it is during this early period of life, while a large part of the brain is still developing, that the bases of all the complex processes of learning, perceiving, remembering, and

> emoting are laid down. Although conditions must be rather drastic for these to develop abnormally, such can occur and when they do, the results, . . . are correspondingly drastic (p. 124).

It can be concluded that, although the bulk of research concerned with the effects of extensive perceptual experience during infancy on problem solving at maturity suggests a facilitation effect, there is no one answer to theoretical questions arising from such data. Perhaps one is safest in concluding with Hebb and Thompson (1954) that, "For the rat, then, adult intelligence depends both on heredity and the stimulating action of the post natal environment" (p. 533).

D. Perceptual Experience and Avoidance Learning

Although a wide variety of studies have attempted to understand the effects of early avoidance learning on later experience with shock (Chevalier and Levine, 1955; Scott, 1955; Weininger, 1956; Levine, 1957a), they are not relevant to this study since one would put oneself in a precarious and dubious position if he assumed that early avoidance learning and restriction of environment, although both are believed to be traumatic agents, are analogous. For the purpose of this study, the concern will be centered on the effect early experience has on subsequent experience with avoidance learning.

Levine (1956) found that adult rats not handled in infancy were inferior to handled rats in their ability to learn to avoid electric shock. Denenberg (1959), attempting to establish parameters, found that handling during the rat's first ten days of life was more positively related to avoidance learning than handling occurring at a later point in the rat's life span. Melzank and Scott (1957) report essentially the same finding in their work with dogs raised in isolation. In two tasks requiring an avoidance response to shock, restricted dogs performed significantly poorer than control dogs, that is, they required more trials to learn to avoid shock.

E. Anatomical Responses to Traumatic Events

1) Elimination. Hall (1934) reports that defecation and elimination can be used as reliable indicators of emotionality. Morganson and Ehrich's (1958) shocked groups showed less elimination than controls and gentled subjects while Stanley and Monkman (1956) found no differences in amount of defecation between mice shocked when infants and their controls. Hunt and Otis (1959) as well as Gertz (1957) support Stanley and Monkman on this issue but are contradicted by the study of Hall and Whitman (1951). Ader (1959) explains these contradictory findings on the basis of inappropriate control groups.

2) Adrenal Gland[1] Size. Although Ader (1959) found no difference in adrenal weights between experimental and control animals, Weininger (1956) found his nongentled subjects to have heavier adrenals than his gentled animals. Levine's (1957c) study supports Weininger as do Herrington and Nelbach (1942) and Hall (1939). Yeakel and Rhodes (1941) carry the proposition further by showing that adrenal gland size is

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[1]In actuality there are two adrenal glands but for the purposes of this report a singular form "gland" rather than "glands" will be used. The glands were extirpated separately but their weights were combined to give "glandular weight."

positively correlated with emotionality. Selye (1950) also deals with the relationship between adrenal size and reaction to stress and is in accord with Yeakel and Rhodes.

3) Weight of Body. Morgenson and Ehrich (1958) shocked some rats while gentling others. After three weeks of such treatment, the shocked subjects weighed significantly less than either the controls or the gentled groups. McClelland (1956), Weininger *et al.* (1954) and Ruegamer *et al.* (1954) all found gentled animals to weigh more than non-gentled or non-handled animals. Herrington and Nelbach's (1942), Griffiths and Stinger's (1952), and Scott's (1955) findings are opposed to these and it is possible that Binda (1957) may be correct in criticizing the aforementioned researchers for not controlling either activity or body warmth. Ader (1959) points out that weight loss to anxiety situations is but an initial response; this possibly could account for reported differences since the experimenters in question weighed their Ss only at the time of testing. Thus, this is another area fraught with equivocal results.

For the purposes of the present thesis, a study performed by Raymond *et al.* (1955) merits mention. They found that weight loss is positively related to speed. It should be expected, then, that heavier animals would perform less favorably in a task requiring speed.

4) Physical Response to Stress. Levine and Otis (1958) report that rats handled prior to weaning show less mortality following food and water deprivation than appropriate control groups. Bovard (1958), Hammett (1922), Weininger (1954), and Reugamer and Silverman (1956)

also found gentled Ss better able to withstand stress. King and Cannon (1955) report that mice reared in isolation were less viable than those reared in groups. Bovard (1954) theorizes that this kind of response is:

> . . . mediated by a permanent alteration in the balance of hypothalmic activity, . . . This alteration results in increased growth hormone output under normal conditions and decreased activity of the pituitary-adrenal cortex and sympathetico-adrenal medulla systems under normal and stress conditions. In turn, this alteration in hypothalmic balance is itself the result of a change in amygdaloid complex activity, arising from the sensory input from early handling (p. 267).

Levine et al. (1957c) support Bovard by also contending that "handling leads to more rapid maturation of the pituitary adrenal axis" (p. 405). Levine and Lewis (1959) stipulate, however, that the handling must occur within a certain period of life--the first few days following birth--to be effective.

At this point the work of Selye (1950) becomes relevant. Agents such as extreme changes in temperature, surgery, and emotional excitement are called "stressors." If an organism is exposed to a stressor for an appreciable period of time, a response pattern labeled by Selye, "The General Adaptation Syndrome," occurs. This consists of an alarm reaction, during which time resistance increases, and the stage of exhaustion, during which time internal resources are depleted and following which organic damage occurs. Selye's concept is an important one for this present thesis in that sensory deprivation is posited by the present writer to constitute a stressful situation with its concommitant behavioral and structural anomalies.

F. Conclusions from These Data

It is evident that the greatest contribution made to date through experimentation has been to specify the type of response, a pathological one, which can occur as a result of curtailing severely and abruptly an organism's perceptual environment. Thus, one can accept the general hypothesis that a highly restrictive sensory environment will create serious motivational, social, and intellectual impairments. However, the many possible parameters have not been isolated, for example, how long an individual need be exposed to perceptual deprivation before experiencing aberrant reactions. The present study was designed to add to the general fund of knowledge concerning this vast problem area.

INQUIRIES

With regard to the present study's focus of interest, it can be seen that a consistent body of knowledge from which definitive hypotheses could be made simply does not exist. It therefore seemed more appropriate to summarize the areas of concern as points of inquiry rather than as formal hypotheses. They will be enumerated and then the rationale for the selection of the dependent variables used will be presented. The inquiries are as follows:

1. Will a restricted environment (complete isolation, absence of sound and sight, and limited opportunity for movement) affect the learning and retention of an avoidance response to shock? If so, is this effect related to:
    a) the age of the animal at the time restriction was imposed?
    b) immediacy of the test for this effect?
2. Will a restricted environment affect physiological characteristics of the animals as measured by:
    a) body size?
    b) adrenal gland weight?
    c) frequency of elimination?

The first question which arises concerns the use of avoidance conditioning as one test of behavioral anomalies. Hebb and McGill associates effectively used avoidance conditioning as the measure of changes in dogs exposed to a restricted environment. They also were able to show that their experimental Ss could not learn to avoid most pain-evoking stimuli as quickly as control animals. Another consideration was the fact that the experimental manipulation called for a limiting of the Ss' experience with visual and auditory stimuli. In light of Riesen's (1950) work with the chimpanzees who became blind as a result of being reared in darkness, it seemed important not to use a test requiring visual skills. It is true that sound was masked in the present study yet served as the conditioned stimulus for the avoidance conditioning task. This was done because sound was experienced by the Ss, albeit masked sound.

On a more subjective level, the use of avoidance conditioning was deemed appropriate on the basis of the present writer's observation of extremely disturbed children (those diagnosed "early infantile autism"). It was her perception that these children, believed to have been rejected by parents and, therefore, not recipients of cuddling, rocking, and the like, were unable to adapt constructively to their environments. One aspect of their maladaptation was the inability to learn to avoid aversive stimulation. Thus, a measure of avoidance responsivity appeared to be a fruitful approach to the problem.

As far as retention of an avoidance conditioning response was concerned, the work of Kamin (1957) and Denny (1958) is pertinent. Kamin found a decrease in retention when retesting occurred within one hour of original learning, whereas retesting 24 hours later or even longer resulted in about as good retention as when animals were retested immediately after the first learning session. Denny theorized that the "Kamin" effect was due to an incubation of anxiety during the first hour or so. Beyond this point, the anxiety gradually declined to a minimum. When anxiety was maximal, it resulted in freezing behavior in the rat which interfered with the instrumental avoidance act of running and thus lowered the retention score. When Denny replicated portions of this study while introducing what appears to be a crucial variation--providing for anxiety reduction during the retention interval--he found no "Kamin" effect, that is, there was no decrease in retention. In light of the fact that the present study seemed to be dealing with factors such as emotionality and anxiety and the effects of deprivation on them, a study of the Ss' reaction to the Kamin type of avoidance learning procedure was incorporated into the present study. Another strong point favoring use of this measure was the simple fact that it provided additional measures of behavior for analysis.

More specific reactions studied, e.g., the relation of age at which time restriction was imposed to ability to avoid noxious stimulation, were deemed important by the present writer on the basis of her interpretation of the contradictory research findings reported, as well as from King's (1958) listing of some of the parameters which needed to be studied. According to King, the following seven variables warrant systematic study if psychologists are ever to ferret from research findings a consistent, comprehensive understanding of early environment's influence on personality development:

1. The age of the animal when the experience is given.
2. Age at the time of test.
3. The duration or quantity of the experience.
4. The type or quality of the experience.
5. The type of performance task required of the adult animal.
6. The method for testing persistence of the effect.
7. The relation of the experience to the genetic background of the animal (p. 46).

It can be seen that the present study was designed to study variables similar to numbers one, two, and six.

A study of the subjects' anatomical and physiological characteristics as measured by adrenal size, frequency of elimination, and body weight also was determined essential to the present research on the basis of the equivocality of the results reported in the literature. It will be recalled that for each study which reported experimental differences in one direction, there were almost as many studies which reported differences in the opposite direction. Thus, a careful study using a number of controlled variables relevant to adrenal size, frequency of elimination, and body weight seemed warranted.

METHODOLOGY

A. Subjects

The subjects (Ss) used in this study were 110 experimentally naive albino rats whose mothers had been selected at random from the colony of albino rats maintained by the Michigan State University Department of Psychology. These females were bred and produced their litters at various intervals throughout January, February, and March of 1959.

Since each animal born was used, no attempt was made to control for the sex of the subjects. The resulting sex breakdown was 60 males and 50 females. Eight subjects died[1] during the experimental manipulations; four additional rats died while waiting to be adrenalectomized. All were replaced but, obviously, were exposed to experimentation at a time somewhat later than that of other members of their groups. Eleven groups consisting of ten animals per group were used.

B. Apparatus

1. Deprivation Chamber. The deprivation chamber was a darkened cardboard and wooden enclosure set against the high ceiling of the laboratory. This enclosure was of the following dimensions: 73" x 39½" x 58½". Placed within this chamber was a small structure consisting of 20 separate cages measuring 5" x 6" x 6". These cages had wooden sides and wire mesh tops and bottoms. The chamber was placed eight feet above the floor.

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[1] Causes of these deaths will be given in the Results and Discussion sections.

Despite the presence of small holes near the top of the enclosure for ventilation purposes, the chamber was almost completely dark at all times. The Ss were never handled except when placed in the cages and removed for testing. Sound was masked and, therefore, kept constant by means of a noise produced by a large fan which also ventilated the chamber and was operating at all times. The fan emitted a monotonous buzz which essentially obliterated all noises in the laboratory and sounds created by the Ss scratching on the walls of their cages. The flaps of the fan were nailed almost completely shut so that: 1) light could not enter there, and 2) only a small amount of air could be circulated so as not to have the Ss in a draft. Temperature was controlled insofar as was possible and usually approximated 72^{o}. Movement of the animals was limited due to the relative smallness of the cages.

The cage for the mothers who were placed in restriction with their unweaned pups measured 12" x 12" x 12". It was made of solid metal with the exception of a wire mesh top. It was placed in one corner of the cardboard chamber.

2. Avoidance Conditioning Box. Ss were given avoidance conditioning in a modified Miller-Mowrer black shock box measuring 14" high, 27" long, and 4" wide. The box had no barrier between the two halves.

C. Procedure

1. Scrambling of Litters. In order to control for heredity, rats were scrambled at birth with litters of the same age. This posed somewhat of a problem since the litters produced in any one day varied in

size from two to eighteen and it was necessary to have 10 pups in each cage with a mother rat. Thus the scrambling was not entirely random since an attempt was made to minimize the number of rats reared by their biological mother.

2. Groups Used and Treatments Received. In order to facilitate the identification of each of the nine experimental and two control groups, a code will be used which is based on the number of days a group was exposed to normal and restricted conditions. A plus sign (+) indicates placement in a home cage with rats of a similar age, in other words, in normal laboratory conditions. A minus sign (-) indicates placement in the restricted environment, that is, placement either in the small cages within the cardboard chamber or with their mother in the metal cage. The first numbers given indicate that for the first 25 days of their lives the subjects were placed with a mother rat in the restriction chamber (-) or with her in the home cage in the normal environment (+). The second numbers indicate placement in the small cages within the larger cardboard chamber if a minus sign precedes the number, or else placement in the normal laboratory cages if the number is preceded by a plus sign. This same meaning will be ascribed to a third group of numbers, the -30 indicating 30 days in individual restriction and a +30 indicating 30 days in normal laboratory cages. Three examples will be given.

1. E+25-30. This code indicates that the 10 rats in this group experienced normal laboratory conditions during the first 25 days of their lives and then were placed in individual restriction for a total of 30 days. The letter "E" indicates that this is an experimental group.

2. E-25-30+30. This group was isolated immediately at birth with a mother rat in the aforementioned metal cage within the chamber. After 25 days of this treatment, the Ss were placed for 30 days in individual restriction. Finally, at 55 days of age, they were returned to the home cages to experience 30 days of routine laboratory existence. At 85-days-old they were tested.

3. C+55. The letter "C" indicates that this is a control group. The numbers indicate that they experienced 55 days of routine, normal laboratory existence.

The following 11 groups were used:

E+25-30	E+55-30
E-25-30	E+25-30+30
E-25+30	E-25-30+30
E+25-30[2]	E-25+30-30
C+55	E+25-60
	C+85

E+25-30[2] differs from E+25-30 only in regard to treatment during avoidance learning. These Ss were returned to their restriction cages during the one hour interval between sessions one and two. All other Ss were kept in a regular cage during this time.

E-25+30 was a kind of secondary control for studing the effect of that initial 25 day period with a mothering rat in restriction. Because of the following two factors, the experimenter did not expect this group to differ appreciably from C+55: 1) a portion of the environmental restriction occurred before the rat Ss' eyes were opened, and 2) the deprivation was only partial since a mothering rat and litter mates were present. (Obviously total deprivation during this early period could not be studied since a mothering rat had to be present to feed the unweaned pups.)

One aspect of the procedure merits special mention. Since the restricted environment consisted of but 20 cages, it is readily apparent that the experimental subjects had to be worked with over a four month period. The experimenter does not feel that this created a serious problem since the Ss were raised in a well-ventilated, heat-controlled environment. Three groups, E+25-60, E-25+30, and E-25+30, were tested during a spring month while all other groups were tested during winter months.

D. Tests for Effects of Sensory Deprivation

1. Avoidance Conditioning. Ss were given standard avoidance training consisting of a CS-US interval of five seconds at a shock level of 1.4 milliamperes. Twenty-five trials with a one minute intertrial interval were given following a two minute adaptation to the shock box. After completion of this group of trials (session #1), the rats were placed in a cage housing all subjects who had been exposed to the same experimental conditions (with the exception of E+25-30[2]). After one hour, they were given an additional 25 trials (session #2), the procedure being patterned after Kamin's (1957) work. During this conditioning a record was kept of any unusual behaviors such as self aggression.

2. Frequency of elimination. During avoidance conditioning trials, the examiner recorded instances of defecation and urination. No attempt was made to estimate, let alone record, the quantity of either fecal matter or urine eliminated.

3. <u>Body Weight</u>. Immediately following removal from the sensory deprivation chamber, the rats were weighed by the examiner on a standard balance scale. The weights were recorded in grams.

4. <u>Adrenal Gland Weight</u>. Within one day of avoidance learning trials, the rats were sacrificed and their adrenals removed. The adrenalectomies were performed by a veterinarian who was given no information as to whether the animal was a control or experimental subject. Following the adrenalectomies, the adrenals were weighed. It is important to note that the veterinarian was checked before the experiment to ascertain his reliability in weighing minute objects, i.e., weighing in milligrams. The resulting reliability coefficient was .91 which indicates that his weights agree with other weights. However, there were serious problems involved in the extirpation of the gland. It is obvious that the rat's adrenal glands are extremely small; thus, it was difficult to extirpate the glands and be assured that: 1) all had been removed, and 2) only gland tissue and not surrounding fatty tissue was removed. The reader will want to consider these extirpation difficulties as the analysis of adrenal gland data is pursued.

RESULTS

Statistical Analysis

Two types of comparisons were made on the present study's data, namely, mean and standard deviation comparisons. If comparisons were made between means, *t* tests for significance were used. If comparisons were made between standard deviations, F tests were used to determine significance in variability. When all experimental groups of the same age were compared with each other on variability, Bartlett's tests of homogeneity of variance was first computed.

1. Avoidance Learning. Figure 1[1] presents the data for the first avoidance conditioning session; each asterisk represents the avoidance score of an animal for that session. Figure 2 presents the data for the second conditioning session in the same fashion. These figures reveal the fact that restriction of an organism's perceptual world strikingly increases the variability of performances in an avoidance learning situation. Some experimental Ss show facilitation and some inhibition, that is, some perform better and some worse than any member of the control groups. Thus, the distribution of scores is bimodal.

As one inspects the figures, two questions arise. Are those Ss who perform poorly in Session 1 also poor performers in Session 2? Do those scoring high in the first session score equally well in the

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[1] The means and standard deviations for each group on the avoidance conditioning test can be found in Appendix I.

FIGURE 1

AVOIDANCE CONDITIONING SCORES (Session 1)

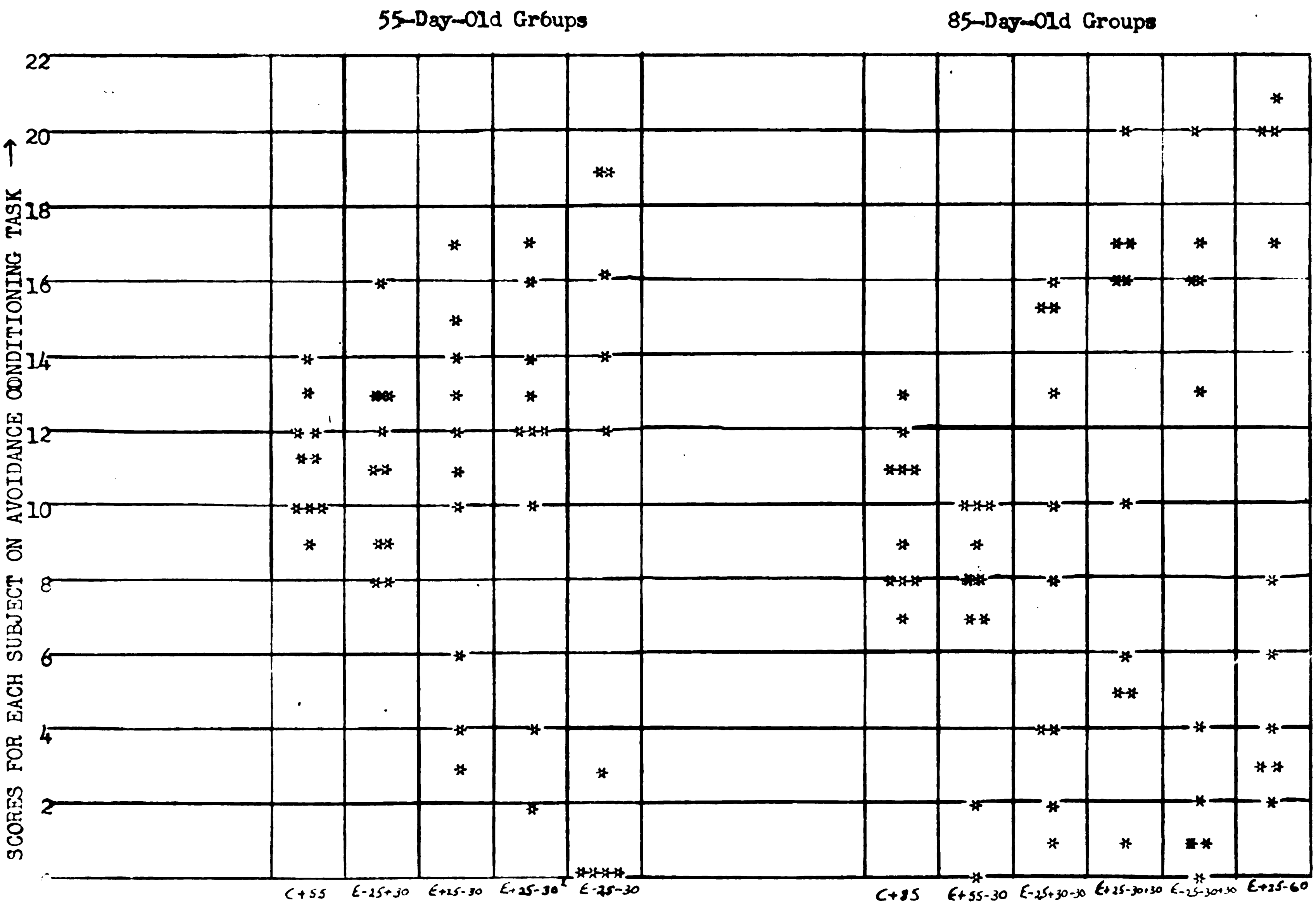
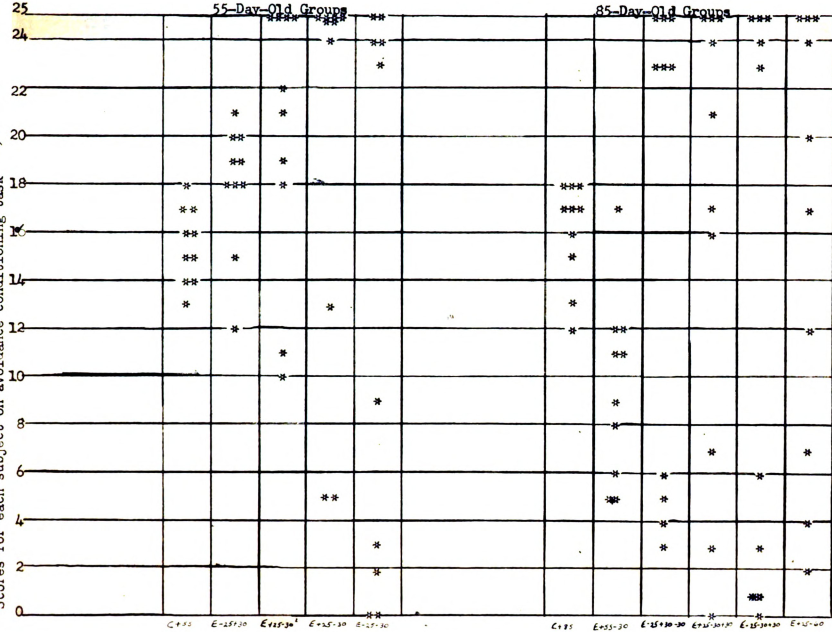


FIGURE 2
AVOIDANCE CONDITIONING SCORES (Session 2)



second session? A survey of the raw data indicates the following:

1. Of the 10 55-days-old Ss whose mean performance was six or less on the first session, eight remained low whereas two increased markedly (6--->25, 3--->18). Thus, 80% were consistent.

2. All of the 55-days-old Ss whose mean performance was 16 or more on the first session remained above that level on the second session, i.e., they were 100% consistent.

3. Of the 85-days-old Ss whose mean performance was six or less on the first session, only two increased their performance appreciably (6--->18, 3--->25). Therefore, consistency was at the 90% level for the low performers.

4. All of the 85-days-old Ss whose mean performance was 16 or more on the first session remained above this level on the second session. Therefore, they were performing at the 100% level of consistency.

Thus, the two sessions, in one sense, provided a reliability measure and the effect is shown to be almost the same from session to session. The fact that the variability difference between experimental and control groups remains consistent from the first session to the second session adds credence to the present findings.

The statistical analyses[1] of the data in Figures 1 and 2 are presented in Tables I and II and here it can be seen that all groups

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[1]From Appendix I it appears that differences in variability are greater than differences in means. Thus, standard deviation differences will be treated first.

TABLE I

DIFFERENCES IN VARIABILITY FOR FIRST SESSION OF AVOIDANCE CONDITIONING TRIALS

Groups Compared	F	Significance
E+25-30 and E-25-30	3.03	n.s.
E+25-30 and C+55	9.62	< .02
E+25-30 and E+25-30^2	1.03	n.s.
E+25-30 and E-25+30	3.46	n.s.
E-25-30 and C+55	29.17	< .02
E-25-30 and E+25-30^2	3.11	n.s.
E-25-30 and E-25+30	10.50	< .02
C+55 and E+25-30^2	9.37	< .02
C+55 and E-25+30	2.78	n.s.
E-25+30 and E+25-30^2	3.37	n.s.
C+85 and E+55-30	2.84	n.s.
C+85 and E+25-30+30	10.64	< .02
C+85 and E-25-30+30	15.93	< .02
C+85 and E-25+30-30	8.85	< .02
C+85 and E+25-60	15.56	< .02
E+55-30 and E+25-30+30	3.74	n.s.
E+55-30 and E-25-30+30	5.60	< .02
E+55-30 and E-25+30-30	3.11	n.s.
E+55-30 and E+25-60	5.47	< .02
E+25-30+30 and E-25-30+30	1.50	n.s.
E+25-30+30 and E-25+30-30	1.20	n.s.
E+25-30+30 and E+25-60	1.46	n.s.
E-25-30+30 and E-25+30-30	1.80	n.s.
E-25-30+30 and E+25-60	1.02	n.s.
E-25+30-30 and E+25-60	1.76	n.s.

TABLE II

DIFFERENCES IN VARIABILITY FOR SECOND SESSION OF AVOIDANCE CONDITIONING TRIALS

Groups Compared	F	Significance
E+25-30 and E-25-30	1.53	n.s.
E+25-30 and C+55	34.8	< .02
E+25-30 and E+25-30[2]	3.87	n.s.
E+25-30 and E-25+30	12.59	< .02
E-25-30 and C+55	53.4	< .02
E-25-30 and E+25-30[2]	5.34	n.s.
E-25-30 and E-25+30	19.3	< .02
C+55 and E+25-30[2]	9.0	< .02
C+55 and E-25+30	2.76	n.s.
E-25+30 and E+25-30[2]	3.25	n.s.
C+85 and E+55-30	7.16	< .02
C+85 and E+25-30+30	46.61	< .02
C+85 and E-25-30+30	67.1	< .02
C+85 and E-25+30-30	51.3	< .02
C+85 and E+25-60	16.13	< .02
E+55-30 and E+25-30+30	6.51	< .02
E+55-30 and E-25-30+30	9.37	< .02
E+55-30 and E-25-+30-30	71.64	< .02
E+55-30 and E+25-60	2.25	n.s.
E+25-30+30 and E-25-30+30	1.43	n.s.
E+25-30+30 and E-25+30-30	1.10	n.s.
E+25-30+30 and E+25-60	2.89	n.s.
E-25-30+30 and E-25+30-30	1.30	n.s.
E-25-30+30 and E+25-60	4.15	n.s.
E-25+30-30 and E+25-60	3.18	n.s.

excepting E+55-30 and E-25+30 differed significantly in variability from appropriate control groups on the first session of the avoidance learning tasks while only E-25+30 was not different from its control on Session 2 of the task.

The Behavior of E+55-30. E+55-30 did not differ from the control group in variability on the first session because nearly every animal in this group engaged in behaviors incompatible with running to avoid shock. Instead of running, many bit their feet, whirled about, bit the grids, and made repeated wild leaps in what appeared to be attempts to escape the shock box.[1] Since this group was also treated differently than all other experimental groups by being deprived after a lengthy normal existence and thus there were included violation of expectancies as well as sensory deprivation *per se*, it was considered justified to compare this one group with the control on mean score alone. Inspection of Appendix I shows the means of E+25-30 to be depressed in comparison with other experimental groups and the 85-days-old controls. Accordingly, *t* tests were calculated and the results indicate that there was a significant

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[1]Six of these animals actually died during sensory deprivation. In addition, this group was anomalous in other ways, e.g., this was the only group which necessitated extreme caution on the experimenter's part when being handled, that is, when being removed from restriction to the shock box. In fact, the only physical damage incurred by either the experimenter or the laboratory maintenance man was inflicted by this group of animals. Four animals in this group also died while waiting to be adrenalectomized. Death was caused by their being eaten by the remaining members of that particular experimental group. Their being attacked cannot be attributed to the victims' size for they did not happen to be either the smallest or largest animals in the group. No other animal was bitten let alone eaten by members of its group throughout the course of this experiment. In all cases, the deceased Ss were replaced by experimentally naive animals and subjected to experimental manipulation at a later date.

difference between C+85 and E+55-30 on both sessions (see Table III). Therefore, E+55-30 is significantly different from its control but it is a mean difference rather than a variability one. It also seems appropriate to mention at this point that E+55-30 was the only group which differed significantly from both experimental and control groups on the elimination measures (see Appendix III). Since this group generally behaved in an emotional manner and since frequency of elimination is believed to be an indicator of anxiety, evidence of greater elimination in E+55-30 supports the present analysis—both theoretically and statistically.

These data indicate rather conclusively, then, that age of the animals at the time of initial restriction is a relevant variable. Not only does the behavior of these animals deprived after 55 days of normal laboratory existence differ in a marked qualitative manner from those deprived earlier than 55 days but also in the quantitative manner mentioned above, e.g., there was a significant mean difference between C+85 and E+55-30.

The Behavior of E-25+30. Inclusion of the E-25+30 group into the experimental design was based primarily on the fact that it would serve as a secondary control for the effects of being in a curtailed stimulus environment from birth and facilitate the interpretation of the other experimental groups' data.

Despite the fact that F tests show E-25+30 to be not significantly different from the control group, this does not necessarily indicate that those first 25 days of partial deprivation did not have an effect.

TABLE III

$\underline{t}$ TESTS OF AVOIDANCE CONDITIONING SCORES ON SESSIONS 1 AND 2

	Groups	
	E+55-30	C+85
Session 1		
Mean	7.1	9.8
Standard deviation	3.27	1.94
n	10	10
t = 2.91 p <.02 (two-tailed test)		df=18
Session 2		
Mean	9.6	16.0
Standard deviation	3.59	1.34
n	10	10
t = 4.6 <.02 (two-tailed test)		df=18

Since 30 days elapsed between removal from partial restriction and testing, it is possible that the interval under normal conditions provided a kind of countereffect. In other words, it is quite possible that the effects of restriction are not irreparable at least when the deprivation is partial and particularly when the animal is so young.

If one inspects the data in Table IV, where F and t tests for certain other groups are presented, a good deal of support for this hypothesis is offered, namely, that partial restriction early in life may be reversible. This is true despite the fact that 55-days-old Ss were no less variable in their performances than 85-days-old Ss because the 55-days-old Ss were tested immediately following termination of experimental manipulation whereas 85-days-old Ss were tested 30 days following release from deprivation.[1]

The hypothesis about reversible effects is supported by the fact that, for the 55-days-old groups in particular there is a significant[2] "stairstep" effect, that is, as the degree of deprivation is increased, the degree of variability also increases (see Figures 1 and 2). This progression seems to be the case even though an increment of deprivation is only partial when the first 25 days of life are involved. The differences between the treatments received by C+55 as contrasted to

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[1]The comparisons between 85-days-old and 55-days-old animals seemed completely justified since there were no differences between the control groups at these two ages.

[2]Bartlett's test of homogeneity of variance was computed for both sessions of the 55-days-old experimental groups' performance on the avoidance conditioning task. The resulting X^2's were 24.31 and 34.15, both of which are significant at the .01 level.

TABLE IV

t AND F TESTS FOR DURATION VARIABLE

		Groups E+25-30	Groups E+25-30+30
Session 1			
Mean		11.2	11.3
S.D.		4.56	6.33
n		10	10
t = .034	n.s. for 18 df		F=1.96 n.s.
Session 2			
Mean		19.7	16.3
S.D.		8.85	9.16
n		10	10
t = 1.36	n.s. for 18 df		F=1.05 n.s.

		Groups E-25-30	Groups E-25-30+30
Session 1			
Mean		8.4	9.0
S.D.		7.94	7.74
n		10	10
t = 1.6	n.s. for 18 df		F=1.0 n.s.
Session 2			
Mean		13.5	13.5
S.D.		10.97	10.99
n		10	10
t = 0	n.s. for 18 df		F=1.0 n.s.

E-25+30 and by E+25-30 as compared with E-25-30 involves the initial 25 days of deprivation. In the case of E-25+30, however, the initial 25 days of deprivation was followed by 30 days of ordinary laboratory existence. Now, if one inspects Table V where the standard deviations of these groups are presented, one will see that the difference between C+55 and E-25+30 is considerably smaller than the difference between E+25-30 and E-25-30. On the basis of the experimental differences between these groups, one would have expected the standard deviation differences (C+55 vs E-25+30; E+25-30 vs E-25-30) to be somewhat similar. Thus, since they are not, it is conceivable that a period of normal laboratory existence could have counteracted the effect of the initial deprivation. However, because the specific differences (means and standard deviations) are not significant, these conclusions are only tentative.[1]

Retention Analysis. As far as retention or relearning one hour following original avoidance training was concerned, most control and experimental groups derived benefit from the first avoidance session (see Appendix II for mean and standard deviation differences between sessions). As indicated in Table VI, nine of the eleven groups improved their performances at the .02 level of significance, a finding somewhat opposed to that reported by Kamin (1957). This discrepancy may be due to the age of the animals when first used, differences in shock level or apparatus dimensions, genetic differences between rats employed, or

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[1]Certainly inclusion of a group deprived for the first 25-days-of-life with a mothering rat (E-25) and its appropriate control group (C+25) would have facilitated interpretation of this data. In subsequent study in the area, such groups would be included in the experimental design.

TABLE V

STANDARD DEVIATIONS FOR 55-DAYS-OLD SUBJECTS

	Session 1	Session 2
C+55	1.47	1.50
E-25+30	2.45	2.72
E+25-30	4.56	8.85
E-25-30	7.94	10.97

TABLE VI

t TESTS FOR DIFFERENCES IN PERFORMANCE ON AVOIDANCE LEARNING TASK FROM SESSION TO SESSION

Groups			Groups		
	E+25-30 (Session 1)	E+25-30 (Session 2)		E+55-20 (Session 1)	E+55-30 (Session 2)
Mean	11.2	19.7	Mean	7.1	9.6
S.D.	4.56	8.85	S.D.	3.27	3.59
n	10	10	n	10	10
t = 5.28	<.02 (two-tailed test) 18 df		t = 3.29	<.02 (two-tailed test) df = 18	
	E-25-30 (session 1)	E-25-30 (Session 2)		E+25-30+30 (Session 1)	E+25-30+30 (Session 2)
Mean	8.4	13.5	Mean	11.3	16.3
S.D.	7.94	10.97	S.D.	6.33	9.16
n	10	10	n	10	10
t = 3.72	<.02 (two-tailed test) 18 df		t = 3.88	<.02 (two-tailed test) 18 df	
	E+25-30^{2} (Session 1)	E+25-30^{2} (Session 2)		E-25-30+30 (Session 1)	E-25-30+30 (Session 2)
Mean	10.5	20.1	Mean	9.0	13.5
S.D.	4.5	5.39	S.D.	7.74	10.99
n	10	10	n	10	10
t = 5.49	<.02 (two-tailed test) 18 df		t = 3.21	<.10 (two-tailed test) 18 df	
	E-25+30 (Session 1)	E-25+30 (Session 2)		E-25+30-30 (Session 1)	E-25+30-30 (Session 2)
Mean	11.0	18.0	Mean	8.9	16.2
S.D.	2.45	2.72	S.D.	5.77	9.61
n	10	10	n	10	10
t = 6.19	<.02 (two-tailed test) 18 df		t = 4.32	≤.02 (two-tailed test) 18 df	
	C+55 (Session 1)	C+55 (Session 2)		E+25-60 (Session 1)	E+25-60 (Session 2)
Mean	11.2	15.5	Mean	10.4	16.1
S.D.	1.47	1.50	S.D.	7.65	8.72
n	10	10	n	10	10
t = 7.05	<.02 (two-tailed test) 18 df		t = 2.29	<.10 (two-tailed test) 18 df	
				C+85 (Session 1)	C+85 (Session 2)
			Mean	9.8	16.0
			S.D.	1.94	1.34
			n	10	10
			t = 11.85	<.02 (two-tailed test) 18 df	

differences in early history. In this last connection, one can mention the fact that the groups which most closely approximated the "Kamin" effect (poor retention after one hour) were: 1) the group oldest when first deprived, and 2) the group deprived for the longest period.

In summary, the restricted environment affected the learning and retention of an avoidance response to shock by causing marked deviations from control group performances. Further exploration of this variability suggested it might be related to immediacy of the test and age of the Ss at the time restriction was imposed.

2. Frequency of Elimination. With the exception of E+55-30, frequency of elimination was not a discriminative measure of the effects of environmental restriction.[1] It has already been mentioned that the significant mean differences between E+55-30 and other 85-days-old experimental groups and the 85-days-old control supports the contention that this group was anomalous as far as emotionality was concerned. The fact that the other experimental groups did not differ from each other helps suggest that the results of this present study are not simply random findings. Furthermore, failure to find differences excepting for the completely anomalous group supports the results of Hoffman (1959), Stanley and Monkman (1956), Gertz (1957), Hunt and Otis (1953) and Ader (1957) but is contradictory to the work of Hall (1934), Morgenson and Ehrich (1958) and Hall and Whitman (1951). As far as the present study

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[1] See Appendix III for elimination means and standard deviations, Tables VII and VIII for t and F tests on this measure, and Figure 3 for the graphing of the raw data.

TABLE VII

t TESTS FOR DIFFERENCES IN FREQUENCY OF ELIMINATION

	Groups	
	E+55-30	C+85
Mean	5.2	2.4
S.D.	1.49	.92
n	10	10
t = 5.02 < .02 (two-tailed test) 18 df		
	E+55-30	E+25-60
Mean	5.2	2.8
S.D.	1.49	1.25
n	10	10
t = 3.49 < .02 (two-tailed test) 18 df		
	E+55-30	E-25-30+30
Mean	5.2	2.3
S.D.	1.49	1.91
n	10	10
t = 4.07 < .02 (two-tailed test) 18 df		
	E+55-30	E+25-30+30
Mean	5.2	2.2
S.D.	1.49	.75
n	10	10
t = 8.01 < .02 (two-tailed test) 18 df		
	E+55-30	E-25+30-30
Mean	5.2	2.3
S.D.	1.49	.90
n	10	10
t = 7.38 < .02 (two-tailed test) 18 df		

TABLE VIII

VARIABILITY DIFFERENCES IN FREQUENCY OF ELIMINATION

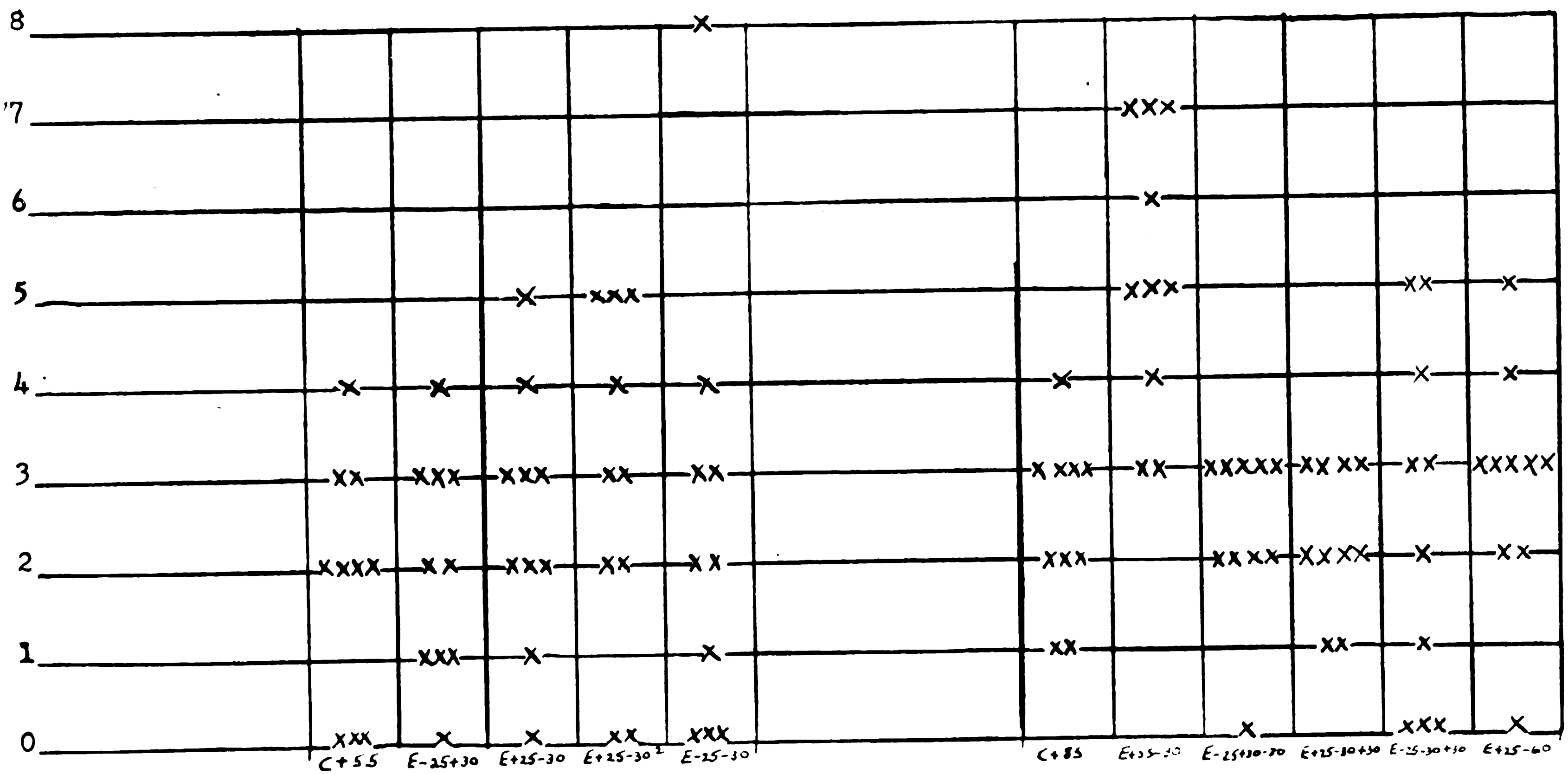
Groups Compared	F	Significance
C+55-30 and E+25-30	1.05	n.s.
C+55 and E-25-30	3.07	n.s.
C+55 and E+25-30^2	1.85	n.s.
C+55 and E-25+30	1.27	n.s.
C+85 and E+55-30	2.62	n.s.
C+85 and E+25-30+30	.15	n.s.
C+85 and E-25-30+30	4.31	n.s.
C+85 and E-25+30-30	1.04	n.s.
C+85 and E+25-60	1.84	n.s.
E+25-30 and E-25-30	2.93	n.s.
E+25-30 and E+25-30^2	1.77	n.s.
E+25-30 and E-25+30	1.33	n.s.
E-25-30 and E+25-30^2	1.66	n.s.
E-25-30 and E-25+30	3.91	n.s.
E+25-30^2 and E-25+30	2.35	n.s.
E+55-30 and E+25-30+30	3.95	n.s.
E+55-30 and E-25-30+30	1.64	n.s.
E+55-30 and E-25+30-30	2.74	n.s.
E+55-30 and E+25-60	1.43	n.s.
E+25-30+30 and E-25-30+30	6.48	$< .02$
E+25-30+30 and E-25+30-30	1.44	n.s.
E+25-30+30 and E+25-60	2.77	n.s.
E-25-30+30 and E-25+30-30	4.50	n.s.
E-25-30+30 and E+25-60	2.34	n.s.
E-25+30-30 and E+25-60	1.93	n.s.

FIGURE 3

FREQUENCY OF ELIMINATION

55-Day-Old Groups

85-Day-Old Groups



is concerned, frequency of elimination seems to be an innate expression of fear which is not markedly influenced by the experimental manipulation since most Ss, experimental and control alike, responded to noxious stimulation with at least one instance of eliminating.

3. Body Weight. The experimental treatment did, however, affect body size. As far as body size was concerned, the variability differences were not present in 55-days-old Ss, that is, in general, physiological characteristics were not affected until the animals were older than 55-days-of-age. At this time experimental groups were significantly more variable than the control group, (see Table IX, Appendix IV, and Figure 4). The data support Ader's (1959) finding that weight differences are related to age. ". . . it is possible that . . . the weight difference first becomes manifest (. . .) late rather than early during the period of manipulation" (p. 24). He hypothesizes that this is caused by the rapid growth characteristics during early age masking weight differences. In Ader's study, emotional stress consisted of being shocked, thrown in the air, pinched (with forceps), being shaken, and placed in a metal can which was covered and then banged upon.

4. Adrenal Gland Weight. It is somewhat more difficult to interpret the adrenal gland data. Inspection of Figure 5 shows that there were considerable differences between younger and older experimental groups. The mean weight of 55-days-old Ss' adrenal glands all differed significantly from that of the controls with the controls having heavier adrenal glands[1] (see Table X). On the other hand, 85-days-old Ss differed from

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[1]Adrenal gland means and standard deviations can be found in Appendix V.

TABLE IX

VARIABILITY DIFFERENCES IN BODY WEIGHT

Groups Compared	F	Significance
E+25-30 and C+55	1.26	n.s.
C+55 and E-25-30	3.44	n.s.
C+55 and E+25-30[2]	4.98	n.s.
C+55 and E-25+30	2.14	n.s.
E+25-30 and E-25-30	2.72	n.s.
E+25-30 and E+25-30[2]	3.94	n.s.
E+25-30 and E-25+30	1.69	n.s.
E-25-30 and E+25-30[2]	1.45	n.s.
E-25-30 and E-25+30	1.61	n.s.
E+25-30[2] and E-25-30	2.33	n.s.
C+85 and E+55-30	70.4	< .02
C+85 and E+25-30+30	73.6	< .02
C+85 and E-25-30+30	83.6	< .02
C+85 and E-25+30-30	98.9	< .02
C+85 and E+25-60	107.1	< .02
E+55-30 and E+25-30+30	1.05	n.s.
E+55-30 and E-25-30+30	1.19	n.s.
E+55-30 and E-25+30-30	1.41	n.s.
E+55-30 and E+25-60	1.52	n.s.
E+25-30+30 and E-25-30+30	1.14	n.s.
E+25-30+30 and E+25-60	1.46	n.s.
E+25-30+30 and E-25+30-30	1.34	n.s.
E-25-30+30 and E-25+30-30	1.18	n.s.
E-25-30+30 and E+25-60	1.28	n.s.
E-25+30-30 and E+25-60	1.08	n.s.

FIGURE 4

BODY WEIGHTS

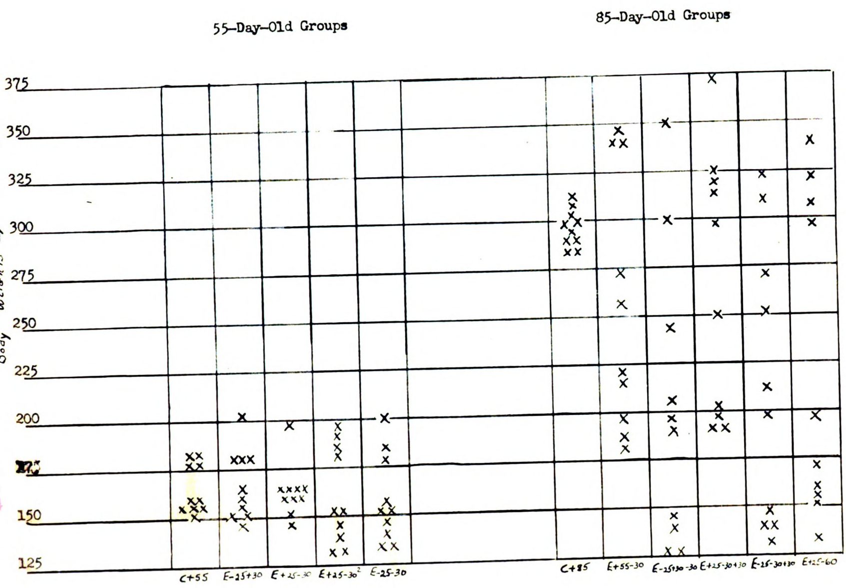

FIGURE 5
ADRENAL GLAND WEIGHTS

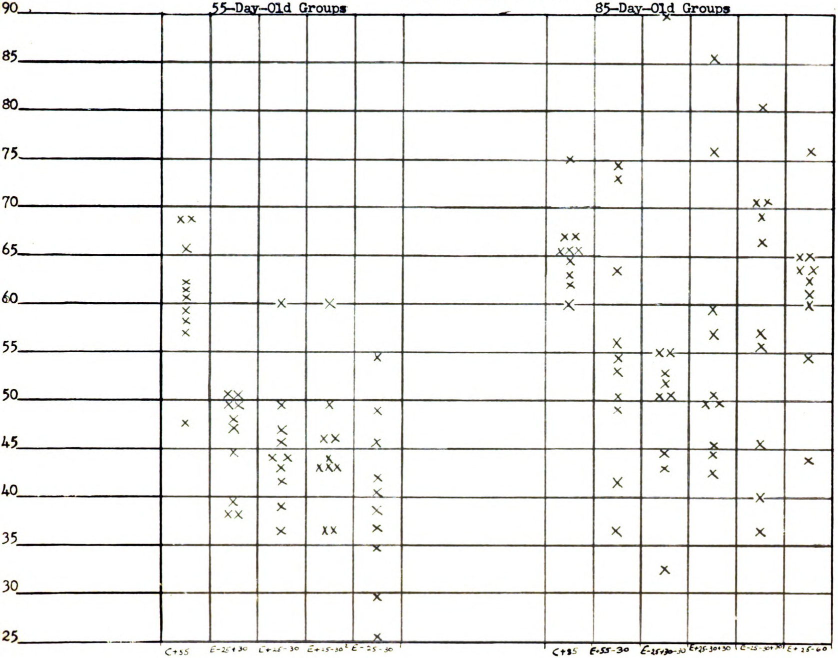

TABLE X

t TESTS FOR DIFFERENCES IN 55-DAYS-OLD GROUPS' ADRENAL GLAND WEIGHTS

	Groups	
	C+55	E-25+30
Mean	61.3	45.81
S.D.	5.78	16.22
n	10	10
t = 6.01 < .02 for 18 df (two-tailed test)		
	C+55	E+25-30
Mean	61.3	45.1
S.D.	5.78	6.25
n	10	10
t = 11.4 < .02 for 18 df (two-tailed test)		
	C+55	E-25-30
Mean	61.3	39.5
S.D.	5.78	8.86
n	10	10
t = 6.17 < .02 for 18 df (two-tailed test)		
	C+55	E+25-30[2]
Mean	61.3	45.2
S.D.	5.78	6.27
n	10	10
t = 11.4 < .02 for 18 df (two-tailed test)		

their controls not in mean size but in variability (see Table XI) with the exception of differences between E+25-60 and C+85; between these two groups there is a significant mean difference (control group had heavier glands) rather than a variability one. This topic will receive further attention in the discussion portion of the present study.

In order to determine if something other than the experimental manipulation was responsible for the avoidance learning performance, product moment r's were calculated between: 1) adrenal gland weight and avoidance learning performance; 2) body size and avoidance learning performance, and 3) adrenal gland weight and body size (see Tables XII, XIII, and XIV). Since only four of the 30 r's were significant,[1] it can be concluded that avoidance learning task performances probably are not dependent on either adrenal gland size or body weight since one cannot say, for example, that fat rats are poor learners and skinny ones good learners since the variables are uncorrelated.

In summary, frequency of elimination was not a discriminative measure of the effects of sensory deprivation except for the anomalous E+55-30; the experimental manipulation had a differential effect on body weights; a variability effect which became apparent at 85 days of age rather than 55 days of age; and finally, adrenal gland size was influenced rather peculiarly in that the glands of the younger animals were lighter than the controls while the glands of the older rats were the same as far as mean size was concerned but differed significantly in variability.

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[1]When scores were lumped, the resulting r's still were not significant, e.g., the correlation between adrenal gland size and avoidance learning performances for the 55-days-old experimental groups was -.2536 and -.017 for the 85-days-old experimental groups (excepting E+55-30).

TABLE XI

VARIABILITY DIFFERENCES IN ADRENAL GLAND WEIGHTS

Groups Compared	F	Significance
C+55 and E+25-30	1.17	n.s.
C+55 and E-25-30	2.35	n.s.
C+55 and E+25-30^{2}	1.17	n.s.
C+55 and E-25+30	7.87	< .02
E+25-30 and E-25-30	2.01	n.s.
E+25-30 and E+25-30^{2}	1.01	n.s.
E+25-30 and E-25+30	6.73	< .02
E-25-30 and E+25-30^{2}	1.99	n.s.
E-25-30 and E-25+30	3.35	n.s.
E-25-30 and E+25-30^{2}	6.69	< .02
C+85 and E+55-30	9.95	< .02
C+85 and E+25-30+30	12.70	< .02
C+85 and E-25-30+30	13.88	< .02
C+85 and E-25+30-30	19.10	< .02
C+85 and E+25-60	4.27	n.s.
E+55-30 and E+25-30+30	1.28	n.s.
E+55-30 and E-25-30+30	1.40	n.s.
E-55-30 and E-25+30-30	1.92	n.s.
E+55-30 and E+25-60	2.33	n.s.
E+25-30+30 and E-25-30+30	1.09	n.s.
E+25-30+30 and E-25+30-30	1.50	n.s.
E+25-30+30 and E+25-60	2.97	n.s.
E-25-30+30 and E-25+30-30	1.38	n.s.
E-25-30+30 and E+25-60	3.25	n.s.
E-25+30-30 and E+25-60	4.47	n.s.

TABLE XII

CORRELATIONS BETWEEN ADRENAL WEIGHT AND AVOIDANCE LEARNING PERFORMANCE

Group	Correlation	Significance
E+25-30	-.219	n.s.
E-25-30	-.66	<.01
C+55	-.071	n.s.
C+85	-.32	n.s.
E+55-30	+.063	n.s.
E+25-30+30	-.028	n.s.
E-25-30+30	+.381	n.s.
E-25+30-30	-.411	n.s.
E+25-30[2]	+.421	n.s.
E+25-60	-.257	n.s.
E-25+30	+.364	n.s.

TABLE XIII

CORRELATIONS BETWEEN BODY WEIGHT AND AVOIDANCE LEARNING PERFORMANCE

Group	Correlation	Significance
E+25-30	-.674	<.01
E-25-30	-.437	n.s.
C+55	-.399	n.s.
C+85	-.673	<.01
E+55-30	+.029	n.s.
E+25-30+30	+.30	n.s.
E-25-30+30	+.166	n.s.
E-25+30-30	+.356	n.s.
$E+25-30^2$	-.208	n.s.
E+25-60	+.163	n.s.
E-25+30	+.057	n.s.

TABLE XIV

CORRELATIONS BETWEEN BODY WEIGHT AND ADRENAL GLAND WEIGHT

Group	Correlation	Significance
E+25-30	-.032	n.s.
E-25-30	.01	n.s.
E+25-30[2]	.018	n.s.
E-25+30	.007	n.s.
C+55	.177	n.s.
E+55-30	-.201	n.s.
E+25-30+30	-.195	n.s.
E-25-30+30	.158	n.s.
E-25+30-30	.030	n.s.
E+25-60	-.457	<.05
C+85	-.595	<.01

DISCUSSION

The data provided by this study indicate that an environment which severely restricts opportunity for perceptual experience can create a wide variety of behavioral and physiological effects. When the experimental animals are compared with control animals, they tend to fall at the extremes of the distribution of scores, and, conversely, the control group falls in the middle. As noted in the results, these variability differences are present in avoidance learning and in adrenal gland and body weights. As far as avoidance learning is concerned, the variability is related to age of the S at the time of exposure to a restricted environment (onset variable) and possibly to length of time elapsing between sensory deprivation and testing for effects (duration variable) whereas variability of body and adrenal gland size is related to age of the S at the time of testing.

That restriction of the perceptual world has a differential effect on individual animals is in agreement with the responses to a variety of stress situations reported by Rosensweig (1955), Mandler and Sarason (1952), and Ramsdell (1949) who worked with humans, King and Eleftherious (1959) who studied the responses of mice, Clarke *et al.* (1951) who worked with dogs and Hoffman (1959) who studied rats. All of these experimenters found that organisms seem to respond in many different ways to stress, with the responses frequently being in exactly opposite directions, e.g., one S will run while another freezes.

By and large, E+55-30 is the group to which the aforementioned generalizations do not apply, e.g., they did not differ in variability from the control group on avoidance conditioning. Since E+55-30 was the group which engaged in the most deviant behaviors, further mention of it seems merited. These were the Ss who bit, whirled, scratched, and froze. In short, they displayed the same strikingly unintelligent behaviors the McGill dogs showed (Hebb and McGill associates). The experimenter posits that the effects of restriction were more damaging to this group on the basis of the above mentioned qualitative findings. This was the only group which did not undergo some sort of experimental manipulation until 55-days-old and it appears that individual restriction has a more uniform but even more marked effect on them as compared with those deprived very early in life. In the extreme instance the effect was death.[1]

Although an interspecies analogy may appear to be farfetched, some data presented by Spitz and Wolf (1946) seems relevant. A relatively small number of the institutional babies they observed died of no known

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[1]Since cause of death was not established by means of post-mortem examinations, the question may arise as to whether these Ss were infected with a communicable disease. This possibility cannot be completely outruled but the fact that the 14 Ss in the experimental chamber during the same period as the Ss did not succumb let alone show any sign of a disease process would seem to negate against the infectious disease hypothesis. All that can be said is that these six animals seemed unable to assimilate their food in that they ingested the same amount as others yet gradually lost weight until death occurred. Two other Ss died, both of which were from E+25-60. These were not unexpected findings since this group was deprived for an exceptionally long period in a somewhat abortive attempt at determining whether longer than 30 days would create even more deviant responses--which it did not except for the two deaths.

somatogenic disorder while others believed to be recovering from anaclitic depression were noted to aggress against themselves. One would hardly consider these rats to be experiencing anaclitic depression but at one level or another there might be something analogous between the rats' and infants' tendency toward self-mutilation in the face of a novel situation, namely, stimulation. This is supported by Spitz's assertion that a child must have experienced a meaningful relationship with his environment before deprivation results in depression. These rats were the ones which had the longest experience under normal laboratory conditions so it is possible that the same phenomenon was responsible for their emotional reaction to the novel situation including the shock box. According to Thompson (1955), when an organism is prevented from functioning in a manner to which it had become accustomed, the effects will be emotional and motivational rather than cognitive. There is little doubt in the face of all the evidence adduced in the results that this one group responded emotionally.

The behavior of E+55-30 is in keeping with the results of Freud and Burlingham (1943) who found that separation from the family and evacuation from London was more debilitating for young children than enduring the blitz with their family. In other words, interruption of relationships was more damaging than enduring trauma in the presence of persons and objects to which one had become accustomed. Thus, one may theorize that disruption of expectancy for stimulation leads to more consistent aberrant behaviors than sensory deprivation, *per se*.

It is rather difficult to attempt to explain why Ss respond so differently to the same perceptual cues on the basis of any one theoretical viewpoint. The most reasonable hypothesis seems to be that the perceptual environment during much of the treatment simply was not the same for each animal because of varying neurological and physiological development. In other words, it is possible that each animal responded in an idiosyncratic manner to perceptual deprivation on the basis of innate structural capabilities.

A basic question not yet dealt with is why perceptual restriction influences behavior in the first place. As far as the present writer is concerned, this question really cannot be answered. The most parsimonious assumption is that it (need for stimulation) is a "given." However, this does not mean that someone won't someday specify the physiological changes occurring. Furthermore, whether certain aspects of sensory deprivation are more crucial than others also remains to be studied, e.g., is isolation from other rats as crucial as separation from visual stimuli?

At the risk of being somewhat speculative, one could assume that the data provided by the present study might explain the equivocality of some findings reported by other workers in the field. For instance, results of the present study indicate that length of time elapsing between experimental manipulation and testing for effects of the manipulation might be a relevant variable. Thus, testing of extremely young rats immediately following removal from a restricted environment might result in variant responses whereas testing at a later period may lead to a modification or lessing of the variance.

With regard to body weight, one factor merits consideration. By taking the weight of the rat before and then following experimental manipulation, and calculating the percentage of increase or decrease in body weight over the initial weight, a more accurate measure of this variance probably would have been derived.

Adrenal gland data also seem to provide many interpretive pitfalls. Despite its grossness as a measure of adrenal functioning, the quantitative measure of glandular influence used in the present study was adrenal gland weight; glandular weight also was used by Weininger (1956), Levine (1957c), Ader (1959), and Bovard (1958). Unfortunately, the more complex yet more meaningful techniques such as colorimetric assay of urinary excretion of 17-Ketosteroids (Lowenstein _et al._, 1946) or the determination of L-ascorbic acid, dehydro-L-ascorbic acid, and diket-L-gulonic acid in tissue (Glick _et al._, 1953) could not be used due to financial limitations, that is, the experimenter was unable to execute these calculations alone and funds were not available to have assistance from laboratory technicians. The reader will want to remember that adrenal gland size is but an indicator of _capacity_ for sustained secretion, not an indicator of actual glandular activity (Hartman and Brownell, 1949).

In addition to adrenal weight being a relatively indelicate measure, it has already been mentioned that there were attendent problems involved in the extirpation of the gland (see page 26). Although the best precaution possible was taken, namely, the use of a veterinary surgeon for the operative procedure, the limitations of glandular weight as a measure of adrenal influence and the extirpation difficulties must be considered in any analysis of the adrenal gland data. One cannot help but wonder who performed the adrenalectomies reported by Levine (1957c), Ader (1959), Weininger (1956), and Herrington and Nelbach (1942), what assurance these men had that they extirpated the entire gland without including surrounding tissue, and what was their reliability in weighing minute objects.

These are but a few of the many possible procedural problems which conceivably could be responsible for some of the contradictory findings reported in this general problem area. In designing subsequent experiments on this topic, it would seem reasonable to assume that investigators would want to give careful consideration to such controls.

SUGGESTIONS FOR FURTHER RESEARCH

In subsequent research on sensory deprivation, two of the three major refinements which the present writer feels would lead to more meaningful data are concerned with the anatomical measures. They are:

1. Determination of the extent of the adrenal gland's participation in the animal's responses by using either the adrenal ascorbic acid technique suggested by Glick _et al._ (1953) or Jailer's (1951) method of determining adrenocorticotropin content.
2. Calculate the percentage of change in body weight from time of first introduction to the experimental manipulation to the time of testing.

In order to derive a more sensitive measure of the influence of restriction on behavior, the experimenter suggests using rate of extinction of an avoidance conditioning response in addition to acquisition of this response. This procedure would appear to be of value in light of the work of Solomon _et al._ (1953) which indicates that extinction of avoidance conditioning responses is difficult to achieve if emotionality is involved in the response process. This is because learning behavior is reinforced by the aroused emotional reaction of anxiety and is secondarily reinforced by stimulus contiguity. Thus, the habit pattern originally associated with anxiety and similarities of stimuli unconnected originally with the anxiety arousing situation act to reinforce or continue the disorganized behavior.

A further refinement of the experimental design includes use of other groups, C+25, E-25, and E-25-60. Obviously the results of these groups' avoidance learning performances would facilitate interpretation of the effect of partial deprivation (-25).

As far as actual designs for studying the problem area are concerned, the writer believes that King's (1958) suggestions regarding the seven parameters have much validity and bear careful study. This study has shed some light on his suggestions numbered 1, 2, and 6 (see page 20) but it would be folly to assume that any definitive answers have been provided.

Possibly the major contribution the present study could make to the problem area lies in the fact that many testable hypotheses have been generated by the data, (e.g., that the effects of sensory deprivation early in a rat's life may be reversible whereas the effects of similar treatment later in a rat's life are not) as well as suggesting some possible explanations for the lack of consistency in other studies.

SUMMARY

The present study was designed to investigate certain behavioral and physiological characteristics of albino rats which had been exposed to a restricted environment (darkness, masked sound, restricted opportunity for movement, and isolation from other rats) during various periods of their life cycle and tested for effects at varying intervals following release from perceptual deprivation.

These effects were studied in 110 experimentally naive rats divided into nine experimental and two control groups, each group consisting of 10 animals. Four experimental groups were composed of 55-days-old[1] Ss while five other experimental groups consisted of 85-days-old[2] animals; there was one 55-days-old[3] and one 85-days-old[4] control group. Experimental manipulation consisted of placing the experimental animals in a highly limited sensory environment either at birth for a period of 25 days (in this instance a mothering rat and litter mates were present), or at 25-days-old or at 55-days-old for a 30 day period (onset variable). Testing for effects by means of avoidance conditioning took place either immediately following release from restraint or 30 days later (duration variable). Body weight was determined before avoidance conditioning began whereas adrenal gland size was determined directly following conditioning.

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[1] Age of the animal at the time of testing.
[2] _Ibid._
[3] _Ibid._
[4] _Ibid._

As a result of this study, the following conclusions would appear warranted:

1. An environment lacking in stimuli increases the variability of performance in an avoidance learning task. A plotting of the scores resulted in a bimodal distribution. Furthermore, there is some evidence to suggest, at least as far as 55-days-old Ss are concerned, that the amount of variability is related directly to the degree of sensory deprivation. The effects of sensory deprivation as measured by avoidance conditioning also seem to be related to:

    a) age of the animal at the time restriction was imposed as indicated by the fact that animals older when first deprived seemed to be more anomalous in almost every possible way;

    b) amount of time elapsing between release from deprivation and testing for effects in that there was evidence to suggest that the strength of the effect might abate with time.

2. Sensory deprivation also had a differential effect on body size and adrenal gland weight of animals of different ages. Fifty-five-days-old Ss did not differ from the controls in body weight but had smaller adrenal gland weights. Eighty-five-days-old Ss, on the other hand, differed significantly in variability (the distribution again being bimodal) from their controls on both measures. When combined with the fact that 85-days-old experimental Ss had large variability differences on the avoidance conditioning task, this

finding of significant variability differences on physiological measures seems to suggest that the older an animal is, the more different his response to sensory deprivation is likely to be.

3. Correlations between a) adrenal gland size and avoidance learning performance; b) body weight and avoidance learning performance, and c) body weight and adrenal gland size were not, for the most part, significant. This finding makes it difficult to attribute the variant avoidance conditioning responses to obvious physiological variables.
4. In general, frequency of elimination did not prove to be a discriminative measure of the effects of sensory deprivation. The group which was oldest when exposed to sensory deprivation was the only one to differ (more instances of elimination) from both control and experimental groups on this measure.

The main experimental findings of the study are clear-cut, though their full interpretation at the present state of knowledge appears to be an insurmountable task. However, the findings seem to merit careful consideration especially for those interested in the human being's need for a normal sensory environment. If relatively simple organisms such as a rat, animals whose personality is seldom, if ever, referred to, can become disturbed when placed in a sensory deprivation condition, it would seem likely that man, with his multiplicity and complexity of temperament—would also be markedly influenced by such deprivation. Certainly further study of the parameters of this problem area seems warranted.

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APPENDICES

APPENDIX I

MEAN AND STANDARD DEVIATION SCORES FOR AVOIDANCE LEARNING TASKS

Group	Mean of Session #1	S.D. of Session #1	Mean of Session #2	S.D. of Session #2
E+25-30	11.2	4.56	19.7	8.85
E-25-30	8.4	7.94	13.5	10.97
E+25-30[2]	10.5	4.50	20.1	5.39
E-25+30	11.0	2.45	18.0	2.72
E+55-30	7.1	3.27	9.6	3.59
E+25-30+30	11.3	6.33	16.3	9.16
E-25-30+30	9.0	7.74	13.5	10.99
E-25+30-30	8.9	5.77	16.2	9.61
E+25-60	10.4	7.65	16.1	8.72
C+55	11.2	1.47	15.5	1.50
C+85	9.8	1.94	16.0	1.34

APPENDIX II

MEANS AND STANDARD DEVIATIONS FOR DIFFERENCES BETWEEN SESSIONS

Group	Mean	Standard Deviation
E+25-30	8.5	4.82
E-25-30	5.1	3.41
E+25-30[2]	9.6	5.43
E-25+30	7.0	3.41
E+55-30	2.5	2.32
E+25-30+30	5.0	4.15
E-25-30+30	4.5	4.19
E-25+30-30	7.3	5.12
E+25-60	5.7	7.47
C+55	4.3	1.84
C+85	6.4	1.62

APPENDIX III

MEANS AND STANDARD DEVIATIONS FOR ELIMINATION MEASURES

Group	Mean	Standard Deviation
E+25-30	2.5	1.36
E-25-30	2.3	2.33
E+25-30[2]	2.9	1.81
E-25+30	2.0	1.18
C+55	1.8	1.33
E+55-30	5.2	1.49
E+25-30+30	2.2	.75
E-25-30+30	2.3	1.91
E-25+30-30	2.3	.90
E+25-60	2.8	1.25
C+85	2.4	.92

APPENDIX IV

MEANS AND STANDARD DEVIATION FOR BODY WEIGHTS

Group	Mean	Standard Deviation
E+25-30	164.5 (grams)	12.59
E-25-30	159.7	20.78
E+25-30[2]	161.3	25.0
E-25+30	170.4	16.37
C+55	166.8	11.2
E+55-30	255.9	62.35
E+25-30+30	267.1	63.76
E-25-30+30	212.6	67.96
E-25+30-30	201.3	73.91
E+25-60	221.9	76.87
C+85	295.7	7.43

APPENDIX V

MEANS AND STANDARD DEVIATIONS FOR ADRENAL GLAND WEIGHTS

Group	Means	Standard Deviation
E+25-30	45.1 (Milligrams)	6.25
E-25-30	39.5	8.86
$E+25-30^2$	45.2	6.27
E-25+30	45.81	16.22
C+55	61.3	5.78
E+55-30	55.4	11.80
E+25-30+30	56.3	13.33
E-25-30+30	59.2	13.94
E-25+30-30	52.7	16.35
E+25-60	61.8	7.73
C+85	65.3	3.74