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## **The Effect of Stabilized and Nonstabilized Hunger Drive, Age, and Situation Complexity Upon Exploratory Behavior**

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To the Graduate Council:

I am submitting herewith a dissertation written by Stanley Wechkin entitled "The Effect of Stabilized and Nonstabilized Hunger Drive, Age, and Situation Complexity Upon Exploratory Behavior." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

Ernest Furchgott, Major Professor

We have read this dissertation and recommend its acceptance:

William O. Jenkins, Edward E. Cureton, Leo Simons, L. M. Deridder

Accepted for the Council:

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Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

June 1, 1959

To the Graduate Council:

I am submitting herewith a thesis written by Stanley Wechkin entitled "The Effect of Stabilized and Nonstabilized Hunger Drive, Age, and Situation Complexity Upon Exploratory Behavior." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

Ernest Furbush  
Major Professor

We have read this thesis and  
recommend its acceptance:

W. O. Jenkins  
Edward E. Cureton  
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Accepted for the Council:

Dale Hantling  
Dean of the Graduate School

THE EFFECT OF STABILIZED AND NONSTABILIZED  
HUNGER DRIVE, AGE, AND SITUATION  
COMPLEXITY UPON EXPLORATORY  
BEHAVIOR

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A THESIS

Submitted to  
The Graduate Council  
of  
The University of Tennessee  
in  
Partial Fulfillment of the Requirements  
for the degree of  
Doctor of Philosophy

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by  
Stanley Weohkin

June 1959

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S. W.

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## CHAPTER I

### INTRODUCTION

#### Background

##### General and Theoretical Aspects

The study of behavior based on motives of exploration, manipulation, or curiosity is both old and very recent -- old in terms of the earliest relevant experiments, and recent in terms of the considerable amount of research done in this area since about 1950. Dennis (1955) has noted that "intrinsically motivated" problem solving behavior was studied by Romanes and Thorndike around 1900, and Nissen in 1930 found that animals will cross an electrified grid to explore a modified Dashiell maze.

Spontaneous alternation, or the tendency of rats to make alternate right and left turning responses upon successive exposure to the same choice point, was probably the area to receive earliest intensive investigation. Alternation had already been observed by Hamilton in 1911, and Tolman in 1925 is credited by Montgomery (1951) with the first suggestion that it was based on "exploratory impulses" -- still the current conception: e.g., Barnett (1958), Glanzer (1958), Montgomery (1951b, 1952a), Sutherland (1957). Since this early work a number of experiments have confirmed and extended the findings in the area (Dennis, 1935; Dennis, 1939; Dennis and Sollenberger, 1934; Denny, 1957; Heathers, 1940;

Kivy, Earl and Walker, 1956; Montgomery: 1951a, 1951b, 1952a, 1952b; Sutherland, 1957; Walker, Dember, Earl, and Karoly, 1955a; Walker, Dember, Earl, Fliege, and Karoly, 1955; Walker, Dember, Earl, Fawl, and Karoly, 1955) and have tended to support the explanation of alternation behavior as an effect of stimulus satiation (the tendency of an organism to make a reduced response to a stimulus object as a function of previous exposure to it) against the earlier reactive inhibition concept. However, Barnett (1958) and Dember and Fowler (1958) have suggested that reactive inhibition may be a special case of stimulus satiation via sensory feedback of motor responses. The stimulus satiation viewpoint has been formalized by Glanzer (1953) and the alternation literature relevant to it has been reviewed by Dember and Fowler (1958) and Glanzer (1958).

A great deal of work has been done with exploration and manipulation per se. It has been abundantly demonstrated that organisms ranging from cockroaches to human beings will explore and move towards conditions of greater stimulus complexity (Berlyne: 1950, 1954a, 1957; Butler, 1954; Butler and Alexander, 1955; Darshan, 1955; Dember, 1956; Dember, Earl and Paradise, 1957; Montgomery, 1954; Thompson and Solomon, 1954; Welker: 1956a, 1956b). This is even true of food-deprived and rewarded subjects, these tending to take the longer, more indirect route to food (Hebb and Mahut, 1955). In addition, monkeys will solve puzzles with no apparent reward other than the solution (Davis, Settlage, and Harlow, 1950; Harlow, 1950; Harlow, Harlow, and Meyer, 1950; Harlow, and McClearn, 1954), and this is probably not due

to the effects of secondary reinforcement (Harlow, Blazek, and McClearn, 1956; Miles, 1958).

The relation between exploration and learning has also been investigated. In addition to the work of Harlow and associates cited above which showed learning across trials in puzzle manipulation (i.e., less time and fewer errors in solution across trials), it has been shown that monkeys will learn a discrimination habit when only an opportunity at visual exploration (Butler, 1953; Butler and Harlow, 1954) and/or noise from the colony room (Butler, 1957) are used as rewards. Similarly, for rats a Dashiell maze may be used as a "reward" (Montgomery and Segall, 1955). The onset of light will also serve as a reinforcer for rats (Forgays and Levin, 1958; Hurwitz, 1956; Kish, 1955; Kling, Horowitz, and Delhagen, 1956) and monkeys (Moon and Lodahl, 1956) in learning bar-pressing responses. The decrement in exploratory behavior produced by exposure to one maze will generalize to other mazes along a dissimilarity continuum (Montgomery, 1953), and a maze task interpolated between two exploration tests can have both retroactive inhibiting and facilitating effects on exploration in rats (Thompson and Kahn, 1955).

A number of experiments have dealt with the effects of other variables upon exploration. Butler (1957) found that the frequency of response in monkeys to gain visual incentives went up with zero, two, four, six, and eight hours of visual exploratory deprivation. Hill (1956) found a similar effect with activity. Using zero, five, twenty-four, and forty-six and one-half hours confinement, he found

that the rat's performance in an activity wheel increased monotonically as a function of degree of confinement. Siegel (1946), on the other hand, found a significant decrease in activity after six hours confinement, an insignificant decrease after twelve hours, and an insignificant increase after twenty-four hours as measured photoelectrically in an activity chamber. Patton (1954) reports two studies in which free animals were found more active than restricted animals in a closed field test. Montgomery (1953) found no significant difference in Y-maze exploration between rats that had access to an activity wheel prior to the experiment and those kept in confined conditions. Montgomery and Zimbardo (1957) found no difference in the same conditions of exploration between behaviorally deprived, sensorally and behaviorally deprived, and control rats in exploration, emotionality, and orderliness of behavior. Hill (1956) has argued that activity and exploratory behavior are not comparable on the ground that exploration is a sensory drive while activity is a drive in its own right. Nevertheless the distinction remains unclear, and Thompson and Heron (1954) have found, in contrast to Montgomery (1953), that early restriction of activity of dogs leads to an increase in exploration in open field and maze type situations.

Two experiments have been conducted by Montgomery on the relation between fear and exploration. In the first (with Monkman, 1955), it was shown that fear induced immediately prior to exploration by shocking the Ss does not affect exploratory activity, but that fear induced the same way during the test reduces it, since fear and explor-

ation are antagonistic. The experimenters hypothesized that exposure to a less novel situation would produce escape -- increasing activity -- while exposure to a less novel situation would lead to avoidance and less activity. This formulation is somewhat at variance with that of Berlyne (1951). According to Berlyne, avoidance is precipitated by stimulation new in terms of what the animal has experienced in the particular stimulus situation, whereas exploration is caused by something new to the S's whole history. Montgomery and Monkman (1955) also found that shock momentarily increased exploration, but that it then fell sharply below the level of controls after cessation. In a second experiment, Montgomery (1955) found that rats increased exploration over ten-minute test periods in a "dangerous" elevated maze situation and decreased exploration in a "safer" enclosed maze, though total exploration was higher for the enclosed group. He cites this fact as evidence for the avoidance-exploration paradigm: The effect of novel stimulation is the excitement of both avoidance and exploration tendencies; avoidance goes up more sharply than exploration with novelty, and decreases faster with exposure, allowing for exploration to take place. Fear was also found to affect orderliness of behavior, since percent alternation declined with increased use of the elevated maze. In a somewhat related experiment Welker (1957) found that rats forced into an exploratory situation by being placed directly into it explored more than those that had been allowed to enter it freely from the carrying cage, with the forced animals sharply decreasing exploration during the five minute sessions and the free animals going up or remaining the same. Interpreting some of Montgom-

ery's data (1951b, 1953, 1955) in this light and claiming the same effect to be true there, he states that the high initial activity and subsequent decline of the forced animals can only be explained in terms of escape. This latter explanation would be in agreement with the Montgomery and Monkman (1955) statement, i.e., strong fear leads to escape, but probably opposed to the Montgomery (1955) position, since it would be supposed that exploration would increase with the dissipation of fear. At any rate, the interaction of fear, in reference to avoidance and escape, and exploration is not clear at this time.

Several theoretical papers dealing with exploratory behavior have been published. Harlow (1951, 1953, and 1954) has criticized homeostatic and derived drives as being inadequate, both in frequency and duration, to account for most behavior and has postulated an exploratory drive elicited by external stimulation. In commenting on Harlow's position Brown (1953) has stated that "the empirical fact of 'exteroceptively elicited patterns of behavior' need not require the postulation of co-variant 'exteroceptively aroused' drives." Reviewing Butler's experiment (1953) in which monkeys learned a habit with the opportunity to look out of a window as the reward, Brown notes that if visual exploration were drive-arousing, then the animals would not be motivated until they could see outside the box. Since this was not the case, the animals must have been motivated by the inability to see, but this inability to see is not a case of an externally-caused drive. In addition, if seeing outside the box was drive-arousing, Harlow ". . . would be forced to conclude that responses followed by an increase in drive would be learned. This would lead to a drive increase theory of learn-



ing." To two writers, at least, this last possibility is not as frightening as it would appear. Leuba (1955) has stated a model in which:

Tension reduction would not seem to be a general or only principle of learning. It may be only one aspect of a more general principle which might be called one of optimal stimulation: the organism tends to learn those reactions which will produce an optimal level of total stimulation.

And he says:

The organism tends to acquire those reactions which, when overall stimulation is low, are accompanied by increasing stimulation, and when overall stimulation is high, those which are accompanied by decreasing stimulation.

Similarly Glanzer (1958) has proposed that "The organism. . . (be) viewed as an information processing system that requires certain amounts of information per unit time," and that the organism responds to his environment to secure this information:

The increase or decrease of activity with respect to parts of the environment is a function of the difference between the average amount of information the individual is accustomed to and the current rate of flow of information from the environment.

Unfortunately neither of these formulations makes clear how the "optimal" or "accustomed" level of stimulation can be ascertained so that a prediction of activity level or exploration may be generated in specific situations. Seward (1956), in a somewhat similar model, has proposed that "exploratory behavior is evoked neither by the unknown or familiar but by a ratio of the two," presumably the smaller the ratio, the greater the probability of exploration, i.e., too much unknown leading to fear and avoidance, too much familiar leading to boredom.

Berlyne (1950, 1951, 1954) has attempted to fit his own and other experiments on curiosity into the framework of Hullian theory. His

reasoning runs something like this. Stimulus events happen -- there is no previous response to the whole event. The elements composing the stimulus event elicit responses conditioned to them, the irrelevant ones are rejected by "the drive to be relevant" (sic) and if the remaining ones are of similar strength, a drive to allay the conflict is excited with curiosity and consequent exploration and manipulation as its result. Since these activities are need-reducing, learning may also occur. This, though an interesting approach, is admittedly based on "postulated and unobservable central processes," and is an example of the proliferation of secondary and derived drives that Harlow has called strained. Similarly, Dember and Earl (1957) have offered an "information theory" type model in which exploratory behavior is subsumed under the heading of attention. Attention is aroused when stimulation is discrepant from the organism's expectations; the probability that this discrepancy occurs is a direct function of stimulus complexity. Nissen (1954) has suggested an explanation of exploration and manipulation in terms of an instinctual need of parts of the body, including the brain, to "use themselves." This is fairly anthropomorphic, though it is close to what Kooh (1956) has called for in the way of intrinsic or "in and of themselves" motives as opposed to an extrinsic or "in order to" concept of motivation.

In a recent article Barnett (1958) has summarized some of the theoretical issues and relevant experimentation in this area and he has proposed a rather complete view of exploratory behavior. Exploration according to him is related to primary needs and is a means to their satisfaction -- e.g., increased exploration in a state of nutritional

deprivation increases the likelihood of finding sustenance -- and it is probably because of this survival value the result of natural selection. However, this is not to say that it is confined to internally produced drive states. It may function autonomously:

. . .the fact that behavior is a product of natural selection, and tends to insure survival does not necessarily imply that particular activities are always a direct consequence of the needs they help to satisfy. . . .A kind of behavior may tend to satisfy a need, and yet be performed regardless of the presence or absence of the need: it may be evoked by internal processes which are independent of such states as hunger or thirst, and by external stimuli which are neutral as far as survival is concerned. This is the case with exploratory behavior.

Exploration then assumes the state of an independent drive, capable of arousal and satisfaction by external stimuli. This position is basically similar to that of other theorists -- Harlow, Berlyne, Glanzer, and Leuba, Barnett expresses his agreement with the stimulus-absence type of theorizing, but his approach has the virtue of reconciling the experimental findings which generated it to the Darwinian drive-reductionist-survival theories, as well as incorporating other data and giving it an ecological rationale. His approach relates exploration to learning (exploration makes possible a variety of sensory and motor experiences in infancy, allowing for learning to take place); to avoidance (the "combination of exploring and avoidance with learning is elegantly adapted to giving a rat the maximum of information about the resources and dangers of its environment, in the safest possible way"); and to arousal (stimulus-seeking behavior serves to maintain general arousal level). Unfortunately, as will be seen below, it is not in agreement with all experimental evidence.

### The Effects of Deprivation

Much work has been done on the effect of food and/or water deprivation upon activity and exploration.<sup>1</sup> One of the earliest experiments was by Dashiell (1925), who found that twenty-four hour food-deprived rats will enter more sections of a grid-type maze than food-satiated animals during a sixty-second interval. Wald and Jackson (1944) cite six references to the effect that "animals in general exhibit increased activity when in want of food," and these authors state, that "this is in fact the indispensable sign of hunger." They report their own work in which rats that had been deprived of food, water, thiamin, riboflavin, or magnesium all showed greater activity in an activity wheel than satiated subjects. Siegel and Steinberg (1949) report a negatively accelerated increasing number of interruptions of a photoelectric beam running across a cage as a function of increasing (zero, twelve, twenty-four, thirty-six, and forty-eight) hours of food deprivation. Finger (1951) and Finger and Reid (1952) got similar results with food or water deprivation. Using twenty-four and seventy-two hour deprivation periods after a twenty-one day habituation period they found that the twenty-four hour groups increased activity in an

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<sup>1</sup>The distinction between activity and exploration has not always been clarified. While "exploration" is usually invoked only in changing stimulus situations, the "activity" concept has been applied both to relatively stable (activity wheel) as well as changing (open-field) stimulus situations. Similarly, on the dependent variable side both the "exploration" and "activity" concepts have been applied to the measurement of locomotion. No attempt will be made to sort out the empirical findings in terms of these distinctions, though emphasis will be on those studies dealing with changing stimulus situations.

activity wheel over their normal level, and the seventy-two hour group showed a progressive increase through each of the three twenty-four hour periods. The effect of return to an ad lib water or food schedule was a sharp reduction in activity below the initial normal level with a subsequent return to normal. Hall (1955) found a similar initial increase in activity wheel revolutions of twenty-three hour water-deprived rats over satiated controls, but the difference remained the same over a twenty-one day period. Cotton (1953), using a self-control design, showed that while running speed in a ten-foot runway increased with hours of food deprivation (zero, six, sixteen, and twenty-two hours were used) the groups were similar when competing responses were factored out. The author hypothesized that the effect of hunger might be to eliminate these competing responses. This has received some vindication in the work of Strong (1957), who found decreasing responses on a contact stabilimeter designed to measure fine movements as a function of increasing deprivation (zero, twenty-four, and forty-eight hours), while the groups showed no significant differences on a micro-stabilimeter which measured grosser responses (though not as gross as those in an activity wheel).

The results are less clear out in the cases of more exploratory, or changing stimulus responses. Using two sizes of open fields, Broadhurst (1951) reports no differences in number of squares traversed between nineteen and one-half to twenty-one and one-half hour food-deprived and food-satiated rats. Thompson (1953) used an elevated maze and found no significant differences in units explored in five and ten-minute testing periods among zero, twenty-four, and forty-eight hour food-deprived male rats, and none between zero and twenty-four

hour deprived females, though these groups were significantly less active than forty-eight hour deprived females. Montgomery (1953) conducted two experiments using an enclosed single unit Y-maze. In the first, in three successive days of testing he found no significant differences, in twelve inch units explored, between rats on a seven gram daily feeding schedule and rats on twenty-three hour water-deprivation schedule, though both of these groups explored significantly less on each of three days than a group of satiated animals. It may be argued that inanition accounted for the lower performance of at least the food deprived group, since Zimbardo and Miller (1958) had found that a seven gram diet will lead to death by starvation in about two weeks, and Montgomery's animals had been on their diet for five days before the first trial. However, there was no progressive decline during the three day testing period. In the second experiment in which the same group of animals was tested at zero, twenty-four, forty-eight, and seventy-two hours of food deprivation on successive days and compared to a satiated group, there was no significant difference between the twenty-four hour deprived animals and the second day's performance (The first in which a ten minute testing period was used) of the seven gram animals of Experiment I (58.9 for the twenty-four hour group, 63.2 for the seven gram group). In the second experiment, the food-deprived group again explored less than the satiated group on each of the three deprived days (on the first day both groups were satiated and means were almost identical), though here the significant decrease was from zero to twenty-four hours of deprivation, with no further decrement. In both experiments orderliness of behavior, as measured by amount of alternation, was the

same for satiated and deprived groups. Montgomery explains the disparity between his data and those which report increasing activity with increasing deprivation on the grounds that the latter experiments use subjects habituated to their environment (as in most studies using activity wheels), and that this leads to a satiation of exploration, and what therefore emerges is the effect of deprivation on general activity, not exploration. Exploration according to this view, is relatively independent of other drives, and primarily a function of situation novelty, or exteroceptive stimulation. However, while this explains why deprived animals do not explore more than satiated animals, it does not explain why they explore less. Theoretically, increased general activity with deprivation, which Montgomery admits, should serve to increase rather than decrease general movement, particularly since Strong has shown that this deprivation-induced-activity is not composed of fine, competing responses. Perhaps we may assume that deprived animals engage in competing consummatory-like responses (e.g., biting the edges of the maze). However, the author rejects this on the basis of observation and the fact that exploration does not decrease after twenty-four hours. The question as to why deprived rats explore less is ignored by the author.

An experiment which partially replicates these findings was conducted by Zimbardo and Montgomery (1951). Testing for ten minutes in a modified checkerboard maze they exposed their male rats to zero, twenty-four, forty-eight, and seventy-two hours of food or water deprivation. They found that satiated animals explored more than either food or water-deprived animals and that exploration declined in a fairly linear fashion

with hours of food deprivation, whereas with the water deprived animals there was a significant decrease from zero to twenty-four hours deprivation, an insignificant increase from twenty-four to forty-eight hours, and an insignificant decrease from forty-eight to seventy-two hours.

These findings are at variance with those of Jerome, Moody, Conner, and Fernandez (1957). These experimenters found that food-deprived rats (the deprivation operation is not clear) will make a greater number of crossings in a multiple door situation than food-satiated animals. However, this may have been an artifact resulting from the fact that the deprived Ss were fed immediately upon the completion of their trials.

In an attempt to reconcile the differences in deprivation studies it has been hypothesized that while deprivation does not increase activity or exploration per se, it lowers thresholds for external stimuli, which do produce increased activity. The classic experiment in this area is one by Campbell and Sheffield (1953). Using a flat microswitch activity cage they found that while deprived animals increased their activity slightly during a seventy-two hour no-feeding period while there was only limited stimulation, their activity rose rapidly with the presentation of a stimulus. Similarly, Murray (1953) has found that there was only a slight, insignificant difference between satiated and twenty-three hour food-deprived rats in the operant level of pulling a short bar in a Skinner box, while the deprived animals pulled a long bar and a chain (presumably more complex stimuli) about ten times more on the average than the satiated animals.

The work of Hall and his associates contests the deprivation-



stimulation hypothesis. Hall, Smith, Schitzer, and Hanford (1953) found a substantial difference in activity wheel performance in favor of animals on a twenty-three and one-half hour food deprivation schedule when compared to food-satiated rats in two separate experiments -- the first using a self control design, the second using a control group -- when all animals had substantially reduced environmental stimulation by means of a deafening operation and minimal visual and temperature changes. These findings were replicated by Hall and Hanford (1954) with minimal auditory stimulation substituted for the deafening operation, and by Hall (1955) with water in lieu of food deprivation. In a fourth experiment, also using activity wheels, Hall (1956) reports that both three day continuous food deprivation and stimulation increased activity. He concludes that this is evidence against the Campbell-Sheffield position which does not emphasize the role of deprivation per se.

At apparent variance with these findings are those of Chapman and Levy (1957). These experimenters report that twenty-two hour food-deprived animals ran a five and one-half foot runway at a slower rate than satiated animals and this difference increased over a nine-day testing period. The effect of introducing novel stimulation on the tenth through the fifteenth day was a significant increase in running speed for the satiated animals and a very slight, insignificant decrease for the deprived Ss. The authors conclude, contra Campbell and Sheffield, that novelty has less effect (in terms of Campbell and Sheffield's formulation upon reactivity; in terms of their own formulation, upon reinforcement; although operationally the concepts are similar here) upon hungry animals than upon non-hungry ones. It is possible, however, that the parameters in the activity-wheel

and in the runway are sufficiently different to preclude comparisons.

In an attempt to extend the Campbell-Sheffield position to more exploratory-type behavior, Adlerstein and Fehrer (1955) using a self-control design, tested the effects of a seven gram daily maintenance schedule upon exploratory behavior in a complex maze. It was hypothesized that the greater complexity (i.e., greater than in the experiments of Montgomery (1953) and Thompson (1953)) would lead to increased exploration for the deprived group. The hypothesis was borne out by the data, for the animals entered fifty to seventy-five percent more units when deprived than when satiated. In a followup experiment Fehrer (1956) reported that twenty-four hour food-deprived rats were more prone than food-satiated rats to leave a box that they had been exposed to for twenty-four hours during a fifteen minute trial period, though there were no significant differences between them and groups that had been put in the cage ten minutes before testing. The author concludes that it is the hunger-novelty interaction that accounts for the superiority of the hungry animals.

Zimbardo and Miller (1958) using a somewhat similar procedure, got similar results. In a series of two-minute maximum trials they found that rats on a 10.5 gram food maintenance schedule were initially inferior (i.e., ran slower) and subsequently similar to satiated Ss in crossing into the second half of a modified Miller acquired-drive apparatus where both groups had been allowed to cross immediately after being put in, while the hungry Ss were significantly superior to the satiated Ss where crossing was delayed by a partition for two minutes. As with Fehrer's finding, the hungry animals were more inclined than the sati-

ated rats to explore only after some adaptation to the original stimulus situation had taken place. In addition, Zimbardo and Miller found that increasing the novelty of the runway served to increase exploration for both the immediate-deprived and delay-deprived groups; the increase was greater for the latter.

In sum, there appears to be considerable evidence for a deprivation-novelty interaction, with deprivation producing an increase in exploration and activity in a complex stimulus situation, though having no effect or possibly decreasing exploration in a simple situation. Only one experiment, that of Zimbardo and Montgomery (1957), contests this conclusion. In addition, deprivation increases exploration when an organism has been exposed to a stimulus situation and has an opportunity to leave it, but appears to have no effect where this exposure has not taken place. The common assumption (e.g., Barnett, 1958) that hunger simply increases exploration, thus increasing the probability that the hungry or thirsty animal will come in contact with food or water, is by itself inadequate in explaining these data. In its stead we may suggest that while hunger may serve to increase exploration initially (i.e., it may elicit a stronger exploratory drive and/or lower the thresholds to the stimuli by which this drive is elicited), it would later serve to decrease exploratory drive, either directly or by raising the stimulus thresholds in the continued presence of the same stimuli, i.e., the time factor is crucial. This would serve to conserve body energy in the deprived state when the likelihood of finding sustenance is small. This approach would explain the superiority of hungry animals in a complex

situation and their similarity or inferiority to satiated animals in a simple one. The delayed-immediate experiments of Fehrer and Zimbardo and Miller fit this explanation quite nicely. Their deprived-delayed animals had exhausted (or had been satiated on) the stimulus properties of the home box or cage and they explored more upon release than the satiated-delayed because of the exploratory-drive-producing aspects of hunger. On the other hand, the immediate-deprived groups, because of the summation of the initial high and subsequent low levels of exploration, are at the same level as the immediate-satiated group. Zimbardo and Miller's data indicates this to be so; Fehrer does not cite data indicating the trend during the testing interval. Deductions, then from this approach are that hungry animals should initially explore more and subsequently less than satiated organisms, even though overall differences may not be significant; and that the slope of the deprived Ss' curve should decrease with increasing stimulus complexity. These points will be examined later.

In a theoretical discussion of the effects of drive, Glanzer (1958) has postulated the effects of drive as being twofold: energizing ongoing behavior and introducing drive stimuli:

With respect to exploratory behavior these would have opposed effects. The energizing aspect of drive should give rise to more exploratory behavior. However, additional internal stimuli would reduce the relative importance of the external stimuli that the animal responds to in its exploratory behavior. Therefore, there should be less exploratory behavior.

He suggests that "using animals with varying degrees of adaptation to cycles of food deprivation" would give results in either direction, i.e., with little or no stabilization on a given food deprivation schedule, the

distracting internal effects would be greater, with greater stabilization, these effects should be minimized, and the energizing effects would result in greater exploration.

There is very little experimental evidence which bears directly on this point and no experiment has been reported in which this was the object of investigation. Lawrence and Mason (1955) have dealt with the effect of sustained deprivation schedules per se. They found that the effect of a shift from ad libitum feeding to a twenty-two hour deprivation schedule is a negatively accelerated increase in food intake for the first seven to ten days. There was a corresponding progressive weight loss during this period, leveling off about the thirteenth day. Reid and Finger (1955) used a twenty-three hour deprivation schedule and also found the greatest loss in body weight during the first ten to fifteen days. They conclude that fifteen days is the "irreducible minimum" for stabilization of hunger-caused motivation. These results have been confirmed with a twenty-three hour, ten-minute deprivation schedule (Ramond, Carlton, and McAllister, 1955).

These findings appear to account for the shape of the curves in at least two of the activity experiments cited above (Hall, et al., 1953; Hall and Hanford, 1954) where extended periods of deprivation were used. Both experiments used twenty-three hour deprivation schedules following long activity adaptation periods and both report a negatively accelerated activity curve with the point of inflection at about the twelfth day. The activity curve nicely paralleled the weight loss curve. There is some slight evidence, however, that adaptation to hunger takes place independently of drive stabilization. Moll (1956) found that running

time in a straight runway with food reward at the end decreased with increased stabilization -- zero, seven, and fourteen days -- at a constant 85 percent satiated body weight. However, these results were not borne out by replication and no differences in starting latency between zero and thirty days stabilization of animals at eighty and ninety percent of satiated body weight were found.

That the effect of stabilization upon exploration may not be as important as Glanzer hypothesizes is indicated by two experiments. In one, the experiment by Montgomery (1953b) cited earlier, there was almost no difference in absolute level of exploration between animals that had been on a seven gram maintenance schedule for five days, and animals on a twenty-three hour deprivation schedule for two days. That these groups are not at similar body weights is shown by the data of Ramond, et al. which indicate that the seven gram animals weighed at least eight percent less than the twenty-three hour group. In the other study, Zimbardo and Miller had their animals on a 10.5 gram maintenance schedule for two weeks before starting experimentation. They achieved results similar to Fehrer, who deprived her animals only a day before experimentation. Nevertheless, the effect of stabilization has never really been exposed to experimental test.

### The Effects of Age

It is commonly assumed that curiosity and exploration decrease with increasing age. The few studies in this area corroborate this assumption. Finger (1951) reports that rats with a mean age of 180 days were sixty-four percent less active in a circular activity cage than

animals with a mean age of eighty days. Thompson and Heron (1954) used Scotch Terriers in three age groups and found exploration of a seven-unit maze was a decreasing function of age in an indoor setting, though differences were not significant in a more stimulus-rich outdoor situation.

Using two age groups of chimpanzees, Welker (1956) found that older animals tended to respond less to various stimulus objects. This responsiveness dropped off at a faster rate than with younger animals. In a subsequent experiment (1956c) he found that manipulation of various stimulus objects tended to increase with age and experience, whereas orientation towards (without manipulation) the objects decreased with age. In general, the younger and the less experienced animals approached the objects more cautiously and adapted to their presence more slowly. Harlow, Blazek, and McClearn (1956) report an early appearance of manipulation behavior, and found that it improved in amount and efficiency with age and practice. These results are not in contradiction to Welker's; the monkeys of Harlow, et al. were infants, Welker's chimpanzees were at least ten months old.

#### The Effects of Continued Exposure

The effect of continued exposure upon manipulation and exploration is not clear. Four separate experiments (Butler, 1955; Butler and Alexander, 1955; Butler and Harlow, 1954; Harlow, 1950) report no satiation (as measured by decreased responding) in visual exploration and puzzle manipulation in monkeys either during or between trials. In addition, as was just mentioned, Harlow, Blazek, and McClearn (1956) report a rise

in manipulation across trials in very young monkeys. Montgomery (1954) reports that rats which had been rewarded for running a Y-maze by being allowed to explore a Dashiell maze, showed an increasing amount of exploration of the D-maze over six blocks of eight trials. In a subsequent experiment Montgomery and Segall (1955) found no significant differences in D-maze exploration over twelve trials. They attribute the differences to the greater pre-experimental adaptation of the animals to the maze in this latter experiment; that is, a rise in number of units traversed is the result of the reduction in the fear precipitated by novel situation by continued exposure (as indicated in Montgomery, 1955 and Montgomery and Monkman, 1955) rather than an increase in exploration per se. This explanation fits the data of Thompson and Solomon (1954), in which three measures of exploration (sniffing, crossing, and looking) showed an increase (reduction of fear) and subsequent decrease (satiation) when visual figures were introduced into rat living boxes. However it does not explain the difference between this sort of data and those of Butler (1953) in which satiation did not occur even after 100 hours of exposure.

Opposed to the experiments which show no decrease in exploration with continued exposure, are the majority of the experiments in the area. With the exception of those cited, all other experiments heretofore mentioned which report continuous data, indicate a decline during trials, though most report a recovery at the beginning of a new trial (Glanzer, 1958).

As was mentioned earlier, it may be deduced from the conservation of energy explanation offered for the discrepancy in data between food-satiated and deprived animals in simple and complex stimulus situations,



that even where no overall differences appeared, the food-deprived animals should show a faster rate of decline in exploration. Some data (that of Zimbardo and Miller, 1958) were shown to bear this out. Unfortunately, some of the relevant experiments (Broadhurst, 1957; Murray, 1953; Thompson, 1953; Zimbardo and Montgomery, 1957) do not report comparative data across trials. Among these that do, little further confirmation is offered for the hypothesis. Chapman and Levy (1957) do report a greater decline for the deprived groups in a simple runway, but the disparity is present from the first trial on, and there is no difference in slope in Montgomery's (1953) and Zimbardo and Montgomery's (1957) data; in both, the deprived animals start at a lower rate and parallel the decline of the satiated Ss.

#### Purpose of the Present Study

As the preceding review indicates there are still a large number of unanswered questions and ambiguous data in the area of exploratory behavior. First, while there is some evidence that deprivation increases exploration in a complex situation and decreases it in a simple one, no study has heretofore compared deprived and satiated subjects in both situations. In addition, no study has undertaken to compare exploratory behavior in subjects that had been stabilized on hunger drive with subjects put on a deprivation schedule just prior to testing. It is the purpose of the present study to investigate both of these problems. Thirdly, while there is substantial evidence that exploration decreases with age after a certain point, there is little data on the differences in the

shape of the exploration curve both during and across trials for young and old animals. It was hoped that this experiment might shed some light on the effects of age as well as the effect of the other independent variables -- deprivation, stabilization of deprivation, and maze complexity -- on the shape of the exploration curve.

## CHAPTER II

### METHOD AND PROCEDURE

The experiment was originally conceived as a factorial study with four simultaneous dimensions of variation: three levels of food-deprivation, two levels of stabilization on the deprivation schedules, two degrees of runway complexity, and two age groups, with five subjects in each of the resulting twenty-four cells. However, it was found during the experiment that the older animals could not survive the extreme deprivation-stabilization schedule and most of the younger animals died before the completion of testing on all deprivation schedules. Since the need for replication of some of the findings occurred, the number of Ss per cell was increased. The resulting design was a three by two factorial with three levels of deprivation and two degrees of runway complexity with only older Ss used, plus one stabilized group for each of the two degrees of runway complexity, also using only older Ss, plus one group of younger animals for each of the two degrees of runway complexity. The number of Ss in each group (or cell) was the same with two exceptions and all entries were independent. The experimental paradigm is presented in Table 1.

#### Subjects

The Ss were 129 experimentally naive male albino rats of the Wistar strain. Of these, thirty-nine did not survive the testing period and since even their incomplete performances partially reflected the effects

TABLE 1

DESIGN OF THE EXPERIMENT<sup>A</sup>

		Deprivation				
		0	23		47	
		Stabilization				
Age	Old	0	0	14	0	14
		10	10	5	10	-
	Complexity	10	10	5	10	-
	S	10	-	-	-	-
	C	10	-	-	-	-

<sup>A</sup>Table entries refer to the number of Ss in cell.

of inanition, they will not be considered further. Of the remaining ninety, seventy were ninety to ninety-four days old and twenty were thirty-four or thirty-five days old at the beginning of testing. All of the younger animals and fifty-five of the older Ss were born and raised at the animal colony of the University of Tennessee. Prior to the taming period these Ss were handled only once, when they were weaned on their twenty-first day. After weaning all were assigned by brood to cages of identical size. The remaining fifteen Ss were received from Budd Mountain Rodent Farm one week prior to testing and nothing is known of their history. Prior to the introduction of the deprivation schedules all Ss were maintained on an ad lib diet of water and Purina lab chockers.

Ss were given identifying markings five days before the beginning of testing and were tamed by being held and petted for thirty seconds on each of the three succeeding days.

### Apparatuses

Two runways were used. Both were constructed of three-quarter inch pine, with a linoleum floor and a hardware cloth top. Both were three and three-quarter inches high, three and one-quarter inches wide, and one-hundred and eighty inches long. They were divided into fifteen twelve-inch units by green wire strung through the hardware cloth. The simple runway was straight all the way through. The complex runway consisted of right angle turns at twelve inch intervals in the following sequence: LRRLLRLLRRLRR.<sup>1</sup> The entrance to the runways was a wooden drop

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<sup>1</sup>The use of this design for the complex runway was necessitated by

-door, and Ss were removed by being lifted out after the hardware cloth was raised.

The runways lay next to each other in a room illuminated by two 150-watt light bulbs hanging approximately nine feet above the level of the floor. Illumination in both runways was about the same. The temperature ranged from 72° to 78° F. The motor of an air conditioner used to maintain temperature was kept running throughout the trials. This served to keep a constant level of noise (approximately forty db above threshold) and to mask extraneous noise. The runways were swabbed with a fifty percent vinegar solution prior to the days' trials and fecal matter was removed before a new rat was started on its trial.

### Procedure

The three degrees of food deprivation used were zero, twenty-three, and forty-seven hours. Ss in the non-stabilized deprived groups were put on the feeding schedule just prior to the first testing and maintained on it throughout experimentation. All of these Ss were from the older group. Both runways were used for each deprivation schedule and there were ten Ss in each of the resulting six independent cells. All the Ss used in the simple runway were from the University of Tennessee colony. Half the Ss used in the complex runway for each deprivation level were from this colony and half were from Budd Mountain Farm.

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the desire to make results on the two runways comparable. A maze with culls, though farther out on the complexity continuum, would have prevented comparison, since a traversal from a cul would not be comparable to a traversal of an ordinary unit: it would have been the function of escape from the cul as well as the animal's exploratory tendency.

Two groups of stabilized Ss were used in each of the two runways. There were five Ss in each group and they had been fed for one hour daily for fourteen days prior to the first testing. This schedule was maintained throughout the experiment. Here too, only older Ss were used.

One group of the younger Ss was used in each of the two runways. There were ten Ss in each group and none had any history of food deprivation.

Assignment to cells was arbitrary and largely a function of brood, litter members by and large tending to occupy the same cell. However, no cell was composed entirely of a single litter, and most were composed of about three litters.

Fifteen minutes prior to testing, the groups to be tested for that day (usually between five and ten Ss) were removed from their home cages, placed in an 18" x 7 $\frac{1}{2}$ " x 10" retaining cage and taken to the experimental room. After this minimum adaptation period Ss were taken individually from the retaining cage, put in the appropriate runway via the drop-door for a five-minute period, and returned to it immediately thereafter. After all Ss in the group had been tested, the animals were returned to their home cages. In the case of deprived Ss, one-half hour elapsed between this return and feeding. Feeding was for one hour and all food was removed from the cage at the end of that time.

A total of five five-minute trials was given each animal. The use of forty-seven hour deprived Ss necessitated that all trials be on alternate days. The order of Ss run was rotated during these days. Testing was begun at five P.M. every day and generally ran between thirty minutes and an hour. Ss on a deprivation schedule not being run on

a given day were fed for an hour beginning between six and six-thirty P.M.

Throughout the experiment, and, in the case of colony rats, throughout their lives, all Ss were handled by a single experimenter. As far as possible Ss were held in the standard manner of thumb and forefinger underneath the front shoulders with the palm supporting the spine. During the actual testing the experimenter sat over and to one side of the runways and remained as motionless as possible except for recording the data. Since none of the Ss appeared to "regard" him for more than two or three seconds, it is extremely doubtful that he was a source of extaneous stimulation.

### Measures

Only one measure was taken: the number of twelve inch unit traversals during each minute for each of the five five minute testing periods. Since retracing was allowed, traversal of a given unit could occur more than once. A unit was judged traversed when the S had placed all four feet beneath the overhead unit dividers. Since the experimenter had a clear view of all sections of the runway, the reliability of this measure is probably very high. Before experimentation got under way it was hoped that other measures could be taken: the number of rears, bites, and grooming responses, the farthest point achieved on each testing day, and latency, as defined by the time before the S left the first unit. However, it was found that the Ss moved too quickly for the experimenter to satisfactorily record the first three, that almost all Ss reached the farthest point in the runways during almost all trials, and



that latency was so short for most Ss as to be make reliable measurement with the stop watch used impossible.

## CHAPTER III

### RESULTS

Because of the preclusion of the complete block design which would have permitted simultaneous comparison on all dimensions of variation, the analysis has been broken down into three sections: 1) the effects of nonstabilized deprivation, 2) the effects of stabilized deprivation, and 3) the effects of age; as well as the interactions of each of these dimensions with runway complexity and their effects across trials. By necessity these intrasection comparisons were not independent; some of the same scores appear in two comparisons, though none appear in all three. Since no hypotheses were made, two-sided probabilities were used throughout. The desired significance level was set at .05 and probabilities greater than this were not considered.

#### The Effects of Deprivation

The mean minute-by-minute scores and the mean total trial for the six nonstabilized deprivation groups used in this comparison are shown in Table 2. The individual and group total scores are shown in Table 3. The five-minute trial means are plotted in Figure 1, and the variances for each of these points are shown in Table 15. A Hartley  $F_{\max}$  test for homogeneity of variance was performed on these, and the  $F_{\max}$  of 3.75 was not significant at the .05 level, indicating homogeneity.

An analysis of variance test for repeated measurements was run on the five-minute trial means. This showed the triple interaction of deprivation x complexity x trials significant at the .001 level, and to

TABLE 2

MEAN UNIT TRAVERSALS PER MINUTE UNDER THREE CONDITIONS OF DEPRIVATION  
AND TWO CONDITIONS OF RUNWAY COMPLEXITY<sup>a</sup>

Runway							
Trial	Min.	Simple			Complex		
		Deprivation (hours)					
		0	23	47	0	23	47
1	1	14.7	17.8	20.8	15.3	13.2	10.3
	2	10.4	10.3	12.8	12.5	10.8	9.0
	3	9.3	17.2	15.4	14.0	10.2	9.2
	4	11.8	14.5	10.1	12.7	10.8	9.6
	5	13.6	13.9	11.7	11.4	11.7	9.4
Total		59.8	73.7	70.8	66.4	56.7	47.2
2	1	11.0	18.2	16.5	16.6	15.8	11.2
	2	9.4	13.4	9.1	10.8	9.7	6.3
	3	9.5	11.8	7.5	9.2	10.4	6.3
	4	6.7	12.7	11.1	10.2	9.9	6.0
	5	6.5	10.8	5.5	7.8	10.3	7.2
Total		43.1	66.9	49.7	54.6	56.1	37.0
3	1	7.5	17.7	10.4	12.8	12.2	9.9
	2	6.1	10.6	6.8	11.2	6.3	4.3
	3	4.7	10.8	6.9	11.5	7.6	6.9
	4	3.9	12.8	4.6	9.5	8.1	6.2
	5	4.0	15.8	7.4	9.8	9.4	6.1
Total		26.2	67.8	36.1	54.8	43.6	33.4
4	1	6.6	16.7	11.1	15.7	11.7	10.4
	2	4.0	9.4	9.1	12.3	7.1	9.8
	3	4.2	9.0	14.1	12.7	8.4	12.5
	4	2.4	5.0	9.1	11.2	8.8	9.8
	5	8.3	5.4	13.5	9.5	6.2	8.3
Total		30.5	45.5	56.9	61.4	42.2	51.1
5	1	6.8	15.3	17.9	16.9	11.1	12.2
	2	5.5	10.7	15.8	12.4	8.8	10.3
	3	4.7	8.4	14.4	13.6	8.1	9.6
	4	5.4	9.6	18.5	11.1	8.7	8.7
	5	3.9	11.2	14.0	10.9	5.9	8.2
Total		26.3	55.2	80.6	64.9	42.6	49.0

<sup>a</sup>N = 10 per group

TABLE 3

INDIVIDUAL TOTAL UNIT TRAVERSALS UNDER THREE CONDITIONS OF  
DEPRIVATION AND TWO CONDITIONS OF RUNWAY COMPLEXITY

S	Runway					
	Simple			Complex		
	Deprivation (hours)					
	0	23	47	0	23	47
	196	386	466	429	167	76
	140	511	270	196	183	151
	447	335	166	234	246	151
	19	248	272	267	247	158
	290	207	297	378	289	272
	46	286	430	348	135	199
	224	388	239	189	488	225
	125	316	366	292	228	397
	159	319	120	365	336	235
	213	95	315	323	93	313
Mean	185.9	309.1	294.1	302.1	241.2	217.7

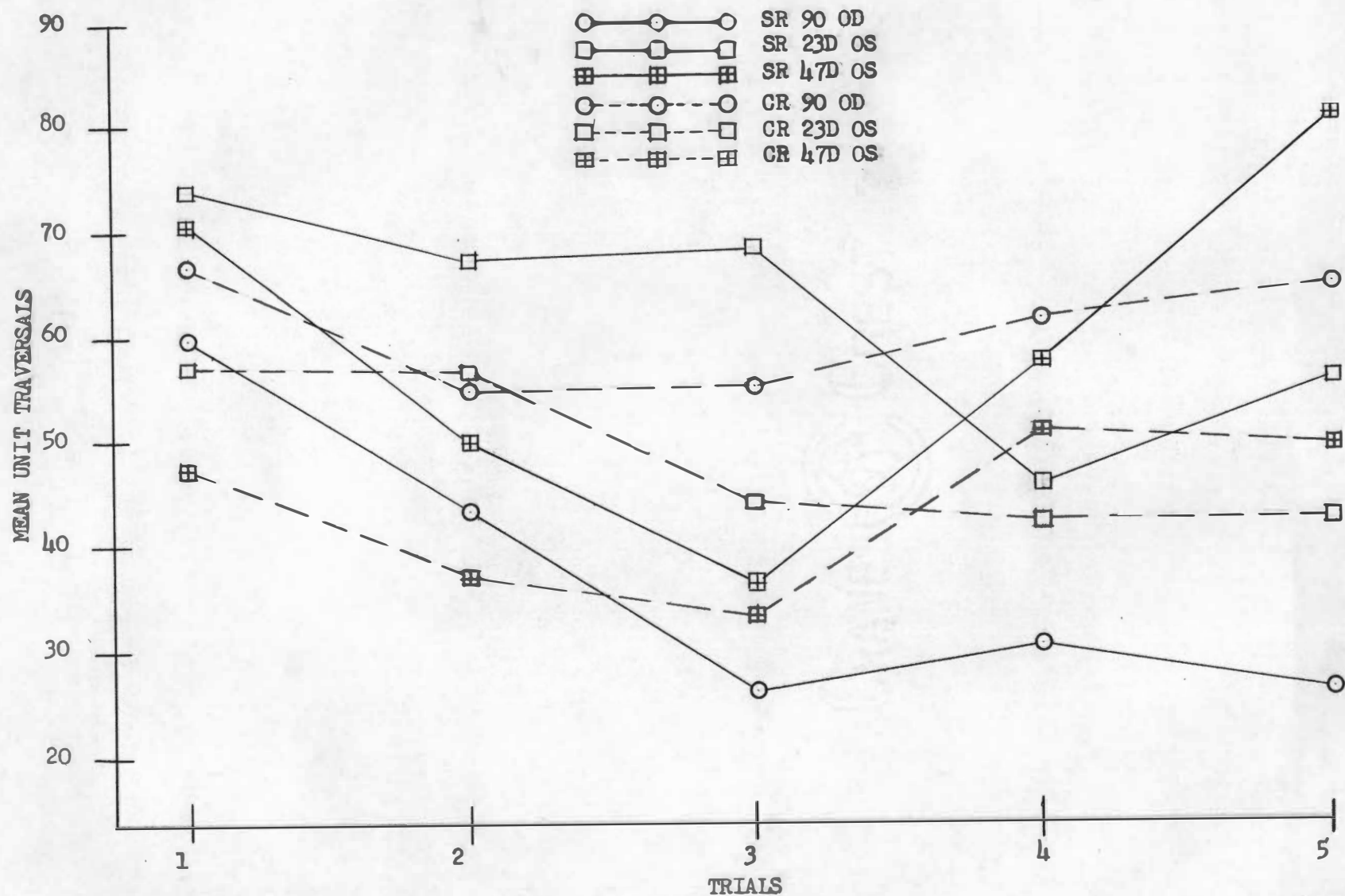


Fig. 1. Mean unit traversals across trials for six groups under three conditions of deprivation and two conditions of runway complexity.

get at the differential trial effects, a trend analysis of variance test, as outlined by Grant (1956), was performed. The results of this analysis, which incorporates the original analysis of variance, are summarized in Table 4. This table was interpreted as follows. The high significance of the overall trend indicated that the scores varied from trial to trial. Of the possible curves that might describe the summed curves of Figure 1, a quadratic curve fits best, i.e., a curve with a single maximum or minimum. Examination of the curves would indicate that this point is at either the third or fourth trial, and probably at the former. Neither runway complexity nor deprivation by itself produced significant differences; however, the interaction is highly significant. Inspection of the group totals in Table 3 indicates that this significant interaction was caused primarily by the lower performance of the nondeprived simple runway group (SR 90 OD) as compared to the simple runway twenty-three and forty-seven hour deprived groups (SR 23D OS and SR 47D respectively), and probably by the decreasing performance with increasing deprivation characteristic of the three complex runway groups (CR 90 OD, CR 23D OS and CR 47D).

Unfortunately, this last finding is not unambiguous. As mentioned earlier, each of the complex runway groups was composed of five University of Tennessee colony rats and five from Budd Mountain Farm. Early results using only the Tennessee rats indicated that the depressing effect of hunger in the complex runway as relatively clearcut, the total means here being 300.8, 226.4, and 147.0 for zero, twenty-three, and forty-seven hours deprivation respectively. Analysis of variance of the total scores gave an  $F$  of 6.22, ( $df = 2, 12$ ), significant at better than the .05

TABLE 4

SUMMARY OF ANALYSIS OF TRENDS OF UNIT TRAVERSALS PER TRIAL  
IN THE DEPRIVATION COMPARISON

Source of Variation	df	Mean Square	F
A. Over-all Trend	4	2,945.520	9.25***
1. Linear	1	2,895.207	4.80
2. Quadratic	1	8,524.971	26.35***
3. Cubic	1	44.827	.23
4. Quartic	1	317.075	2.02
B. Between Group Means	5	5,185.294	2.32
a. Complexity	1	263.203	.12
b. Deprivation	2	988.330	.44
c. Interaction	2	11,843.304	5.29**
C. Between Group Trends	20	988.724	3.12**
1. Linear	5	1,933.979	3.21*
a. Complexity	1	1,368.060	2.27
b. Deprivation	2	3,008.932	4.99*
c. Interaction	2	1,141.985	1.89
2. Quadratic	5	1,231.197	3.81**
a. Complexity	1	1,016.400	3.14
b. Deprivation	2	1,724.818	5.33*
c. Interaction	2	844.975	2.61
D. Between Individual Means	54	2,238.249	7.03***
E. Between Individual Trends	216	318.370	
1. Linear	54	602.754	
2. Quadratic	54	323.556	
3. Cubic	54	190.333	
4. Quartic	54	156.643	
Total	299		

\*  $p$  less than .05

\*\*  $p$  less than .01

\*\*\*  $p$  less than .001

level. As a replication the Budd Mountain animals were run under the same conditions. For these Ss the nondeprived group mean was 303.4, the twenty-three hour deprived group mean was 256.0, and the forty-seven hour deprived group mean was 288.4. These do not appear to be significantly different and the greater exploration of the forty-seven hour group in comparison to the twenty-three hour group constitutes a reversal. Nevertheless when the groups are combined (as in Table 3), as they have to be to give a balanced design, the original trend is still strong enough to exhibit itself in the new combined means, and it probably contributes to the significance of the interaction. Unfortunately, there appears to be no way of testing this.

In Table 4 the differences in trend between groups are highly significant. These differences are mostly the result of differences in deprivation, and they are due to both differences in slope (linear) and in shape (quadratic). In view of Figure 1, it seems reasonable to say that it was the forty-seven hour deprived groups that caused both these differences. If the zero and twenty-three hour deprived groups were each averaged across complexity, they would form a relatively smooth gently declining curve that would not deviate too far from linearity. If the forty-seven hour deprived curves were so averaged they would show a downward slope up to trial three, with a sharp upturn from that point to trial five. Attempting to fit a straight line to these points would result in large deviations and a slight upward slope that would be different from that of the other two. Since the trend analysis shows the quadratic components to be significantly different for deprivation groups, and since only the forty-seven hour-groups showed any marked deviation from



linearity, the increase in exploration of these groups after the third trial is probably a real effect. This effect may be deduced from the fact that eighteen of the twenty Ss in the forty-seven hour deprived groups showed an increase from the third to fourth trials, i.e., the high significance was not due to a few highly deviant cases. The high significance of differences between individual means is simply a reflection of the high reliability of the measurements.

The analysis outlined above deals only with whole trial effects. To have performed similar analyses for the minute scores for each of the five minute trials would have been extremely laborious (it would have involved five separate trend analyses), and probably not very meaningful, since there would have been difficulty in statistically comparing the curves for each trial. Comparing mean percentage change for each minute by groups would also have been difficult because of the presence of zero exploration scores. Consequently, a consistency analysis was performed in which the percentage of subjects showing a decreasing number of traversals during successive intratrial minutes was calculated. These data are shown in Table 5. That the overall percentage is not larger than fifty does not indicate an absence of overall decline; rather it is a function of the percentage taking method in which the Ss which showed ties, of which there were a considerable number, were included in the denominator. Inspection of the table indicates that the percentage decline was greatest from the first to second minute, with little further change thereafter, and that this effect was independent of trials. A Wilcoxon T-test was performed in which the first-to-second minute percent decline means for each trial were tested against the means of those

TABLE 5

PERCENT OF SS SHOWING DECREASED MINUTE-  
TO-MINUTE INTRATRIAL UNIT TRAVERSALS.  
DEPRIVATION ANALYSIS

Trial	Group	Minutes				Mean
		1 - 2	2 - 3	3 - 4	4 - 5	
1	SR 90 OD	80	50	40	20	47.5
	SR 23D OS	70	20	50	60	50.0
	SR 47D	90	40	70	20	55.0
	CR 90 OD	60	20	50	60	47.5
	CR 23D OS	70	40	50	40	50.0
	CR 47D	70	40	50	30	50.0
Mean		73.33	36.65	51.67	38.33	50.00
2	SR 90 OD	40	40	40	40	40
	SR 23D OS	60	40	40	40	45.0
	SR 47 D	70	50	20	70	52.5
	CR 90 OD	90	70	40	70	67.5
	CR 23D OS	100	50	50	40	60.0
	CR 47D	80	40	60	50	57.5
Mean		73.33	48.33	41.67	51.67	53.75
3	SR 90 OD	30	50	40	40	40.0
	SR 23D OS	80	50	30	50	52.5
	SR 47D	70	30	40	30	42.5
	CR 90 OD	70	20	60	40	47.5
	CR 23D OS	100	30	30	30	47.5
	CR 47D	80	10	40	40	42.5
Mean		71.67	31.67	40.00	38.33	45.42
4	SR 90 OD	50	50	10	20	32.5
	SR 23D OS	80	50	40	30	50.0
	SR 47D	40	10	60	10	30.0
	CR 90 OD	90	30	60	50	57.5
	CR 23D OS	90	30	40	80	60.0
	CR 48D	40	40	60	40	45.0
Mean		65.00	35.00	45.00	38.33	45.83

(Table continued on next page).

TABLE 5

PERCENT OF SS SHOWING DECREASED MINUTE-  
TO-MINUTE INTRATRIAL UNIT TRAVERSALS.  
DEPRIVATION ANALYSIS. (Continued)

Trial	Group	Minutes				Mean
		1 - 2	2 - 3	3 - 4	4 - 5	
	SR 90 OD	40	40	20	30	32.5
	SR 23D OS	70	50	20	40	45.0
	SR 47D	70	40	50	70	57.5
	CR 90 OD	80	40	50	50	55.0
	CR 23D OS	70	50	30	50	50.0
	CR 47D	90	60	60	50	65.0
Mean		70.00	46.67	38.33	48.33	50.83
Grand Mean		70.67	39.67	43.33	43.00	

of the other columns. The probability of this being due to chance was smaller than .01. The mean percentage of Ss showing a decline did not seem to be very different among the five trials. The group mean scores were as follows: SR OD: 38.50; SR 23D OS: 48.50; SR 47D: 47.5; CR OD 55.00; CR 23D OS: 53.50; and CR 47D: 52.00. These scores appear to primarily reflect differences due to complexity. The mean for the simple runway groups with deprivation ignored was 44.83, for the complex runway groups it was 53.50. A test of the significance of these differences by the Mann-Whitney-Wilcoxon T-test, in which group scores were used, gave a p of less than .05. To ascertain that this decline occurred with equal frequency throughout the minute comparisons rather than during a specific point during each of the five minute trials, another comparison was made. Since there were no important intertrial differences in percentage changes from minute to minute, runway percentage decline scores were summed across trials. Since there were significant column differences, a percentage of these was gotten by dividing the simple runway sums by the complex runway sums. Both the sums and quotients are shown at the top of Table 16. The percentage decrease disparity was greatest from the second to third minute. However, this was not significant at the .05 level when these percentages were tested against the mean of the other three percentages by the Wilcoxon T-test. Summing across complexity gave the following percentage decline scores for deprivation: zero: 46.75; twenty-three hours: 51.0; and forty-seven hours: 49.75. It is highly unlikely that these are significantly different.

To round out the analysis, percentages of Ss increasing exploration from the last minute of one trial to the first minute of the next

trial were calculated. These are shown at the top of Table 17. They are fairly similar with the exception of those of group SR 90 OD, which shows a smaller percentage increase than the others. However, there are too few scores to permit adequate analysis.

### The Effects of Stabilization

The individual total scores and the minute-by-minute means for the two stabilized drive groups (SR 24D 14S and CR 24D 14S) are shown in tables 6 and 7 respectively. The trial means are plotted in Figure 2, along with the trial means for the two twenty-three hour deprived nonstabilized Ss with which these groups are compared. The variances for each trial of the stabilized groups are shown in Table 18. The Hartley  $F_{\max}$  for these and those of the twenty-three hour deprived nonstabilized Ss is 8.88, insignificant at the .05 level. The summary of the analysis of variance for the stabilized data appears in Table 8.

The only significant differences were the result of differential runway complexity; the simple runway groups exploring more. The greatest contribution to the significance of these differences came from the wide disparity between the scores of the two stabilized groups. Examination of Figure 2 shows this effect to be consistent over trials, group SR 23D 14S continually exploring more than group CR 23D 14S. The curves of the two nonstabilized groups converge over trials. This is not necessarily a reversal of the trend of increasing differential (for runway complexity) exploration with increasing drive stabilization. As the data of Reid and Finger (1955) mentioned earlier show, weight loss on a twenty-three hour deprivation schedule continues for at least ten days. Therefore it

TABLE 6

INDIVIDUAL TOTAL UNIT TRAVERSALS OF DRIVE STABILIZED SS  
UNDER TWO CONDITIONS OF RUNWAY COMPLEXITY.

Subject	Runway	
	Simple	Complex
	<del>308</del>	<del>175</del>
	310	205
	271	212
	189	212
	343	86
Mean	299.2	178.0

TABLE 7

MEAN UNIT TRAVERSALS PER MINUTE OF DRIVE  
STABILIZED SS UNDER TWO CONDITIONS  
OF RUNWAY COMPLEXITY<sup>a</sup>

Minute	Trial									
	1		2		3		4		5	
	Complexity									
	Simp.	Comp.	Simp.	Comp.	Simp.	Comp.	Simp.	Comp.	Simp.	Comp.
1	15.0	14.0	15.0	13.4	18.2	9.0	17.0	12.0	17.8	10.6
2	7.8	12.4	8.6	4.8	10.6	8.2	10.8	6.4	9.2	5.2
3	12.8	9.0	10.4	3.6	7.4	5.4	11.4	6.6	13.2	4.8
4	11.4	9.0	9.4	4.6	10.0	6.2	17.0	4.4	11.6	2.8
5	15.0	9.4	6.4	3.0	9.2	5.2	11.8	4.0	12.2	4.0
Total	62.0	53.8	49.8	29.4	55.4	34.0	68.0	33.4	64.0	27.4

<sup>a</sup>N = 5 per group

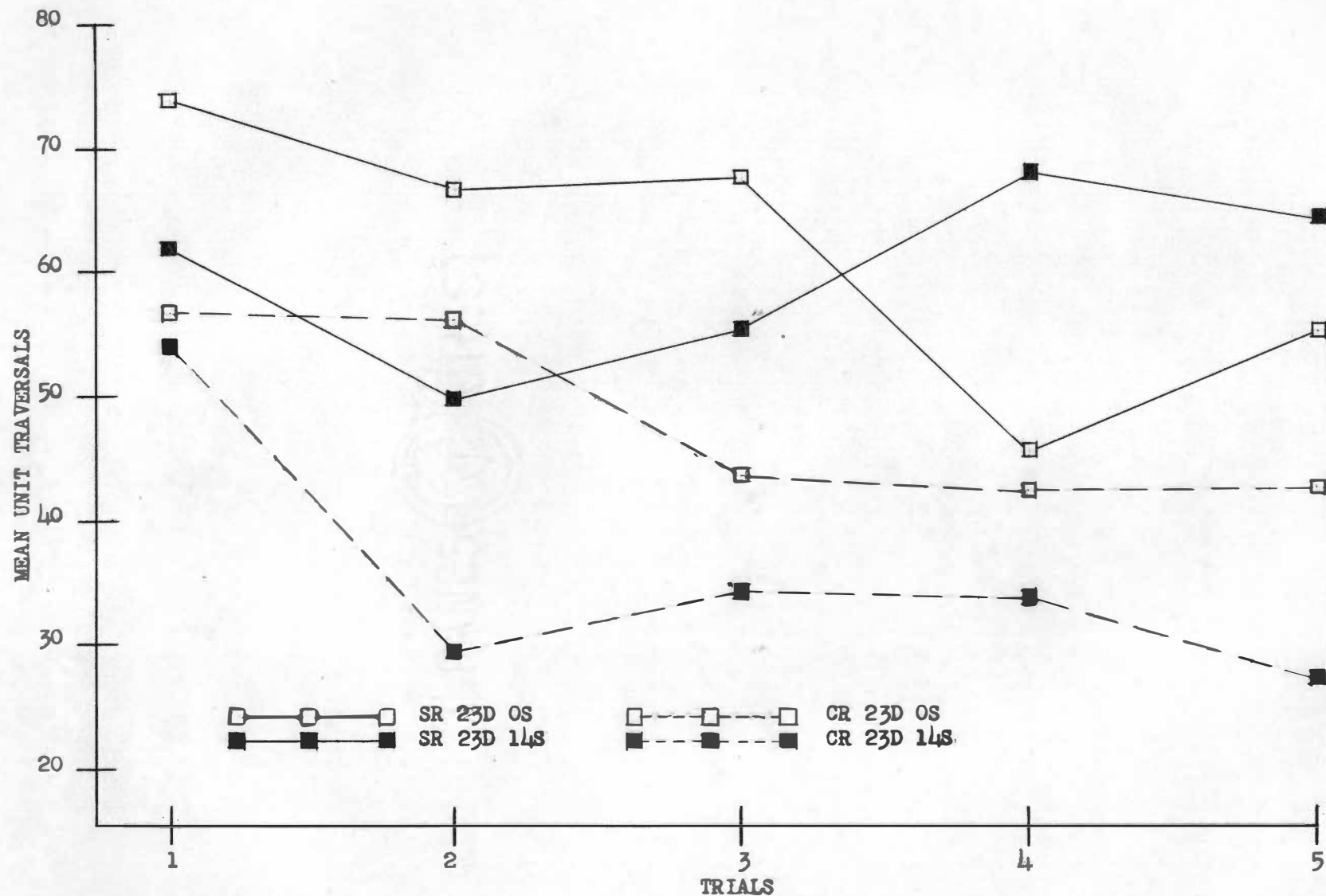


Fig. 2. Mean unit traversals across trials for four groups under two conditions of drive stabilization and two conditions of runway complexity.



TABLE 8

SUMMARY OF ANALYSIS OF VARIANCE  
IN THE STABILIZATION COMPARISON

Source	df	Mean Square	F
Between Ss	29		
Stabilization	1	1,781.203	4.36
Complexity	1	11,008.166	26.93***
Stabilization x Complexity	1	946.964	2.32
error	26	408.745	
Within Ss	120		
Trials	4	1,280.857	2.01
Trials x Stabilization	4	739.803	1.16
Trials x Complexity	4	150.784	.24
Trials x Stabilization x Complexity	4	485.397	.76
error	104	638.069	
Total	149		

\*\*\*  $p$  less than .001.

is unlikely that stabilization is a factor in the nonstabilized deprived groups.

A minute-by-minute consistency analysis similar to that performed in the deprivation comparison was performed on the data of the stabilization groups. The results of this are shown in Table 9. To facilitate comparison with the nonstabilized groups their data is also shown in the table. The mean for the simple runway stabilized group (SR 24D 14S) was 42.00, and 54.00 for the complex runway stabilized group (CR 24D 14S). Inspection of Table 9 shows, as in the deprivation analysis, no important trial differences and a greater percentage decline for the first column. Testing this latter against the others by the Wilcoxon T-test again gave a probability of less than .01. The mean of the simple runway groups was 45.25 and the mean of the complex runway groups was 53.75, the differences here were significant at better than the .05 level by same test. The minute-by-minute sums for runway complexity and the resulting quotients are shown in the middle of Table 16. As in the nonstabilized deprivation analysis, the disparity was greatest between the second and third trials, though here in the opposite direction. Analysis by the Wilcoxon T-test showed insignificance at the .05 level. The mean for the combined nonstabilized groups was 51.00; the mean for the combined stabilized groups was 48.00. These differences are not significant at the .05 level by the Mann-Whitney-Wilcoxon T-test.

The last-minute-to-first-minute percentage increases are shown for the stabilization groups at the middle of Table 17. No important differences are apparent.

TABLE 9

PERCENT OF SS SHOWING DECREASED MINUTE-TO-MINUTE  
INTRATRIAL UNIT TRAVERSALS. STABILIZATION  
ANALYSIS.

Trial	Group	Minutes				Mean
		1 - 2	2 - 3	3 - 4	4 - 5	
1	SR 23D OS	70	20	50	60	50.0
	SR 23D 14S	100	0	40	20	40.0
	CR 23D OS	70	40	50	40	50.0
	CR 23D 14S	80	100	40	20	60.0
Mean		80.0	40.0	45.0	35.0	50.0
2	SR 23D OS	60	40	40	40	45.0
	SR 23D 14S	80	20	40	20	40.0
	CR 23D OS	100	50	50	40	60.0
	CR 23D 14S	100	80	20	60	65.0
Mean		85.0	47.5	37.5	40.0	52.0
3	SR 23D OS	80	50	30	50	52.5
	SR 23D 14S	80	60	20	40	50.0
	CR 23D OS	100	30	30	30	47.5
	CR 23D 14S	40	40	60	40	45.0
Mean		75.0	45.0	35.0	40.0	38.75
4	SR 23D OS	80	50	40	30	50.0
	SR 23D 14S	80	20	0	80	45.0
	CR 23D OS	90	30	40	80	60.0
	CR 23D 14S	80	40	60	40	65.0
Mean		82.5	35.0	35.0	57.5	52.50
5	SR 23D OS	70	50	20	40	45.0
	SR 23D 14S	40	20	60	20	35.0
	CR 23D OS	70	50	30	50	50.0
	CR 23D 14S	80	40	40	20	45.0
Mean		65.0	40.0	37.5	32.5	43.75
Grand Mean		77.50	41.50	38.00	41.00	

### The Effects of Age

The mean minute-by-minute means and the total scores for the two groups of thirty-five day old animals are shown in Tables 10 and 11 respectively. The trial means for these two groups (SR 35 and CR 35) along with those of groups SR 90 OD and CR 90 OD are plotted in Figure 3. The variances for each trial of the thirty-five day groups are shown in Table 19. A Hartley  $F_{\max}$  test performed on these trial variances and those of the nondeprived groups in Table 15 gave an  $F_{\max}$  of 17.86. Unfortunately, no tables could be found that contained values for the twenty mean squares used, but a free hand extrapolation of the Pearson and Hartley tables (1956, p. 179) indicated that the two-sided probability was near .05. This would indicate marked but not extreme heterogeneity and some caution must be used in evaluating the probability figures based on parametric techniques using these scores.

As with the deprivation analysis, the analysis of variance performed on trial means yielded a significant  $p$  for the triple interaction of complexity  $\times$  age  $\times$  trials, though the  $p$  here was only .05. This necessitated another trend analysis of variance, the results of which are summarized in Table 12. The overall trend here was not significant; this fact indicates the scores did not vary much from trial to trial. However, the significance of the quadratic component indicates that the summed curves do not simply form a horizontal line. Inspection of Figure 3 would show instead that they would form a U-shaped function with a minimum at the second or third trial. The overall group differences were not significant at the desired level. The only significant differences in group trends were as a result of differences in slope. These differences

TABLE 10

MEAN UNIT TRAVERSALS PER MINUTE OF 35 DAY OLD  
SS UNDER TWO CONDITIONS OF RUNWAY  
 COMPLEXITY<sup>a</sup>

Minute	Trial									
	1		2		3		4		5	
	Simp.	Comp.	Simp.	Comp.	Simp.	Comp.	Simp.	Comp.	Simp.	Comp.
1	10.6	12.1	13.1	14.3	14.7	16.8	12.5	16.7	15.4	20.6
2	7.9	12.5	11.5	10.2	10.5	10.2	10.0	10.3	10.9	11.0
3	12.2	9.2	7.8	8.5	8.6	9.8	9.4	10.8	7.8	11.9
4	9.9	8.2	7.0	8.7	4.7	9.3	8.5	9.2	11.2	11.1
5	10.5	8.4	5.2	8.6	7.4	10.3	9.9	8.7	8.1	12.7
Total	51.1	50.4	44.6	50.3	45.9	56.6	50.3	55.7	53.4	67.3

<sup>a</sup>N = 10 per group

TABLE 11

INDIVIDUAL TOTAL UNIT TRAVERSALS OF 35 DAY OLD SS  
UNDER TWO CONDITIONS OF RUNWAY COMPLEXITY

S	Simple	Complex
	457	299
	320	234
	98	253
	212	341
	265	382
	219	313
	44	119
	224	239
	180	293
	434	330
Mean	245.3	280.3

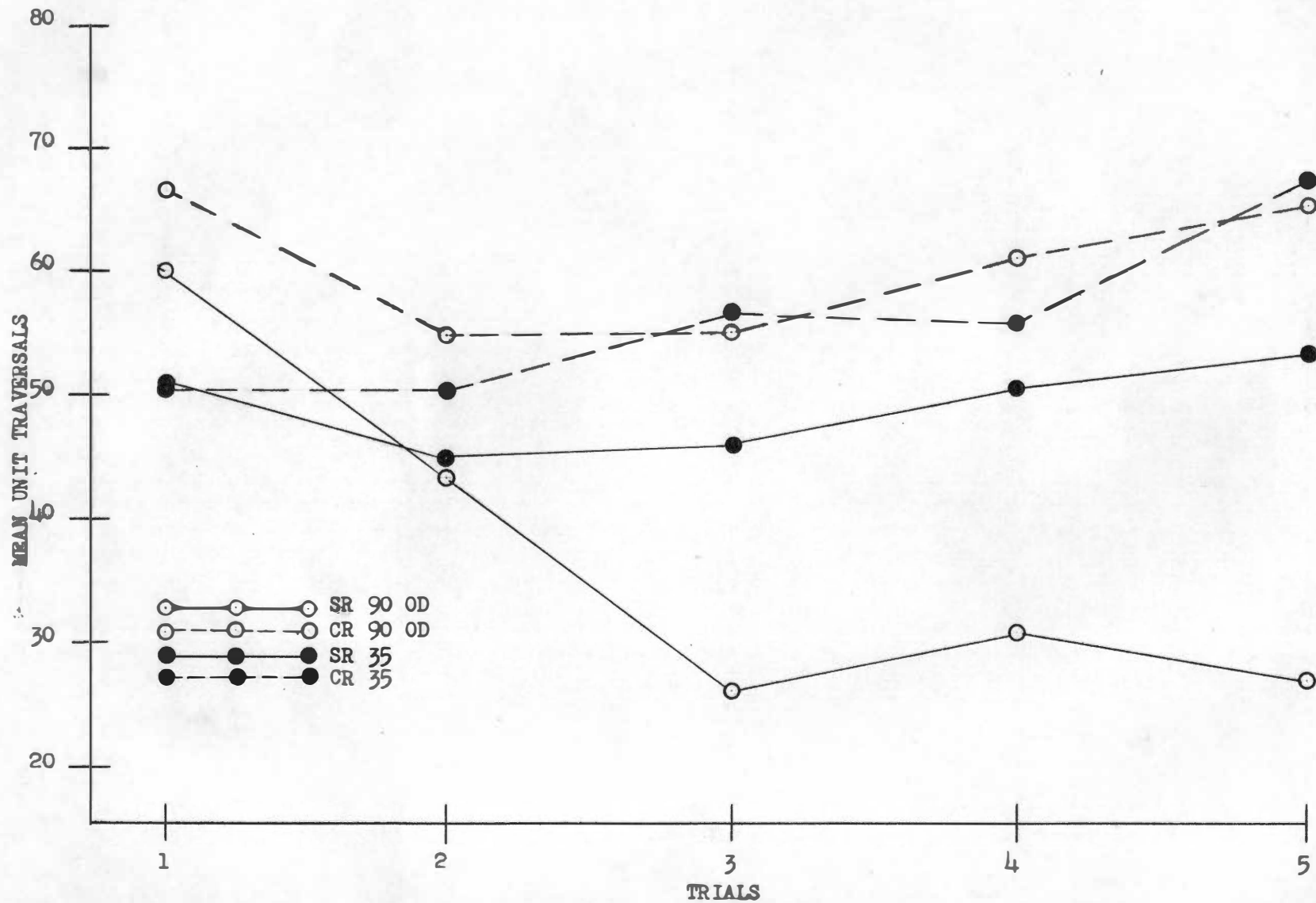


Fig. 3. Mean unit traversals across trials for four groups under two age conditions and two runway conditions.

TABLE 12

SUMMARY OF ANALYSIS OF TRENDS OF UNIT TRAVERSALS PER TRIAL  
IN THE AGE COMPARISON

Source of Variation	df	Mean Square	F
A. Over-All Trend	4	752.080	2.18
1. Linear	1	172.923	.31
2. Quadratic	1	2,644.802	10.88**
3. Cubic	1	174.240	.44
4. Quartic	1	16.356	.09
B. Between Group Means	3	5,144.773	2.33
a. Complexity	1	11,430.720	5.18
b. Age	1	706.880	.32
c. Interaction	1	3,296.720	1.49
C. Between Group Trends	12	748.390	2.17
1. Linear	3	2,606.802	4.65
a. Complexity	1	3,152.822	5.63*
b. Age	1	3,925.022	7.01*
c. Interaction	1	742.563	1.33
2. Quadratic	3	133.445	.55
a. Complexity	1	41.802	.17
b. Age	1	356.802	1.47
c. Interaction	1	1.715	.01
D. Between Individual Means	36	2,208.178	6.39***
E. Between Individual Trends	144	345.457	
1. Linear	36	560.116	
2. Quadratic	36	243.118	
3. Cubic	36	391.863	
4. Quartic	36	187.020	
Total	199		

\* p less than .05  
 \*\* p less than .01  
 \*\*\* p less than .001



are reflected in both runway complexity and age comparisons. From inspection of Figure 3 it would appear that the summed curves of the simple runway groups gave a negative slope whereas those of the complex runway groups were more nearly horizontal or even slightly positive. Similarly, the summed curves of the older groups yielded a negative slope whereas those of the younger groups were horizontal. Both of these slope differences appear due to the marked negative slope of a single group -- SR 90 OD. The shapes of the other group curves are nearly identical. As with the other trend analysis the differences between individual means were highly significant, again indicating high reliability of measurement.

It was thought, before testing began, that despite overall insignificance, there might be significant differential effects over trials between age groups. It was felt that the young Ss would be initially more fearful than the old Ss, and explore less. However, this fear would dissipate with continuing exposure, and the young Ss would explore more than their older counterparts toward the end of the five trials. That this did not happen where total trial scores were used is evident from the preceding trend analysis. It was therefore decided, to test for this effect in the first minute of the trials, since it was thought that the effect might have been vitiated by the continued exposure after the first minute. Accordingly, an analysis of variance was run on the first minute, first trial scores. The results of this analysis are summarized in Table 13. None of the differences were significant. However, the scores were in the suggested direction. The mean for the young Ss was 10.85, the mean for the old Ss was 15.00. To test for the effect over trials, a savings score for each subject was obtained. This score was

TABLE 13

SUMMARY OF ANALYSIS OF VARIANCE  
OF FIRST MINUTE UNIT TRAVERSALS  
IN FIRST AND FIFTH TRIALS.  
AGE COMPARISON

Source	df	Mean Square	F <sup>a</sup>
Between Subjects	3	133.225	3.86
Age	1	11.250	3.66
Complexity	1	1.800	.31
Age x Complexity	1	36.417	.05
Within Subjects (error)	36		
Total	39		

<sup>a</sup>All ps higher than .10

computed by subtracting the score for each S for the first minute of the first trial from the score for the first minute of the fifth trial, and dividing the result by the former. These scores were summed across runway complexity for each age group. The mean saving score was positive (.87) for the young Ss and negative for the older Ss (-.07). The critical ratio for the differences was 2.97, significant at better than .004. Since the mean for the first minute of the fifth trial was 18.00 for the young Ss and 11.85 for the old animals, this would indicate that the young Ss had significantly increased exploration between the two periods, while the old Ss declined or remained the same.

An intratrial minute-by-minute consistency analysis similar to those outlined above was also performed on the age comparison data. The resulting percentages, as well as those of the ninety day nondeprived groups are shown in Table 14. The effects here are almost identical to the other findings. The intertrial means show no important differences. The first column shows a greater percentage decrement than the others and the probability that this was due to chance is less than .01 when calculated by the Wilcoxon T-test. The group means are as follows: SR 90 OD: 38.50; CR 90 OD 55.00; SR 35: 50.5; and CR 35: 58.5. When the mean trial percentages were summed across age, the runway complexity means were 44.50 and 56.75 for simple and complex runway respectively. These were significantly different at the .01 level by the Mann-Whitney-Wilcoxon T-test. The summed percentages for complexity across minutes are shown toward the bottom of Table 16. As in the other analyses, the disparity was greatest from the second to the third minute. However, again this difference was insignificant at the .05 level when tested against the

TABLE 14

PERCENT OF SS SHOWING DECREASED MINUTE-TO-MINUTE  
INTRATRIAL UNIT TRAVERSALS.  
AGE ANALYSIS

Trial	Group	Minutes				Mean
		1 - 2	2 - 3	3 - 4	4 - 5	
1	SR 90 OD	80	50	40	20	47.5
	CR 90 OD	60	20	50	60	47.5
	SR 35	60	20	50	40	42.5
	CR 35	50	60	60	60	57.5
Mean		62.5	37.5	50.0	45.0	48.75
2	SR 90 OD	40	40	40	40	40.0
	CR 90 OD	90	70	40	70	67.5
	SR 35	30	60	50	40	45.0
	CR 35	90	90	60	40	70.0
Mean		62.5	65.0	47.5	47.5	55.63
3	SR 90 OD	30	50	40	40	40.0
	CR 90 OD	70	20	60	40	47.5
	SR 35	80	70	50	30	57.5
	CR 35	90	40	50	20	50.0
Mean		67.5	45.0	50.0	32.5	48.75
4	SR 90 OD	50	50	10	20	32.5
	CR 90 OD	90	30	60	50	57.5
	SR 35	60	50	50	30	47.5
	CR 35	100	50	50	30	57.5
Mean		75.0	45.0	42.5	32.5	48.75
5	SR 90 OD	40	40	20	30	32.5
	CR 90 OD	80	40	50	50	55.0
	SR 35	70	60	40	70	60.0
	CR 35	100	40	50	40	57.5
Mean		72.5	45.0	40.0	47.5	51.25
Grand Mean		68.0	47.5	46.0	41.0	

average of the other three columns by the Wilcoxon T-test. When the trial means were summed across complexity for age, the young groups gave a mean of 54.50 and the old groups one of 46.75. The probability of this difference just missed the .05 significance level by the Mann-Whitney-Wilcoxon T-test.

As with the older animals, the last-to-first minute intertrial percentage increases were computed and these are shown toward the bottom of Table 17. Again no important differences were apparent here.

## CHAPTER IV

### DISCUSSION AND CONCLUSIONS

The findings reported here neither corroborate completely nor contradict completely the research preceding and leading up to them. Mostly they suggest new phenomena, the meaning of which is not entirely clear.

First, on the dimension of nonstabilized deprivation. There is no evidence from the data herein cited that food deprivation in and of itself has either a simple elevating or simple depressing effect on exploration as defined. This fact is reflected in the insignificance of differences of total exploration scores when they are summed for degree of deprivation across trials or runway complexity. This is in contradiction to both the studies which report a simple increase with deprivation (e.g., practically all the activity wheel studies, and Jerome, Moody, Conner, and Fernandez, 1957) and to these that report a decrease with deprivation (e.g., Montgomery (1953b) and Zimbardo and Montgomery (1957)). Similarly, the direction of the interaction between deprivation and situation complexity is apparently a unique phenomenon. Where Adlerstein and Fehrer (1955) report that complexity increased the number of exploratory responses for the deprived Ss, there is a strong suggestion here that the more complex runway served to decrease exploration as a function of increasing deprivation. This phenomenon is also at variance with the suggestion made in Chapter I that increasing stimulus complexity should increase the superiority of the deprived groups because of the survival value involved. However, the overall decreased performance

of the complex runway deprived groups should not be overestimated. For one thing, the effect did not withstand internal replication; for another, doing an isolated analysis of variance on these groups, even though it is an illegitimate operation in terms of the total analysis, did not yield significance at the .05 level. Nevertheless, the fact that there was no suggestion of increased exploration among these groups themselves and in comparison to the simple runway groups strongly militates against the deprivation-complexity interaction heretofore hypothesized and reported.

What then were the significant effects? Aside from this decreasing performance with increasing deprivation among the complex runway groups, the only other contribution to overall (i.e., summed across trials) significance comes from the scores of the nondeprived simple runway group. This group showed significantly less exploration than any of the others. The subjects in this group were also deviant in their low mean percentage intratrial decrease percentages and in their low mean first-to-last minute percentage increases. In addition, this group showed the most consistent decline over trials. Why this should be is not apparent. That this is probably not the result of sampling is indicated by the fact that these Ss' first trial scores were similar to those of the other groups used in the deprivation analysis. Since no explanations short of those which deny the other data comes to mind (e.g., both complexity and hunger serve to elicit exploration and this is the least-hungry-least-complex-group) no attempt is made to integrate this finding into any sort of schema.

However, the most significant effects were the ones which occurred across trials for the different groups. Unfortunately, though, since no

other experimenters report exploration data for a given level of deprivation for more than one trial, it is difficult to evaluate these effects. The trial significances here were primarily due to the increased performance of the forty-seven hour deprived groups, particularly the simple runway group, after the third trial. Though there was a decrease in exploration decrement by the fourth trial, and two groups (CR 90 OD and SR 24D OS) did show increased exploration, none did so to the extent of the forty-seven hour groups. This is particularly surprising since most of the Ss in these two groups would have died of inanition in a few more days if their deprivation schedule were so continued. A not very convincing explanation suggests itself. The higher emotionality (hypothetical) due to the enfeebled condition of the forty-seven hour deprived Ss led to an initial greater fearfulness of the exploratory situation and consequently reduced exploration in the early trials. With increasing exposure, this dissipated and the exploration-inducing effects of drive asserted themselves. There is some evidence for this in the fact that the forty-seven hour complex runway group explored less initially than its simple runway counterpart -- i.e., the more complex situation was more fear-producing. However the fact that the complex runway group showed a slight decline during the fifth trial after its fourth trial jump militates against this.

As the analysis for the effects of drive stabilization showed, there were no significant differences for either degree of runway complexity between the stabilized and nonstabilized groups. In accordance with Glanzer's (1958) suggestion; had the stabilized groups explored more, the effect of nonstabilized drive might be assumed to be predom-



inantly distracting; had they explored less, it might be assumed to be predominantly energizing. That they neither explored more nor less boils down logically to four alternatives; 1) that there is no change in predominance of either drive effect as a function of stabilization; 2) that drive has only an energizing effect on ongoing behavior, including locomotion, and that this does not change with stabilization; 3) that drive has only a distracting effect and that this does not change with stabilization; and 4) that drive has neither an energizing nor distracting effect upon exploration. The third alternative may be dismissed by definition, since if the effect of drive is not energizing, then what is it? The fourth may be rejected on the basis of the differential performances of the various drive groups across trials. Alternative two is also in contradiction to the data, since if the effect of drive was simply energizing, exploration would be an increasing function of increased drive. This leaves only the first alternative as likely.

However, issue may be taken with the whole comparison on the grounds that drive was increasing for the nonstabilized Ss during the trials. As Reid and Finger (1955) showed, rats lose weight for at least ten days on a one hour daily feeding schedule, and the nonstabilized Ss were actually at a lower drive level throughout the experiment, particularly during the initial trials, thus confounding any possible real effects due to stabilization. The fact that the curves of the stabilized and nonstabilized groups did not converge over the trials is some evidence against this, i.e., if exploration is a function of drive level, defined as percent of satiated body weight, then the nonstabilized groups

should approach the exploration level of the stabilized groups with increasing number of days (or trials) on the deprivation schedule. Nevertheless, this lack of convergence may have been due to a trial interaction effect. It is therefore suggested that further experimentation be done to establish the effects of stabilization, with percent satiated body weight held constant instead of hours feeding. This was not done here because of the fear of differential effects resulting from differential amount of handling involved in weighing the Ss. That this is probably not an important factor may be inferred from the fact that the Budd Mountain animals, whose handling history was probably different from that of the University of Tennessee stock, did not appear to be different from them in most respects.

The only significant difference between the stabilized groups was the greater exploration of the simple runway groups. Again, the meaning of this is not clear.

This discussion of the effects of deprivation may be concluded with the observation that one thing remains clear: there are differences, whatever their meaning, across trials resulting from differences in deprivation and the interaction of these with situation complexity. Practically all preceding research in dealing with these variables has confined measurements of exploration to a single score per subject or to scores during contiguous temporal intervals, for any given level of deprivation. It is therefore strongly suggested that future research concern itself with these intertrial effects.

The results from the age analysis also stand in some contrast to

those previously reported. Chiefly, there were no overall differences favoring the younger animals. In addition, there were no significant differences in percent of subjects showing decreased responses over successive intratrial minutes, though there is a suggestion that this percentage was greater for the younger animals. What significant trial differences were present were due primarily to the deviantly low performance of the Ss in Group SR 90 OD. The age-fear interaction suggestion, which predicted that the younger Ss would start out at a lower exploration level than the older Ss, and eventually surpass them, was not vindicated by the mean trial scores. There is evidence for it in the analysis which relates the first minute scores on the first and fifth trials. However, this is somewhat vitiated by the fact that the significance of this effect is also due to the deviant performances of Ss in Group SR 90 OD. The reasons for the relative lack of significant overall age differences may be partially attributed to the relatively small actual age differences. The young group might have been younger. Had it not been originally desired to replicate the deprivation and stabilization findings on the young animals, these Ss might have been twenty-one days old at the first trial. The older Ss were not really old. Their age would correspond to early adulthood in humans. Should further experimentation in this area be done with age as an independent variable it is suggested that groups spaced further apart on this dimension be used.

The overall effects exclusive of experimental parameters are perhaps the most interesting. For one thing, there was no wholesale decrement in exploration across trials. If anything, a curve for all trial

data would probably fit a quadratic function with a minimum at about the third trial, at a high degree of significance. This unusual finding fits no previously promulgated explanation; not even explanations which contradict each other. In the view of previous writers, the two main uncontrolled variables in any exploratory situation are fear and stimulus satiation. Welker (1957) claims that fear should lead to increased locomotion, i.e., escape. This would explain the first half of the quadratic curve: With increasing exposure, fear dissipates, and therefore so does locomotion. However, it is to be assumed that the novel, exploratory drive producing aspects should also dissipate. Why, therefore, should exploration increase after the third trial? Montgomery (1955) and Montgomery and Monkman (1955) state that fear should lead to decreased exploration. The Ss are presumably most fearful on the first trial and should therefore explore least. This is not the case here. Perhaps a more satisfactory, though more complex explanation may be derived from a synthesis of these two. Fear may be postulated as having a facilitating effect on locomotion, but a depressing one on exploration. With the waning of fear, locomotion decreases. The exploration-inducing situation stimuli that the animal had been "blind" to while trying to escape then take effect, and exploration begins and locomotion increases. Presumably, after a sufficient exposure (more than allowed in this experiment) exploration falls off as a result of stimulus satiation. This explanation is of course at variance with the operational definition used here, which equates exploration with locomotion. In addition, it is quite hypothetical. Nevertheless, it is the only one which seems capable of handling the data.

However, whatever the explanation for the effects across trials, the one for the intratrial effects is probably different. Here the usual exploration function held, with ~~greatest~~ greatest exploration during the first minute and a subsequent decrease. The fact that neither this nor last-to-first-minute increase varied in an important way from trial to trial strongly suggests that intra and intertrial locomotion are a function of different controlling variables. This is an extremely interesting phenomenon well worth further investigation.

The final item of significance is the disparate levels of intratrial decrement between the summed simple and complex runway groups, with the latter showing the greater decrement. Since the probability figures for this reported in Chapter III are not independent, i.e., some of the same groups were used in arriving at them, it is not legitimate to combine them. Nevertheless, there is no doubt that this effect is highly significant. Its meaning is puzzling. Inspection of the data does not indicate this to be an artifact of higher initial exploration for the complex groups, since this did not occur. When the facts are regarded anthropomorphically and in terms of all the theories put forth to deal with exploratory behavior, it must be concluded that the opposite should have happened: the Ss in the complex situation having more to explore, should have shown a smaller decrement. That they did not is at variance with practically all experimentation and theorizing that has gone on in this area, and this finding is certainly in need of replication.

## CHAPTER V

### SUMMARY

An experiment was conducted to ascertain the effects of nonstabilized food deprivation, stabilized food deprivation, runway complexity, and age on exploratory behavior of male albino rats both during and across five five-minute trials. Three levels of deprivation: zero, twenty-three, and forty-seven hours were used. The stabilization dimension included groups stabilized on the twenty-three hour schedule for zero and fourteen days prior to the beginning of the experiment. The two age groups were respectively about thirty-five and ninety days old at the beginning of the experiment. All groups were equally divided into simple and complex runway groups. The simple runway groups were exposed to a fifteen foot straight runway, the complex group to a runway different only in that there were right angle turns every twelve inches. The only measurement taken was the number of twelve inch runway units traversed during each minute of the trials. The data were analyzed for differences in trend for the total trial sums and for intratrial effects.

The major findings are as follows: 1) There were no significant differences for degree of deprivation, stabilization of deprivation or age when the group sums were taken exclusive of trials. 2) There was a suggestion of decreasing exploration with increasing deprivation for the complex runway groups. 3) The forty-seven hour deprived groups showed a marked increase in exploration after the third trial. 4) There was a significant difference favoring the simple runway stabilized deprived group when compared to its complex runway counterpart. 5) There was a

suggestion of an age-complexity interaction; the young Ss starting low and showing increased exploration, the older Ss either remaining the same or showing decreased exploration. 6) The across-trials shape of the summed group curves was curvilinear with a minimum at about the third trial. 7) The intratrial curves for all groups showed that Ss in all groups showed the greatest decrease in exploration at the beginning of the trial with little subsequent change, and that there was an increase with the beginning of a new trial. 8) The percentage of subjects declining during the intratrial intervals was greater for the complex runway groups than for the simple runway groups.

An attempt was made to explain some of these findings. Others were simply allowed to stand by themselves. Future experiments with these variables were suggested, with particular emphasis on trial effects.

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## APPENDIX

TABLE 15

VARIANCES PER TRIAL OF MEAN UNIT TRAVERSALS UNDER  
THREE CONDITIONS OF DEPRIVATION AND TWO  
CONDITIONS OF RUNWAY COMPLEXITY

Trial	Runway					
	Simple			Complex		
	Deprivation (Hours)					
	0	23	47	0	23	47
1	537.07	7782.01	901.73	260.27	373.79	396.18
2	823.43	1027.43	824.46	651.16	976.10	592.22
3	452.18	822.84	748.32	358.40	608.27	369.82
4	1069.83	376.94	873.21	428.49	562.62	622.77
5	1414.23	1201.96	1149.82	670.10	535.60	585.11

TABLE 16

SUM OF GROUP INTRATRIAL PERCENTAGE DECREASES BY  
RUNWAY COMPLEXITY

Complexity	Minutes			
	1 - 2	2 - 3	3 - 4	4 - 5
<b>Deprivation Analysis:</b>				
Simple	940	610	570	570
Complex	1,180	580	730	720
Simple/Complex	.80	1.05	.78	.79
<b>Stabilization Analysis:</b>				
Simple	740	330	340	400
Complex	810	500	420	420
Simple/Complex	.90	.66	.81	.95
<b>Age Analysis:</b>				
Simple	820	460	530	460
Complex	540	490	390	360
Simple/Complex	.66	1.07	.74	.78
<b>Total:<sup>a</sup></b>				
Simple	1,530	990	970	960
Complex	1,990	1,120	1,220	1,090
Simple/Complex	.77	.88	.80	.88

<sup>a</sup>Duplicated percentages are omitted in total sums.

TABLE 17

PERCENT OF SS SHOWING INCREASED UNIT TRAVERSALS FROM  
LAST MINUTE OF TRIAL TO FIRST MINUTE OF NEXT  
TRIAL

Group	Trials				Mean
	1 - 2	2 - 3	3 - 4	4 - 5	
Non-Stabilized Deprived:					
SR 90 OD	30	40	50	20	35.0
SR 23D OS	70	70	60	100	75.0
SR 47D	60	50	40	60	52.5
CR 90 OD	90	80	80	80	82.5
CR 23D OS	50	50	70	80	62.5
CR 47D	50	80	50	70	62.5
Stabilized-Deprived:					
SR 24D 14S	40	100	80	100	80.5
CR 24D 14S	60	100	80	80	80.5
Younger Groups:					
SR 35	50	80	70	50	62.5
CR 35	80	80	100	100	90.0
Mean	58.0	73.0	67.0	74.0	

TABLE 18

VARIANCES PER TRIAL OF MEAN UNIT TRAVERSALS  
UNDER TWO CONDITIONS OF RUNWAY  
COMPLEXITY FOR STABILIZED SS

Trial	Runway	
	Simple	Complex
1	381.50	201.70
2	460.20	135.30
3	137.30	221.50
4	269.50	360.50
5	456.50	279.30

TABLE 19

VARIANCES PER TRIAL OF MEAN UNIT TRAVERSALS UNDER TWO CONDITIONS  
OF RUNWAY COMPLEXITY FOR 35 DAY OLD SS

Trial	Runway	
	Simple	Complex
1	679.66	126.71
2	1,031.60	313.79
3	579.21	537.16
4	2,262.90	393.12
5	1,324.04	446.68