ENVIRONMENTAL PREFERENCE: A MULTIDIMENSIONAL ANALYSIS OF THE RAT'S RESPONSE TO THE COMPLEXITY OF ITS SURROUNDINGS

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ABSTRACT

ENVIRONMENTAL PREFERENCE: A MULTIDIMENSIONAL ANALYSIS OF THE RAT'S RESPONSE TO THE COMPLEXITY OF ITS SURROUNDINGS

By

Michael Denny

The complexity of an animal's environment can be defined on numerous variables. The significance of the level or the presence or absence of these variables varies among species. Further, the optimal level of environmental complexity which an animal may seek can change as the organism-environment interaction changes. Environmental preference has usually been determined by examining a few specific responses to an operationally defined complexity dimension. The common dependent measure has been approach behavior in the form of a choice response measured under the assumption of a fixed organism-environment interaction.

The present study used 20 albino rats to examine the multiplicity of responses made during a 48 hour period of confinement to a large (32 square feet) four compartment cage. The four compartments represented four levels of three-dimensional complexity. Each compartment, containing its own food, water and resting box, had a monitoring capability which allowed continuous recording of movement in and out of

the compartment as well as general locomotor activity.

An artificially controlled 12 hour light and dark cycle was maintained throughout the experiment and was treated as a two level factor in an ANOVA along with the four level complexity factor. The ANOVA was applied independently to a number scores in order to assess the differential responses to complexity and illumination. A total of 15 different scores derived from general activity including locomotion, feeding, resting and defecation were analyzed under ANOVA and appropriate nonparametric tests. In addition, a correlational review of the scores was made.

Results indicated that the highest complexity level was preferred over the others on a number of scores reflecting appetitive behavior and one score reflecting consummatory behavior - resting. In general, preference in terms of these criterion scores was a positive monotonic function of complexity. It was also found that the complexity effect was considerably reduced during the night periods. In fact, the overall behavior patterns were markedly different between day and night with most activity and feeding occurring in the night period.

It was suggested that high complexity is preferred because of its association with shelter and relaxation. Movement between compartments was discussed in terms of stimulus discrepancy from an adaptation based standard which was found to account best for short-term patterns. Arousal explanations of complexity preference (e.g. Fiske and Maddi,

1961) were not confirmed.

The study also included a discrete trial phase incorporating a more traditional paradigm for preference testing. The test tended to reinforce the first phase findings. Based on a correlational comparison of the two phases the complexity effect was interpreted as a shelter seeking response reflecting an escape tendency induced by the mildly aversive character of the procedure.

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TABLE OF CONTENTS

Table of contents (continued)

LIST OF TABLES

List of Tables (continued)

LIST OF FIGURES

List of Figures (Continued)

INTRODUCTION

The experimental study of environmental preferences has historically been limited to two rather distinct areas of investigation. On the ethological side, the habitat preferences of a variety of organisms have been tested along specified environmental dimensions (e.g. Harris, 1952; Sexton et. al., 1964; Kolpfer, 1963; Sale, 1969; Reese, 1963; Kolpfer and Hailman, 1965). The dimensions of interest were of a species-specific nature, simulating natural conditions (e.g. foliage or cover type, water depth, shell configuration, etc.) For example, in the field, Wecker (1963) experimentally tested deer mice of different environmental-genetic backgrounds for selection of natural woods or grassland habitats using a number of behavioral measures. He found that both heredity and early experience contributed to the definition of a habitat preference.

The other line of investigation has dealt with preference for a specific, biologically weak, aspect of the environment. This means any factor of an environment, which is not essential to the maintenance of the organism as opposed to such factors as food, shelter and temperature. Stimulus complexity, having been treated as an elicitor of exploratory or approach behavior (Dember et al., 1957; Berlyne, 1950; Welker, 1957) and as an operant reinforcer (Butler, 1953; Barnes and Baron, 1961), has been experimentally the most productive of these environmental variables. Although some of these early studies failed to isolate complexity from novelty they did show that the preference for complexity increased over exposure time suggesting an interaction between novelty and complexity.

A major reason responsible for the confounding of complexity with novelty was the failure to define adequately the concept of stimulus complexity. This situation has since been rectified primarily by the distinction made between two operationally defined forms of complexity. Berlyne and Slater (1957) produced complexity by either changing the stimulus on each trial ('Y' maze problem) or providing a well differentiated complex stimulus on all trials. They considered these procedures to yield 'successive' and 'simultaneous' complexity, respectively, where only successive complexity involved novelty. Persistent exploration was found only in the simultaneous complexity condition. Another way of viewing this distinction separates complexity into dynamic and static stimulus states. Thus, if an environment is highly complex in physical structure but is unchanging it is reflecting static complexity. On the other hand, a stimulus can be considered complex because short-term or frequent changes in its quality or magnitude occur. This would be an example of dynamic complexity.

The concern of the present study is with static complexity which can be defined by the number and variety of three-dimensional elements fixed in a given space or in other words, the density and heterogeneity of elements in the stimulus field (Berlyne, 1960). These independent parameters of complexity were linked together such that progressively higher operational levels of complexity always represented increases in both the density and heterogeneity of elements in the environment. In all other ways environmental stimuli were constant across levels and over time (excluding illumination cycles). This means that, essentially, after an initial exposure to all levels, the animal becomes familiar with the environment and no stimuli can be considered novel except in the restrictive sense of short-term novelty (Berlyne, 1960) which is present any time a change occurs in the animal's perception of the proximal stimulus complex.

The Significance of Environmental Complexity.

The relevance of static environmental complexity to the individual is primarily a subject of conjecture, however, a number of possibilities exist. Ecological studies have only considered environmental complexity in terms of species diversity (e.g. Kohn, 1967; Rosenzweig and Winakur, 1969) but the higher abundance as well as diversity of fauna found to be associated with more complex environments suggests an environmental contribution to the success or viability of the individual. The contribution may stem from the organism's use of complexity as a stimulus dimension to pattern its physical world. For example, its cue value (association with or information about the environment) may be instrumental in locating appropriate shelter, food or conspecifics. At this juncture, any biological effect of environmental complexity is a mediated one not necessarily crucial to the maintenance of the organism. In this vein, Hilden (1965) suggests that:

> The process of habitat selection is not likely to be a response to ultimate factors, but to series of proximate factors. These may, in themselves, lack any direct biological meaning for the organism, but will collectively define habitats likely to possess the necessary ultimate factors.

Conversely, environmental complexity may contribute directly to the development and maintenance of the biology, including nervous functioning of the animal. Investigations have shown that environmental complexity can affect brain development (Rosenzweig, _et_ _al_., 1962; Riege, 1971), learning behavior (Bingham and Griffiths, 1952; Hynovitch, 1952) and emotional reactivity (Denenberg, 1964, 1967). The adaptive value of approaching complex stimulus situations, considering these results, is inherent in the consequences of experiencing the complexity. Hebb (1949) has theorized that optimal perceptual and intellectual functioning requires a background of some sufficient level of sensory stimulation. The idea that organisms tend to actively seek this level of stimulation has been forwarded rather independently by a number of researchers including Hebb (1955), Leuba (1955), Dember and Earl (1957), McClelland, Atkinson, Clark and Lowell (1953), Schneirla (1959) and Butler and Harlow (1954).

Stimulation Seeking

Excluding Schneirla and Harlow, most discussions of stimulation seeking have included the hypothesis that approach or orientation behavior is a $\cap$-shaped function of the discrepancy between a standard and a new level of stimulus complexity or intensity. While these interpretations rest at the stimulus level some authors have extended their theoretics to focus on the concomittant effects of the stimulus. More precisely, they posit that higher animals tend to select stimulus levels which result in moderate changes in their "arousal" level (Berlyne, 1960; Fiske and Maddi, 1961). Thus we find both stimulus-based and response-based forms of the discrepancy hypothesis. The response-based form implies that the attractiveness of a discrepant stimulus rests on the character of the resultant responses induced by the stimulus. The stimulus-based form implies that the attractiveness is simply the approach eliciting strength of the stimulus itself. If the level of induced arousal is positively and monotonically related to the degree of change in a stimulus, then both forms yield identical predictions of the stimulus' attractiveness. Attractiveness is used here as if it were operationally defined in terms of approach or choice strength.

To a large extent, for either form, the prediction depends on what dynamics are imparted to the internal standard used to compare a new stimulus level. That is, whether the standard is intrinsically fixed or a product of adaptation (i.e. transient). If, when dealing with static complexity, the standard is fixed, exploratory behavior in the form of stimulus change seeking would be expected to decrease and remain at low levels when the optimum discrepancy from the standard is attained. Conversely, when the standard is transient, the reduction in exploratory behavior would be temporary. This is because a trend to actively seek a moderate change in the stimulus level develops after some passage of exposure time to the new stimulus situation. At this point, the new stimulus situation has replaced the original standard as the reference point for determining stimulus discrepancy.

As a potential elicitor of approach behavior, recent studies have demonstrated that, intermediate levels of stimulus complexity are often the most effective (e.g. Sales, 1968; Dutch and Brown, 1971). These results question the assumption that approach tendency is positively and monotonically related to stimulus complexity and lend support to the discrepancy hypothesis with an implied fixed internal standard. In similar studies, approach preference for moderate complexity is found to shift to higher complexity levels after sufficient exposure to the environment (Walker and Walker, 1964; May, 1968; Haben, 1969), supporting the notion of an adaptation based standard.

The recurring problem of novelty, however, may be responsible for the observed shift. For example, the approach eliciting strength of high stimulus complexity may be suppressed by the commensurate high novelty which can elicit fear or avoidance responses. Following commerce with the environment the animal habituates to the novelty and in this situation tends to show an affinity toward higher complexity. Evidence supporting this interpretation has been reported by Montgomery (1955) and Welker (1957). The behavioral time course of approach behavior deserves scrutiny because as a component of preference (preference as used here implies seeking and maintaining an optimal level of stimulus quality; after Dember, 1965) the importance of approach behavior is directly related to the persistence of the behavior. The present study circumvents this problem by allowing the animals ample time to habituate to the novelty of the environment before any behavior is sampled.

State Variables

The discussion so far has considered the way parameters of a stimulus situation, (i.e. environmental complexity) are processed by the animal in terms of a preference response and the possible consequences of this preference. The discussion has been intentionally general in nature but it is important that a few factors be introduced which may conditionalize preference behavior. Obviously, in contrast to the mechanisms for selection of habitats along biologically imperative dimensions, the motivational base for those behaviors which temporarily put an animal in its preferred or psychologically optimal environment, and the consequences of this placement, are open to substantial variation.

Any organism is usually characterized by having the capacity to operate under a variety of short-term internal or motivational states, (e.g. fear, hunger, and fatigue or sleepiness). Approach toward or non-withdrawal from stimulus complexity must be viewed in terms of the animal's current state. Previous research has been primarily concerned with the effects of stimulus complexity on arousal (Berlyne, 1960) rather than the effects of arousal state on the response to stimulus complexity. However, there is evidence that hunger heightens the exploratory response to novelty (Fehrer, 1956; Hughes, 1965) and maze complexity (Adlerstein and Fehrer, 1955). While fear can be induced by high levels of stimulus complexity, as mentioned before, there is no current evidence that fear influences complexity preference. In fact, Montgomery and Monkman (1955) found that electric shock and loud auditory stimulation preceding a maze experience had no affect on subsequent exploratory behavior.

The present experiment was designed to look at the behavior of rats within an environment over an extended time period (48 hours) during which the animal's motivational state is likely to change several times. One way of identifying the states is by their behavioral manifestations. Thus behaviors such as sleeping, locomotion and eating can serve as state indicators as well as criterion measures of environmental preference.

Obviously the functional properties of these behaviors are basically different and, likewise, the extent to which each is vulnerable to the stimulus control of environmental complexity would be expected to differ. The mechanics of how the state of the animal might modify stimulus control is not within the scope of this study. However a plausible and parsimonious explanation is that it alters stimulus sensitivity or attentional threashold levels (Campbell and Sheffield, 1953).

Behavior Classes

Another consideration which may be related to the concept of state is the nature of behavior classes. A widely accepted scheme for behavior classification, especially among ethologists, distinguishes between appetitive and consummatory responses. In some cases a third class, post-consummatory, is also distinguished (see Denny and Ratner, 1970). A classificatory scheme is used as a device to identify and group the distinct purposive behaviors in an animal's repetoire. It's functional value comes primarily from the ability to impart "motives" or "intentions" to these behaviors based on how they are grouped. Appetitive behavior is viewed as those responses instrumental in achieving contact (perceptual or physical) with a particular stimulus. This generally includes seeking, orientation, and approach responses. Consummatory behavior is considered to be a response which regularly consummates or terminates a recurring behavior sequence, usually of a species-specific stereotyped nature (e.g. resting, contacting, eliminating, drinking and feeding). Finally post-consummatory acts are defined as coordinated responses which disengage the animal from a consummatory act and serve as a transition into the appetitive components of subsequent behavior.

An application of this classificatory model to exploratory behavior by Fowler (1967) treats orienting toward, attending to, locomoting toward, and manipulation of the stimulus object as consummatory action. Appetitive acts are those which involve the animal in any response which alters or changes those stimuli currently impinging upon it. These stimulus seeking behaviors increase the probability of new or different (e.g. more complex) stimuli being perceived. It is worth noting that this application implies a Spencian concept of drive (Spence, 1956) and is consistent with exploratory drive concepts forwarded by Harlow et al (1950) and Berlyne (1960).

Obviously, the usefulness of this schema is relative to the preciseness with which the observer can infer the animal's state from its ongoing behavior or the existing environmental conditions. Approaching a specific stimulus complex may be a "consumption" of the perceptual qualities of the complex; but, on the other hand, the animal may be approaching the complex in search of food or as a place to defecate, etc. If so, the behavior would be classified as appetitive not consummatory. In a manner of speaking it is the "intention" of the animal that has to be known or determinable before a behavior can be classified.

If a complete behavior sequence can be identified then the "intention" can be inferred from the terminal element. In addition, knowing the state of the organism usually increases the validity of a classificatory conclusion. For example, if the animal has been deprived of food and after approaching a stimulus complex it immediately engages in feeding behavior, the approach behavior is obviously appetitive. If a well fed animal approaches a specific stimulus complex and subsequently eats there, the interpretation is more difficult. The animal may have been drawn to the stimulus complex because it elicited exploratory responses and only incidentally did the animal find and eat the food. If the animal does not eat but continues to stay in the stimulus complex it would be possible to label the approach behavior as consummatory (after Fowler) assuming that the "intention" of the behavior is to maintain an orientation to, and the perceptual impact of, the stimulus complex. A more convincing demonstration of the animal's intention, and thus, the reasonableness of such a classification, would be for the animal to approach and remain within the stimulus complex without eating when it was known to be hungry, that is under food deprivation.

Without complete information on the sequential organization of ongoing behavior, adopting Fowler's classificatory concept is risky. For this reason the present study will rely on the more restrictive traditional conception of consummatory behavior, that is feeding, drinking, resting/sleeping, and defecation. All other behaviors which are considered in this study will be classed as appetitive.

Experimental Design and Hypotheses

The stimulus complexity studies mentioned have relied on using one or two measures over short sessions of responding to assess the animal's apparent preference for a more complex (or more novel) environment. Because of the ubiquitous nature of the stimulus condition of complexity and the vaguely defined nature of the responses (exploratory or approach activity), a multivariate analysis of various behaviors could lead to a clearer picture of the multiplicity of specific responses differentially elicited by the complexity dimension. Specifically, determining the nature of the relationship between these behaviors--the response pattern--is needed for an understanding of complexity preference. Few multidimensional investigations of free responding to complexity have been made. Multidimensional studies of the rat have suggested relationships of feeding, grooming and exploration to complexity (Pereboom, 1968; Hughes, 1968; Bindra and Spinner, 1958) but these have not attempted to formulate a response pattern directly by correlating the behavioral measures. Some correlational work has been done on the free responding situation of the home cage (e.g. Jennings, 1971) but no manipulations of complexity were made.

In an attempt to assess the complexity preference of laboratory rats in broader terms than has been previously achieved the present study attends to a number of different behaviors. Using both a longterm free-choice or _ad lib_ situation and a more traditional discrete trial situation, response patterns within environments of specific complexity were compared. An environment, in this study, is viewed as a place (a set of conditions) to feed, a place to locomote, a place to rest, a place to defecate, etc.

In the *ad lib* phase of the experiment a rat had free access to four large compartments (32 square feet of area) differing in the density and heterogeneity of chains hanging down to the floor from a false-ceiling insert. The large area was intended to minimize the extent to which exploratory behavior can draw the animal into compartments of less preferred complexity levels. That is, each compartment was sufficiently large to provide considerable area for exploration and general exercise. As well, each compartment provided sufficient environmental support in terms of food and water resources and appropriate resting sites.

Assuming that the propensity displayed by rats to approach environments of higher complexity reflects a general preference rather than simply a transient attraction, it would be expected that rats would tend to favor high complexity as a place to perform a wide variety of behaviors. The strength of this preference, however, was expected to vary according to the behavior class examined and the internal state of the animal. Adopting the belief that, after the effects of any fear inducing stimuli are partialled out, the incentive value of an environment increases with its complexity (up to some extreme limit) it was expected that the appetitive class of behaviors would be most highly associated with high complexity. This assumed that exploratory responses would be a major component of appetitive behavior. For the same reason and because it was assumed that satiation rates would decrease with increasing complexity (a notion proposed by Glanzer, 1953, and applied to stimulus-seeking by Myers and Miller, 1954), it was expected that the consummatory class of behaviors would be most highly associated with high complexity as well. This assumed that once attracted to a high complexity area the animal would tend to stay in the area to perform most consummatory acts.

State variables were expected to exaggerate or diminish the relative differences in response strength between the different complexity levels depending on whether the response probability of interest was raised or lowered by the specific state condition. Because identification of state conditions suffers from the same shortcoming as behavior classification, namely a requirement for complete knowledge of the sequence of behavior, a systematic examination of state effects in the *ad lib* phase of the present experiment was limited to active *versus* inactive (resting) states determined by illumination level. In this context if inactivity was found to be controlled by complexity the effect would be most striking under day illumination. Obviously this is only relevant to consummatory behavior as appetitive responses are characterized by locomotor activity. If, on the other hand, some active behaviors were found to be under the control of complexity the effect would be exaggerated during night conditions.

This expectation applied to both appetitive and consummatory behaviors.

A discrete trial phase of the experiment was included to compare the results of the _ad lib_ phase to those of a procedure typical of previous research on stimulus complexity preferences. Here, rather than being left to roam through four complexity compartments for 48 hours, the rat was given a choice of compartments which once made terminated the trial.

Overall, the strength or frequences of all measured responses including choice, feeding, locomoting and resting were hypothesized to increase as the complexity level increased across the four environments available to the animal.

EXPERIMENTAL DESIGN

I. SUBJECTS. Twenty male albino rats, 70-80 days old when received from the suppliers, were used. Sixteen of the rats were obtained from Sprague-Dawley in Madison, Wisconsin and the remaining four were of Sprague-Dawley descent obtained from a local supplier.

II. APPARATUS. Four 4-compartment cages with removable complexity inserts and recording cabability were used.

A. ENCLOSURES. Each cage was a 4'x8'x2' wooden frame constructed of 1½"x1½" pine and covered with ½" hardware cloth forming the floor, ceiling and outside walls. Each cage was subdivided into four equal sized compartments (approximately 2'x4'x2') by 1/8" masonite panels bisecting each wall and extending to within 4 3/4" of the center. These panels were joined at the cage center by four 8"x2' strips of ½" hardware cloth which formed a small (9½" square) section at the center of the enclosure. Centered at the base of each hardware cloth strip was a 2¼"x3" clear plexiglass door, hinged at the top. This allowed access, through the center section, from one compartment to any of the other three compartments (see Figure 1). The floor of the center section was 24 gauge galvanized sheet metal.

The hardware cloth ceilings of each compartment were

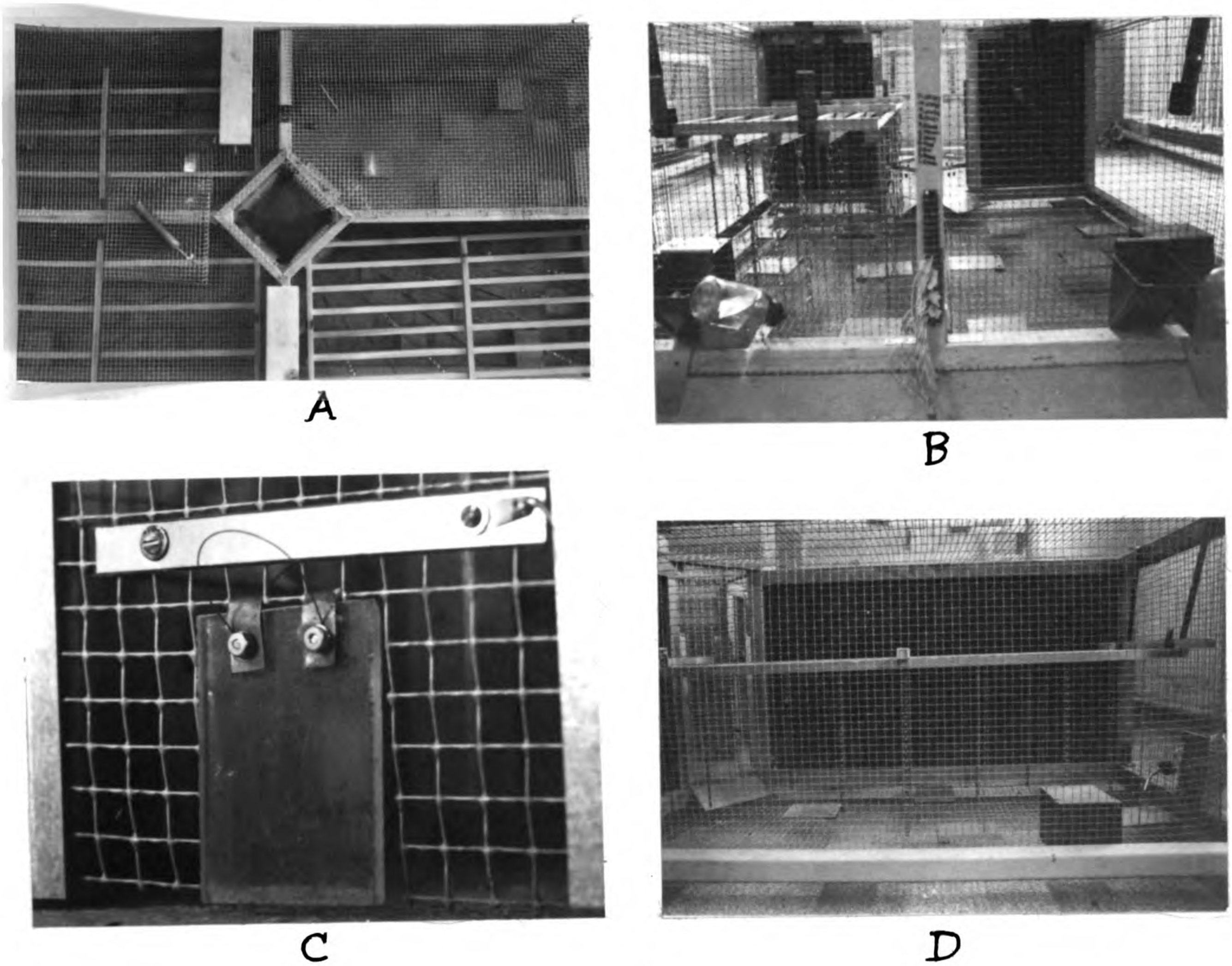


Figure 1. Four views of the experimental cage: A) top view showing center section and four compartments, B) end view of high and open complexity compartments, C) view of a center section door, and D) side view of one compartment showing resting box, foot plates and litter tray.

hinged and a removable cover was separately fixed over the center section. The latter was provided for introduction of the animal to the enclosure.

The cages were raised 4" above the floor so that a galvanized sheet metal tray filled with crushed corn husks and topped by paper could be positioned under each compartment and easily removed for observation and cleaning.

B. COMPLEXITY INSERTS. Complexity was created by fixing one of three inserts in a compartment. The inserts were approximately 20"x44" and consisted of three or five longitudinal pieces connected to 3 crossmembers all of 3/4" square pine. Eighteen inch lengths of chain of three types were hung from these frames. The attached chain lengths were approximately equally spaced and intermixed along the longitudinal members of a frame in the following fashion:

Open complexity:	no insert
Low complexity insert:	9 lengths of bead chain
Medium complexity insert:	9 lengths of bead chain and 13 lengths of furnace chain
High complexity insert:	9 lengths of bead chain, 13 lengths of furnace chain, 13 lengths of tensor link chain

Aluminum brackets mounted along the top of the cage walls allowed easy attachment and removal of the insert frame at a fixed height 18" above the floor of the cage. In this position the chains extended down to within 1/8" of the floor. A view of the cage from one end showing the insert as well as footplates, rest box and food hopper is included in Figure 1.

C. LOCOMOTOR ACTIVITY SENSORS. Each compartment contained eight 4"x5" sensor plates distributed across the floor. The plates, constructed of 28 gauge galvanized sheet metal, were attached to the hardware cloth floor at one end of their long axis by two machine screws with a narrow phenolic spacer (1/16" thick) between the plate and the hardware cloth at the point of mounting. A wire terminal was connected underneath the cage to one of the mounting screws of each plate. The upper surface of the plates were painted with a grey enamel. The plates mounted in the above fashion formed SPST normally open momentary contact switches with the underside of the plate as one contact and the cage floor as the other contact. These switches closed when a rat stepped upon any part of the plate except the edge used for mounting.

Of the eight plates located in a compartment (See Figure 1) one was positioned in front of the food hopper and water bottle which were attached to the compartment wall. To another plate a four-sided aluminum box was attached creating a small enclosure, 4"x5"x4", open at one end. This will be referred to as the resting box.

In addition to the front plate switches, a switch was integrated with each center section door. The hinges (2 per door) were 'U' shaped brass strips attached to the top of each plexiglass door and looped over a strand of wire in a cutout made in the hardware cloth sides of the center section. Attached to the brass strips, were two loops of stainless steel wire, one on either side of the hardware cloth wall.

These loops projected upwards and about ½" out from the wall. Attached to either side of the wall, directly in line with the wire loops, was a 2" length of stainless steel tape insulated from the wall itself by a phenolic washer. A wire terminal was attached to the 2 strips (see Figure 1).

The above arrangement resulted in a normally open SPDT momentary contact switch with the wire loops as one contact and the steel tape as the other contact. These switches closed when a rat passed through the door from either direction, as the wire loop moved with the door and was brought in contact with the steel tape on the wall above the door. Because electrical continuity existed between the wire loops and the cage floor through the brass hinges and center section wall, all switches within a cage had a common ground.

D. RECORDING DEVICES. Two 20 channel Esterline Angus event recorders operated in tandem were used to record activation of the plates and door switches. An 18 volt power supply was connected in series between the common ground of the recorders and the cage bottoms. In addition each pen terminal was jumped to ground through a reverse polarity silicon diode to suppress electrical arching across the foot plate switches. For each cage eight pens were used, one for each door and four for the foot plates. The nest box and food-water plates were each connected to a separate pen while the remaining 3 plates in the rear of the compartment (away from the center section) were connected in parallel to a single pen. In like manner the 3 foot plates in the forward half of the compartment were wired to a common pen.

The recorders were run at 12" per hour which allowed discrimination between repeated events occurring at intervals as short as 5 seconds.

E. EXPERIMENTAL ENVIRONMENT. The experiment was conducted in two adjacent rooms (approximately 15'x17'). The rooms were cinder block with concrete floors and heated by steam with ambient temperatures ranging between 70°F and 80°F. The continuous sound of exhaust fans tended to mask most outside noices. All outside sources of light including the windows were covered with black plastic sheeting. The Esterline Angus recorders and associated electronics were located in one room and were surrounded with 3" thick sound insulation. An upright cage rack containing 16 small cages was located in the other room. These cages were used for holding animals between testing and for initial habituation to the room environment.

III. PROCEDURE. The ad lib phase, consisting of 7 days within the experimental cages (with high, medium, low and open complexity), was followed by 3 days of discrete trial testing in the same cage. The first five days of ad lib occupancy served as a habituation period intended to stabilize responding. Table 1 is a timetable of procedures for a complete experimental session.

The ad lib procedure guarantees that stimulus satiation is developed enough to exclude the possibility of stimulus novelty operating at any meaningful level. Indeed habituation to novelty has been shown to be rapid (Montgomery, 1951; Berlyne, 1955; Glanzer, 1961) and long lasting (Blanchard *et al*, 1970). The novelty satiation effects as well as the animals' general familiarity with the cage and its layout are expected to carry over into the discrete trial testing. Thus the order of implementation of the two phases is important in eliminating novelty effects and in assuming stability of responding. Meeting one objective of the study, comparison of the two testing modes, requires maximizing the consistency of correlations between the two phases.

A. PRELIMINARY. The foot plates including the nest box and the doors were cleaned with "Lime-Away" before every experimental session. Three complexity inserts were fixed in each cage leaving one compartment empty. The pattern of placement was semi-random such that 1) each cage contained three different inserts ("high", "medium", and "low"), 2) no compartment had the same kind of insert for two consecutively run subjects, 3) during a session no two cages had the same pattern of insert placement.

Subjects were obtained from the supplier in lots of four and were held in individual cages for 5 days with free access to food and water. During this holding time the animals were handled once daily for about one minute.

B. *AD LIB* PHASE. At 8 a.m. on the morning following the fifth day of habituation to the room environment one rat was placed into the center section of each cage. After the

Table 1. Procedural Timetable of 15 day Experimental Session

Phase	Day	Time	Procedure
preliminary	-5	a.m.	Animal placed in holding cage with free access to food and water.
	-4,-3,-2,-1	varied	Animal removed from holding cage and handled for approximately one minute.
ad lib	0	8 a.m.	Animal placed in center section of experimental cage with free access to the four complexity compartments (habituation).
	4	8 a.m.	Chart recorders turned on.
	4, 5	8 a.m. + 8 p.m.	Food and water supplies weighed and replenished, fecal boli counted and removed.
discrete trial	6	8 a.m.	Animal removed from experimental cage and returned to holding cage.
	6	8 p.m.	Animal removed from holding cage and given 3 choice trials (30 minute ITI) in experimental cage and then returned to holding cage.
	7, 8	8 a.m. + 8 p.m.	As above
	9	8 a.m.	As above, animal is terminated.

Note: the lights were automatically switched on at 8 a.m. and off at 8 p.m. except during the evening testing sessions on days 6 through 8 when the light period was extended to about 9 p.m.

animals had spent 120 hours in the cage, the recorders were turned on and measured amounts of food and water were put into their respective containers. In addition the litter trays were cleaned.

Subsequently, food and water consumption and defecation were measured every 12 hours. Food and water consumption was determined by weighing the remaining food pellets ("Purina Lab Chow") and the water bottle, then replenishing the supplies to a standard weight. Defecation was measured by counting and removing the fecal boli from the litter trays.

Following 48 hours of this regime the animals were removed from their cages and returned to their respective holding cages.

C. DISCRETE TRIAL TESTING. At 8 p.m. on the day of removal from the experimental cages subjects were given 3 discrete testing trials. The procedure for any of the subjects was as follows, for each of six sessions which were given every 12 hours. The animal was transported in his holding cage to the experimental cage it previously occupied for one week. It was then introduced into the center section of the cage and once it entered into one of the four compartments the door was blocked to prevent the rat from leaving the compartment. After 3 minutes the subject was removed from the compartment and returned to the holding cage. This procedure was repeated twice more with an intertrial interval of 30 minutes.

During the testing, the recorders were operative and activity was recorded. In addition the latency to enter a compartment after placement into the center section was noted.

Each animal received a total of 18 trials over 6 sessions. The side of the cage from which the rat was introduced into the center was alternated from one trial to the next.

RESULTS

I. *Ad Lib Phase*.

A. The multivariate design.

The experimental design was essentially a 4 x 2 factorial with repeated measures. Viewed this way there were four complexity levels, one for each compartment, and two illumination levels. The latter, although artificial light on a 12 hour schedule (light on from 8 a.m. to 8 p.m.), approximately coincided with the true daylight period and will be referred to as "day" and "night". The design implies that each subject served in each of the eight conditions. Contrary to procedures typifying this factorial design, the complexity factor was subject selected. That is, the rat and not the experimenter determined when and for how long the rat served in each level, or in other words, when and for how long it occupied each compartment.

1. Basic Scores. From the recordings on the 6th and 7th days of experimental cage occupancy a number of scores were derived. In doing so, the two day sessions of the 48 hours were combined as were the two night sessions. Thus a day and night score was derived for the following measures for each of the four compartments representing high, medium, low and open complexity levels.

1. Occupancy time (total time in minutes within compartment).

2. Locomotor activity (total number of discrete depressions of all foot plates).

3. Feeding time (total time in minutes foot plate in front of food and water containers was depressed).

4. Resting time (total time in minutes foot plate at bottom of rest box was depressed).

5. Entry frequency (number of entries made into compartment).

In addition to scores based on data obtained from continuous recording, the following scores were derived from observations made every 12 hours.

6. Food consumption in grams.

7. Water consumption in grams.

8. Defecation (number of fecal boli).

2. Ratio Scores. Six ratio scores, generated from the eight basic measures, were also used. Because of low general activity during day sessions which created some scores with zero as a denominator the scores given below were considered only for the night sessions.

1. Mean occupancy (occupancy time divided by number of entries).

2. Resting rate (rest box occupancy time divided by occupancy time).

3. Locomotor activity rate (locomotor activity count divided by the sum of occupancy time minus resting time).

4. Defecation rate (feces count divided by the sum of total time minus resting time).

5. Mean active occupation (the sum of occupancy time minus resting time divided by number of entries).

6. Feeding speed (the sum of food and water consumption divided by feeding time).

A final score was derived from the continuous recordings and is the only one which reflects a temporal trend, _al beit_ short term. The composite "exit pattern" score is the frequencies of entry into each of the other compartments made directly from the compartment in question.

As mentioned before, general activity was particularly low during the day. For example the mean number of entries per day was 6.00 as compared to 74.72 per night, however, two animals spent the total 48 hours in one compartment (high complexity for one and low for the other). These subjects were not included in any data analyses. Analysis of data from the remaining 18 animals included a test of the overall design (4 x 2 ANOVA), separate tests of day and night behavior (4 x 1 ANOVA's) including planned comparisons, and a correlational review of the dependent measures. Non-parametric tests of a few special cases were also conducted.

B. General Behavior - Effects of Light Period.

The following results represent distinctions between day and night behavior without regard to which complexity compartment it occurred in. That is, data from the four compartments are combined within an illumination level. The overall 12 hour means of the basic scores for day and night are presented in Table 2.

The mean basic scores all showed a marked depression of active behavior in daylight hours. All scores were significantly greater for the night period (except resting

Table 2. Overall 12 hour Means of Basic Scores

Score	Day	Night
Locomotor activity	26.20	342.80
Feeding time	2.20	25.78
Nesting time	511.06	143.02
Entry frequency	6.00	74.72
Food consumption	3.20	18.80
Water consumption	8.88	31.50
Defecation	5.22	23.86

time which was significantly less) at $\alpha < .0005$ under an ANOVA with 1 and 17 df (see Table 3). A look at the distribution of activity showed most daylight behavior occurring in the initial hour which appears to be, in part, a continuation of a build up in activity during the terminal hours of darkness. The sudden change of environmental state from dark to light could also contribute to this phenomenon. The nighttime distribution, using the number of entries as a representative activity score, was a relatively smooth trimodal curve peaking during the first, last and 5th hours as shown in Figure 2. The highest peak was during the first hour of darkness suggesting, again, an excitatory effect of state change.

C. Effects of Complexity.

The following results represent the incidences of various behaviors compared across complexity levels within day and night periods (basic scores) or only night periods (ratio scores). Planned comparisons on each score were made in addition to the overall ANOVA. These were based on the original hypothesis, applied to all basic scores, that the direction of differences in magnitude between complexity levels would conform to high medium low open. Three pair-comparisons of cell means, high-medium > 0, medium-low > 0, and low-open > 0, served as a critical test of the hypothesis. This was accomplished statistically using correlated *t* tests or, in the case of occupancy time, the Wilcoxon rank difference test.

Table 3. ANOVA on the Effects of Light Period

Score	Source	df	Mean square	F	∝
Locomotor activity	Lt. period	1	9082183	115.102	<.0005
	Error	17	7838.1		
Feeding time	Lt. period	1	4999.7	36.734	<.0005
	Error	17	136.11		
Resting time	Lt. period	1	646617	72.908	<.0005
	Error	17	8868.9		
Entry frequency	Lt. period	1	42504	257.921	<.0005
	Error	17	164.80		
Food consumption	Lt. period	1	2185.6	189.262	<.0005
	Lt. period	17	11.548		
Water consumption	Lt. period	1	4601.4	127.630	<.0005
	Error	17	36.052		
Defecation	Lt. period	1	3124.8	369.877	<.0005
	Error	17	8.4482		

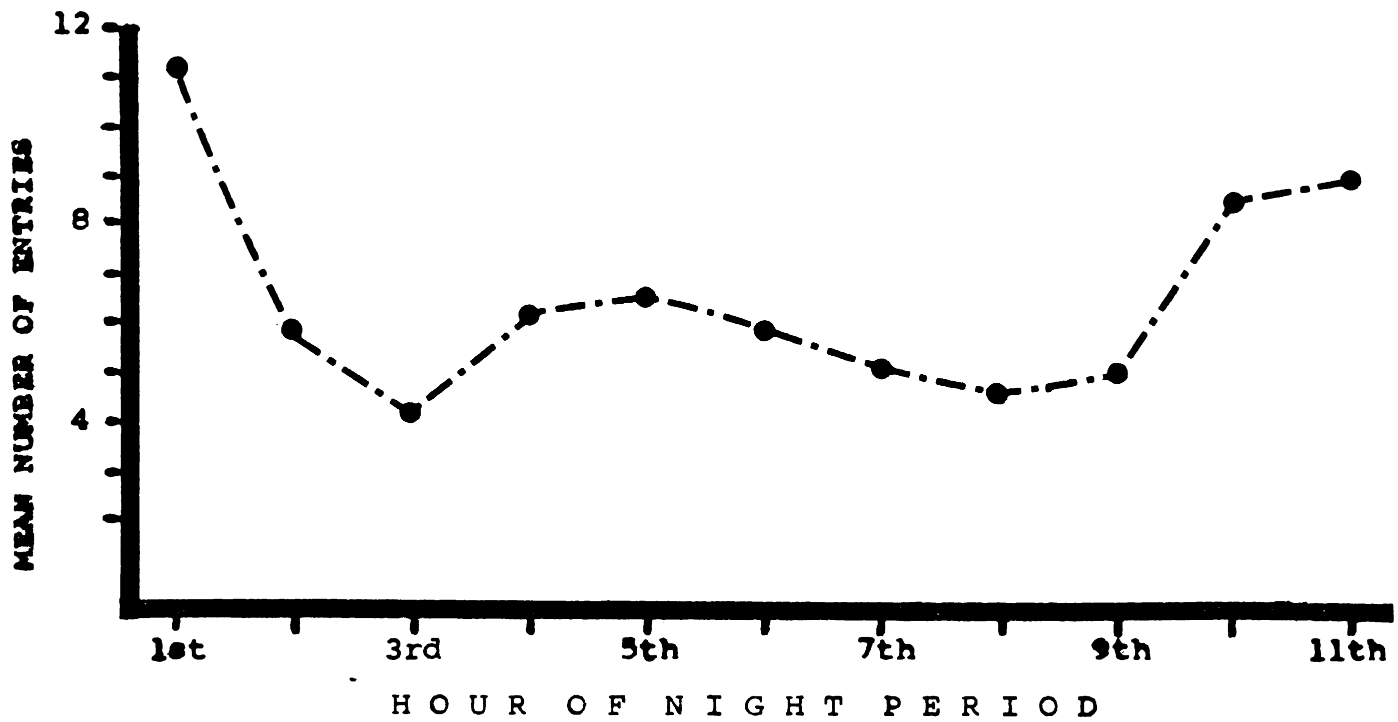


Figure 2. The distribution of activity in terms of entry frequency under night conditions.

For some contrasts two alpha values may be given. The first, which is always given, indicates the alpha value consistent with the one-tailed nature of the original hypothesis. The second value is included when the direction of the difference is opposite to that predicted. In this case the alpha is two-tailed. The use of t test based planned comparisons is not particularly conservative, statistically, but, based on the remarkable consistency in the trend revealed by the contrasts, the procedure is justifiable.

1. Daytime.

For daytime behavior complexity level was found to significantly affect locomotor activity, resting time, and entry frequency all at an alpha level less than .0005 (ANOVA with 3 and 51 degrees of freedom). All other basic scores were insignificant (see Table 4). The last column of Table 4 (and comparable tables that follow) contains the eta squared statistic which indicates the proportion of the total variance of the score explained by the complexity variable. The means of these scores are presented in Table 5.

The analysis of the occupancy time data was treated somewhat differently because of certain restrictions imposed by the experimental design. Because the sum of occupancy time across the four complexity levels was constant for all subjects (i.e. total occupancy time in a 12 hour period has to equal 12 hours) a Friedman test of the ranked data was used in place of an ANOVA. This procedure was applied to the nighttime results as well. For daytime periods occupancy

Table 4. ANOVA on the Effects of Complexity under Day Conditions: Basic Scores

Score	Source	df	Mean square	F	α	eta^2
Locomotor activity	Complexity	3	696.6800	11.708	<.0005	.41
	Error	51	59.5000			
Feeding time	Complexity	3	7.7442	2.279	.0910	.12
	Error	51	3.3986			
Resting time	Complexity	3	906908.0000	9.379	<.0005	.36
	Error	51	96692.0000			
Entry frequency	Complexity	3	29.1480	13.757	<.0005	.45
	Error	51	2.1187			
Food consumption	Complexity	3	5.8924	1.448	.2400	.08
	Error	51	4.0688			
Water consumption	Complexity	3	4.9259	.226	.8780	.01
	Error	51	21.7860			
Defecation	Complexity	3	38.5930	2.271	.0910	.12
	Error	51	16.9950			

Table 5. Planned Comparisons on the Effects of Complexity Under Day Conditions: t Tests on Basic Scores.

Score	Complexity level	Mean	t value of difference	α under original hypothesis	α under two-tailed test
Locomotor activity	High	10.780			
			5.13	$<$.0001	
	Medium	5.470			
			-.84	.7950	.410
	Low	6.550			
			2.14	.0220	
	Open	3.390			
Feeding time	High	.8890			
			1.99	.0310	
	Medium	.2780			
			-1.63	.9390	.122
	Low	.7780			
			1.67	.0590	
	Open	.2640			
Resting time	High	265.8000			
			3.76	.0008	
	Medium	71.1000			
			.12	.4630	
	Low	65.1000			
			1.08	.1500	
	Open	9.1000			
Entry frequency	High	2.2800			
			3.89	.0006	
	Medium	1.8300			
			-1.26	.8850	.230
	Low	1.6400			
			3.66	.0010	
	Open	.7500			
Food consumption	High	.8610			
			0.00	.5000	
	Medium	.8610			
			-.66	.7380	.524
	Low	1.0830			
			2.02	.0300	
	Open	.4030			

Table 5. (Continued)

Water consumption	High	2.47			
			.68	.258	
	Medium	1.94			
			-.61	.723	.552
	Low	2.42			
			.46	.338	
	Open	2.05			
Defecation	High	2.05			
			1.21	.133	
	Medium	1.22			
			- .57	.710	.580
	Low	1.61			
			1.86	.041	
	Open	.33			

time showed significant differences ($\alpha < .001$) with a χ^2 of 26.5 and three degrees of freedom. The means are found in Table 6.

The four scores which achieved significance, as well as feeding time, tended to show a relationship, vis a vis complexity level, similar to that predicted by the general hypothesis with numerous contrasts revealing significant differences. In general high complexity yielded means greater than medium complexity and low complexity yielded greater means than open complexity. Across the board, a small negative difference was found between medium and low complexity levels. The high-medium contrast was significant for occupancy time ($\alpha < .005$), locomotor activity ($\alpha < .0001$), feeding time ($\alpha \approx .031$), nesting time ($\alpha \approx .0008$), and entry frequency ($\alpha \approx .0006$). Low-open comparisons were significant for locomotor activity ($\alpha \approx .022$), entry frequency ($\alpha \approx .001$), food consumption ($\alpha \approx .030$), and defecation ($\alpha \approx .041$). A summary of these contrasts and the associated t values with 17 degrees of freedom are present in Tables 5 and 6.

Figures 4 and 5 are graphical depictions of the contrasts. The scores are compared on the basis of their distributions across complexity levels. For each complexity level the proportion of the total incidence of the behavior that occurred in that compartment is represented by a bar. The dotted horizontal line indicates the proportion expected by chance (.25).

Table 6. Planned Comparisons on the Effect of Complexity: Wilcoxon Rank Difference Test on Occupancy Time.

Complexity	Mean	Mean rank	Wilcoxon T	Hypothesis based α
		-DAY-		
High	373.4	3.53		
			26	$< .005$
Medium	82.2	2.25		
			111	$> .800$
Low	83.2	2.70		
			23	$< .005$
Open	12.7	1.64		
		-NIGHT-		
High	233.4	3.05		
			47	$< .050$
Medium	138.0	2.61		
			76	$> .300$
Low	146.2	2.61		
			32	$< .010$
Open	71.8	1.72		

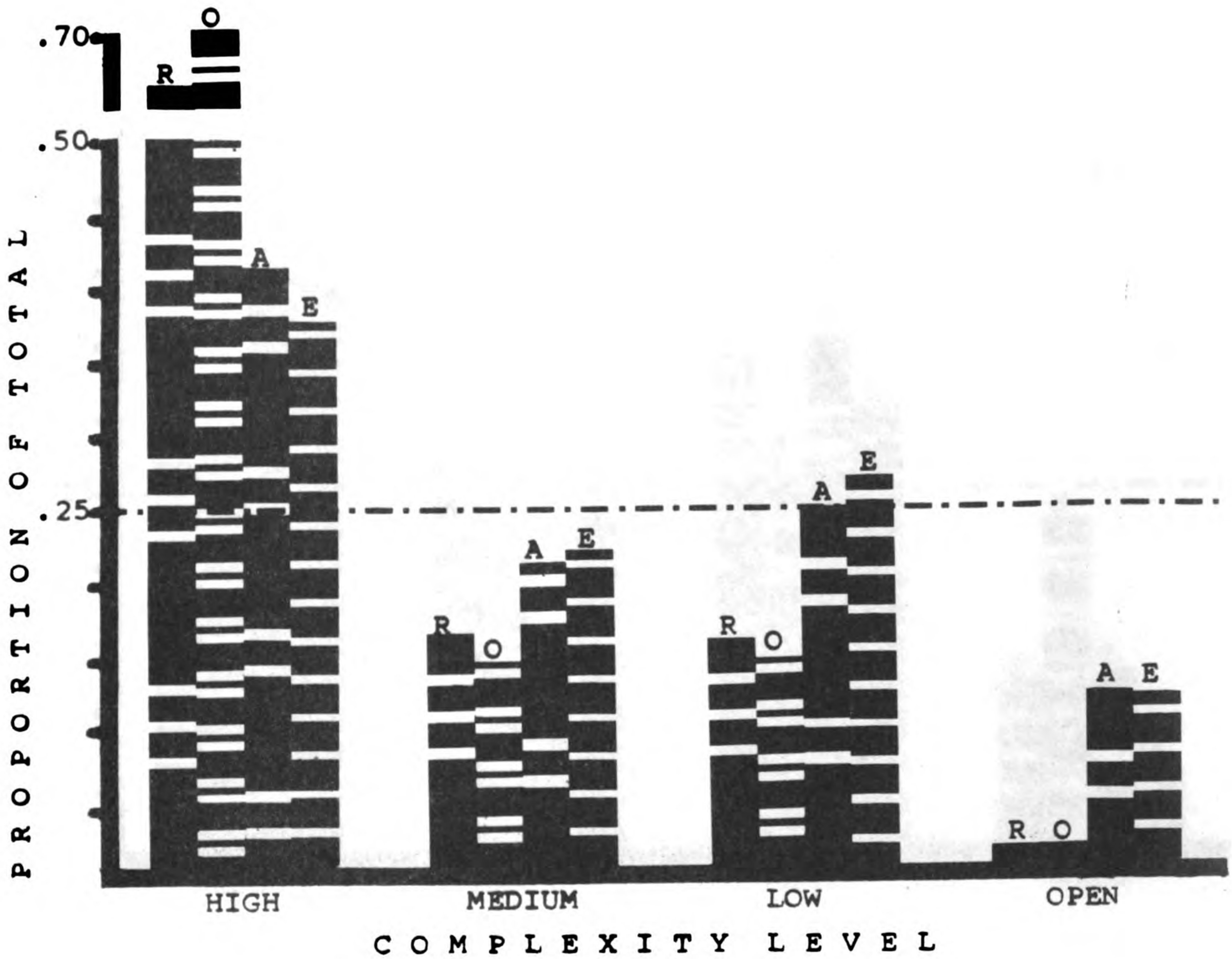


Figure 3. Comparison of the effects of complexity under day conditions on four basic scores; resting time (R), occupancy time (O), locomotor activity (A), and entry time (E).

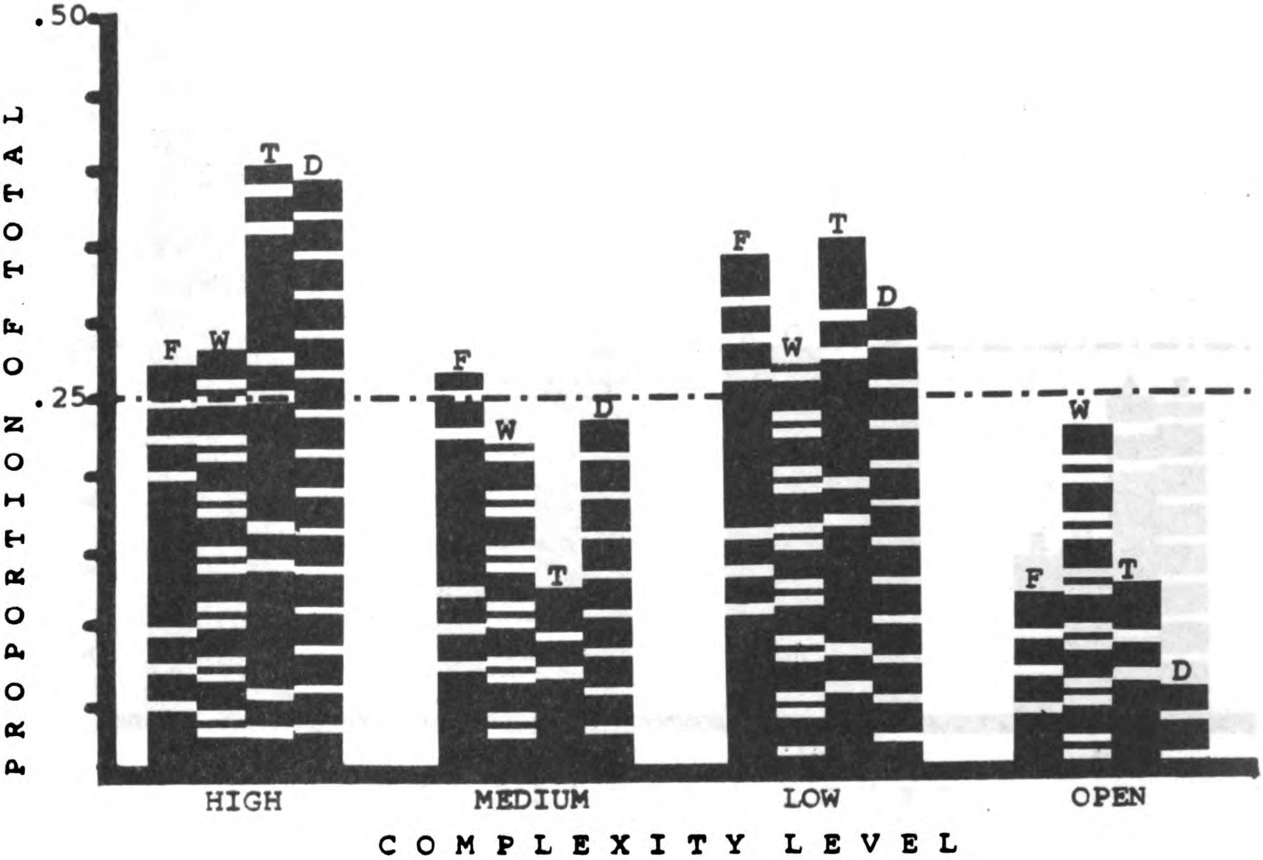
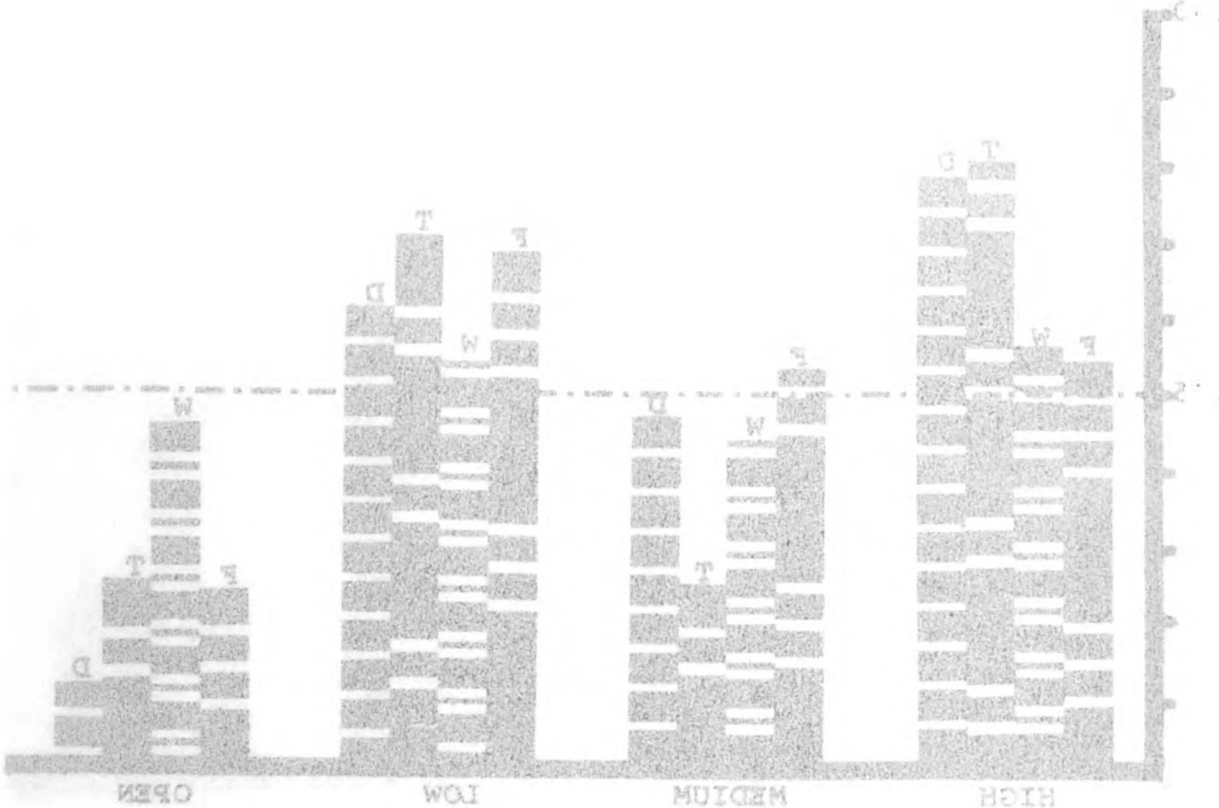


Figure 4. Comparison of the effects of complexity under day conditions on four basic scores; food consumption (F), water consumption (W), feeding time (T), and defecation (D).



OPEN
LOW
MEDIUM
HIGH

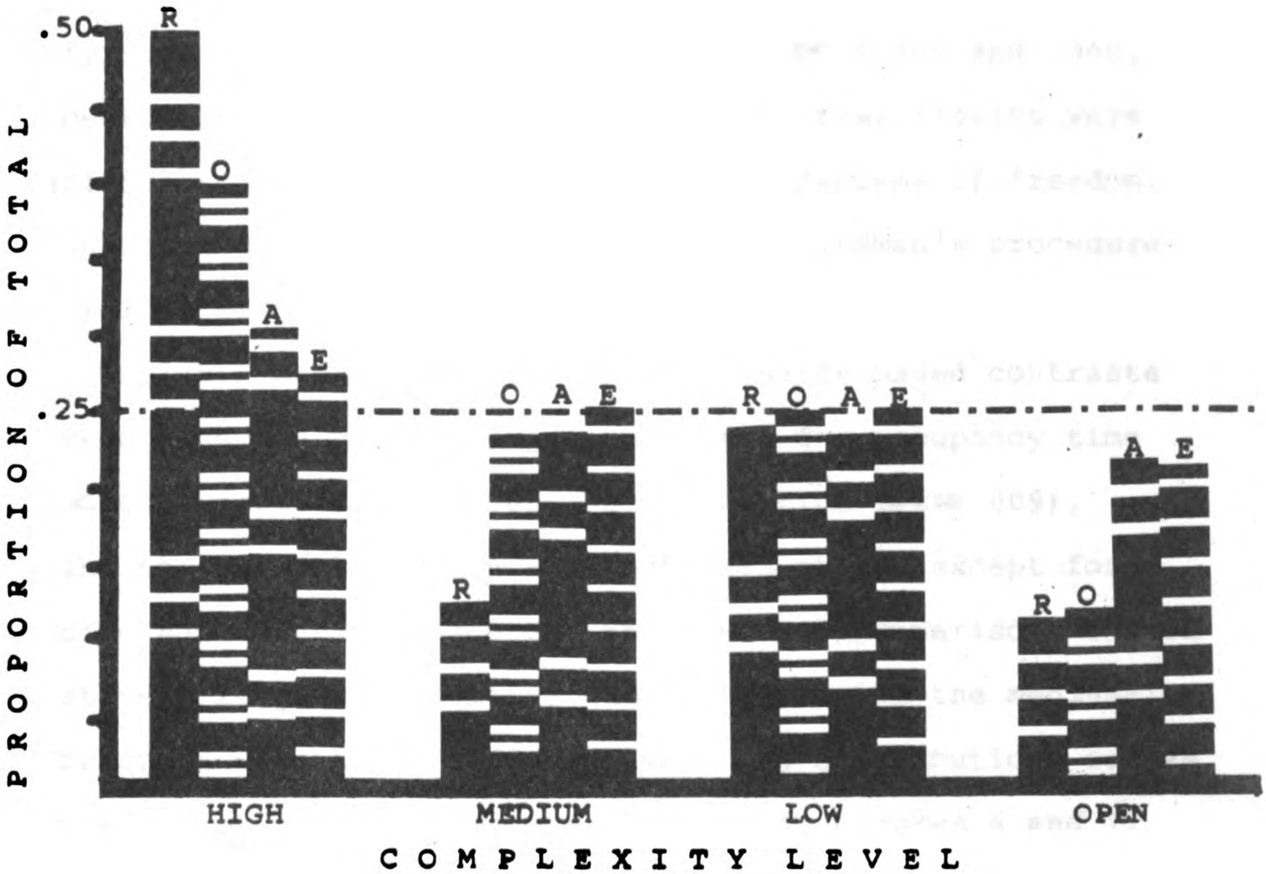


Figure 5. Comparison of the effects of complexity under night conditions on four basic scores; resting time (R), occupancy time (O), locomotor activity (A), and entry frequency (E).

2. Nighttime.

The results from night periods were not as differentiated as those of daylight behavior. Occupancy time and rest time showed significant effects of complexity at alpha levels of .020 and .037, respectively, while activity and entry frequency approached significance ($\alpha \approx .069$ and .060, respectively). As Table 7 indicates, no other results were significant based on ANOVA with 3 and 51 degrees of freedom. Occupancy time was again analized using Friedman's procedure ($\chi^2 = 10.1$ with 3 degrees of freedom).

Tables 6 and 8 show that the hypothesis based contrasts between high and medium were significant for occupancy time ($\alpha < .05$), activity ($\alpha \approx .006$) and rest time ($\alpha \approx .009$). Again, the general pattern was sustained where, except for feeding and defecation scores, the low-open comparisons showed relatively large and positive differences while the medium-low differences were small and negative. The distributions across complexity of these scores are compared in Figures 6 and 7.

When nighttime behavior is viewed in terms of rates the differences among complexity levels are more striking. Analysis of the ratio scores (ANOVA with 3 and 51 degrees of freedom as summarized in Table 9) revealed significant effects on mean occupancy time ($\alpha \approx .028$), mean active occupancy ($\alpha \approx .023$), locomotor activity rate ($\alpha < .0005$), and defecation rate ($\alpha \approx .001$). Resting rate approached significance ($\alpha \approx .073$) while feeding speed was not significant.

The hypothesis based contrasts (Table 10) revealed a

Table 7. ANOVA on the Effects of Complexity Under Night Conditions: Basic Scores.

Score	Source	df	Mean square	F	α	eta^2
Locomotor activity	Complexity	3	13098.000	2.517	.069	.13
	Error	51	5204.600			
Feeding time	Complexity	3	25.981	.132	.941	.01
	Error	51	197.500			
Resting time	Complexity	3	44659.000	3.052	.037	.15
	Error	51	14634.000			
Entry frequency	Complexity	3	330.980	2.637	.060	.13
	Error	51	125.510			
Food consumption	Complexity	3	48.476	.630	.599	.04
	Error	51	77.003			
Water consumption	Complexity	3	182.080	.930	.433	.05
	Error	51	195.740			
Defecation	Complexity	3	53.124	.426	.735	.02
	Error	51	124.760			

Table 8. Planned Comparisons on the Effects of Complexity Under Night Conditions: t Tests on Basic Scores.

Score	Complexity	Mean	t value of difference	α under original hypothesis	α under two-tailed test
Locomotor activity	High	100.1			
			2.82	.006	
	Medium	83.2			
			.23	.410	
	Low	80.5			
			.55	.296	
	Open	76.0			
Feeding time	High	6.32			
			-.12	.546	.908
	Medium	6.59			
			-.24	.598	.804
	Low	7.15			
			.62	.272	
	Open	5.71			
Resting time	High	71.34			
			2.62	.009	
	Medium	18.43			
			-.80	.783	.434
	Low	34.58			
			.79	.218	
	Open	18.65			
Entry frequency	High	21.11			
			1.15	.134	
	Medium	18.97			
			.12	.454	
	Low	18.75			
			1.56	.070	
	Open	15.89			
Food consumption	High	5.65			
			.37	.359	
	Medium	5.11			
			.77	.223	
	Low	3.99			
			-.04	.516	.968
	Open	4.04			

Table 8 (Continued)

Water consumption	High	7.81			
			-.02	.508	.982
	Medium	9.18			
			-.05	.520	.960
	Low	9.29			
			1.32	.103	
	Open	6.22			
Defecation	High	5.69			
			-.75	.767	.466
	Medium	7.08			
			1.10	.143	
	Low	5.03			
			-.55	.704	.592
	Open	6.06			

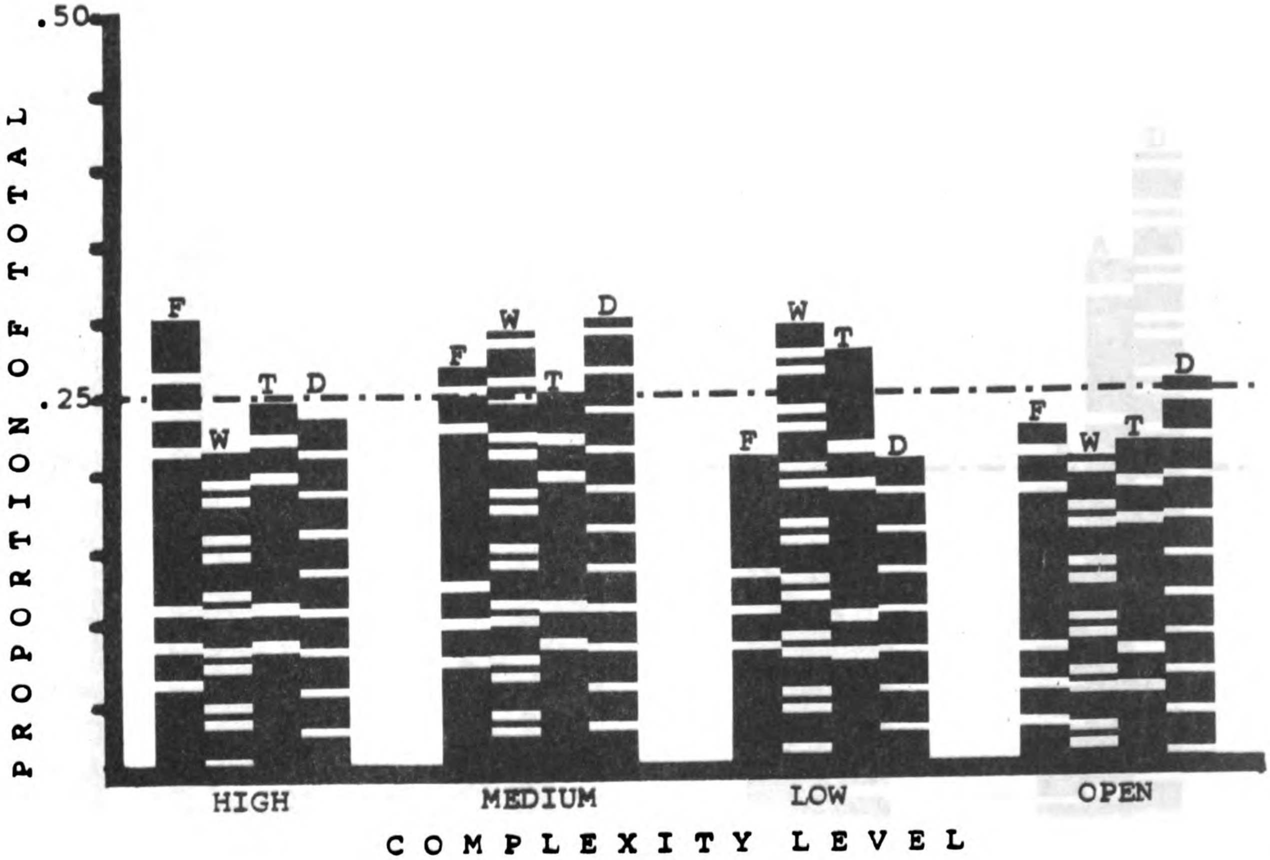


Figure 6. Comparison of the effects of complexity under night conditions on four basic scores; food consumption (F), water consumption (W), feeding time (T), and defecation (D).

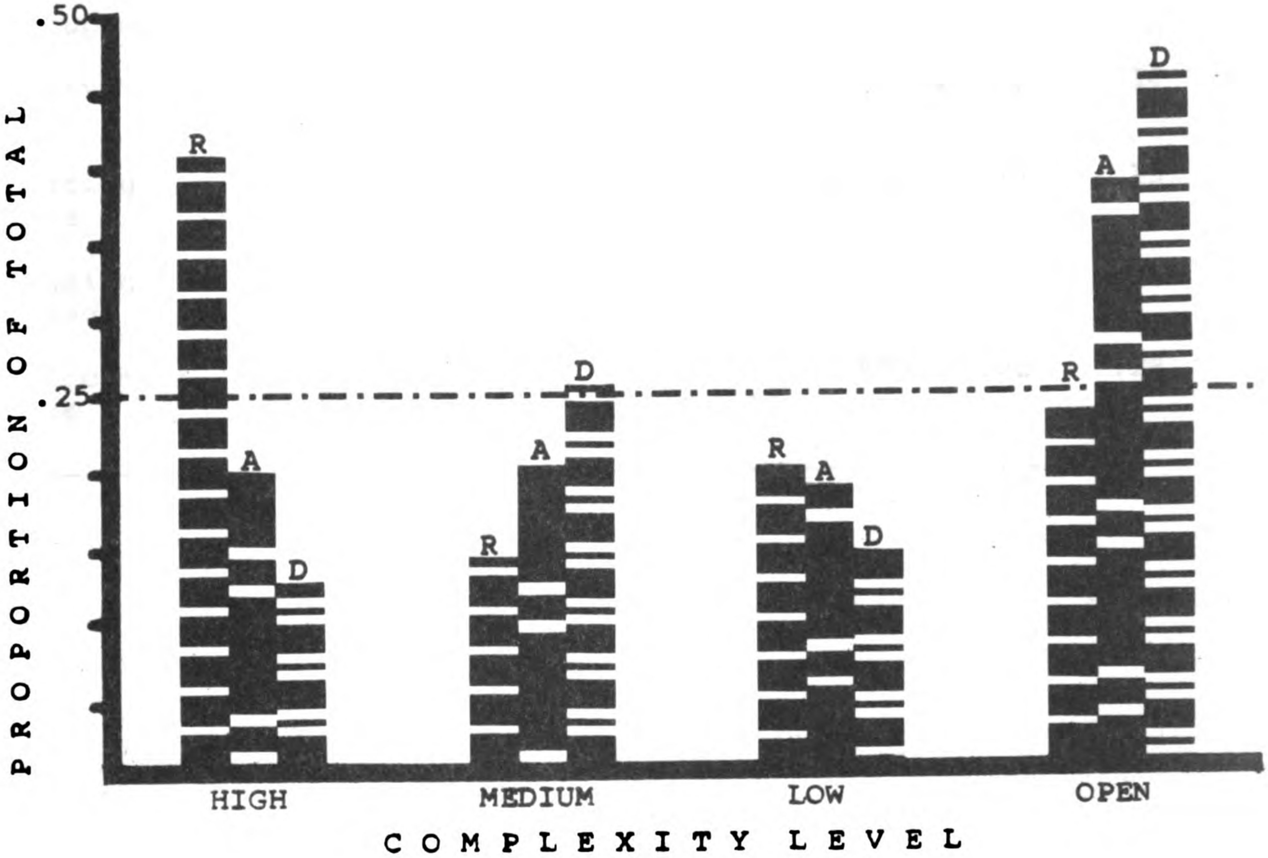


Figure 7. Comparison of the effects of complexity under night conditions on three ratio scores; resting rate (R), locomotor activity rate (A) and defecation rate (D).

Table 9. ANOVA on the Effects of Complexity Under Night Conditions: Ratio Scores.

Score	Source	df	Mean square	F	α	eta^2
Mean occupancy	Complexity	3	117.24	3.287	.028	.16
	Error	51	35.666			
Mean active occupancy	Complexity	3	59.001	3.465	.023	.17
	Error	51	17.029			
Activity rate	Complexity	3	3.6107	8.712	$<$.0005	.34
	Error	51	.41445			
Resting rate	Complexity	3	.087219	2.458	.073	.13
	Error	51	.035482			
Feeding speed	Complexity	3	2.6005	.105	.957	.01
	Error	51	24.849			
Defecation rate	Complexity	3	.031201	6.87	.001	.28
	Error	51	.0045390			

Table 10. Planned Comparisons on the Effects of Complexity Under Night Conditions: t Tests on Ratio Scores.

Score	Complexity	Mean	t value of difference	α under original hypothesis	α under two-tailed test
Mean occupancy	High	10.817			
			2.94	.005	
	Medium	6.956			
			-.35	.663	.734
	Low	7.661			
			1.52	.074	
	Open	4.633			
Mean active occupancy	High	7.742			
			2.26	.019	
	Medium	5.994			
			.29	.388	
	Low	5.581			
			1.82	.044	
	Open	3.341			
Activity rate	High	.952			
			-.59	.718	.564
	Medium	1.079			
			.80	.217	
	Low	.907			
			-4.46	.999	.0004
	Open	1.863			
Resting rate	High	.2528			
			2.61	.009	
	Medium	.0899			
			-.61	.723	.552
	Low	.1281			
			-.38	.644	.712
	Open	.1516			
Feeding speed	High	4.849			
			.26	.404	
	Medium	4.421			
			.30	.384	
	Low	3.919			
			-.28	.608	.784
	Open	4.387			

Table 10 (Continued)

Defecation rate	High	.03689			
			-1.50	.924	.152
	Medium	.07056			
			1.28	.112	
	Low	.04183			
			-3.83	.999	.0014
	Open	.1275			

pattern similar to those based on other scores except that in some cases the relationship was reversed. Specifically, activity rate and defectation rate showed a negative relationship to complexity level. The largest difference was between low and open with two-tailed alphas of approximately .0004 for activity and .0014 for defecation. Confirming the general hypothesis were contrasts between high and medium for mean occupancy time ($\alpha \approx .005$), mean active occupancy ($\alpha \approx .019$) and resting rate ($\alpha \approx .009$). In addition the low-open comparison was significant for mean active occupancy ($\alpha \approx .044$) and nearly so for mean occupancy time ($\alpha \approx .074$). The scores are compared in Figures 8 and 9.

D. Light Period x Complexity Interaction.

The similarity between day and night behavior in the complexity compartments suggested by the separate ANOVA's was substantiated by an overall 4 x 2 ANOVA with 3 and 51 degrees at freedom. The interaction results are presented in Table 11 and show that only resting time significantly changed in its relationship to complexity. Actually, as figures 4 and 6 show, the change was primarily a depression in the relative resting time occurring in the high complexity compartment.

E. χ^2 Test of "Exit Patterns"

The distribution of entries into the three possible compartments directly from a specified compartment (i.e., the conditional probabilities) was determined for each of the four complexity levels. An exit pattern is given in

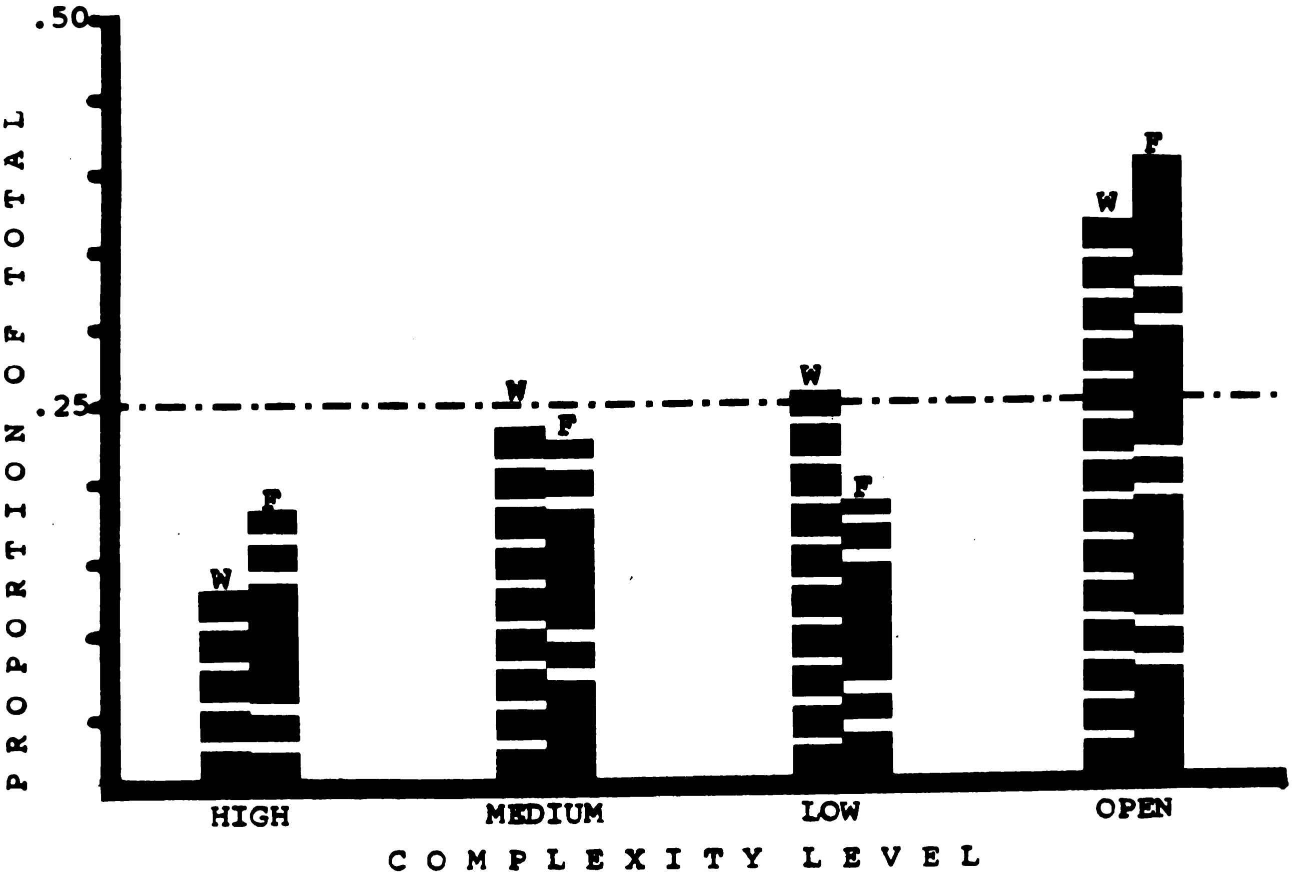


Figure 8. Comparisons of the effects of complexity under night conditions on two ratio scores; water consumption rate (W) and food consumption rate (F).

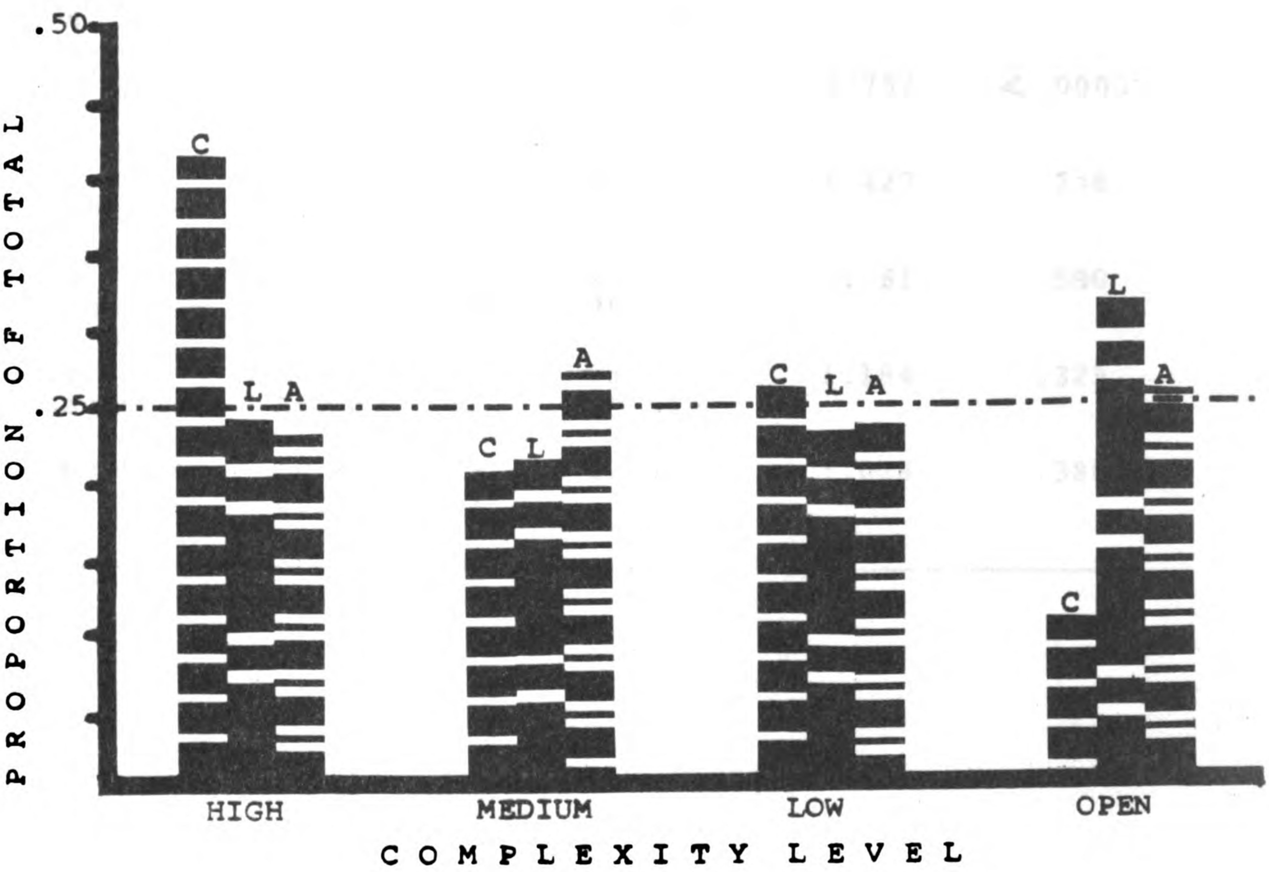


Figure 9. Comparison of the effects of complexity on three discrete trial scores; choice (C), latency (L), and locomotor activity (A).

Table 11. ANOVA on the Interaction between Light Period (LP) and Complexity (C).

Score	Source	df	Mean square	F	α
Locomotor activity	LP X C	3	3979.9	1.550	.213
	Error	51	2568.0		
Feeding time	LP X C	3	9.9508	.101	.959
	Error	51	98.192		
Resting time	LP X C	3	283821	8.752	$<.0005$
	Error	51	31429		
Entry frequency	LP X C	3	85.380	1.427	.246
	Error	51	59.816		
Food consumption	LP X C	3	23.762	.661	.580
	Error	51	35.923		
Water consumption	LP X C	3	95.403	1.184	.325
	Error	51	80.609		
Defecation	LP X C	3	62.051	1.028	.388
	Error	51			

terms of the frequency count of entries. Table 12 presents exit patterns separately for each compartment under day and night conditions. Expected values were obtained by multiplying the total number of exits made from the compartment in question by the proportions of the total entries into one compartment over the total entries into all possible compartments. Expected values obtained in this manner are weighted to correspond with the unequal distribution of total entries into the four compartments. This means that the resulting χ^2 values reflect the degree to which a preference for visiting a particular complexity level, upon leaving the compartment under consideration, is beyond the average entry frequency for the chosen compartment. The χ^2 tests are with two degrees of freedom.

During the day exits from the low complexity compartment significantly favored the high complexity compartment ($\alpha < .001$). This trend continued under night conditions as well ($\alpha < .05$). Further nighttime preference was shown for medium complexity when exiting from high complexity ($\alpha < .025$). All other exit patterns demonstrated a lack of complexity preference above chance.

II. Discrete Trial Phase.

A. Design and Scores.

The present phase of the experiment was treated as a 4 x 1 factorial design for analysis. Except that no illumination factor was involved the design is compatable with that of the _ad lib_ phase. The consistency in design allows

Table 12. Chi-squared Test of "Exit Pattern" Distributions. The Observed Number of Movements from one Compartment to Another Compartment Appears as the Upper Entry in each Cell. The lower Value is the Expected Number as explained in the text.

-DAY-

Exits from \ Entries into	High	Medium	Low	Open	χ^2	α
High	-	17.0 18.5	29.0 27.0	14.0 14.5	.29	.75
Medium	13.0 15.8	-	13.0 13.1	10.0 7.1	1.73	.25
Low	44.0 29.8	11.0 17.0	-	5.0 13.3	13.99	.001
Open	8.0 12.1	9.0 6.9	12.0 10.0	-	2.42	.25

-NIGHT-

Exits from	High	Medium	Low	Open	χ^2	α
High	-	289.0 258.1	250.0 252.3	190.0 218.3	7.37	.025
Medium	252.0 250.0	-	219.0 223.0	195.0 192.9	.11	.95
Low	276.0 244.9	202.0 223.5	-	179.0 188.9	6.53	.05
Open	203.0 200.3	176.0 182.8	183.0 178.7	-	.40	.75

comparison between the two stages of the experiment.

Three measures were recorded during the discrete trial testing; the compartment chosen on each trial, the choice latency (time between placement in center section and entrance into a compartment) for that trial and the subsequent activity during three minutes of confinement in the chosen compartment. These data were represented by four basic scores for each complexity level.

1. Number of entries for all trials.
2. Number of entries on first trial of all sessions.
3. Entrance latency time in seconds.
4. Locomotor activity (number of discrete depressions of all foot plates).

B. Effects of Complexity.

Because both entry scores had fixed sums across complexity conditions, ANOVA was statistically inappropriate and a Friedman test of the ranked data was used to detect significant effects. Means and planned comparisons (Wilcoxon rank difference test) of the scores are presented in Table 13. Complexity did affect choice when all trials were considered at an alpha less than .025 ($\chi^2 = 10.42$) with 3 degrees of freedom, but the effect was not so clear when only the initial trials of each session were considered. The χ^2 value of 6.87 with 3 degrees of freedom was marginally significant ($\alpha < .10$). None the less, the first trial was felt to represent the best test of "preference" in that later trials within a session could be influenced by the recent prior

Table 13. Planned Comparisons on the Results of the Discrete Trial Phase: Wilcoxon Rank Difference Test on Choice Score.

Complexity	Mean	Mean rank	Wilcoxon T	Hypothesis based α
All trials				
High	5.78	3.03		
			43.5	$<.05$
Medium	4.39	2.53		
			98.5	$>.70$
Low	4.94	2.75		
			20.5	$<.005$
Open	2.89	1.70		
First trial of each session				
High	2.44	3.00		
			47.5	$<.05$
Medium	1.28	2.50		
			89.0	$>.50$
Low	1.56	2.61		
			38.0	$>.025$
Open	.72	1.89		

exposure to other complexity levels. For this reason a score was devised which weighted the total trial score by the number of first trial instances it contained. The weighted choice score was obtained by multiplying the total trial score by the first trial score plus one.

ANOVA with 3 and 17 degrees of freedom on this new score showed a significant difference among complexity levels ($\alpha \approx .004$). Table 15 shows that both the high-medium and low-open hypothesis-based comparisons were different from zero ($\alpha \approx .011$ and .035, respectively).

No overall differences for activity or latency were found with ANOVA (see Table 14), however, under a two-tailed _t_ test the low-open latency contrast was nearly significant but negative ($\alpha \approx .084$). The weighted choice score is compared to the other scores in Figure 9.

B. Correlation with _Ad_ _Lib_ Phase.

One objective of the study was to compare the results of the two experimental phases in order to determine whether "preference" as tested in the more traditional discrete trial manner was consistent with "preference" derived from a more extensive long term analysis of behavior. For this reason Table 16 and Table 17 are included to provide the correlations between three discrete trial scores and the basic and ratio scores of the first phase.

As can be seen from the Tables, choice correlates relatively well with occupancy time, resting time, and entry frequency in that order and more strongly for the night version

Table 14. ANOVA on the Effects of Complexity: Discrete Trial Scores

Score	Source	df	Mean square	F	α	eta^2
Weighted choice	Complexity	3	862.19	4.966	.004	.23
	Error	51	173.61			
Locomotor activity	Complexity	3	5.2761	.402	.752	.02
	Error	51	13.129			
Latency	Complexity	3	35.697	1.700	.179	.09
	Error	51	20.993			

Table 15. Planned Comparisons on Effects of Complexity: *t* Tests on Discrete Trial Scores.

Score	Complexity	Mean	*t* value of difference	α under original hypothesis	α under two-tailed test
Weighted choice	High	22.39			
			2.51	.011	
	Medium	11.39			
			- .65	.736	.528
	Low	14.28			
			1.94	.035	
	Open	5.78			
Locomotor activity	High	6.944			
			- .97	.826	.348
	Medium	8.111			
			.68	.258	
	Low	7.289			
			- .51	.691	.618
	Open	7.911			
Latency	High	7.472			
			.45	.331	
	Medium	6.794			
			- .33	.626	.748
	Low	7.294			
			-1.74	.958	.084
	Open	9.944			

Table 16. Correlations among Discrete Trial Scores and the Following Basic Scores: Occupancy Time (OT), Locomotor Activity (LA), Feeding Time (FT), Resting Time (RT), Entry Frequency (EF), Food Consumption (FC), Water Consumption (WC), and Defecation (D).

	OT	LA	FT	RT	EF	FC	WC	D
-DAY-								
Weighted choice	.445	.204	.098	.454	.296	.007	.256	.180
Locomotor activity	-.077	.124	.141	-.070	-.004	.039	-.109	-.198
Latency	-.038	-.026	-.138	-.063	-.153	-.086	.032	-.162
-NIGHT-								
Weighted choice	.653	.246	-.058	.578	.395	.133	.211	.356
Locomotor activity	-.099	.242	.010	-.032	-.101	-.093	.007	-.032
Latency	.051	-.026	-.007	.085	-.042	-.018	-.038	.067

Table 17. Intercorrelations among Discrete Trial Scores including Latency (L) and Locomotor Activity (LA), and Correlations with the following Ratio Scores: Mean Occupancy Time (MO), Mean Active Occupancy Time (MAO), Locomotor Activity Rate (AR), Resting Rate (RR), Feeding Speed (FS), and Defecation Rate (DR).

	MO	MAO	AR	RR	FS	DR	L	LA
Weighted choice	.488	.110	-.242	.301	.006	.026	.516	.125
Locomotor activity	.146	.106	.497	-.081	.127	-.027	-.362	
Latency	.310	-.077	.087	.268	-.045	.062		

of these scores. The discrete trial activity and latency scores appear essentially unrelated to the *ad lib* scores with the exception of locomotor activity which correlates .497 with nighttime *ad lib* locomotor activity rate.

Table 17 also includes discrete trial score intercorrelations demonstrating a relatively strong relationship between latency and choice. Latency also shows a negative relationship to activity.

III. Summary.

The idea that rats "prefer" higher complexity was confirmed, in part, by a number of different measures. Occupancy time, locomotor activity, feeding time, resting time, entry frequency, food consumption and defecation were all greater for higher complexity levels in at least one comparison. In general these scores were ordered across complexity levels as follows, with greatest magnitude first: high-low-medium-open. The smallest difference occurring between low and medium levels. The graphs in Figures 3, 4, 5, and 6 show the relationships of these measures to complexity. The graphs indicate proportion of the total contributed by each level for day and night behavior. The differences due to complexity were greater during the day when general activity was lower.

Figures 7 and 8 include similar graphs for the ratio scores derived from night behavior and the discrete trial results. The graphs reveal that resting rate and the weighted discrete choice score take on patterns similar to the basic scores. In contrast, locomotor activity rate, defecation rate, and food and water consumption rates tend to decrease with increasing complexity.

The comparable results from the discrete trial and _ad lib_ phases, as suggested graphically, are also indicated by the relatively high correlations between the choice score and occupancy time and resting time, particularly at night (.653 and .578, respectively, as given in Table 16).

The preference for a particular compartment seemed to be partially conditioned by the rat's immediate history of complexity exposure. A strong preference for high complexity was evident when exiting from the low compartment and a preference for medium complexity existed after having experienced high complexity (during the night).

Finally, the data was also analyzed correlationally using Pearson's product moment coefficients. The Appendix includes comparisons of separate response patterns for each complexity level. It also presents the overall correlations among the basic scores for day and night behavior. A short summary of the response pattern findings is given below.

In respect to behavioral organization in the _ad lib_ phase, medium and low complexity conditions were similar during both day and night periods, although the patterns underwent substantial change from day to night. During the day these complexity levels shared little similarity with high and open behavior patterns which were quite similar to one another. Under night conditions behavior in the high complexity compartment tended to change while open complexity showed no such shift. The high complexity shift brought the behavioral pattern into substantial agreement with those displayed in the low and medium compartments under opposite illumination conditions (day).

DISCUSSION

Interpreting the value of environmental complexity, as this study has operationally defined it, can be approached in a number of ways. The simplest and most direct method is to assess the approach eliciting power of the stimulus complex. This requires examination of those appetitive behaviors which bring the rat into proximity with the different complexity areas. Approach, however, only represents part of the process of preference (e.g. when occupancy time is considered). The other important component is what this author will call the "staying response". This includes all behaviors which have the effect of keeping the animal in its proximate environment or more specifically in the same compartment. For example, feeding, grooming, sleeping, and even exploration can contribute to this staying response. It is apparent that, on the whole, these behaviors are consummatory. On the other hand, consummatory behaviors like feeding can be considered separately as complexity preference criteria. Determining in which complexity situation a rat is most likely to eat is such an attempt to define complexity preference in terms of a specific biologically relevant variable. At a higher level of organization, these behaviors can be interpreted as contributors to a response complex representing a dynamic preference which is conditionalized by the state of the organism. The approach at this level is more amenable to consideration of the value of complexity in terms of habitat use and selection.

Approach Responses

The power of complexity to elicit approach responses is reflected by two separate dependent measures. Both entry frequencies of the *ad lib* phase and choice frequencies of the discrete trial phase each state the relative instances of approach to the four levels of complexity. Examining these scores indicates that complexity does serve as a differential approach eliciting stimulus, however, the marginal differences under *ad lib* night conditions suggest that the comparative efficiency of the stimulus dimension is subject to attenuation.

It will be useful at this point to distinguish between two antecedents of approach. Once the animal is in the compartment it may engage in consummatory behavior, tending to stay in the compartment for long durations, or it may engage in nonspecific exploration and tend to exit after a short time. During the initial five day habituation period the situation may have been quite different in that lengthy bouts of specific exploration probably occurred. These bouts being motivated by the unfamiliarity of the cage.

Although complexity has been shown to elicit differential levels of appetitive behavior it is suggested that during the early stages of habituation the exploratory incentive offered by higher complexity was greater than is indicated. The basis for specific exploration such as novelty and the necessity to find food and water are greatly diminished as the animal spends more time in the environment. Once the rat is completely familiarized with the environment and the variety of surroundings it offers, appetitive kinds of behavior are likely to be very efficient with no excessive incidence of exploratory approach behavior which does not lead to a consummatory act. Under this assumption frequency of consummatory responses becomes the critical measures of complexity effects.

Staying Response.

Occupancy time, representing the undefined collection of behaviors which keep the rat where it is, provides a better differentiation of complexity effects even though a night-time leveling of the distribution across complexity levels still occurs. Occupancy time appears to be primarily a result of resting behavior (intercorrelations of .890 and .730 under day and night conditions, respectively)(see Appendix) with little relationship to feeding behaviors or locomotor activity. Consequently, resting can be assumed to be the predominate staying response responsible for keeping the rat in its immediate environment. Particularly during the day, when the resting rate is greatest, occupancy time in the high complexity compartment is extreme.

In nature it is quite rare to see animals sleeping or resting in the open. A rather obvious interpretation is that complexity is associated with shelter or hiding places for the rat. In this sense the high complexity compartment or environment becomes "home base" for the animal from which it ventures out into surrounding territory (other compartments) to explore, find food, or in other ways interact with the more remote surroundings. Shelter has previously been shown by Sale (1969) to be an important parameter of suitable habitat for fish. In both field and laboratory studies Sale found that plant and rock cover were major factors in habitat selection to the exclusion of many presumably salient variables.

The importance of shelter as the salient parameter of complexity preference may be seen in the loss of a strong differentiated response under night conditions. While night behavior was concerned with feeding and general locomotion, day behavior was characterized by resting or sleeping. Thus, one may conclude that the reason for the apparent greater approach value associated with higher levels of complexity is primarily founded on its attractiveness for resting (or shelter) rather than for feeding or locomotor activity. Indeed, feeding and activity rates are highest in the least complex environments.

Results of the discrete trial testing are also compatible with this interpretation if the experience for the animal is considered slightly traumatic and remembering that day illumination was present. The consequences of the approach response may well be escape (to an environment associated with shelter and relaxation). The consistently short latencies to enter a compartment supports the escape notion. If it can be assumed that the animal knows where it is going when it leaves the center section, it is possible to conclude that the discrete trial procedures primarily test the "home base" qualities of the stimulus complex. Considering the previous <u>ad lib</u> exposure, familiarity with all levels of the complexity dimension seems certain. It is the <u>ad lib</u> results, in fact, which have allowed a much better specification of the parameters of discrete trial choice.

The discrete trial phase of this experiment yielded a choice score based on a response which would conventionally be thought of as appetitive in nature. The power of complexity manifested in the discrete trial procedure by high approach frequencies is interesting in its unique relationship to complexity effects of the <u>ad lib</u> phase. The choice score, rather than reflecting the entry frequencies of the first phase, best reflects occupancy and resting time. Its correlation with nighttime occupancy is .653 as compared to a .296 correlation with daytime entry frequency (see Appendix). In other words, there is a strong relationship between the appetitive behavior in one situation and the consummatory behavior in another. Thus, the choice score takes on a predictive value associated most strongly with the most powerful effect of environmental complexity under freer conditions. The discrete trial technique for testing complexity preference, then, seems to be justified in terms of its validity, once the motivational base of the response is understood.

Feeding and General Activity.

While rats tend to use the high complexity compartments for daytime inactivity, their bouts of locomotor activity are not so restricted to high complexity. Likewise, food and water are consumed equally in all compartments (except open where eating is uncommon during the day). In general the rat's attraction to high complexity is subordinated by behaviors which reflect an internal state consistent with locomotor activity and feeding. This internal state can be interpreted further as one consistent with non-specific exploration. Exploration is assumed, here, from high locomotor activity, frequent entries into all compartments and short mean occupancy intervals. During these periods of activity is when most feeding occurs and feeding may well be a prime incentive for the locomotion displayed (locomotor activity correlating .545 with feeding time) (see Appendix).

Another incentive for the locomotion could be exploration for its own sake as Butler and Harlow (1954) and Berlyne (1960) have treated such behavior. Experiments where food and stimulus complexity have been kept orthogonal (e.g. Timberlake and Birch, 1967; Taylor, 1971) usually indicate that high levels of complexity can substantially reduce the probability of a deprived animal choosing to approach the food area in deference to the complexity area. In terms of approach behavior it is reasonable to assume that locomotor activity can reflect separable elements of both exploration and feeding.

A somewhat surprising characteristic of the rats' behavior was that no particular compartment became a favored place to feed. This not only demonstrates that complexity is an irrelevant factor in the elicitation of food searching or feeding itself, but also that rats tend not to form place habits for feeding sites. Whether this is an exclusive trait of confined animals is not known and would be hard to determine because studies in the field, where food and water are not homogeneously distributed, would be unable to detect feeding site habits that were not biased by the distribution of food resources.

Because feeding behavior is nearly independent of environmental complexity in the context of this study, the difference in locomotion between that highest complexity level and lower levels is probably a result of a heightened exploratory response. Exploration, though it may occur most in high complexity areas, which have the greatest occupancy times, is also a function of exposure time or familiarity. The lower the complexity level the lower the total occupancy time and the greater the locomotor activity rate. It appears that regardless of time spent within a compartment the organism is inclined to equalize the total expense of activity across all levels of complexity. This phenomenon applies to feeding behavior as well.

Thus, the primary factor in complexity preference appears to be manifested in the resting/sleeping response. This is in contrast to other consummatory responses such as feeding, drinking and defecation, the frequencies of which are relatively homogenously distributed across the four complexity levels. Obviously, the original expectation of a pervasive complexity effect has not been born out. Even the expectation that the strength of appetitive behaviors would be positively related to environmental complexity is not fully confirmed.

Dimensionality of Complexity.

An important aspect of the experimental design is the assertion that the complexity variable is essentially unidimensional or monotonically organized across the four compartments. This can only be ascertained indirectly by looking at the unidimensionality of the variable's effect. The rather consistent ranking from high to open on most dependent measures supports the assumption. The exception is evidenced by the medium-low comparisons where no significant differences were found. In addition, the intercorrelational patterns of these two levels were similar during both day and night periods. The similarity is particularly significant in view of the substantial shift that occurred in the patterns from day to night (see Appendix). Considering these facts, condensing the complexity variable into three levels by treating medium and low as one level would be a logical step to ensure monotonicity. Although this was not done for any analysis, it would be a good way to look at the results *post hoc*.

Another question relating to unidimensionality concerns behavior in the open compartment. Only in this compartment was the behavioral pattern constant across illumination levels. Rates of locomotor activity and defecation were higher than in any other compartment suggesting arousal effects similar to those found in standardized openfield situations. In addition, water was consumed at the fastest rate in open complexity. Drinking in this situation could be an emotional response to the arousal elicited by the open environment. The arousing properties of the open compartment may explain the lack of a shift in day-night behavioral patterns. That is, the arousing properties of night may have little effect because the open environment is already arousing even under day conditions.

Stimulus Discrepancy Hypothesis.

A limited arousal explanation of behavior has been proposed to handle the apparently unique response to the open compartment. A much broader application of the arousal concept has been adopted by some theorists to explain stimulus seeking behavior in general. Fiske and Maddi (1961) contend that stimulus deviations in either direction from a familiar standard serve to arouse the animal and can elicit approach responses toward the moderately dissimilar stimulus. If we assume that on the average the familiar standard in the *ad lib* situation is the mean level of stimulation provided by all four compartments then the Fiske and Maddi interpretation would predict that both extremes of the complexity dimension would be arousing and good approach elicitors. This interpretation might be applicable to the extent that it concerns general arousal, however, in respect to the approach value associated with these moderately discrepant stimulus levels, the hypothesis clearly has some problems when the frequency of visiting the open compartment is less than chance.

Assuming that an animal is operating with a middle-valued standard it can be argued that stimulus discrepancy does produce arousal. When arousal levels are inferred from appetitive response rates, the high and low ends of the complexity dimension appear to be the most arousing. The similarity in the daytime response patterns for these two levels (see Appendix) provides further justification for the claim that high and open levels can produce the same effects. Beyond this claim, however, it is clear that arousal cannot work as an approach incentive as Fiske and Maddi suggest. If it did, open complexity would be approached equally as often as high complexity. Yet, the preference for high complexity is much stronger in terms of at least one appetitive response (approach frequency) and at least one consummatory response (resting). In this example, the response consequences of the stimulus complex apparently have no effect on the complex's attractiveness.

Forgetting about this contradiction for a moment, suppose the high complexity level attracts the animal because it is arousing. Why, then, does the animal select this environment for resting and sleeping? Obviously, high complexity can not be arousing the animal very consistently. In general, the application of an arousal process to explain the mechanics of environmental preference is unsatisfactory.

The simple alternative to Fiske and Maddi's response-based explanation is to exclude arousal as an intervening variable. Instead of assuming that the effect of environmental stimuli are response produced it is necessary only to consider them as elicited. Particularly, there is no need to require that a preference response be reinforced by a change in arousal state. Appealing simplicity is achieved when the mechanics of a process are stimulus bound and response produced effects, although they may have beneficial consequences, are not construed as important motivational variables.

The discrepancy hypothesis, in its stimulus-based form, probably works best in situations where the standard can be viewed as a transient internal representation reflecting short-term habituation to the immediate stimulus surround. Under this assumption the standard becomes whatever complexity level the animal has been exposed to most recently. If the relationship between attractiveness and stimulus differences is formulated as a $\cap$-shaped function, complexity levels of moderate rather than extreme or minimal differences from the currently occupied compartment would be more attractive.

Some support for stimulus discrepancy in this context is found in the exit patterns from the high and low complexity compartments. When exiting from high complexity, rats showed a heightened preference for medium complexity while the attraction of the open compartment was suppressed. In other words, under the short term view of immediate change, preference for a moderate but not an extreme change in environmental complexity was suggested. Exits from the low complexity compartment indicated a heightened attraction toward high complexity and a reduced preference for medium complexity. In other words, preference for a moderate but not a minimal immediate change in environmental complexity was suggested. In dealing with the relative differences between complexity levels it is important to remember that the low and medium levels, because of the unified way in which the rats responded to them, should be considered as nearly identical.

Another possibility is that the standard on the average is better represented by high complexity as a consequence of the animal's disproportionately greater exposure to this level. Previously described discrepancy hypotheses would be unable to predict the results obtained in the present study under this definition of a standard. Further, while the above standard is conceived as a product of adaptation, emphasis on the current state of habituation to a specific complexity level is not necessary. In the long run, an overall relatively intransient standard may develop. Again this alternative could not be handled by stimulus discrepancy hypotheses. There is, however, a unilateral discrepancy hypothesis capable of dealing with the proposition that high complexity serves as the discrepancy standard.

Dember and Earl (1957) as proponents of the adaptation viewpoint, have modified the idea of the $\cap$-shaped approach function. They have suggested that when looking at long-term shifts in complexity preference the course of stimulus seeking is one-way. That is, only stimuli of greater complexity than the adaptation level are approached. The approach curve is thus reduced to a $\cap$-shaped function of *positive discrepancy*.

An animal operating with high complexity as the discrepancy standard would be limited in its approach preferences as no higher level of complexity is available. In this case, the approach tendency would be expected to decrease monotonically as the stimulus discrepancy deviates away from the ideal of moderate positive discrepancy. That is, as it becomes more negative. This is exactly what was found in the present study.

During the habituation phase of the experiment, it is possible that the rats initially were operating with low complexity standards derived from the starkness of their home cages. Under Dember and Earl's adaptation hypothesis the standard would have shifted upwards finally reaching and settling at the high complexity level. Subsequently, the long-term aspects of the standard would be fixed. Alternatively, the animals may have entered with a fixed standard already at a high level. The latter seems unlikely but discrimination between the two conditions is impossible based on the limited data on early behavior.

The preceding explanation is primarily intended for long-term trends and not the minute to minute behavior of the rats. Obviously, as previously discussed, short-term patterns in movement from one compartment to another exist. Indeed, the concept of stimulus discrepancy, in its various applications, should be taken only as a reflection of general trends within short-term or long-term preference behavior.

When thinking of Dember and Earl's construction it should be remembered that short-term behavior constantly intervenes. Excursions from the high complexity compartment may be motivated by a multitude of factors including a search for variety in environmental stimulation. Thus, achieving a reduction in the complexity of its surroundings could be considered a desired consequence of the rat's motility.

The determination of the role of environmental complexity in the selection of suitable or optimal habitats and its role in guiding the animal within its adopted habitat await extensive field investigations. However, the present study has found that the more complex an environment is, the more likely it is that the rat will use the region as a home base. Whether the home base quality is attractive because it provides exploratory incentives, stimulation for general arousal, stimuli compatible with seclusion and relaxation, or a combination of these factors is not completely clear.

It appears that both relaxation stimuli and exploratory stimuli are important for the formation of a relatively stable home base, while arousal stimuli are of tertiary concern. Especially, in view of the simple elicited nature of preference behavior, arousal is a burdensome hypothetical construct. The parsimony of a stimulus-based determination of both short and long-term reactions to environmental complexity is entirely adequate to explain previous findings as well as the present results.

The stimulus bound formulation also works well in ethological terms being consistent with Hilden's (1965) notion that animals tend to select habitats on stimulus variables which are often irrelevant to the animals in a biological sense. The cue value of the stimulus or stimulus dimension is presumably determined on a genetic/evolutionary basis, although early experience could modify this (e.g. Wecker, 1963).

State Considerations.

The fact that the behavior most affected by complexity level is also strongly influenced by light period demonstrates the importance of accepting environmental preference as a dynamic process. This author has suggested that the diminuation of complexity effects associated with a change of illumination to night levels reflects a change in the rat's internal state. The dramatic increase in locomotor activity lends obvious support to this interpretation. Yet, this shift in behavior could be explained by the loss of visual cues under the no-light condition of night. For example, it could be argued that with the loss of visual cues the rat is either unable to discriminate between different complexity levels or that without visual support the discrimination is meaningless in terms of any differential response eliciting potential.

It is easily assumed, however, that the rat is operating with both visual and tactual modalities and that the complexity dimension is just as meaningful tactually as it is visually. Considering the extensive use of vibrissae by albino rats in unfamiliar situations this assumption seems reasonable. Even if the visual mode predominates it seems that the animal has had sufficient experience with the environment to effectively integrate the associative aspects of the different stimulus dimensions (visual and tactual) to the extent that the "internal representation" of the environment is the same day or night.

A reliable test of the extent to which any behavior shifts reflect a reliance on visual information would require the nighttime illumination to be raised to a level which allows adequate visual acuity and still represents a substantial drop from the daytime illumination level. If the lack of a strong complexity preference continued, then the effect would appear to be caused by something other than loss of visual information.

A slightly different approach would have to be taken if the effects of illumination cycle _per se versus_ the effects of a circadian rhythm, which in the present experiment are confounded, are to be determined. For example, illumination levels could be changed every few hours and if a diminuation of the differential response to complexity occurred synchronously it could be concluded that the effect is essentially independent of a circadian rhythm.

Accepting environmental preference as a dynamic process, of course, suggests the necessity of plotting the temporal course of behavior much more closely than the present study has attempted. This does not require a change in experimental design or a major change in recording procedure but rather a more sophisticated analysis of behavior. That is, a behavior sampling procedure yielding a fairly continuous flow of data is needed. While this existed in the present experiment for locomotor activity, compartment entry, and resting box occupancy; because of the complex and voluminous nature of the data, a sequential analysis was not attempted. Further, the sampling of food and water consumption and defecation was limited to twelve hour intervals. Continuous recording of at least feeding and drinking would be essential to an accurate assessment of the short-term temporal course of preference behavior. Continuous monitoring of feeding and drinking is particularly important in reference to behavior classification and state identification. As previously discussed, this kind of information is critical to the identification of appetitive behavior and short-term state conditions. Obviously, the day-night illumination variable is a very gross and restrictive division of state levels.

<u>Conclusion</u>.

To summarize, it has been shown that rats select one environment for most of their daytime resting. This is usually the high complexity and never the open complexity compartment. This preference appears stable over the two days and is also reflected, to a lesser degree, under night conditions. The nighttime preference is in terms of occupancy and resting times and entry frequency and not in terms of more active behaviors such as feeding, drinking and nonspecific locomotion.

It was suggested that high complexity evolves as a "home base" from which the animal initiates exploration and feeding activity. These behaviors were found to be controlled by illumination level. The short-term bouts of stimulus seeking showed evidence of being a $\cap$-shaped function of stimulus discrepancy. The long-term evolution of a standard environment (high complexity) was proposed ala Dember and Earl (1957). The existence of a relatively fixed innately determined standard is the alternative explanation.

The inclusion of arousal in a motivational theoretic was found to be unworkable or unnecessary. Particularly in relation to discrepancy hypotheses the concept was problematic. It may be useful, however, in explaining the unique response to the open compartment. The general avoidance of this environment and the high rates of appetitive and consummatory responding, once the animal was in it, can be viewed as derivitives of high induced emotionality.

Finally it was found that the more traditional discrete trial procedure seemed to tap environmental preference founded on the home base qualities of complexity as defined by the *ad lib* results.

APPENDIX

APPENDIX

A. Correlation Among the Dependent Measures Within Treatment Conditions.

For each of the complexity level x illumination level (4 x 2) conditions the intercorrelations of the set of dependent measures under consideration was computed. Thus, when the basic scores were used eight 8 x 8 matrices were constructed. Similarly, eight 6 x 6 matrices were compared when the ratio scores were examined.

1. Basic Scores.

The lack of consistency between the correlational patterns of the different conditions was striking. Even under the same illumination level the behavior in compartments of adjacent complexity level displayed little similarity. Because of high variability and an insufficient number of subjects no comprehensive review of this data such as cluster analysis was attempted. Two rather crude surveys of the data, however, were conducted. One looked for measures which tended to show similar correlations with the other measures across conditions. The other compared the overall correlational patterns among conditions. The latter will be treated first.

The eight matrices based on treatment condition, as described earlier, were divided along their main diagonals.

Using these matrix halves all correlations were reduced to '+', '-', or '0' using the inverse of the square root of the sample size as the error term. Thus all matrix entries greater than .235 were coded as '+', less than -.235 as '-' and all others received a '0' code. The transformed matrices are given in Figure A-1.

All possible pair-comparisons between the matrices were made. Each comparison yielded a congruency or "similarity score" when one matrix was laid atop another and the number and extremeness of deviations in the corresponding correlational entries were tallied. If two corresponding entries were the same, a zero was registered, if one was '0' and the other a '+' or '-' then the value 1 was registered and if one was a '+' and the other a '-' the value 2 was registered. The resulting sum of these deviation values was subtracted from 56 (the maximum possible deviation score) and then divided by 56 giving a percentage similarity score ranging from 1.0 (prefect congruency) to 0.0 (complete dissimilarity). These values for the 28 pair-comparisons are given in Table A-1.

By chance alone a similarity score would have the expected value of .33. The table shows that all scores were above this value suggesting some thread of relationship across all conditions. This is the least that would be expected. Further examination of the condition pairs yielding the more extreme similarity scores led to some tentative conclusions. Reemphasis of the procedural crudeness

		HIGH						
		O	A	T	R	E	F	W
DAY	A	-						
	T	-	o					
	R	o	o	o				
	E	+	-	-	o			
	F	-	+	+	o	-		
	W	o	+	o	+	-	o	
	D	o	o	+	+	-	-	o
NIGHT	A	o						
	T	+	+					
	R	+	+	+				
	E	o	-	-	o			
	F	o	o	o	o	+		
	W	o	+	+	o	o	+	
	D	+	+	+	+	o	+	+

		MEDIUM						
		O	A	T	R	E	F	W
DAY	A	+						
	T	+	+					
	R	+	+	+				
	E	+	+	+	+			
	F	o	+	+	+	+		
	W	+	+	+	+	+	+	
	D	+	+	+	+	+	+	+
NIGHT	A	+						
	T	o	+					
	R	-	o	o				
	E	+	o	o	-			
	F	-	o	o	o	-		
	W	-	o	+	o	-	o	
	D	o	o	+	+	-	o	-

		LOW						
		O	A	T	R	E	F	W
DAY	A	o						
	T	+	+					
	R	o	+	+				
	E	+	+	+	+			
	F	o	o	o	o	o		
	W	o	o	o	o	o	o	
	D	o	+	+	+	o	+	o
NIGHT	A	o						
	T	-	-					
	R	o	o	o				
	E	+	o	o	o			
	F	-	o	o	o	-		
	W	-	o	+	-	-	o	
	D	o	o	o	+	o	o	-

		OPEN						
		O	A	T	R	E	F	W
DAY	A	-						
	T	-	o					
	R	o	o	o				
	E	+	-	-	o			
	F	-	+	o	o	-		
	W	o	o	o	o	o	+	
	D	o	o	+	o	o	-	o
NIGHT	A	-						
	T	-	+					
	R	o	+	o				
	E	o	-	o	o			
	F	o	+	o	o	-		
	W	o	o	o	o	-	-	
	D	o	+	o	+	o	-	o

Figure A-1. Response patterns for each complexity level under day and night conditions. The intercorrelations of the basic scores have been reduced to positive or negative relations. A 'O' indicates the lack of a significant relationship.

Table A-1. Similarity Scores of the Correlational Patterns of Responding (Basic Scores) within each Condition. The Value of the Table Entries Represents the Degree of Similarity found in the Response Patterns of each Contrast between Conditions.

		DAY				NIGHT		
COMPLEXITY		High	Medium	Low	Open	High	Medium	Low
DAY	Medium	.48						
	Low	.61	.74					
	Open	.88	.46	.67				
NIGHT	High	.59	.76	.78	.65			
	Medium	.74	.48	.69	.70	.61		
	Low	.74	.43	.67	.57	.57	.85	
	Open	.79	.48	.72	.81	.67	.69	.79

is necessarily a caution toward accepting these conclusions.

During the day, behavior in the high and open compartments showed similar patterns (similarity score = .88) as did the low and medium compartment behavior (.74). The predominate source of disagreement for both pairs was in the food and water scores where some positive correlations were lacking in one of the compartments (open in the first case and low in the second). In addition substantial dissimilarity existed between the medium and high and the medium and low complexity levels (.48 and .46 respectively).

Nighttime behavior generally showed a different relationship between the compartments and different correlational patterns in the same compartment as compared to the day results. Low and medium maintained their relative similarity (.85), although the relationship was different from that found for daytime behavior. While the food and water correlations tended to match, the intercorrelations of occupancy time, activity, and resting time lost their similarity. The previous high and low congruency was not evident during night periods. Further, open was most similar to low complexity (.74).

Behavior organization at night in high complexity resembled that displayed during the day under medium and low complexity conditions (.76 and .78 respectively). On the other hand the low and medium night patterns were similar to day behavior in the high compartment (.74 and .74) with the major exception of low correspondence for correlations associated with the activity score.

In general, behavioral organization seems to reflect an interaction between light period and complexity level. That is, similar patterns were associated with daylight behavior in high and nighttime behavior in low and medium compartments. Conversely, nighttime behavior in high was most like daytime behavior in low and medium. Behavior in the open complexity compartment did not appear to be affected by this behavioral shift and remained relatively constant.

The other approach to the correlational data was to look for scores which displayed consistent relationships with the other scores across complexity and illumination conditions. Using the same coding (+, -, and 0) the matrices were re-arranged so that a separate matrix was obtained for each dependent measure. Dimensions were conditions (8) X remaining scores (7). Only two meaningful intercorrelations were found to be consistent. Resting time correlated positively with defecation with the single exception of zero correlation for open complexity during the day. Nesting time was also found to have no relationship to food consumption except for medium complexity which showed a positive correlation during the day.

2. Ratio Scores.

Because of the intrinsic statistical problems of interpreting correlations among ratios based on common scores and because a scan of the matrices reveled no discernable patterns these results were not pursued.

B. Correlations Independent of Treatment.

The correlations among the various basic scores independent of complexity level are given in Table A-2. Separate correlations are given for day and for night results.

Table A-2. Intercorrelations among Basic Scores under Day (Left-hand Matrix) and Night (Right-hand Matrix) Conditions. The Basic Scores include Occupancy Time (OT), Locomotor Activity (LA), Feeding Time (FT), Resting Time (RT), Entry Frequency (EF), Food Consumption (FC), Water Consumption (WC), and Defecation (D).

	OT	LA	FT	RT	EF	FC	WC	D
OT		.377	.115	.730	.587	.284	.160	.650
LA	.402		.545	.319	.420	.294	.063	.253
FT	.245	.448		-.057	.339	.618	.411	-.001
RT	.900	.406	.041		.413	.080	.116	.390
EF	.534	.808	.502	.514		.308	.156	.502
FC	.218	.223	.241	.194	.243		.328	.209
WC	.094	.224	-.037	.070	.203	.101		.155
D	.482	.172	.118	.500	.382	.340	.076	

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