

BEHAVIOURAL EFFECTS OF
SOME POST-WEANING ENVIRONMENTAL
VARIABLES UPON THE
RAT

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ABSTRACT

Social and sensory characteristics of post-weaning rearing environments interact to affect the behaviour of rats in a multiple Y maze, on measures of ambulation, emergence latency and weight. On measures of running time, variability, and activity box scores the two variables act independently. Sex is seen to interact with one or both of these variables on all measures.

It is concluded that greater clarification is needed in generalisations concerning types of rearing environments, and that the sex of the animals and the testing situation utilized should be considered in such generalisations.

Some theoretical interpretations are discussed and suggestions for further research put forward.

CHAPTER 1

INTRODUCTION

Preamble

Much developmental research over the past thirty years has been directed toward the investigation of various early environmental experiences of the rat upon a variety of subsequent behaviours. Denenberg (1962) presents a general review of the literature covering various types of animal studies in this area.

The aim of this research has been to develop an understanding of the developmental processes and how the external environment in particular, affects them. We have come at least as far in our understanding to date as Denenberg (*loc. cit.*) states, "The environment is a dynamic force actively interacting with the psychobiological processes of the organism at each stage of its development." Just how it interacts is still a topic of much discussion and a variety of experimental designs.

The type of environment utilized in research involves such experiences as: being handled, and/or living with or without cagemates (e.g. Archer 1969; Greenough et.al. 1972; Hughes 1971); living in a wide variety of restricted and enriched environments (e.g. Forgyas and Read 1962, Hymovitch 1952, Schweikert and Collins 1966). Each of these experiences has been reported, at some stage, to have affected one or more

of such variables as openfield behaviour (e.g. Symne 1971), learning of discriminations (Bingham and Griffiths 1952), various motor tasks (Hymovitch 1952, Morgen 1973, and several different physiological measures (e.g. Bovard 1958, Hahn, 1965, Stern et. al. 1960).

Broadly speaking, three main constructs have been utilized throughout a number of these studies to help in explaining the resultant effects of the various experiences. These are: "emotionality" (referring, normally, to fear-responses); "exploration" (variously called, "curiosity", "manipulation" and "attention"), and "learning ability" (as measured by performance on various learning tasks according to predetermined criteria). All are, of course, inter-related in some way and the measures used to assess them overlap at times, leading to confusion and a certain amount of discussion and controversy. Bearing in mind the possible nebulous nature of these constructs, it is, however, still convenient to use them as part of a theoretical framework upon which to base one's research.

The type of experience to which the animals are subjected in their early environments may, of course, also be fitted into the framework of these three constructs. Such that, a particular experience may have greater significance in distinguishing differences along an emotional measure than along an exploratory one and hence may be regarded as an "emotional" experience. Or, for example, the presence of various "toys" (ramps, mazes, etc.) in the animals' cages may be regarded as an experience in exploration and learning, helping the animal develop motor and perceptual skills necessary for tasks in a

maze or similar such apparatus. Thus, it is reasoned that particular types of environmental experience could be related to specific types of behavioural measures, more so than other experiences.

The aim of the present study is to investigate the relative effects of two major environmental enrichment variables upon measures relating to emotionality, exploration and learning. The two variables, which occur widely in the literature either as separate experiences or combined as one "enrichment" experience, are social stimulation (presence or absence of cagemates), and sensory stimulation (presence of otherwise of various manipulanda in the cage).

Review of Some Behavioural Effects of Early Experience

Experimenters utilizing only social grouping (the presence of cagemates) as an enrichment variable, generally report fewer emotional and more exploratory behaviours among group reared animals than among those reared in isolation. Morrison and Hill (1957) utilized an approach - avoidance test. Food deprived rats were taught to run a straight 5 foot runway in 15 seconds, for a food reward, placed in a goal-box at the end. The floor of the runway was then electrified and the rat placed in the runway for 15 seconds. The number of trials taken before the animal would run to the goal-box in 15 seconds was recorded. In addition, the amount of approach behaviour was recorded by noting the farthest of the 10 inch lines drawn on the floor, that the animal reached on each trial. Group-reared animals scored significantly more approaches and approached more closely

than isolates. Moyer and Korn (1965) found that isolates were more emotional as measured by startle responses to a loud noise. Their methodology, however, can be criticized on the grounds that they used a larger cage for the group condition - introducing a confounding "sensory" type variable, in that the animals had a greater area in which to move. Myers and Fox (1963) tested their animals on a "five choice point multiple U maze"; group reared animals scored significantly lower on number of errors and number of trials to reach a criterion of ten consecutive errorless trials all under 10 seconds. The authors attributed their findings to greater exploratory behaviour and fewer emotional responses of the group-reared animals. Hahn (1965) reached similar conclusions from results of an "emergence test" recording running latencies to a reward of wet mash along a runway. Group housed animals had shorter latencies which Hahn attributed to less "timidity" than the isolated rats. Archer (1969)B isolated female rats for 24 weeks and found them significantly less active as measured by "number of squares crossed in an open field", than animals housed in groups of three, five and eight. A similar experiment with males showed no significant differences.

In his review of social enrichment versus isolation, Archer (1969)A quotes some contradictory evidence from mouse studies by Weltman et. al. (1966) and Essman (1966) who correctly point out the wide range of discrepancies in the literature on this topic such as differential ages and different methods used to measure exploration and emotionality. Archer (loc. cit.) posits an explanation of the various

findings in terms of an interaction between testing conditions. Where the testing environment presents a relatively large change in stimulus conditions from the rearing environment, the animals show more fear responses and move about less. If the animal has been living under conditions of low stimulus input (e.g. isolation) the change may be greater than for an animal living under a higher stimulus input (e.g. group-rearing). Hence the isolated animals might show more fear-responses and explore less. On the other hand, if the change in stimulation is not sufficient to elicit fear-responses in either case, the isolates might show more exploratory behaviour than the grouped animals owing to the low stimulus conditions in their previous environment.

The weight of evidence from studies manipulating only sensory variables tends to go the other way from the above research in that the enriched animals show less exploratory behaviour than the impoverished ones. Zimbardo and Montgomery (1957) found that rats reared in a Hebb-free environment were less "exploratory" than those reared in "normal" laboratory cages as measured by number of 12 inch sections entered in a symmetrical Y maze, and qualitative observations of rearing and sniffing. Though, in an earlier study, the same authors found no differences between normally caged animals and those in restricted environments (Montgomery and Zimbardo (1957)). They conclude from these results that exploratory behaviour is dependent upon exteroceptive stimuli and not upon internal drives. Animals reared in a restricted environment are "stimulus-deprived" and hence explore more than those from an enriched environment. This is, of course,

along the lines of Archer's conclusions (see back).

Luchins and Forgas (1955) obtained results which, to some extent may be regarded as contradictory. They found that enriched animals obtained higher scores on measures of ambulation and variability on a maze task, and showed less rigidity on the Einstellung test. However, these authors included handling as one of their enrichment conditions, hence adding a confounding variable. Also, both groups ("impoverished" and "enriched") were reared in community cages, thus including a social variable. Technically speaking the social effect would be controlled for since both groups were reared under the same conditions. However for the purposes of the present discussion, it is obvious that this presents a significantly confounding variable as the "social" factor is itself under scrutiny. A similar criticism is applied to Forgas (1954) who also found enriched animals more active and "variable" according to the same criteria. He also found the enriched animals superior on "form discrimination" and "reasoning" tests.

The research utilizing both social and sensory variables as enrichment factors arrives at much the same position as the above. Interestingly, most of the literature in this area is concerned primarily with problem-solving ability. This began with the early work of Hebb (1949) who found that rats reared as pets in his home had higher scores on the Hebb-Williams rat "intelligence" test than laboratory reared animals. Since then, much research has supported this contention by observation of improved performance upon learning tasks among rats

reared in enriched environments. Bingham and Griffiths (1952), Forgays and Forgays (1952), Forgays and Read (1962) and Hymovitch (1952), have all found that enriched animals are superior in learning performance to restricted rats as measured by number of errors and trials to criterion on various learning tasks. The common feature in these studies is the inclusion of both social and sensory variables within the design, but without controls for possible differential effects. Restricted animals are isolated and sensorially impoverished, while enriched animals are reared generally in larger cages, with cagemates, and with various ramps, tunnels, etc.

Woods et. al. (1960) and Woods (1961) have provided support for an hypothesis accepted more recently by a number of authors to account for these findings. That is, that the differences in learning "ability" are due less to internal differences, but more to the fact that animals reared in restricted environments spend more time exploring and hence, less time "working on" and completing the task. Woods (1961) showed that under conditions of "high motivation" the differences in learning ability were eliminated. That is, if impoverished animals are food deprived for longer periods, then hunger conflicts with the exploratory tendency and the animals perform as well as enriched rats.

This hypothesis is of course, given support by the evidence above that animals reared under sensorially impoverished conditions explore more than enriched animals. The findings from the studies manipulating only social

variables, tend to complicate the picture somewhat, however, since these findings would indicate that under certain conditions a socially deprived environment may not enhance exploratory behaviour. It may also be significant that socially isolated animals invariably prove to be poorer problem-solvers than group-reared animals (Archer 1969A). Morgan (1973) has thrown a little light in this direction. He conducted a study using three groups:

- (a) socially and sensorially enriched
 - (b) socially and sensorially impoverished
 - (c) socially enriched and sensorially impoverished.
- In a series of gross motor learning tasks which involved learning first a task and then reversing the behaviours required on a second task, he found the (b) group significantly slower than the (a) group on the transfer task. He also found that the isolated groups were more active in the open field and ran faster for food when deprived. He speculates an hypothesis on the basis of his results, that "... rats reared in isolation have a reduced capacity for behavioural inhibition". (p.440).

The present study follows the rearing design of Morgan with the addition of an extra control-group - socially isolated and sensorially enriched - with the aim of clarifying what interaction, if any, there may be between social and sensory variables in rearing environments.

CHAPTER 2

METHOD

Subjects

Forty New Zealand black and white hooded rats (of a strain developed at the University of Otago) were assigned arbitrarily at weaning (25 days old) to one of 4 main conditions with 10 rats in each condition.

Social-Impoverished	(S.I.)
Social-Enriched	(S.E.)
Isolated-Impoverished	(I.I.)
Isolated-Enriched	(I.E.)

Each group contained an equal number of males and females.

Rearing Environments

Animals in the "Social" conditions were housed in groups of five animals per cage (all of the same sex). No attempt was made to keep littermates together. In the "Enriched" conditions, a number of "toys" were placed in the cage:

- (a) an aluminium swing 8 x 4cms hung from the top of the cage on 20cm arms;
- (b) an aluminium see-saw, 4 x 20cms;
- (c) a set of wooden steps cut from a truncated 16 x 4 x 6cms high triangular prism; with four steps up either side and painted white (see Figure A overleaf);
- (d) a solid wooden cube 4 x 4 x 4cms painted white with a 1cm black stripe bisecting each surface;

FIGURE A

STEPS USED IN ENRICHED CAGES

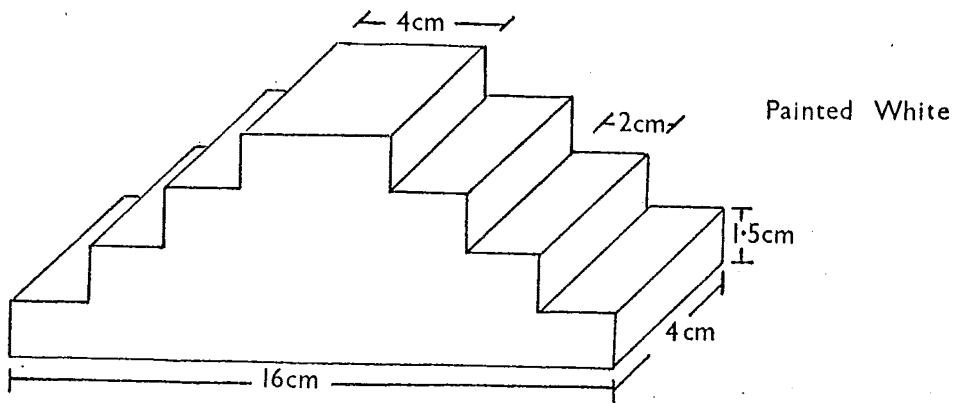
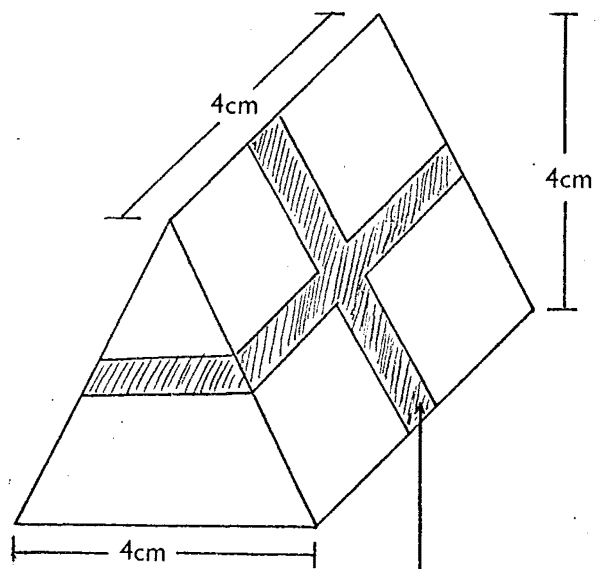


FIGURE B

TRIANGULAR PRISM USED IN ENRICHED CAGES



Painted White with Black Stripe

- (e) a solid wooden triangular prism of the same dimensions and brightness as the cube (see Figure B overleaf);
- (f) a table-tennis ball;
- (g) a one inch galvanized nut and bolt suspended from the top of the cage on a piece of wire;
- (h) a 6 inch length of 3 inch diameter polyurethane water pipe.

Animals in the "Isolated" conditions were housed alone in their cages. The "Impoverished" rats had no toys.

All cages were the same size: 18" x 18" x 10" made of wood with a removable wire gauze lid. The inside was painted a flat grey and wood-shavings covered the floor. All cages were cleaned out once a fortnight to begin with, when all animals were briefly handled. As they grew larger, the grouped animals' cages required more frequent cleaning than the isolates. When this occurred, all the isolated animals were given extra handling also.

The animals were fed on a diet of standard rat pellets and dog biscuits, supplemented with the odd piece of fruit or greenery. Water was supplied from bottles attached to the outside of the cages and directed through a hole in the wall via a glass tube.

All 24 cages were kept in a 12ft. square room at a temperature of 68-72°F on a reversed dark-light schedule (upon which they had lived from birth). Cages were placed

on the floor and at waist height on tables. Thus, all animals would have been able to see through the wire gauze cage tops, the white ceiling and walls and anyone coming into the room. Those on the floor would have viewed the undersides of tables. No animals would have been able to see into other cages.

Testing Apparatus

The testing apparatus consisted of an 11" x 11" x 8" "activity box" and a maze developed after Forgas (1954). The Activity Box was built of wood and painted dark brown inside and out, with a wire gauze lid. The box was mounted on an adjustable movement-sensitive photo electric cell which operated a digital counter. Any slight movement within the box caused the counter to click over. Thus it was possible to obtain a general "movement" measure of animals placed inside.

A plan view of the maze, labelled and drawn to scale, is shown in Figure C overleaf.

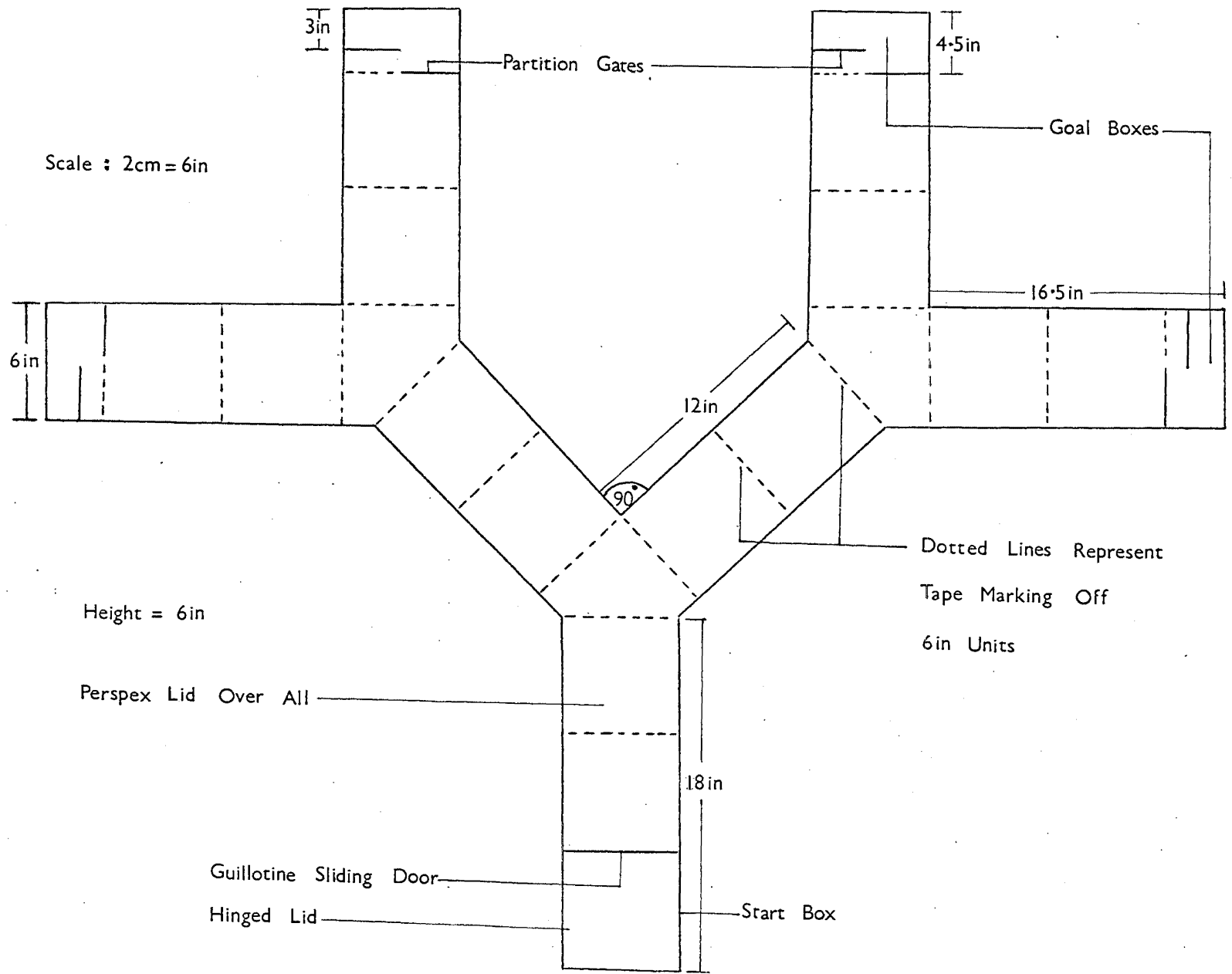
Procedure

Animals were tested when approximately 64-70 days old. Testing consisted of two main sections:

- (a) Adaption to enable the animals to become accustomed to the apparatus and to obtain a general ambulatory measure. Rats were placed in the Start Box of the maze, the guillotine slide was lifted and they were given 5 minutes free "exploration" without food in the goal boxes. At the end of this the animal was taken out and placed in the activity box for 5 minutes.

FIGURE C

PLAN VIEW OF MULTIPLE Y MAZE



Records were kept of:

- i - emergence time from the start box (taken from when the slide was lifted clear to when the animals' hind legs crossed the threshold);
- ii - faecal boli;
- iii - number of 6 inch units traversed (the animal was considered to have traversed one unit when its hind legs crossed one of the black lines on the floor);
- iv - the score from the activity box.

(b) Experimental. Each rat experienced two maze running sessions of 10 trials. On one session the animals were food deprived for 48 hours prior to testing; on the other they were tested undeprived. In both sessions, food was left in the goal-boxes in the form of a mixture of powdered dog biscuits, sugar and milk. Food deprived and non-deprived trials were included to control for possible interaction effects of deprivation with sex and locomotor activity as shown by Hughes (1968). Also to test the hypothesis of Woods (1961) that under conditions of higher "motivation" (i.e. food deprivation), differences between animals on maze running times will be reduced. Each trial consisted of placing the rat in the start-box, raising the door and recording:

- i - emergence time (as in Adaption);
- ii - time to enter a goal-box (taken from when the slide was raised to when the animals' hind legs passed the first portion of the goal-box);
- iii - faecal boli;
- iv - sketched record of animals' path through the

maze (recorded on a sketch plan of the maze).

From the latter record a measure of "variability" was obtained by scoring whenever the rat took a different route on successive trials. Because of the design of the maze, there were two points at which the animal could change its route, traversing either two different arms or only one. Two points were scored if two different arms were traversed and one if only one was traversed. Thus the maximum possible score over 10 trials was 18. Once a rat had entered a goal-box, it was given a few seconds to nibble the food and was then taken out and returned to the start-box from whence the second trial began.

All testing took place in a room nearly adjacent to the rearing room and of similar dimensions. The room was heated, though not thermostatically controlled and a masking background of white noise of 40-50 decibels was present throughout.

For practical purposes, the animals were split into two groups for testing - 20 animals per group. An equal representation of each of the four main conditions and of each sex was present in each group. Testing was then carried out according to an ABAB design - each group of 20 being tested on alternate days. The order of the food deprived and food non-deprived session was reversed for each group.

Thus:

<u>Day</u>	<u>Group Tested</u>	<u>Test</u>
1	A	Adaption
2	B	Adaption
3	A	Food non-deprived

Cont..

<u>Day</u>	<u>Group Tested</u>	<u>Test</u>
4	B	Food deprived
5	A	Food deprived
6	B	Food non-deprived

In this way, all animals had 48 hours rest between testing sessions.

Two post-experimental measures were taken. An Activity Box reading, 48 hours after the end of the experimental sessions. Seven days later the animals were weighed. Both these measures were done in one block and in the room in which the rats were reared.

CHAPTER 3

RESULTS

As only one rat defaecated in the testing apparatus, the faecal boli counts were ignored. This left a total of eight measures upon each of which an analysis of variance was performed. Five of these fitted a $2 \times 2 \times 2$ factorial design, the other three a $2 \times 2 \times 2 \times 2$ design with repeated measures on the last variable (i.e. food deprived and food non-deprived trials) (c.f. Winer 1962).

Summaries of the analyses are given in the appendix, below are presented graphs of all significant effects.

Adaptation

Emergence Latencies

There were no significant differences along this measure, though the tendency was for the isolated animals to be slower than group-reared rats; for sensorially enriched animals to be slower than impoverished rats, and for males to be slower than females.

Activity Units

General ambulatory activity as measured by the number of six inch units traversed showed significant interactions across all three factors.

The interaction of sex, social and sensory variables (Figure I(d) $p < .01$), shows that under impoverished conditions, group-reared female rats are more active than isolates. The difference between grouped and isolated impoverished males, though, showing a slight tendency for isolates to be more active, is negligible. Under conditions of sensory enrichment the isolates show more activity than the group-reared animals, for both sexes.

Figures I(b) and I(c) show the interactions of sex with the social and sensory variables, both significant at $p < .01$. Clearly, sensory enrichment results in a lower activity score than impoverishment for both sexes. Isolation results in a higher score than group-rearing for males, but vice-versa for females.

The interaction of the social and sensory variables is shown in Figure I(a) ($p < .01$). Group-reared rats are more active than isolates when the animals are reared in sensorially impoverished conditions, but isolates are more active than groups when the animals are reared under sensorially enriched conditions.

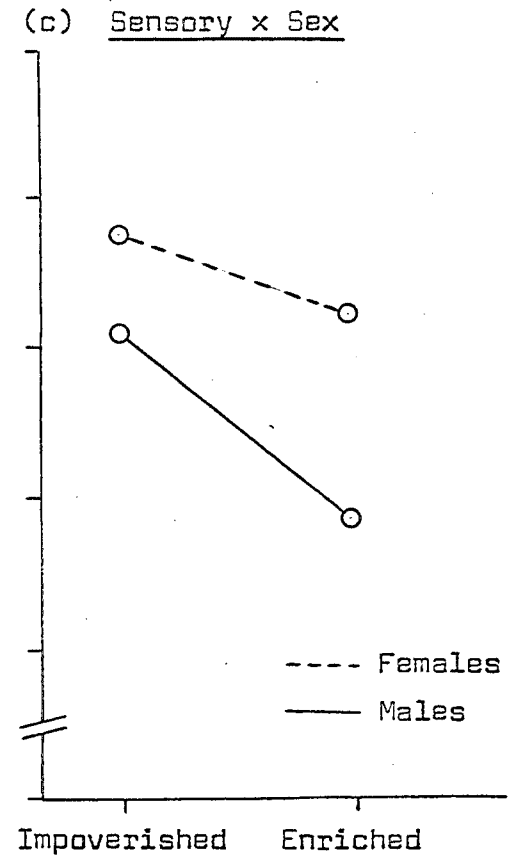
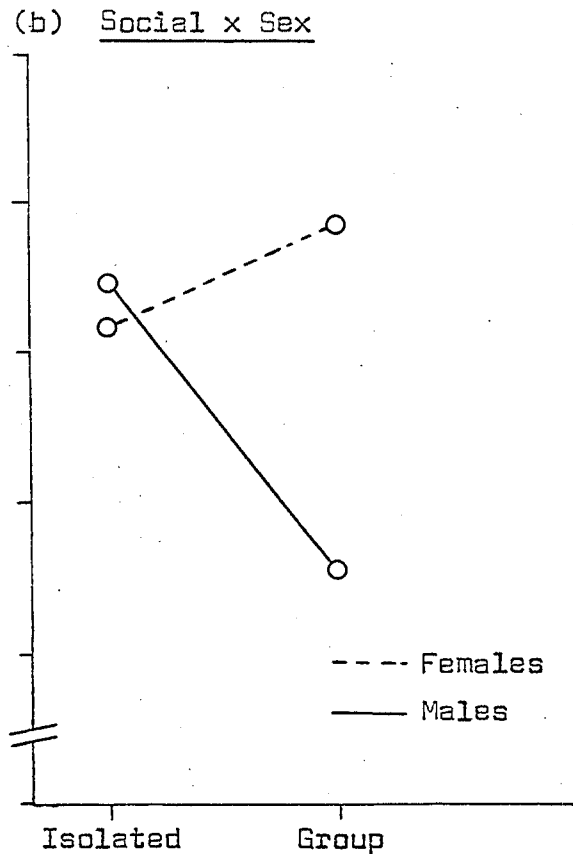
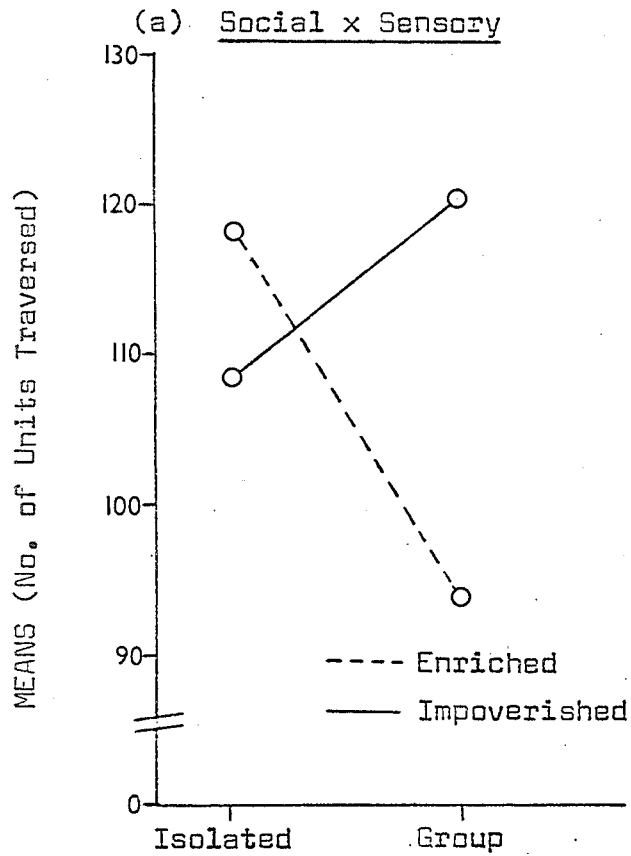
Activity Box

The graphs of these results show a rather different trend to the activity unit scores. As seen in Figure II(a) the main effect is a social one, group-reared animals show more activity than isolates, this is significant at $p < .01$.

FIGURE 1

ACTIVITY UNIT SCORES

Graphs of Significant Effects



(cont. over)

FIGURE I ACTIVITY UNIT SCORES

Graph of Significant Effect

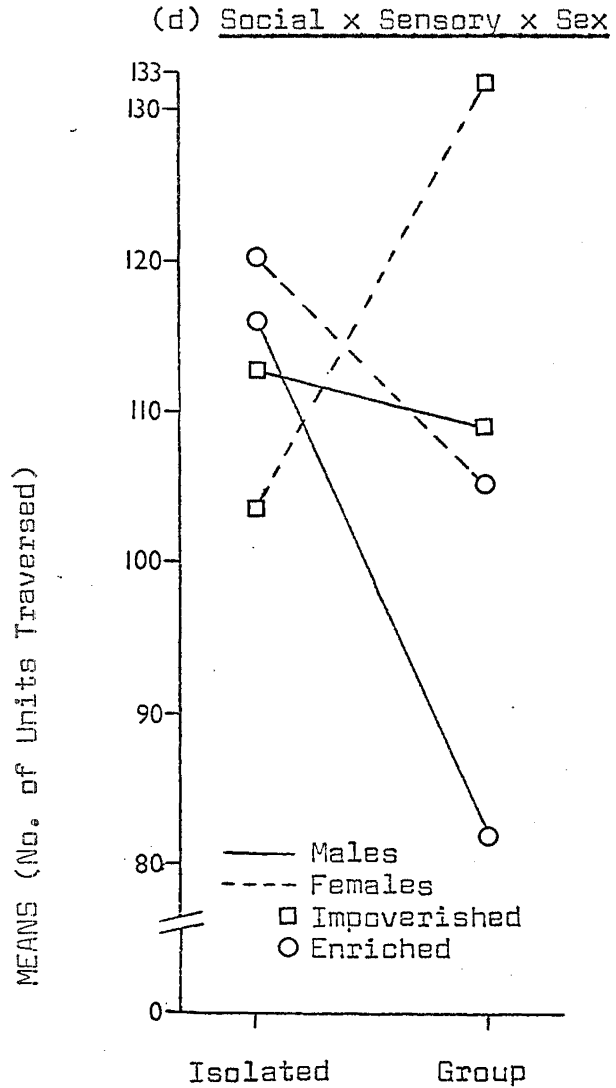
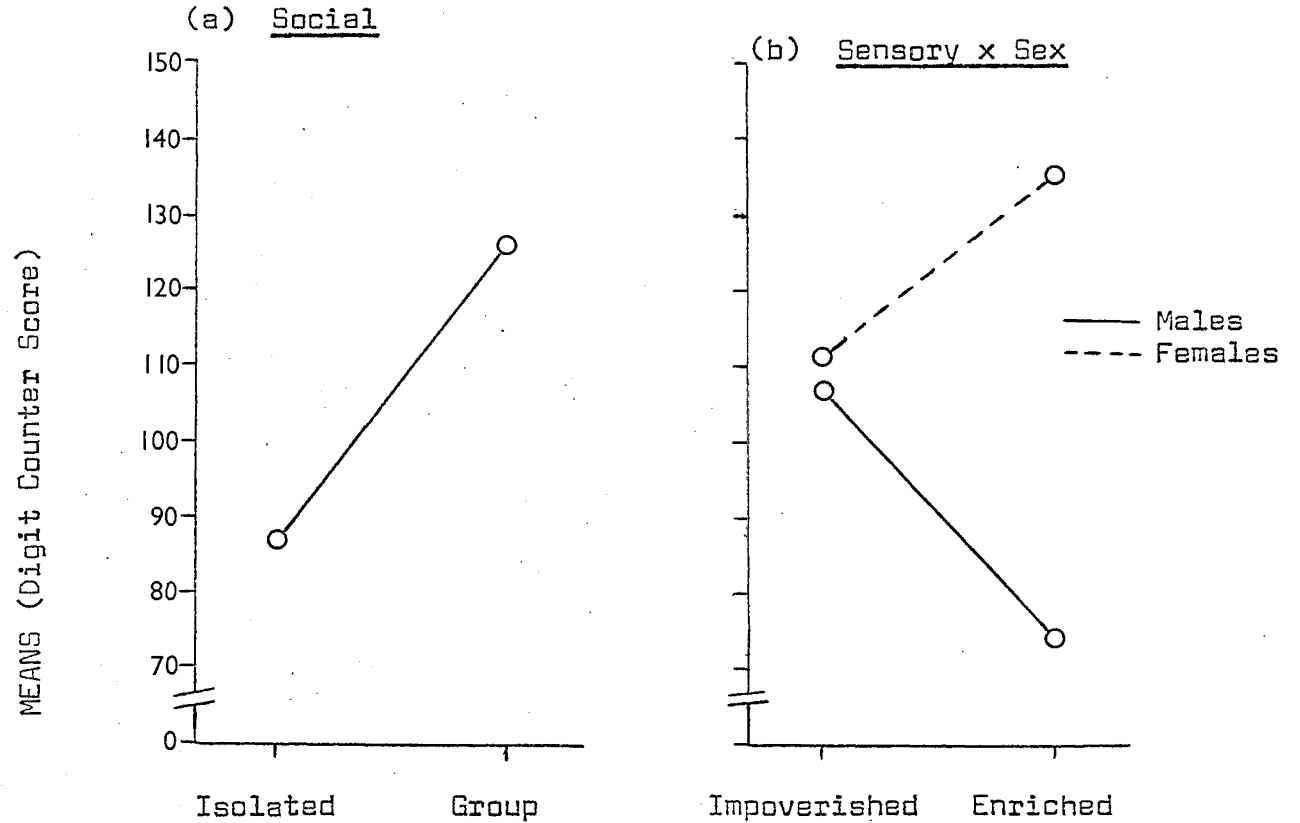


FIGURE II

ACTIVITY BOX SCORES

Graphs of Significant Effects



Also, in contrast to ambulatory scores, enriched females were more active than the impoverished females, (Figure II(b)), though the trend for males is similar - impoverished are more active than enriched. This interaction also is significant at $p < .01$.

Trial Sessions

Emergence Latencies

One three-way interaction emerged from the data, Figure III shows the interaction for social, sensory and sex variables - this is significant at $p < .025$. In contrast to past studies on emergence times (cf. Morgan 1973), the present data show that in all conditions, except for the impoverished males, isolated animals are faster to emerge than group-reared animals. The female S.I. group, despite their high ambulatory scores, were the slowest by far to emerge.

Variability

The main effect on this measure is sex, as shown in Figure IV(a). Males showed a significantly greater amount of variability in their behaviour than females ($p < .01$). This despite the fact that the females generally tended to show a slightly higher level of activity (see Figures I and II back).

Figure IV(b) shows the interaction between sex, sensory and food deprivation variables - significant at $p < .01$.

FIGURE III EMERGENCE LATENCIES

Graph of Significant Effect

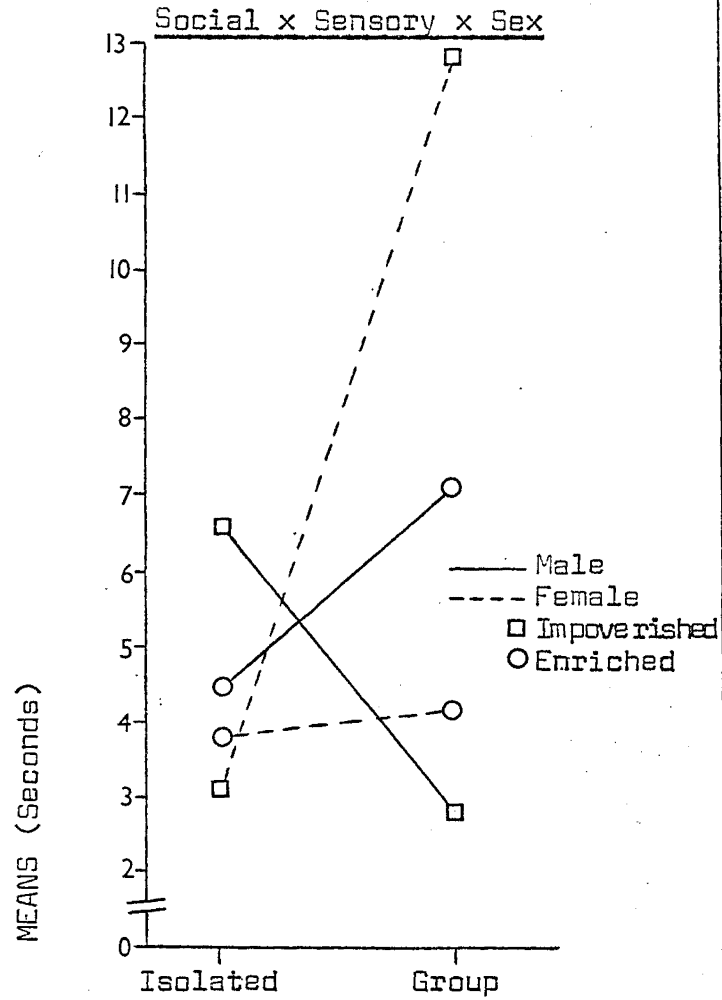
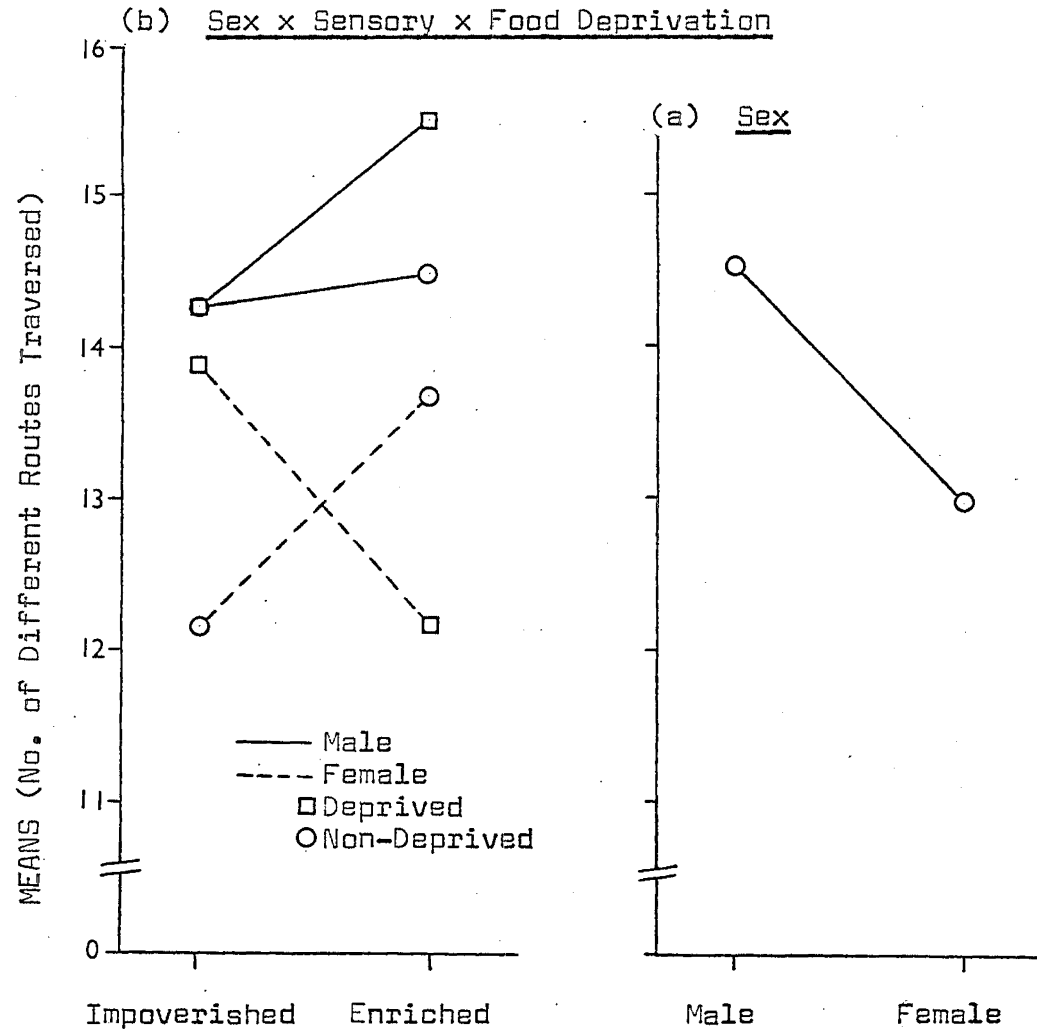


FIGURE IV

VARIABILITY SCORES

Graphs of Significant Effects



Enriched subjects generally show greater variability than the impoverished animals, except among the females during the food deprived trials when this tendency is reversed.

The effects of food deprived trials appears to be quite different for the two sexes. Enriched males are more variable when non-deprived than when deprived, whilst the impoverished males show no difference between the two trials. For females the relative effects upon enriched and impoverished animals are reversed across the different trials. Enriched females are less variable during the deprived trials than the non-deprived, and vice-versa for the impoverished females.

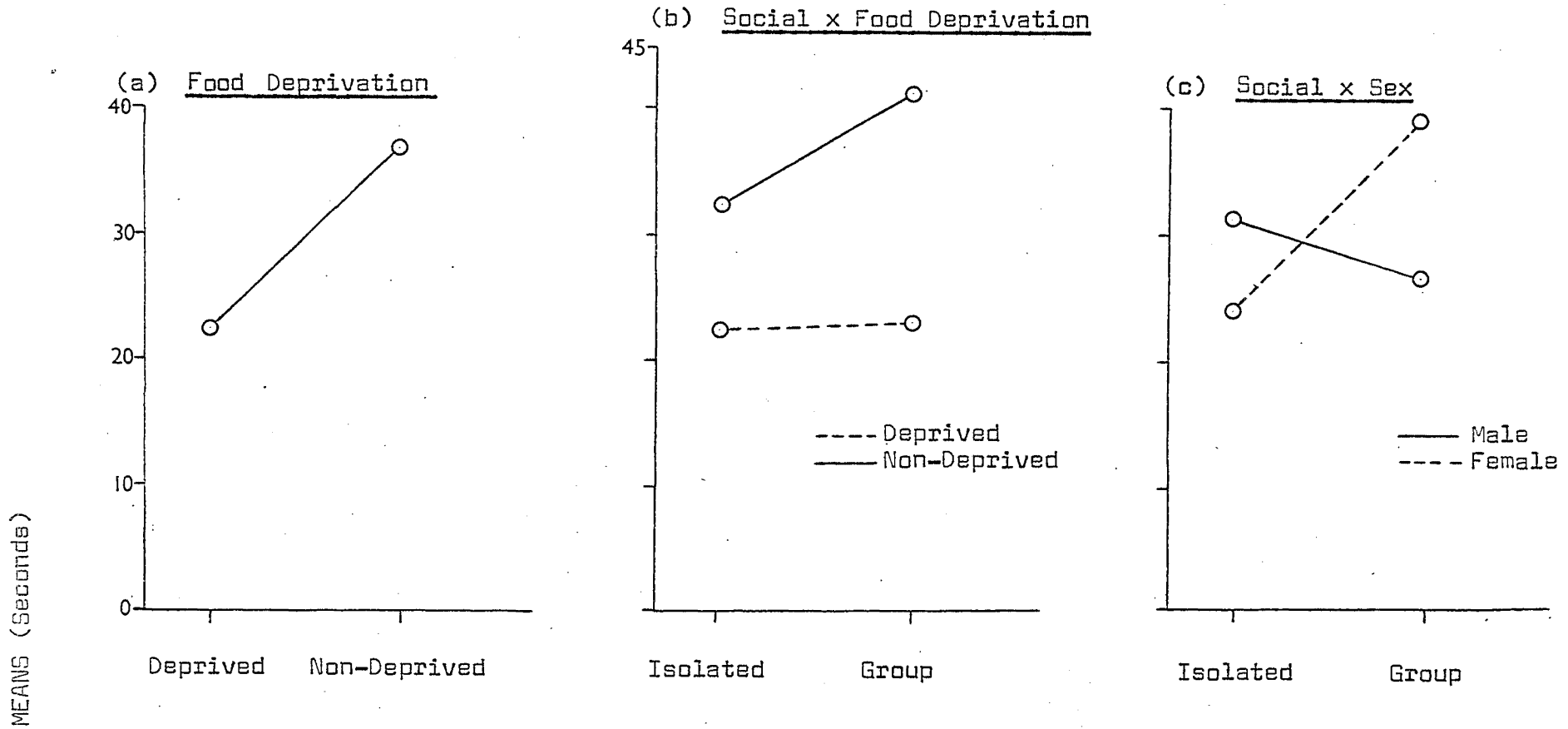
Goal Box Entry Times

As would be expected the animals ran faster when food deprived than when non-deprived (Figure V(a) $p < .01$). The interaction of this with social rearing conditions (Figure V(b) $p < .01$) shows that isolates run faster than group-reared animals when non-deprived, but this difference is eliminated when the animals are food deprived. This confirms the predictions of Woods (1961) that under conditions of "high motivation" the differences between enriched and impoverished rats' running speeds are reduced. Further support is provided by the interaction between sex, social and food deprivation variables (Figure V(d) $p < .01$). Isolated females are faster than group-reared females and vice-versa for males (see also Figure V(c) $p < .01$). These differences are negligible, however, when the animals are food deprived.

FIGURE V

GOAL BOX ENTRY TIMES

Graphs of Significant Effects



(cont. over)

FIGURE V

GOAL BOX ENTRY TIMES

Graphs of Significant Effects

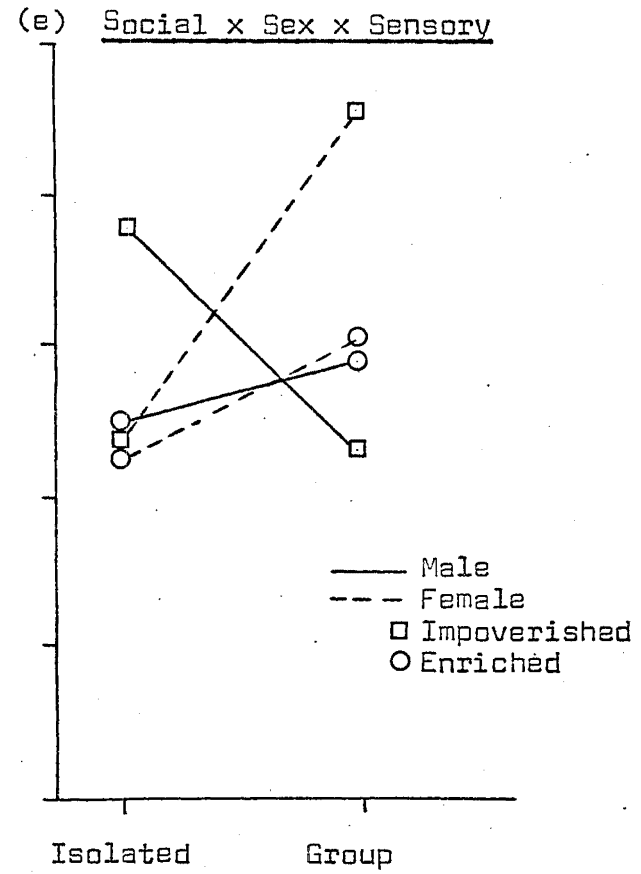
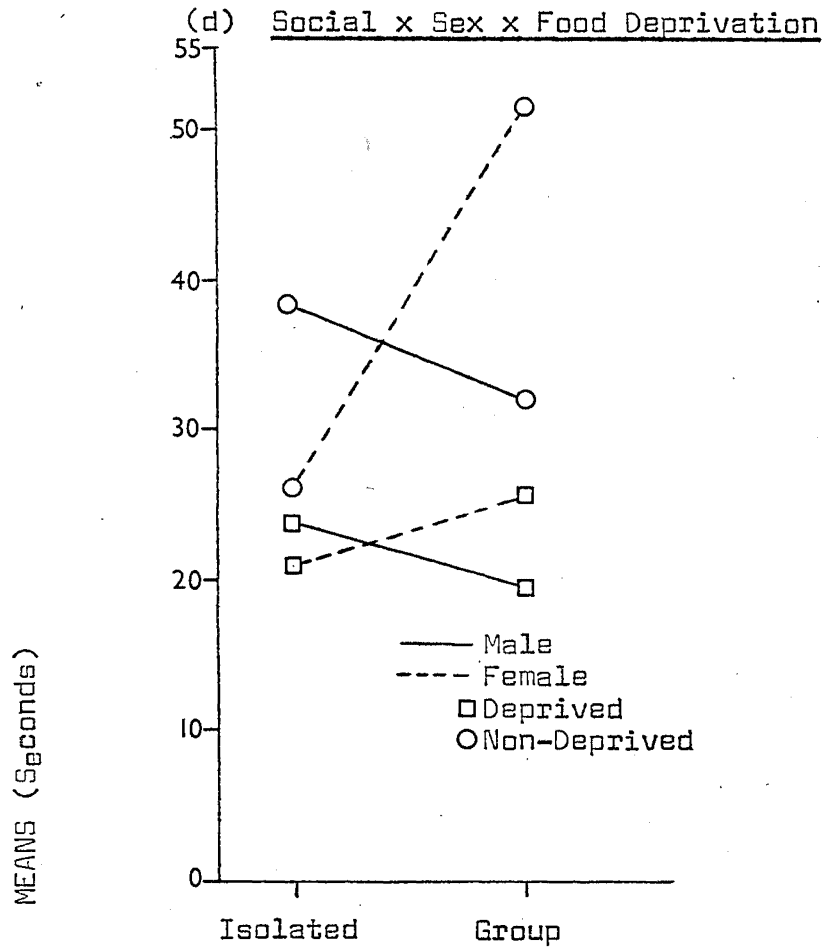


Figure V(e) shows the interaction between sex, sensory and social variables. Under conditions of impoverishment the social and sex interaction described above (Figure V(c)) is apparent. However, under conditions of enrichment, the differences between the sexes is negligible, and isolates are seen to run slightly faster than the group-reared rats. This is significant at $p < .01$.

Post-Experimental

Activity Box

Surprisingly, the data from this measure show quite a different trend from the previous testing in the Activity Box. Figure VI shows that, this time, the impoverished females are more active than the enriched females and both groups are less active than the corresponding male groups. This is significant at $p < .05$.

Weights

Figures VII(a) and (b) show results very much in line with past findings. Males, of course, are heavier than females ($p < .01$); I.I. animals are heavier than I.E., and S.I. are heavier than S.E. rats ($p < .01$).

FIGURE VI

ACTIVITY BOX SCORES

Graph of Significant Effect

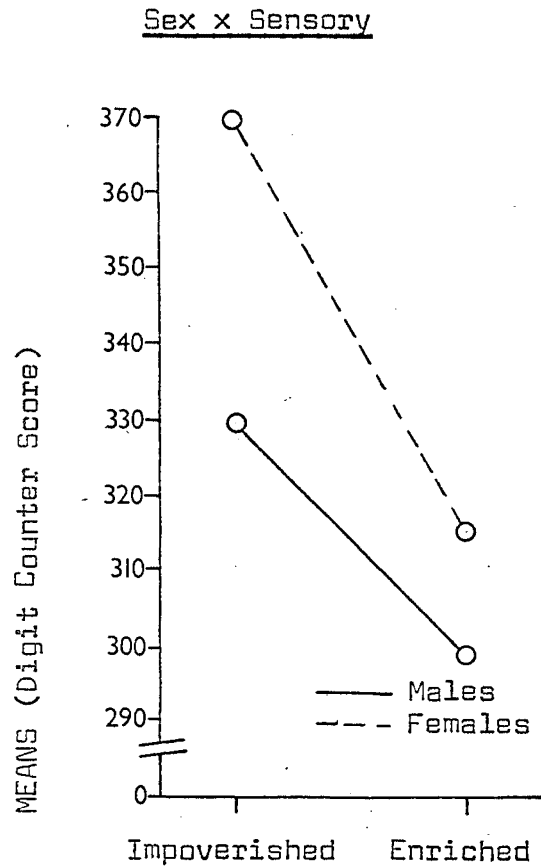
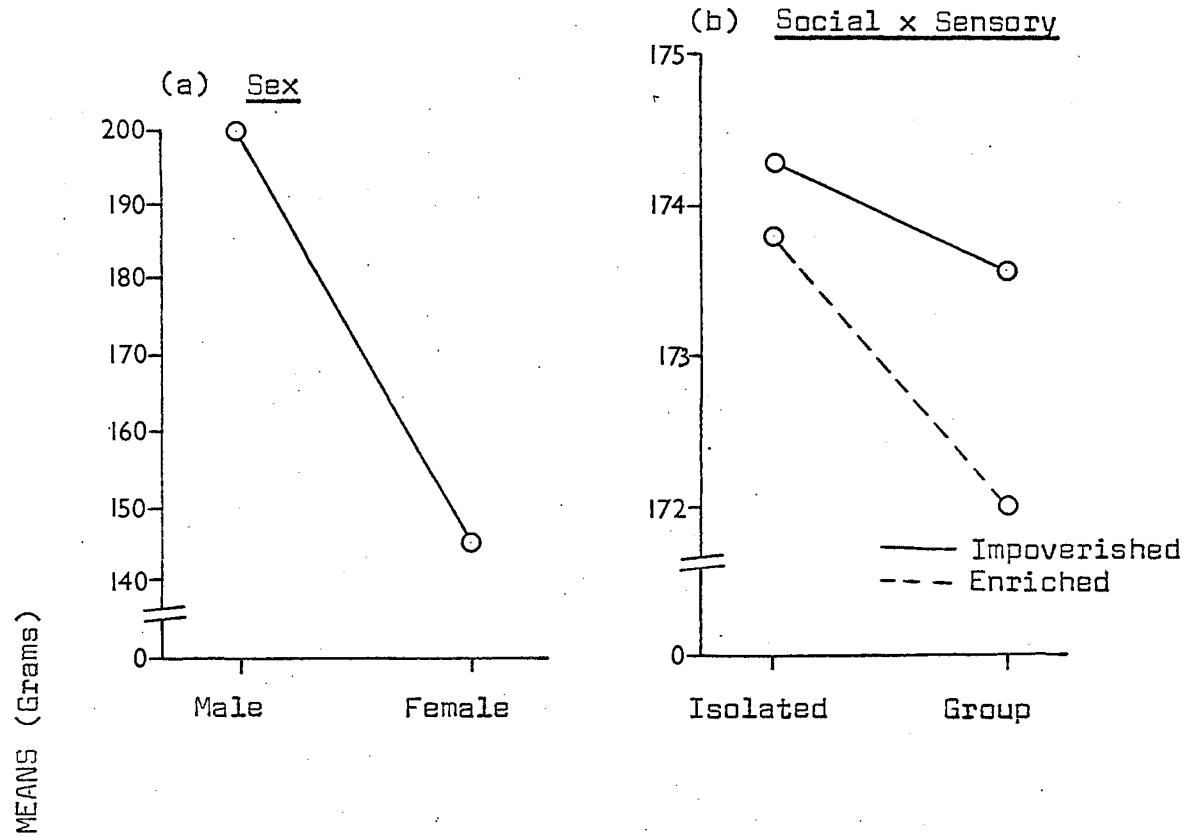


FIGURE VII

WEIGHTS

Graphs of Significant Effects



CHAPTER 4DISCUSSIONActivity Units

The results of Archer (1969)B, that female isolates are less active than group-reared rats, are clearly supported by the findings presented here. The definition of "impoverished" in this study - namely the absence of any particular manipulanda in the cages - can obviously be applied to Archer's study in which all animals were reared in bare cages. Similarly, the findings of Ader and Friedman (1964) and Moyer and Korn (1965) are supported. These authors used male rats and found that group-reared animals were more active than isolates. Ehrlich (1959) also used male rats and found, as in this study, that S.I. animals are more active than S.E. This relationship also holds for female rats which is in contrast to the findings of Luchins and Forgas (1955), who found that female S.I. animals were less active and more "emotional", in terms of faecal boli defaecated, than S.E. animals.

It is interesting to note that the female S.I. animals in this study, although being the most active group, also displayed a great deal more "emotional" type behaviour than the other animals. Unfortunately,

actual measures were not taken, however, this group was observed to freeze frequently; during the experimental session they displayed the slowest emergence time; they were very difficult to retrieve from the maze and struggled wildly when handled. Their running behaviour was hyperactive, hence the high activity score - when they ran it was extremely fast, with none of the typical rearing and sniffing behaviours of the animals which moved at a more moderate speed. In this respect then, it is possibly legitimate to regard the high activity score as a measure of high "emotionality" rather than exploration or "lowered emotionality" as it frequently is (cf. Archer 1973).

Activity Box

The results from the adaptation session are in contrast to Essman's (1966) findings that isolates are more active than group-reared animals. Essman's work of course, was with mice and not rats, whether this fact alone would be responsible for such marked contradictory findings could perhaps be the object of further research.

It is interesting that the two different activity measures taken during the adaptation session should produce such different results. Apart from the males, the trends shown in Figures II(a) and (b) are in the opposite direction to the trends of the activity unit scores. Thus, it would appear that the higher the activity unit score, the lower the activity

box score and vice-versa. Such a relationship is quite meaningful considering the type of activity each is measuring. The activity unit score measures non-specific ambulatory activity, whilst activity box scores would be more pertinent to such activities as rearing, sniffing, grooming etc. that would be confined to a small space. Thus, an animal that scores high in the activity box may feasibly be spending more time sniffing, etc. in the maze and less time actually ambulating, whilst the low activity box scorer would spend more time ambulating. This is, however, obviously not tenable for the male subjects. Possibly such a relationship exists only under conditions of stress, in which case, as suggested in the preceding section, the females are more stressed than the males in the testing situation.

The complete change about in the activity box scores during the second testing, (post-experimental Activity Box) thus can only be attributed to a less stressful experience. This is, in fact, quite plausible since the animals were not moved from their cage-room prior to testing nor had they just undergone the maze adaption session.

The extra handling all the animals received during the testing sessions may also have had some effect. Much literature has been published on the effects of post-weaning handling of rats, with the general conclusion that such an experience results in a less "emotional" animal (e.g. Meyer 1965). This, then implies that the animals' resultant behaviour may be an interaction of their early experience with the testing exper-

ience itself.

Emergence Latencies

Differences in the type of field into which the animals were emerging may account for the disparity between the results presented here and the findings of Morgan (1973) and Lore and Levowitz (1966) who used large open fields; and Gill et. al. (1966) who recorded latencies from the start-box of a Lashley jumping stand. Though Morgan has concluded from these results that isolates are slower to emerge than group-reared animals, careful study of the literature reveals that, more specifically, it is isolated and impoverished animals who are slower than social and enriched rats. Moyer and Korn (1965), on the other hand, used isolated and group-reared animals, both in sensorially impoverished environments, and found isolates slower than grouped rats. This finding is supported by the present data. The results of Forgas (1954) who used male rats in S.I. and S.E. conditions are also supported by this study (S.I. rats are slower to emerge than S.E.). The apparatus used by Forgas is also the one upon which this study was styled (see Method).

It is clear, from the above observations, that there is a need for authors to be more specific in their conclusions. As these data show, the specific type of environment, the sex of the animal and the type of testing environment may all differentially affect the behaviour of the animal.

Interestingly the female S.I. group that scored the highest ambulatory measure, also showed the longest emergence latencies, traditionally regarded by some authors as indicative of "emotionality" (cf. Archer 1973, Moyer and Korn 1965).

The absence of any significant differences during the adaptation session is curious. The raw data show practically identical scores for the two sexes which stands in marked contrast to the trial session results. It appears that the second session may have upset whatever "balance" there may have been among the different conditions.

Variability

These results support the general conclusion of Forgus (1954) that enriched rats show greater variability than impoverished animals. More specifically, however, Forgus found this among male animals reared in community cages, and tested following a period of food deprivation. Though not significant, this trend is clearly evident in the present data. Luchins and Forgus (1955), using female rats, similarly found that enriched animals were more variable than impoverished animals when tested after 24 hours food deprivation. The present data are in line with this finding when the animals are non food deprived, but show quite the opposite trend under conditions of food deprivation. This about face in behaviour may be accounted for (at least for the female enriched animals) by regarding food deprivation as an added stressful experience, hence the reduction in scores for this group. The increase in scores for the impover-

ished females and males, however, would seem not to support this contention.

Goal-Box Entry Times

As mentioned in the Results section, these data support the prediction of Woods (1961), that under conditions of "high motivation" (i.e. food deprivation) the differences between the subjects is reduced. This is to imply that the differences are attributable more to exerceptive stimuli than intrinsic differences within the organisms.

The generally faster running times of isolated animals than grouped animals is somewhat contradictory to results from past studies on maze learning (see references in Introduction). However, they support the findings of Morgan (1973) who utilized a "shuttle box" in which I.I. females ran faster than S.E. females. The "shuttle box" would be a more similar task to the present one, which is not, strictly speaking, a learning task. Morgan suggests a higher motivation level in the isolates as, during the pre-testing restricted feeding schedule, these animals lost a greater percentage of their body weight than the social animals. Unfortunately, pre-test weights were not taken in this study, though it is speculated that a similar phenomenon may have occurred.

Weight

These results are in support of the findings of Morgan (1973) and Shelley (1965), Rosen (1961) and Hatch et. al. (1963), that isolation rearing increases body weight. The interaction

of the sensory and social variables suggests that both these act in a similar way. The more impoverished the animal the heavier it would appear to grow. Probably, as Morgan suggests, the animals from the more impoverished environment have less to distract them from eating. The greater weights of the I.E. animals than the S.I. group, suggests that the social variable has a more significant effect here. That is, animals housed in groups are more "distracted" than animals housed alone but with various "toys" etc. Possibly competition and interference from other animals are added factors affecting the community housed animals.

Implications of the Interactions of Three Major Variables

As pointed out in the Introduction and in a previous section (cf. Emergence Latencies), some conclusions of past authors have tended to neglect the possibility of differential effects of social and sensory variables in studies of early experience. The present results testify to the need to clarify generalisations resulting from such studies in terms of the specific types of environments involved in rearing and the sex of the animals tested.

The sometimes inconsistent findings (e.g. activity box scores) from this research make it difficult to draw specific conclusions concerning the relative roles of social and sensory variables. However, it has become clear that there are differences in the behavioural effects of the two experiences. Interaction effects are seen on the ambulatory, weight and

and emergence latency measures. Thus, the specific effects on these measures of housing an animal alone, or with other animals, will depend also upon what type of sensory experience it is given. On the remaining measures the social and sensory variables act independently of each other, though interact with sex and the change in "motivation" (food deprivation).

On all the measures taken, it can be seen that the sex of the animals has a differential effect, depending upon its interaction with either the social or sensory variables (e.g. activity box, variability, goal-box entry) or both (e.g. ambulation, emergence latency, weight). Although there are, among the literature, research reports examining sex differences along various measures and some fairly widely accepted findings (e.g. females more active than males); few researchers appear to be concerned with stressing the possible effects of sex in their conclusions. Many of the studies quoted in this dissertation (e.g. Morgan 1973, Forgas 1954, Lore and Levowitz 1966) have stated in their methodology the use of only male or female subjects, yet seem to regard their results as primarily a function of only the dependent variables they have controlled for.

This discussion then points toward the need for closer examination and specification of variables that have hitherto been either overlooked or taken for granted.

Some Theoretical Considerations

As pointed out in the Introduction, it has been the intention of many authors in this area to determine the effects of various environments upon the constructs of "emotionality",

"exploration" and "learning ability". The latter construct was suggested by Woods (1961) to be merely a function of the tendency in some animals to explore the apparatus more rather than an inherent lack of "ability". Data from the goal-box entry times, whilst not directly supporting Woods, suggest that the animals' behaviour is, indeed, a function of exteroceptive stimuli.

Interpretation in terms of "emotionality" is difficult due to the absence of a faecal boli count and the inconsistencies among other traditional measures, of this construct (i.e. high emergence latency and low activity scores - cf. Archer 1973). As already discussed, the female S.I. group probably displayed the greatest degree of emotionality with high emergence latencies and high ambulatory scores.

A criticism of this study is the use of an apparatus not conventionally used and hence producing measures not identical to traditional ones. The justification for this is that the use of such a maze permitted the measurement of the added measures of variability and running speeds, plus what are essentially similar measures of activity and emergence latencies. The apparatus has also been used before with comparable results to past research (cf. Forgas 1954, Luchins and Forgas 1955). The inclusion of measures of actual behaviour in the maze would probably have been profitable, however. Especially in regard to interpreting behaviour in terms of "exploration". It may be that the slight differences in the apparatus have, however, made some difference to the way the animals behave. As Archer (1967)A

hypothesised, the previous housing environments may interact with the testing situation to affect the animals' behaviour.

This hypothesis is not incompatible with the psychological structure of exploratory behaviour proposed by Dember and Earl (1957). They suggest that exploration is attention to change in stimuli and is, ".... a function not only of stimulus complexity, but also of the individual's complexity - which itself changes with experience." (p.95) ".... the dynamics of attention are based on the ability of stimuli to increase the psychological complexity of the individual who perceives them". (p.96) ".... the individual will apportion his attention among the stimuli in the set in proportion to their similarity to the pacer, with the modal amount of attention applied to the pacer." A "pacer" is a stimulus or set of stimuli of complexity just above that of the individual, but not too complex so as to be aversive. Thus, under optimum conditions, the organism's experience of certain stimuli will increase its psychological complexity and hence, capacity to experience, without trauma, more complex stimuli. Under these optimum conditions the organism's "attention" (or "exploratory" behaviour) will be maximum. Stimuli of a complexity much lower than itself (in Dember's terms) the organism will find "boring"; stimuli of a complexity higher than the pacer could be found traumatizing.

According to this line of reasoning, it becomes apparent that the actual experience of testing, may itself add to the complexity of the subject, hence affecting its behaviour. The possibility of such a change has been mentioned in a previous section (cf. Activity Box).

An empirical criticism to be made of this theory is the absence of any positive means of quantifying the degree of "psychological complexity" of the organism, and in relation to the complexity of the environment. However, it would probably be fair to assume that among the four conditions in this experiment the most "complex" environment would be the S.E. condition. Similarly, the least complex would be the I.I. condition. Looking at the ambulatory scores (Figure I(a)) from this point of view we see, as might be predicted, that the S.E. animals show the least movement. This is regarding ambulation as an index of "exploratory" behaviour. The I.I. group on the other hand, do not display the greatest amount of ambulation. The two groups, I.E. and S.I. show the greatest activity. Following Archer (loc. cit.) we hypothesize that the change in environment, is too great for the I.I. group to adapt to comfortably, whilst providing optimum or near optimum stimulation, for the I.E. and S.I. animals. Though only marginally, the S.I. rats show more activity than the I.E. group. This could be interpreted as less "emotionality" of the social animals or greater "complexity" of the sensory enriched group. Further research could possibly be directed to elaborating this theoretical framework by utilizing testing situations modelled on the rearing environments of the subjects. Thus providing some indication of the "complexity" of the subjects, in relation to the testing environment.

Conclusions

Due to the rather complicated nature of these results, it is difficult to attempt to draw conclusions concerning the

specific behavioural effects of each of the variables under investigation. However, the scope of the study serves well to illustrate how different types of early environmental experience may interact with each other, and with the sex of the subjects, to affect behaviour in various testing situations. As pointed out in the "Activity Box" discussion section, it is possible that the testing situation itself may also be a factor determining how the animals will behave. Thus experimenters testing subjects over a prolonged period especially, may find that the resultant behaviour is not only a function of the rearing conditions but also of an interaction of these with the test experience.

Future studies could profitably be directed towards examining these interactions further and defining more specifically, under what conditions of rearing and testing, particular behaviours might be expected to occur. With such research may come a greater awareness of the influences of independent variables hitherto either overlooked or taken for granted.

APPENDIX

In all tables the following symbols apply:

<u>Symbol</u>	<u>Factor</u>
A	Social
B	Sensory
C	Sex
D	Food Deprivation

AdaptationEmergence Times

Source	SS	df.	MS	F	
Between	25.77	7	3.68	0.64	N.S
Within	184.00	32	5.75		
Main Effects					
A	2.02	1	2.02		
B	21.02	1	21.02	3.66	N.S
C	0.62	1	0.62		
Interactions					
A x B	2.73	1	2.73		
B x C	4.13	1	4.13		
A x C	23.13	1	23.13	4.02	N.S
A x B x C	2.11	1	2.11		
Total	209.77	39			

Activity Units

Source	SS	df	MS	F	
Between	7376.30	7	1053.76	2.94	p < .05
Within	11451.60	32	357.86		
Main Effects					
A	384.40	1	384.40		
B	739.60	1	739.60		
C	1000.00	1	1000.00		
Interactions					
A x B	6252.30	1	6252.30	17.47	p < .01
B x C	5636.70	1	5636.70	15.75	p < .01
A x C	5992.00	1	5992.00	16.74	p < .01
A x B x C	5252.30	1	5252.30	14.68	p < .01
Total	18827.90	39			

Activity Box

Source	SS	df	MS	F	
Between	45897.50	7	6556.79	1.94	N.S
Within	108223.60	32	3381.99		
Main Effects					
A	35402.50	1	35402.50	10.47	p < .01
B	6002.50	1	6002.50		
C	1612.90	1	1612.90		
Interactions					
A x B	4492.50	1	4492.50		
A x C	8882.10	1	8882.10		
B x C	38282.10	1	38282.10	11.32	p < .01
A x B x C	2879.60	1	2879.60		
Total	154121.10	39			

ExperimentalEmergence Latencies

Source	SS	df	MS	F	
Between					
A	9945.80	1	9945.80		
B	4500.00	1	4500.00		
C	871.90	1	871.90		
A x B	1095.20	1	1095.20		
A x C	15124.30	1	15124.30		
B x C	11809.10	1	11809.10		
A x B x C	30733.50	1	30733.50	5.82	p < .025
Error	169015.40	32	5281.73		
Within					
D	441.80	1	441.80		
A x D	180.80	1	180.80		
B x D	744.20	1	744.20		
C x D	404.30	1	404.30		
A x C x D	168.90	1	168.90		
B x C x D	45.70	1	45.70		
A x B x D	2000.00	1	2000.00	4.09	N.S
A x B x C x D	32.10	1	32.10		
Error	15650.00	32	489.06		

Variability

Source	SS	df	MS	F	
Between					
A	0.19	1	0.19		
B	1.80	1	1.80		
C	54.45	1	54.45	9.65	$p < .01$
A x B	0.06	1	0.06		
A x C	5.01	1	5.01		
B x C	3.20	1	3.20		
A x B x C	2.44	1	2.44		
Error	180.40	32	5.64		
Within					
D	1.80	1	1.80		
A x D	1.26	1	1.26		
B x D	6.05	1	6.05		
C x D	0.80	1	0.80		
A x C x D	4.05	1	4.05		
B x C x D	21.45	1	21.45	7.63	$p < .01$
A x B x D	7.19	1	7.19		
A x B x C x D	0.81	1	0.81		
Error	90.00	32	2.81		

Goal-Box Entry Times

Source	SS	df	MS	F	
Between					
A	44982.62	1	44982.62		
B	62552.12	1	62552.12		
C	12726.02	1	12726.02		
A x B	2070.60	1	2070.60		
A x C	198104.50	1	198104.50	7.60	p < .01
B x C	10057.60	1	10057.60		
A x B x C	147318.63	1	147318.63	5.65	p < .01
Error	833825.60	32	26057.05		
Within					
D	405982.52	1	405982.52	56.89	p < .01
A x D	44887.80	1	44887.80	6.29	p < .01
B x D	6679.50	1	6679.50		
C x D	2587.80	1	2587.80		
A x C x D	64468.03	1	64468.03	9.03	p < .01
B x C x D	6827.53	1	6827.53		
A x B x D	74.13	1	74.13		
A x B x C x D	632.79	1	632.79		
Error	228374.40	32	7136.70		

Post ExperimentalActivity Box

Source	SS	df	MS	F	
Between	46807.50	7	6686.79	1.03	N.S
Within	207506.40	32	6484.58		
Main Effects					
A	24403.60	1	24403.60		
B	9796.90	1	9796.90		
C	2890.00	1	2890.00		
Interactions					
A x B	12607.00	1	12607.00		
A x C	19513.90	1	19513.90		
B x C	34120.60	1	34120.60	5.26	p < .01
A x B x C	9717.00	1	9717.00		
Total	254313.90	39			

Weight

Source	SS	df	MS	F	
Between	28965.20	7	4137.89	18.13	p < .01
Within	7302.40	32	228.20		
Main Effects					
A	10.00	1	10.00		
B	4.90	1	4.90		
C	28622.50	1	28622.50	124.43	p < .01
Interactions					
A x B	28950.30	1	28950.30	124.86	p < .01
A x C	332.70	1	332.70		
B x C	337.80	1	337.80		
A x B x C	327.80	1	327.80		
Total	36267.60	39			

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