1958

Length of Deprivation and the Day-Night Cycle as Determinants of Eating Behavior

George A. Cicala
College of William & Mary - Arts & Sciences

COLLEGE OF WILLIAM AND MARY

Thesis

LENGTH OF DEPRIVATION AND THE DAY-NIGHT CYCLE AS DETERMINANTS OF EATING BEHAVIOR

Submitted by

George Anthony Cicala

(B.S., College of William and Mary, 1956)

In Partial Fulfillment of Requirements

for the Degree of Master of Arts

1958

Acknowledgements

The writer wishes to express his appreciation to Professor John K. Bare, under whose guidance this investigation was conducted, for his patient guidance and criticism throughout the investigation. The author is also indebted to Professor Stanley B. Williams and Professor Peter M. Guthrie for their careful reading and criticism of the manuscript. The many kindnesses of Miss Donna Erdahl helped to make this investigation possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

The basic principle underlying early studies on motivation was first stated by J.J.B. Morgan in 1923. "The strength of a tendency may be measured in terms of the resistance it can overcome," (28, p. 94). In keeping with Morgan's principle, a number of investigators devised resistance techniques for measuring the strength of a drive. For example, Moss studied the number of times an animal would cross an electrified grid in order to secure food, water or an animal of the opposite sex. He also employed a parchment barrier through which animals had to gnaw in order to obtain a goal object. Another technique, later devised by Stone, required animals to burrow through a tube full of sand in order to obtain a reward.

With these diverse techniques, however, comparability of results could not well be achieved, and in 1928, Jenkins, Warner, and Warden (21) recommended standardization of the obstruction technique because "an adequate behavioristic account of the organism cannot be had until different drives, and variations of the same drive have been measured in terms of a common unit of response" (21, p. 362). They devised the Columbia obstruction box as the preferred apparatus, and the number of crossings of a shocked grid in an interval of time as the best index of motivation. They also specified a technique for producing varying amounts of a particular drive. They state, "Systematic variation of the physiological state underlying a given drive cannot be had, of course, in any real sense. The best method of isolating a specific drive, in so far as this is possible, and of obtaining varying degrees of it for measurement, is to deprive the normal animal of the appropriate incentive stimulus for varying periods of time, keeping the general physiological state of the organism as constant as possible. For example, an objective index of hunger can be had by varying the period of food deprivation." (21, p. 378, Italics added.) Thus, Jenkins, Warner and Warden spcified the methods for quantifying both the independent and dependent variables to be used in studies of drive.

Studies employing the techniques of obstruction after food deprivation have yielded results which are relatively consistent. Holden (18) deprived animals of food and at 12-hour intervals measured the number of times the animal would cross an electrified grid in a ten minute test period. He found that the frequency of crossings increased from 12 through 36 hours of deprivation and decreased thereafter. Warner (42) also using a shock barrier, studied deprivation periods of 0, 2, 4, 6, and 8 days, thus extending Holden's deprivation intervals. In Warner's study, each of the animals, however, was subjected to a single deprivation and tested only once. Warner found that longer periods of deprivation increased the number of barrier crossings up to four days, after which barrier crossings decreased. The conclusion reached by both of these investigators is that the level of drive, measured by the number of barrier crossings, is a linearly increasing function of the length of deprivation during the first few days of measurement.

That length of deprivation was becoming, by 1940, a standard technique for manipulating drive is evidenced by the work of Skinner and Heron (38). These investigators employed a bar pressing response, rather than the obstruction technique, and measured mean rate of responding during a daily one-hour test session over a period of at least six consecutive days. Their results showed mean number of responses per test hour to be a linearly increasing function of the length of the period of deprivation, reaching a maximum at five days of deprivation, after which responding declined. At least during the first 36 hours, the results of the Skinner and Heron experiment are clearly comparable to those obtained by Warner and Holden who used the obstruction box technique.

By 1943, both the technique for producing drive and the shape of the function relating drive and deprivation were incorporated into learning theory. Hull cites the findings of Skinner and Heron and Warner in support of his concepts concerning primary motivation.

He states (19, p. 239), "The drive concept for example, is proposed as a common denominator of all primary motivations, whether due to food privation, water privation, thermal deviations from the optimum, tissue injury, the action of sex hormones, or other causes. This means, of course, that drive will be a different function of the objective conditions associated with each primary motivation. For example, in the case of hunger the strength of the primary drive will probably be mainly a function of the number of hours of food privation." Hull does not attempt to state the final precise quantitative relationship between the number of hours of deprivation and drive level because of the lack of sufficient empirical evidence.

In spite of the apparent relationship between level of drive and amount of deprivation, a second line of evidence has suggested that hunger and activity, as occurring in the rat, are cyclical phenomena. The presence of periods of heightened eating and activity alternating with periods of low intake and activity, one might argue, could serve to alter the effect of a period of deprivation. Richter (34), studied the bodily activity of rats housed in a cage which was mounted on a tambour. All movements of the cage were recorded on a kymograph. With animals on an ad libitum feeding schedule, Richter found that the periods of activity and inactivity appear with regularity, and eating occurred during the peak in activity which came at the end of the active period. He further presented evidence for a nocturnal cycle in the animal: the preponderance of active, as well as eating periods, occurred during the dark hours. In a subsequent paper, Richter (35) studied the inter-relationship between eating behavior and general activity. By simultaneously recording eating behavior and bodily activity, he found these behaviors to occur together at regular intervals of from 1½ to 2 hours. He ascribed this correlation to the effect of gastric motility, initiating the bodily activity of the animal. Hunt and Schlosberg (20), studying the activity of rats during periods as long as three days, confirmed Richter's finding that there are differences in activity during the diurnal cycle of the rat. Although the length of the interval between active periods was highly variable for each animal, activity reached a peak during the night and fell to a low point during the day. Inspection of the daily activity curves would indicate the inactive phase of the cycle to begin at about 9:00 A.M. and to end at about 7:00 P.M.

That food intake is greater during the periods of greater activity has been confirmed by Siegel and Stuckey (37). They measured the food and water intake of 16 white rats for a period of three days at six hour intervals. The largest percentage of daily intake occurred from 6:00 P.M. to 12:00 P.M., and decreased for each successive six hour period thereafter.

With the dirunal cycle of eating and activity well established, it became apparent that the single operation of deprivation might not be sufficient to establish varying amounts of drive. Concern for this problem led to the introduction of feeding schedules.

Bousfield and Elliot (5), in 1936, state that the employment of a feeding schedule serves to bring into tow the rhythmic changes which occur in the eating behavior of animals, and it is evident that investigators now commonly follow Bousfield and Elliot's suggestion in manipulating drive, (e.g. Koch and Daniel 23, Finan 10, Saltzman and Koch 36, Perin 31, Kimble 22, Strassberger 39, and Deese and Carpenter 7). But even this technique may be inadequate. Reid and Finger (32) have recently questioned whether it is justifiable to assume that animals on a feeding schedule maintain the same level of drive from one day to another. They measured the adjustment of seven rats to a 23-hour food deprivation schedule for a period of 35 days. Those measures chosen for study were body weight, food and water intake, 24 hour activity, and activity during the last prefeeding hour. When the experimental animals were compared with a control group, it was found that progressive changes were still occurring in all measures after 15 days. With respect to the measure of food intake, the animals appeared to reach an asymptote after the twentieth day, after which point there also occurred relatively little decline in body weight. These findings are consistent with those of Hall, Smith, Schnitzer, and Hanford (15) who found activity level to continue to increase for as long as 12 to 17 days after the introduction of a feeding schedule.

Baker has also presented evidence for the necessity of providing a long adaptation period to a feeding schedule. Using five groups of animals, he placed each of three groups on either a 12-, 24-, or a 48-hour deprivation cycle. The fourth group received all three values in random order. The fifth group served as a control, and was maintained on an <u>ad libitum</u> feeding schedule. During a 40-day period after the introduction of the feeding schedule measures were taken of food intake, time spent eating, activity toward the food container during the deprivation interval, and body weight. Baker found that all the experimental groups gradually increased their average intake during each feeding session over the first 10-day period. Ghent (13) observed the eating and drinking behavior of her subjects after the first and repeated 24-hour deprivations of food or water. Measures of latency of response to the food and amount of food eaten were taken for seven minutes after the food was again available. For both food and water, latencies were seen to decrease significantly from day to day as intake increased.

To be sure, it is conceivable that scheduled feeding over a long period of time can rule out the effect of cyclic physiological and behavioral changes affecting eating behavior. Indeed, some evidence exists in support of this supposition. Lawrence and Mason (24) found that after a 27-day adaptation period to a 24-hour feeding schedule, four groups of animals did not differ significantly with respect to intake or body weight. One group was fed daily at 9:00 A.M., another at 1:00 P.M., another at 5:00 P.M. and the fourth at 9:00 P.M. This evidence suggests that, given adequate time to adapt to a feeding schedule, animals will attain stable levels of ingestion.

In a recent study, Bare (2) has shown that during the 24 hours following deprivation, normal cyclic differences in intake are clearly apparent. Indeed, it was shown that these cyclic differences may counteract the increases in intake which might be expected during the first hour following varying periods of deprivation. Six groups of animals were subjected to a single deprivation, and taught to press a lever in order to secure food on a continuous reinforcement schedule. After adaptation to this method of feeding, the groups were deprived for 2, 4, 8, 12, 18 and 24 hours by the removal of the bar from the apparatus, and all deprivations were <u>begun</u> at 7:00 P.M. Inevitably, this procedure meant that the deprivations would terminate at differing times of day for each of the groups. Thus, the 2-hour deprivation group would be tested at 9:00 P.M., the 4-hour deprivation group at 11 P.M., and so on. As deprivation increased, the animal was tested at times of the day at which his intake would normally decrease. Bare's data showed that during the first hour of eating, deprivation failed to increase intake in the expected way. He interpreted his findings as demonstrating that the natural day-night cycle could counteract the effects of a single deprivation. Although the conclusion seems sound, deprivation and time of testing were never tested separately. It therefore seemed wise to design the present study to provide a more direct measure of the time of testing variable on the eating behavior of rats.

The present study employed two values of the time of testing variable as well as seven values of the length of deprivation variable. The design was thus factorial, and permitted the independent assessment of the effect of the time of testing and the length of deprivation on intake following deprivation, and also permitted the assessment of any interaction which might exist. It might be expected that a more direct measure of the time of testing variable would aid in the determination of techniques making possible the more careful manipulation of drive.

Subjects

The subjects in this experiment were 56 male rats of Wistar strain, averaging $4\frac{1}{2}$ months of age and weighing from 215 to 520 grams upon introduction to the experimental situation. The subjects had not been subjected to deprivation of either food or water prior to their use in the present study except while in transit from the supplier, at which time they were fed raw potatoes. Before and after transit, the animals were fed Purina Lab Chow, the principal ingredient of the pellets used in this study.

The animals were housed in individual cages prior to experimental introduction and assigned to experimental groups consistent with a policy of completing a single replication of all deprivation values before another replication was begun.

Apparatus

Four enclosed animal cages, constructed by Bare (2) were used. The cages were 8" high by 8" wide by 9½" deep; the enclosures were 20" high by 30" wide by 24" deep. External sounds were dampened by the 2" lining of the cage enclosure. Light was permitted to enter the enclosure through a 7" square plastic window.

Each cage was equipped with a removable lever which required a downward force of about 15 grams to activate. This force activated a Gerbrand's dispenser, which delivered a .045 gram food pellet into a dish mounted on the wall through which the lever protruded. Each lever press was recorded cumulatively. Water was available to the animals at all times during their stay in the experimental cages. Normal fluctuations of temperature and light were permitted throughout the experiment. Temperature changes were recorded, and abrupt changes were prevented by adjusting the ventilation of the experimental room.

Procedure

Prior to introduction to the experimental situation, all animals were subjected to a single 24-hour deprivation. Thus deprived, each subject was weighed and placed in one of the four boxes and taught to secure food by pressing a lever. Lever presses were reinforced continuously. Subsequent to the initial training period, the lever remained in the box, and the animals could obtain food at any time by performing the lever pressing response. After an acclimatization of at least 72 hours, at which time lever pressing had reached a stable level, the animals were subjected to deprivation periods of 0, 2, 4, 8, 12, or 24 hours. Deprivations were effected by the removal of the bar. For one-half the subjects in each group deprivations were concluded at 1:00 P.M. For the other half, deprivations ended at 7:00 P.M. Lever presses were recorded for at least 24 hours following deprivation. After this period, the animals were removed from the boxes and re-weighed. The food dishes were examined periodically and were seldom found to contain food; it is presumed that the pellets were consumed shortly after the lever pressing responses had occurred.

Since four experimental boxes were used, each deprivation value was represented twice in each of the boxes; once by an animal deprived until 1:00 P.M., and once by an animal deprived until 7:00 P.M.

Differences between the groups, as revealed by the total intake values for a 24-hour period preceding deprivation, were found not to be significant by an analysis of variance. That the animals readily adapted to the method on feeding is indicated by the fact that all animals, save one, gained weight during the week of the experimental situation. Mean increase in weight while in the boxes was 33.8 gms., and weight changes were randomly distributed among the various groups. Generally, it was observed, that younger animals gained more weight than older animals, as is common with animals in an *ad libitum* feeding situation.

Since the experiment was run over the course of a year, running was discontinued over the summer months so that intake would not be affected by the high temperatures.

Results

The clearest picture of the findings can be obtained by consulting Figs. 1 and 2. The curves show mean intake for each of the deprivation groups for 24 hours following deprivation. Fig. 1 presents the data for the animals tested beginning at 7:00 P.M., and Fig. 2, the data for animals tested beginning at 1:00 P.M. In both figures it is clear that cyclic differences in intake occur even following deprivation. Generally speaking, the animals appear to respond to the deprivation during the first hour, and then the intake of the various groups follow similar courses. Some exceptions to this general statement occur in the middle values of deprivation.

But since the major interest was in the long and short term effects of the time of testing and the length of deprivation variables on intake, the post-deprivation values after 1, 6, and 24 hours were subjected to separate analyses of variance.

Figure 3 shows the relationship between intake and deprivation during the <u>first</u> hour following deprivation, with time of testing as the parameter. It is clear that both curves rise, are not displaced from one another, and have the same general function. An analysis of variance performed on this data showed length of deprivation to significantly increase intake, but neither time of testing nor interaction were found to be significant (Table 1). Student *t*'s were computed on the individual group means with the following results: for the animals tested at 7:00 P.M., the 0-hour group differed significantly from the

Fig. 1 Total cumulative intake during 24 hours following deprivation. Food restored 7:00 P.M.

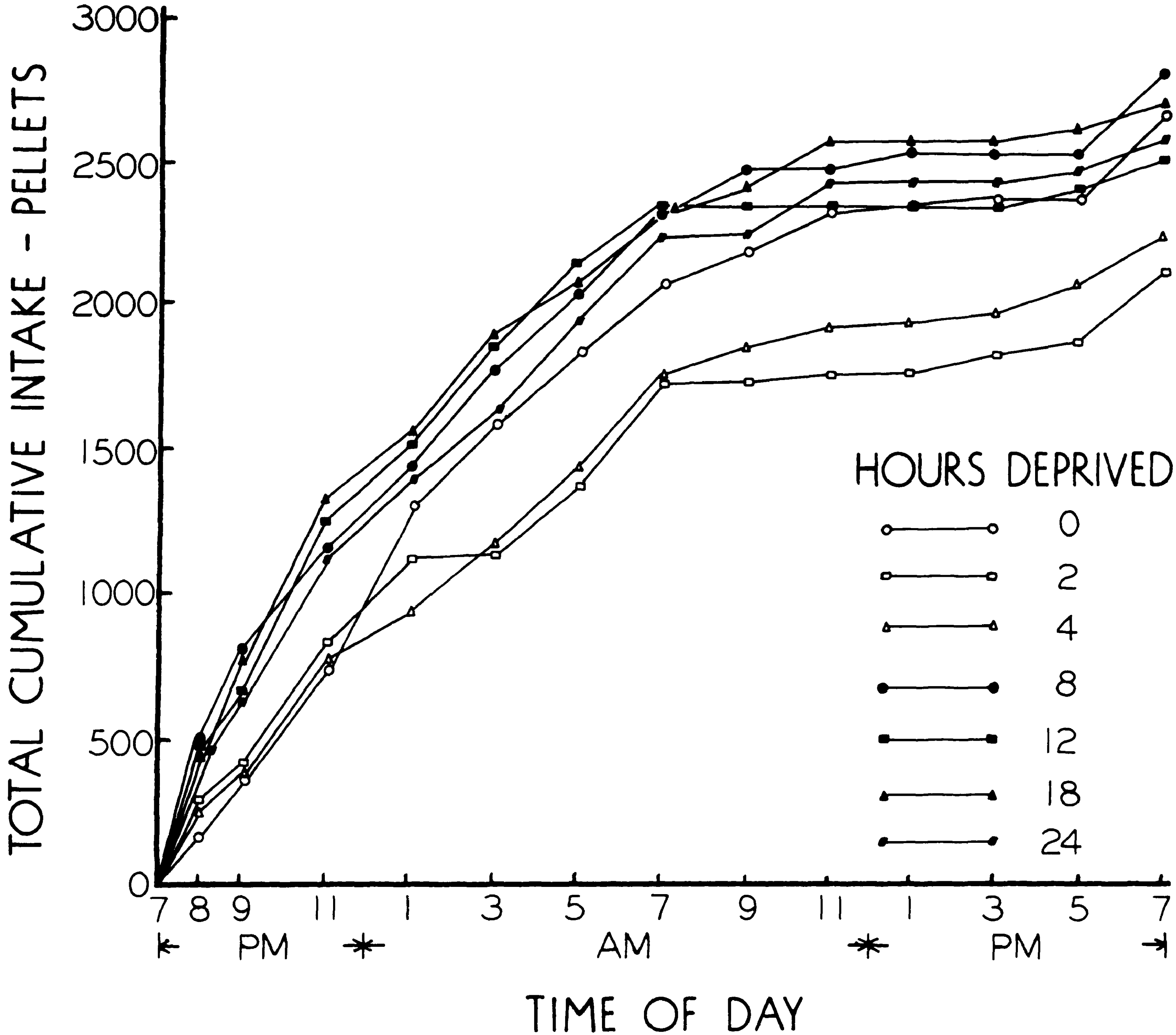
TOTAL CUMULATIVE INTAKE - PELLETS
0
500
1000
1500
2000
2500
3000
7 8 9 11 1 3 5 7 9 11 1 3 5 7
PM
AM
PM
TIME OF DAY
HOURS DEPRIVED
0
2
4
8
12
18
24

Fig. 2 Total cumulative intake during 24 hours following deprivation. Food restored 1:00 P.M.

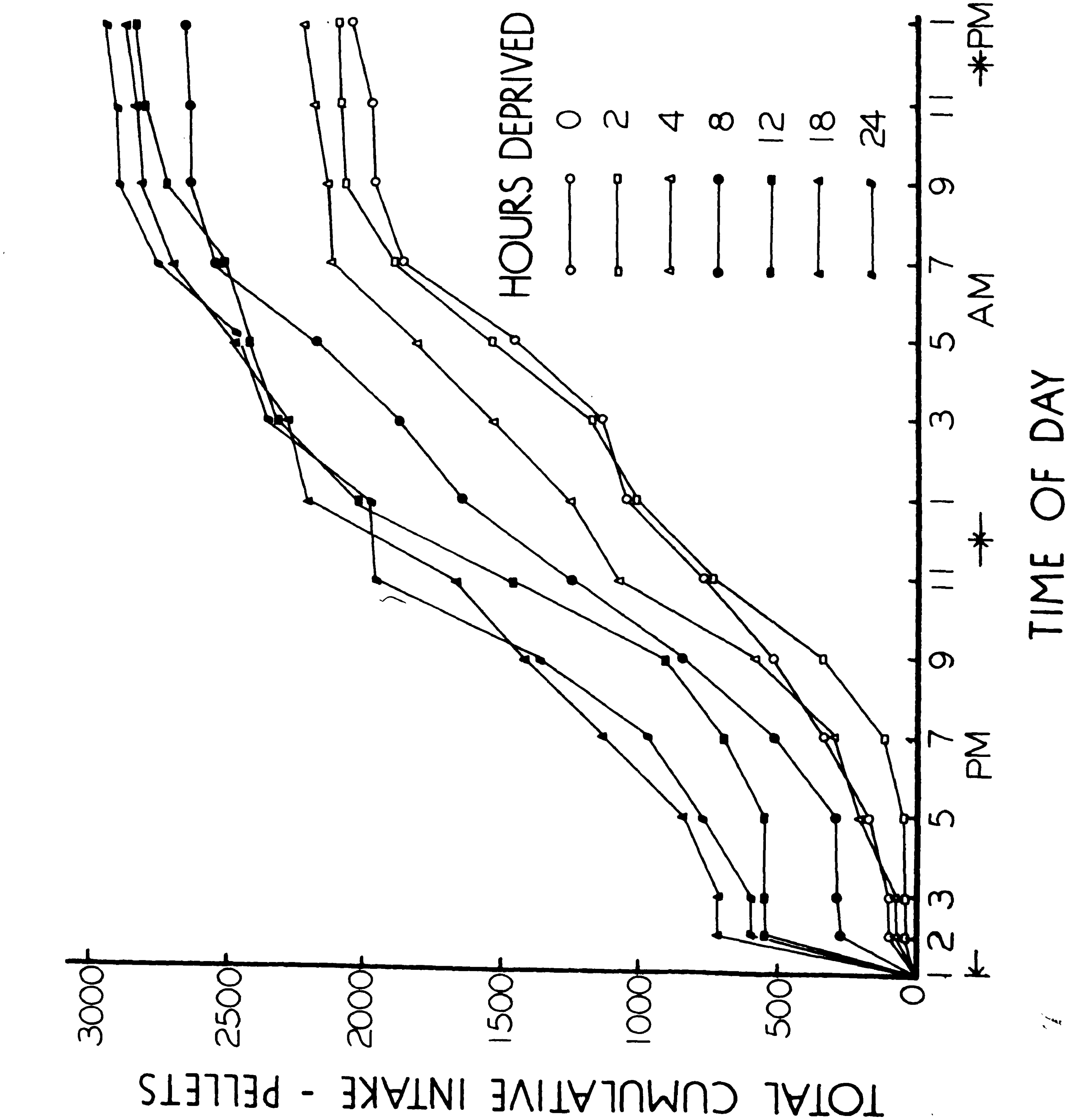
TOTAL CUMULATIVE INTAKE - PELLETS
0
500
1000
1500
2000
2500
3000
TIME OF DAY
1 2 3 5 7 9 11 1 3 5 7 9 11 1
PM
AM
PM
HOURS DEPRIVED
0
2
4
8
12
18
24

Fig. 3 Mean intake for first hour subsequent to deprivation.

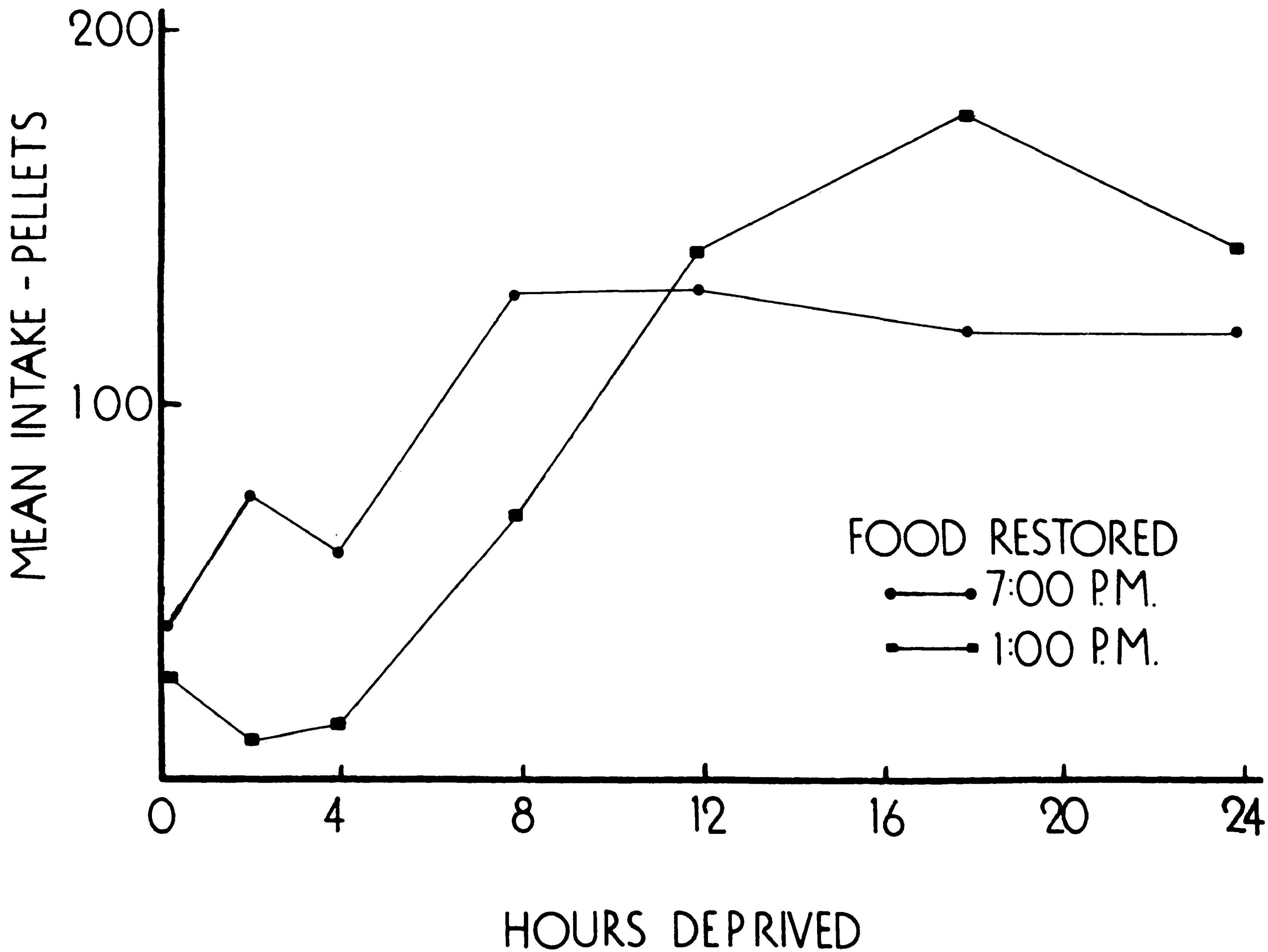
MEAN INTAKE - PELLETS
200
100
0
4
8
12
16
20
24
HOURS DEPRIVED
FOOD RESTORED
7:00 P.M.
1:00 P.M.

Table 1 - Analysis of variance for 1 hour following deprivation

Source of Variance	df	Mean Square	F
Time of Day	1	2,814.4	1.175
Deprivation	6	20,724.5	8.567 *
Interaction	6	4,375.0	1.809
Between Groups	13		
Within Groups	42	2,419.1	

* Significant $P < .01$ level

8-, 12-, 18-, and 24-hour groups and the 4-hour group was significantly different from the 12-hour group; for the animals tested at 1:00 P.M., the 0-, 2-, and 4-hour groups differed from the 12-, 18-, and 24-hour groups, and the 8-hour group differed from the 18- and 24-hour groups. These differences were in the expected direction, with longer periods of deprivation producing greater intake.

Though the analysis of variance described above had not indicated it, differences in the shapes of the two curves in Fig. 3 suggested the possibility that the variables might be interacting. The curve for the 7:00 P.M. group is higher than that for the 1:00 P.M. group for short periods of deprivation, the curves then cross, and for deprivations greater than 12 hours, intake for the 1:00 P.M. group is greater than that for the 7:00 P.M. group. A second analysis was therefore performed. The values for the short deprivations (i.e., 0, 2, and 4 hours) were combined, and the values for longer deprivations (i.e., 12, 18, and 24 hours) were likewise combined with one another. The 8-hour group, representing the middle value, was omitted. This analysis showed both interaction and length of deprivation to be highly significant. Individual *t*'s showed all groups to be significantly different from one another.

The relationship between intake and deprivation for the first *six* hour period following deprivation is presented in Fig. 4. For this six hour period, it is clear that the differences between the two curves are greater than the differences between the points on a single curve. A complex analysis of variance performed on these intake values indicated that both the time of testing and the length of deprivation

Table 2 - Analysis of Variance on intake, one hour following deprivation, for the long versus short deprivation values.

Source of Variance	df	Mean Square	F
Time of Day	1	500	.39
Length of Dep	1	121,102	95.506+
Interaction	1	15,878	12.52+
Between Groups			
Within Groups	44	1,268	

+ Significant P $<$.01 level of confidence

Fig. 4 Mean intake during six hours following deprivation.

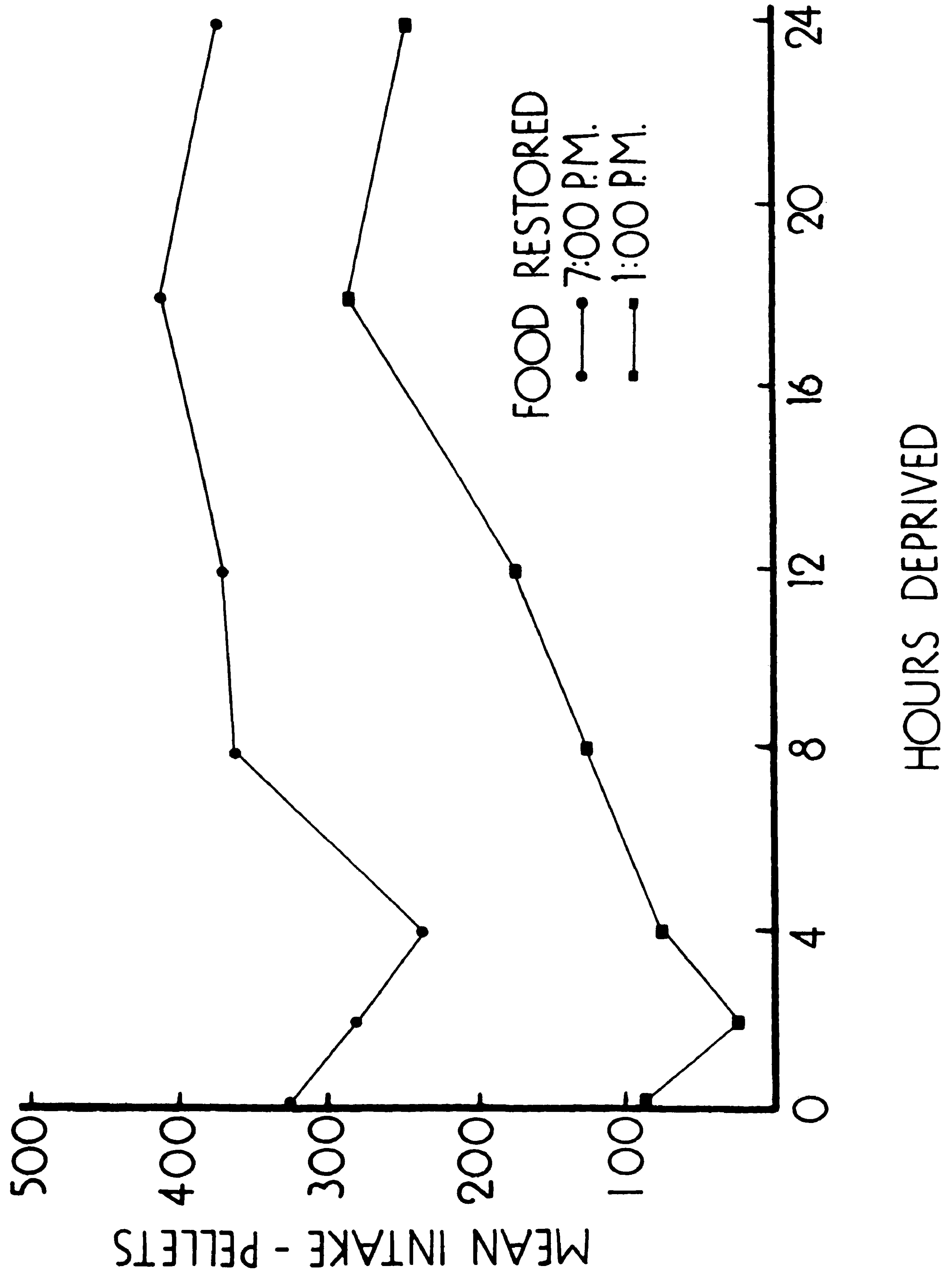
MEAN INTAKE - PELLETS
500
400
300
200
100
0
4
8
12
16
20
24
HOURS DEPRIVED
FOOD RESTORED
7:00 P.M.
1:00 P.M.

Table 3 - Analysis of Variance for 6 hours following deprivation

Source of Variance	df	Mean Square	F
Time of Day	1	523,417.7	97.80 *
Deprivation	6	45,178.9	8.44 *
Interaction	6	6,012.2	
Between Groups	13		
Within Groups	42	5,352	

* Significant P < .01 level

Table 4 - Analysis of Variance on intake, 6 hours following deprivation, for the long versus short deprivation values.

Source of Variance	df	Mean Square	F
Time of Day	1	414,967	9.01+
Length of Dep	1	235,621	5.12*
Interaction	1	12,968	0.28
Between Groups			
Within Groups	44	46,043	

\+ Significant P < .01 level of confidence

* Significant P < .05 level of confidence

had significantly altered intake. As can be seen in Table 3, the greater variance is contributed by the time of testing variable. Interaction was not found to be significant. Student t's, computed on the individual group means, showed the following results: for animals tested at 7:00 P.M., the 2-, and 18-hour groups were found to be significantly different, and the 4-hour group was significantly different from the 12-, 18-, and 24-hour groups; for the animals tested at 1:00 P.M., the 0-, 2-, and 4-hour groups differed from the 18-, and 24-hour groups, the 2-hour group differed from the 12-hour group, and the 8-hour group differed from the 18- and 24-hour group.

Again an analysis combining the low and high values of deprivation was performed. The results of this second analysis do not differ from the first on the six hour intake values.

Figure 5 shows the relationship between deprivation and intake after 24 hours of the post-deprivation day had elapsed. Though it appears that deprivation increased food intake, the analysis of variance indicated that neither length of deprivation nor time of testing produce significant differences in intake, nor was interaction significant.

Again the groups were split into short versus long deprivation periods, and a complex analysis of variance was performed. This analysis showed length of deprivation to alter intake significantly in the expected direction. Time of testing was not significant, nor was the amount of interaction.

Fig. 5 Mean intake during 24 hours following deprivation.

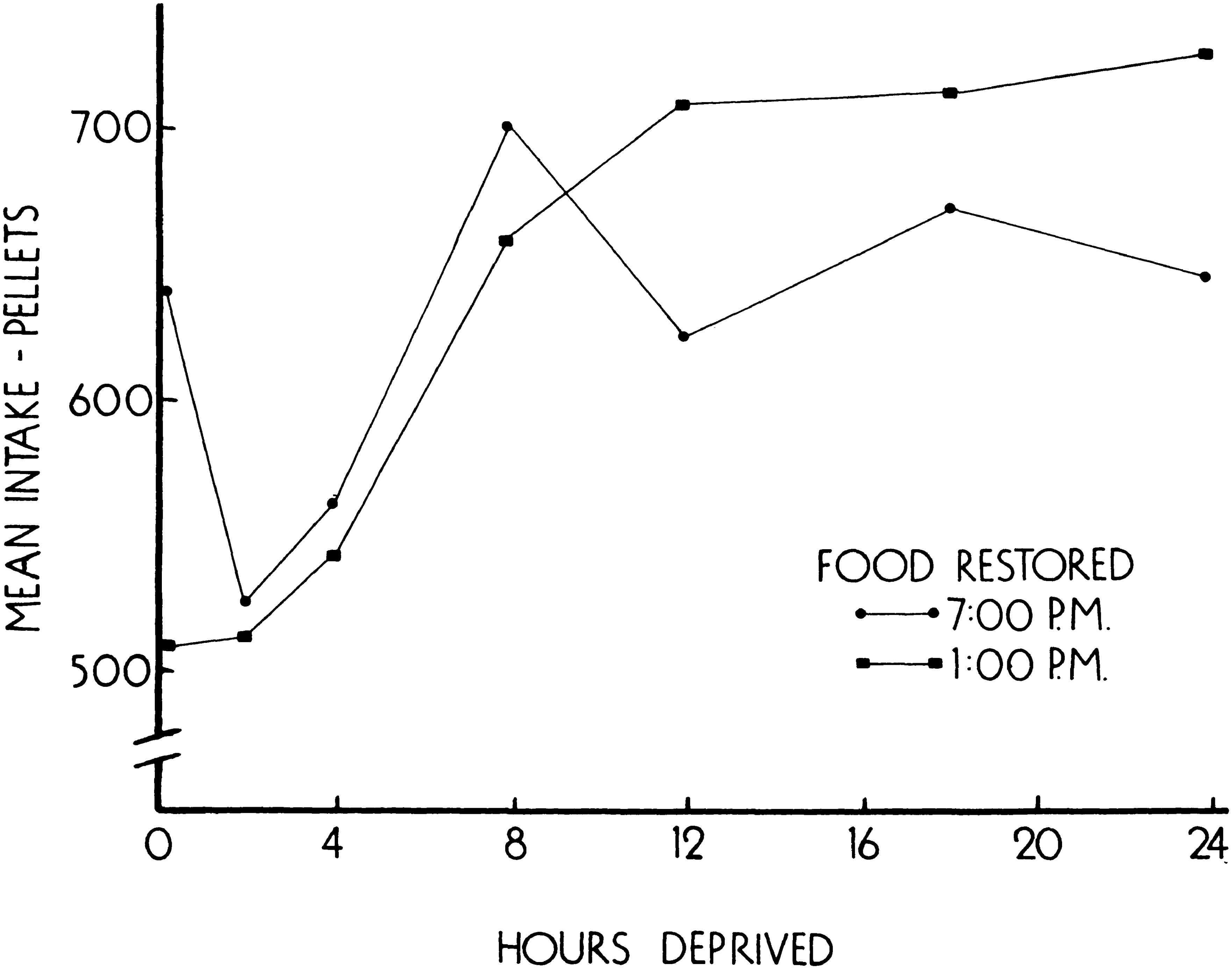
MEAN INTAKE - PELLETS
700
600
500
0
4
8
12
16
20
24
HOURS DEPRIVED
FOOD RESTORED
7:00 P.M.
1:00 P.M.

Table 5 - Analysis of Variance for 24 hours following deprivation

Source of Variance	df	Mean Square	F
Time of Day	1	51	0.00
Deprivation	6	43,677	2.20 +
Interaction	6	11,523	.58
Between Groups			
Within Groups	42	19,843	

+ approaches .05 level

Table 6 - Analysis of Variance on intake, 24 hours following deprivation, for the long versus short deprivation values.

Source of Variance	df	Mean Square	F
Time of Day	1	1,079	0.07
Length of Dep	1	219,511	16.24+
Interaction	1	25,760	1.91
Between Groups			
Within Groups	44	13,516	

+ Significant $P < .01$ level of confidence

Discussion

The present study has demonstrated that, depending upon the measure employed, food intake following a single deprivation may be a function of the length of deprivation, the length of deprivation and the time of testing, or the length of deprivation interacting with time of testing. That food intake was found to be a joint function of the time of testing and the length of the deprivation interval is not surprising. That Siegel and Stuckey (37), Lawrence and Mason (25) and Finger (11) have anticipated this relationship is evidenced by their emphasis on the study of the activity level of the organism, and its relationship to food intake. Lawrence and Mason have emphasized the difficulty one encounters when trying to predict the effect of a period of deprivation on the subsequent intake of the animal. "It is usually assumed that drive is an increasing monotonic function of the number of hours of food deprivation, at least within limits. At the same time hunger is spoken of as a rhythmic phenomenon as though the tendency to eat, and by implication the drive, reaches a maximum at periodic intervals and then subsides" (24, p. 267). These apparently conflicting statements are warranted by the findings of studies on drive. On the one hand, the work of Holden, (18), Warner, (42), and Skinner and Heron (38) contribute the notion that hunger drive is an increasing function of the number of hours of deprivation. Hull cites the findings of these workers, and it is apparent they contributed to his theoretical formulations concerning drive. On the other hand, the work of Richter, (35, 34), Hunt and

Schlosberg (20) and Seigel and Stuckey (37) contribute to our knowledge of the cyclical nature of hunger and its correlation with the activity level of the organism. At the present time, and in the light of what appear to be conflicting sets of facts, the precise prediction of eating behavior subsequent to a period of deprivation does indeed appear difficult. The present study has shown that such predictions must take into account the deprivation factor. But has also indicated that the effect of this variable must be interpreted in the light of facts concerning the normal daily fluctuations of behavior.

Of some concern is the interaction between lengths of deprivation and the time of testing shown to be present in the one hour intake measure following deprivation. This indicates that the effect of deprivation is greater when deprivations are concluded at 1:00 P.M. than when deprivation is concluded at 7:00 P.M., and that the effect of shorter periods of deprivation is less when deprivations are concluded at 1:00 P.M. than at 7:00 P.M. Why this should be the case is a matter for some speculation. It is possible, that for animals under low drive and tested at 1:00 P.M. the deprivation was not sufficient to arouse them since food was restored at a time when they normally would not be eating. For the 7:00 P.M. group, however, food was restored at a time when they, by virtue of the activity cycle, would be awake and active. They might, therefore, be expected to eat more under these conditions.

For longer periods of deprivation, intake is greater for those animals tested at 1:00 P.M. than those tested at 7:00 P.M. This can perhaps be explained by the fact that the latter group animal is aroused and active when food is restored. Many other behaviors, such as drinking, scratching and exploring, which are also dependent upon the activity cycle of the animal may serve to compete with eating behavior and thus depress intake. For those animals tested at 7:00 P.M., however, drive level associated with these competing responses is low. Hence the animal eats uninterruptedly, and intake is enhanced. This hypothesis is certainly open to experimental test. The measurement of behaviors other than ingestion following deprivations ending at different times during the day is suggested.

It is hoped that further examination of the variables involved in producing a drive state in the organism may lead to a more precise specification of drive and its influence on behavior. It is clear that certain areas require further study. First, the technique used in the present study might be employed in the investigation of feeding schedules. It is possible that even when the animal has become adapted to a feeding schedule, the natural day-night cycle of feeding, as revealed by the time of testing, will continue to influence food intake. In addition single deprivations of longer duration should be examined, to determine whether the day-night cycle of eating can be altered by very high drive. Finally, the interpretation of the interaction between the length of deprivation and time of testing during the first hour of eating suggests that the interrelationship between drives requires study. What might be the effect, for example, of manipulating drives to drink or rest on the cyclical food intake of the animal? Might an increase in sex drive alter the pattern of intake? Clearly, it may be necessary to provide experimental answers to some of these problems before the contribution of drive to behavior can be precisely assessed.

Summary

The purpose of the present study was to show that the time at which food deprivation occurs alters intake after a period of deprivation. Fifty-six male albino rats were subjected to a single deprivation and taught to press a lever to secure food on a continuous reinforcement schedule. Thereafter, the animal received all of his food by performing this response. After 72 hours of adaptation to this method of feeding, seven groups of eight animals each were deprived for 0, 2, 4, 8, 12, 18, and 24 hours. For half the animals in each group, deprivation was terminated at 7:00 P.M., and for the other half deprivation ended at 1:00 P.M. Thus, the design was factorial, permitting the effect of both the time at which deprivation was concluded and the length of deprivation to be assessed independently. Food intake was measured for 24 hours following deprivation. The results showed:

1- During the first hour following deprivation, intake increased significantly as deprivation increased and time of testing failed to influence the behavior.

2- The amount of interaction present during the first hour after deprivation was significant and one possible explanation of this phenomenon is offered.

3- Measures of intake during six hours following deprivation showed that both time of testing and length of deprivation to have significantly altered intake, and no interaction was apparent.

4- During 24 hours following deprivation, food intake was found to be a function of the length of deprivation, and neither time of testing nor interaction were significant.

It was concluded that precise prediction of eating behavior following deprivation requires knowledge of both the length of deprivation and the time at which deprivation occurs. Several suggestions for further research were offered.

APPENDIX

Explanatory note: Following, are individual records of each animal's food intake. The entries in each sheet are in terms of pellets.

O Hours Deprived   Feeding Begun 7:00 P.M.

Box No.	1	4	3	2		
Animal No.	20	23	33	28	Σ	Cum
7- 8 P.M.	32	75	-	54	161	161
8- 9 "	93	-	119	-	212	373
9-10 "	41	129	-	64	234	607
10-11 "	-	-	136	-	136	743
11-12 "	28	53	-	184	265	1008
12- 1 A.M.	58	92	143	-	293	1301
1- 2 "	43	55	41	72	211	1512
2- 3 "	-	9	-	68	77	1589
3- 4 "	-	120	-	-	120	1709
4- 5 "	-	13	116	-	129	1838
5- 6 "	52	-	-	99	151	1989
6- 7 "	12	69	-	-	81	2070
7- 8 "	-	-	124	-	124	2194
8- 9 "	-	-	-	-	-	2194
9-10 "	-	-	-	-	-	2194
10-11 "	-	51	-	63	114	2308
11-12 "	-	-	-	-	-	2308
12- 1 P.M.	20	-	-	-	20	2328
1- 2 "	-	-	-	-	-	2328
2- 3 "	24	-	-	-	24	2352
3- 4 "	-	-	-	-	-	2352
4- 5 "	-	-	-	-	-	2352
5- 6 "	63	-	-	56	119	2471
6- 7 "	32	47	-	-	79	2550
	498	713	679	660		

First Hour Intake	32	75	33	28
First 6 Hours Intake	252	349	398	302
First 24 Hours Intake	498	713	679	660

2 Hours Deprived   Feeding Begun 7:00 P.M.

Box No.		2	3	1	4		
Animal No.		21	8	1	35	Σ	Cum
7- 8	P.M.	57	96	92	54	299	299
8- 9	"	37	-	83	-	120	419
9-10	"	90	97	113	-	300	719
10-11	"	45	-	-	73	118	837
11-12	"	91	55	45	-	191	1028
12- 1	A.M.	-	-	31	59	90	1118
1- 2	"	-	-	27	-	27	1145
2- 3	"	-	-	-	-	-	1145
3- 4	"	-	27	47	53	127	1272
4- 5	"	77	-	50	-	127	1399
5- 6	"	85	48	57	73	263	1662
6- 7	"	-	-	-	59	59	1721
7- 8	"	-	-	-	-	-	1721
8- 9	"	-	-	-	-	-	1721
9-10	"	-	-	-	-	-	1721
10-11	"	-	-	-	48	48	1769
11-12	"	-	-	-	-	-	1769
12- 1	P.M.	-	-	-	-	-	1769
1- 2	"	-	48	-	-	48	1817
2- 3	"	-	-	-	-	-	1817
3- 4	"	-	-	-	-	-	1817
4- 5	"	22	-	37	-	59	1876
5- 6	"	-	-	-	-	-	1876
6- 7	"	45	88	63	32	228	2104
		549	459	645	451		

First Hour Intake	57	96	92	54
First 6 Hours Intake	320	248	364	186
First 24 Hours Intake	57	96	92	54

4 Hours Deprived   Feeding Begun 7:00 P.M.

Box No.		4	3	1	2		
Animal No.		31	22	10	2	∑	Cum
7- 8	P.M.	-	57	112	77	241	241
8- 9	"	56	-	50	35	141	382
9-10	"	6	64	58	85	213	595
10-11	"	81	97	-	-	178	773
11-12	"	26	-	43	45	114	887
12- 1	A.M.	56	-	-	-	51	938
1- 2	"	-	-	53	48	101	1039
2- 3	"	53	78	-	-	131	1170
3- 4	"	53	-	63	55	171	1341
4- 5	"	37	49	35	-	121	1462
5- 6	"	51	63	-	42	156	1618
6- 7	"	44	76	-	-	120	1738
7- 8	"	-	65	-	-	65	1803
8- 9	"	-	59	-	-	59	1862
9-10	"	-	27	-	27	54	1916
10-11	"	-	-	-	13	13	1929
11-12	"	-	-	-	-	0	1929
12- 1	P.M.	-	-	-	-	0	1929
1- 2	"	-	-	37	-	37	1966
2- 3	"	-	-	-	20	20	1986
3- 4	"	27	-	18	-	45	2031
4- 5	"	-	-	30	33	63	2094
5- 6	"	-	-	14	-	14	2108
6- 7	"	25	57	11	43	136	2244
		515	692	524	523		

First Hour Intake	-	57	112	77
First 6 Hours Intake	225	218	263	242
First 24 Hours Intake	515	692	524	523

8 Hours Deprived   Feeding Begun 7:00 P.M.

Box No.		1	3	2	4		
Animal No.		37	3	11	41	Σ	Cum
7- 8	P.M.	106	281	92	46	525	525
8- 9	"	74	86	74	52	286	811
9-10	"	1	92	51	1	145	956
10-11	"	99	-	20	101	220	1176
11-12	"	-	-	31	86	117	1293
12- 1	A.M.	-	108	-	54	162	1455
1- 2	"	-	-	32	98	130	1585
2- 3	"	39	102	28	36	205	1790
3- 4	"	33	35	-	91	159	1949
4- 5	"	48	49	2	-	99	2048
5- 6	"	51	-	4	67	122	2170
6- 7	"	-	-	43	100	143	2313
7- 8	"	-	80	51	54	185	2498
8- 9	"	-	-	-	-	-	2498
9-10	"	-	-	-	-	-	2498
10-11	"	-	-	-	-	-	2498
11-12	"	-	-	-	-	-	2498
12- 1	P.M.	-	-	49	-	49	2547
1- 2	"	-	-	-	-	-	2547
2- 3	"	-	-	-	-	-	2547
3- 4	"	-	20	-	-	20	2567
4- 5	"	-	23	39	19	81	2648
5- 6	"	22	14	-	-	36	2684
6- 7	"	13	52	32	29	126	2810
		486	942	548	834		

First Hour Intake	106	281	92	46
First 6 Hours Intake	280	567	268	340
First 24 Hours Intake	486	942	548	834

12 Hours Deprived   Feeding Begun 7:00 P.M.

Box No.	3	2	4	1		
Animal No.	29	24	12	7	Σ	Cum
7- 8 P.M.	87	107	135	183	512	512
8- 9 "	76	-	55	46	177	689
9-10 "	92	43	75	100	310	999
10-11 "	106	108	44	-	258	1257
11-12 "	-	-	49	66	115	1372
12- 1 A.M.	90	-	-	55	145	1517
1- 2 "	13	43	69	78	203	1720
2- 3 "	79	-	-	58	137	1857
3- 4 "	-	82	76	51	209	2066
4- 5 "	-	33	53	-	86	2152
5- 6 "	23	61	55	-	139	2291
6- 7 "	-	54	-	-	54	2345
7- 8 "	-	-	-	-	-	2345
8- 9 "	-	-	-	-	-	2345
9-10 "	-	-	-	-	-	2345
10-11 "	-	-	-	-	-	2345
11-12 "	-	-	-	-	-	2345
12- 1 P.M.	-	-	-	-	-	2345
1- 2 "	-	-	-	-	-	2345
2- 3 "	-	-	-	-	-	2345
3- 4 "	4	-	-	-	4	2349
4- 5 "	12	-	18	29	59	2408
5- 6 "	-	-	27	33	60	2468
6- 7 "	-	33	-	2	35	2503
	582	564	656	701		

First Hour Intake	87	107	135	185
First 6 Hours Intake	451	258	358	450
First 24 Hours Intake	582	564	656	701

18 Hours Deprived   Feeding Begun 7:00 P.M.

Box No.		3	4	1	2		
Animal No.		25	38	34	6	Σ	Cum
7- 8	P.M.	210	99	97	75	481	481
8- 9	"	99	77	77	71	324	805
9-10	"	138	20	29	38	225	1030
10-11	"	111	67	53	78	309	1339
11-12	"	-	137	58	-	195	1534
12- 1	A.M.	59	37	4	29	129	1663
1- 2	"	-	89	-	53	142	1805
2- 3	"	86	-	-	-	86	1891
3- 4	"	4	-	-	-	4	1895
4- 5	"	60	-	2	116	178	2073
5- 6	"	78	72	105	9	264	2337
6- 7	"	-	-	-	-	-	2337
7- 8	"	70	-	-	-	70	2407
8- 9	"	-	-	-	-	-	2407
9-10	"	-	76	-	76	152	2559
10-11	"	-	-	-	-	-	2559
11-12	"	-	-	-	-	-	2559
12- 1	P.M.	-	-	-	-	-	2559
1- 2	"	-	-	-	-	-	2559
2- 3	"	-	-	-	-	-	2559
3- 4	"	-	-	-	21	21	2580
4- 5	"	-	-	20	-	20	2600
5- 6	"	-	-	19	13	32	2632
6- 7	"	-	-	21	42	63	2695
		915	674	485	621		

First Hour Intake	210	99	97	75
First 6 Hours Intake	617	437	318	291
First 24 Hours Intake	915	674	485	621

24 Hours Deprived Feeding Begun 7:00 P.M.

Box No.		4	1	2	3		
Animal No.		26	30	32	36	Σ	Cum
7- 8	P.M.	129	169	82	102	482	482
8- 9	"	-	63	36	79	178	660
9-10	"	75	57	51	-	183	843
10-11	"	55	55	8	168	286	1129
11-12	"	147	30	40	27	244	1373
12- 1	A.M.	-	17	16	-	33	1406
1- 2	"	-	45	-	23	68	1474
2- 3	"	89	-	40	-	129	1603
3- 4	"	83	65	27	61	236	1839
4- 5	"	65	-	24	12	101	1940
5- 6	"	75	54	35	-	164	2104
6- 7	"	30	45	3	57	135	2239
7- 8	"	-	-	-	14	14	2253
8- 9	"	-	-	-	-	-	2253
9-10	"	-	-	66	-	66	2319
10-11	"	68	-	38	-	106	2425
11-12	"	-	-	-	-	-	2425
12- 1	P.M.	-	-	-	-	-	2425
1- 2	"	-	-	-	-	-	2425
2- 3	"	-	-	-	-	-	2425
3- 4	"	-	-	63	-	63	2488
4- 5	"	-	-	-	-	-	2488
5- 6	"	-	-	-	40	40	2528
6- 7	"	-	43	-	21	64	2592
		816	643	529	604		

First Hour Intake	129	169	82	102
First 6 Hours Intake	406	436	233	399
First 24 Hours Intake	816	643	529	604

O Hours Deprived   Feeding Begun 1:00 P.M.

Box No.	1	2	3	4		
Animal No.	42	48	65	70	Σ	Cum
1- 2 P.M.	-	42	52	-	94	94
2- 3 "	-	-	-	-	-	94
3- 4 "	73	-	-	23	96	190
4- 5 "	-	-	-	-	-	190
5- 6 "	-	55	63	-	118	308
6- 7 "	-	-	-	23	23	331
7- 8 "	-	78	-	21	99	430
8- 9 "	54	24	-	28	106	536
9-10 "	-	-	-	59	59	595
10-11 "	58	76	59	-	193	788
11-12 "	67	-	5	37	109	897
12- 1 A.M.	1	-	112	47	160	1057
1- 2 "	69	85	-	40	194	1251
2- 3 "	87	-	-	-	87	1338
3- 4 "	4	-	83	-	87	1425
4- 5 "	-	-	3	43	46	1471
5- 6 "	-	88	84	-	172	1643
6- 7 "	94	-	91	33	218	1861
7- 8 "	55	45	-	-	100	1961
8- 9 "	-	-	-	-	-	1961
9-10 "	-	-	-	-	-	1961
10-11 "	-	-	-	-	-	1961
11-12 "	-	-	-	36	36	1997
12- 1 P.M.	-	-	53	-	53	2050

First Hour Intake	-	42	52	-
First 6 Hours Intake	73	97	115	46
First 24 Hours Intake	562	493	605	390

2 Hours Deprived   Feeding Begun 1:00 P.M.

Box No.	2	1	3	4		
Animal No.	39	49	53	67	Σ	Cum
1- 2 P.M.	39	-	-	-	39	39
2- 3 "	-	-	-	-	-	39
3- 4 "	-	-	-	-	-	39
4- 5 "	-	-	-	-	-	39
5- 6 "	-	-	-	-	-	39
6- 7 "	-	13	50	4	67	106
7- 8 "	61	23	-	73	157	263
8- 9 "	-	23	-	40	63	326
9-10 "	-	126	18	81	225	551
10-11 "	92	-	76	44	212	763
11-12 "	-	59	-	84	143	906
12- 1 A.M.	-	1	126	-	127	1033
1- 2 "	52	76	-	-	128	1161
2- 3 "	-	-	-	-	-	1161
3- 4 "	30	-	100	41	171	1332
4- 5 "	36	66	-	94	196	1528
5- 6 "	63	117	5	-	185	1713
6- 7 "	-	57	103	-	160	1873
7- 8 "	-	56	61	-	117	1990
8- 9 "	50	-	5	-	55	2045
9-10 "	-	-	12	-	12	2057
10-11 "	-	-	-	-	-	2057
11-12 "	-	-	-	-	-	2057
12- 1 P.M.	-	-	-	-	-	2057

First Hour Intake	39	-	-	-
First 6 Hours Intake	39	13	50	4
First 24 Hours Intake	422	617	556	461

4 Hours Deprived   Feeding Begun 1:00 P.M.

Box No.		4	1	2	3		
Animal No.		71	66	51	46	Σ	Cum
1- 2	P.M.	24	35	-	-	59	59
2- 3	"	-	-	-	-	-	59
3- 4	"	19	24	-	-	43	102
4- 5	"	38	-	-	56	94	196
5- 6	"	-	30	-	-	30	226
6- 7	"	17	14	47	-	78	304
7- 8	"	30	30	51	86	197	501
8- 9	"	31	23	37	-	91	592
9-10	"	34	55	27	91	207	799
10-11	"	11	78	72	111	272	1071
11-12	"	21	-	57	11	89	1160
12- 1	A.M.	24	42	-	37	103	1263
1- 2	"	-	30	-	-	30	1293
2- 3	"	-	30	44	165	239	1532
3- 4	"	13	-	40	-	53	1585
4- 5	"	28	40	-	147	215	1800
5- 6	"	14	33	-	39	86	1886
6- 7	"	35	-	100	95	230	2116
7- 8	"	10	-	-	-	10	2126
8- 9	"	-	-	-	-	-	2126
9-10	"	25	-	-	-	25	2151
10-11	"	-	-	44	-	44	2195
11-12	"	11	17	-	-	28	2223
12- 1	P.M.	-	-	-	-	-	2223

	4	1	2	3
First Hour Intake	24	35	-	-
First 6 Hours Intake	98	103	47	56
First 24 Hours Intake	385	481	468	838

8 Hours Deprived   Feeding Begun 1:00 P.M.

Box No.	1	3	4	2		
Animal No.	60	40	47	63	Σ	Cum
1- 2 P.M.	-	159	119	-	278	278
2- 3 "	13	-	-	-	13	291
3- 4 "	-	-	-	-	-	291
4- 5 "	-	-	-	-	-	291
5- 6 "	-	-	57	84	141	432
6- 7 "	36	16	20	-	72	504
7- 8 "	-	70	63	-	133	637
8- 9 "	40	57	114	-	211	848
9-10 "	-	25	-	48	73	921
10-11 "	73	71	52	125	321	1242
11-12 "	69	113	38	-	220	1462
12- 1 A.M.	53	-	-	118	171	1633
1- 2 "	75	-	78	-	153	1786
2- 3 "	38	69	-	-	107	1893
3- 4 "	-	96	42	39	177	2070
4- 5 "	2	32	-	89	123	2193
5- 6 "	74	133	31	50	288	2481
6- 7 "	-	-	27	55	82	2563
7- 8 "	-	76	-	-	76	2639
8- 9 "	-	-	-	-	-	2639
9-10 "	-	-	-	-	-	2639
10-11 "	-	-	-	-	-	2639
11-12 "	-	-	-	-	-	2639
12- 1 P.M.	32	-	-	-	32	2671

First Hour Intake	-	159	119	-
First 6 Hours Intake	49	175	196	84
First 24 Hours Intake	473	916	641	608

12 Hours Deprived   Feeding Begun 1:00 P.M.

Box No.	3	2	1	4		
Animal No.	43	56	54	56	Σ	Cum
1- 2 P.M.	182	141	118	108	549	549
2- 3 "	-	-	-	-	-	549
3- 4 "	-	-	-	-	-	549
4- 5 "	-	-	-	-	-	549
5- 6 "	-	-	24	-	24	573
6- 7 "	-	68	42	11	121	694
7- 8 "	52	-	-	64	116	810
8- 9 "	48	42	-	-	90	900
9-10 "	119	74	53	80	326	1226
10-11 "	87	70	45	28	230	1456
11-12 "	64	73	83	43	263	1719
12- 1 A.M.	105	52	84	65	306	2025
1- 2 "	58	52	67	87	264	2289
2- 3 "	-	-	-	24	24	2313
3- 4 "	23	-	67	-	90	2403
4- 5 "	11	-	-	3	14	2417
5- 6 "	-	88	-	22	110	2527
6- 7 "	-	-	-	-	-	2527
7- 8 "	60	2	-	57	119	2646
8- 9 "	90	-	-	-	90	2736
9-10 "	-	16	-	-	16	2752
10-11 "	-	58	-	-	58	2810
11-12 "	-	-	46	-	46	2856
12- 1 P.M.	-	-	-	-	-	2856

First Hour Intake	182	141	118	108
First 6 Hours Intake	182	209	184	119
First 24 Hours Intake	899	736	629	592

18 Hours Deprived   Feeding Begun 1:00 P.M.

Box No.	1	2	3	4		
Animal No.	69	44	57	52	Σ	Cum
1- 2 P.M.	182	179	165	187	713	713
2- 3 "	-	-	-	-	-	713
3- 4 "	-	-	-	-	-	713
4- 5 "	-	-	68	73	141	854
5- 6 "	-	53	-	8	61	915
6- 7 "	62	41	26	99	228	1143
7- 8 "	102	-	84	7	193	1336
8- 9 "	-	61	34	-	95	1431
9-10 "	69	-	47	-	116	1547
10-11 "	-	-	-	128	128	1675
11-12 "	92	75	-	-	167	1842
12- 1 A.M.	61	122	126	59	368	2210
1- 2 "	-	-	-	92	92	2302
2- 3 "	-	-	-	-	-	2302
3- 4 "	85	17	-	-	102	2404
4- 5 "	3	10	75	-	88	2492
5- 6 "	53	-	90	78	221	2713
6- 7 "	-	8	-	-	8	2721
7- 8 "	-	99	-	-	99	2820
8- 9 "	-	-	-	-	-	2820
9-10 "	-	-	-	-	-	2820
10-11 "	-	-	-	-	-	2820
11-12 "	-	-	48	-	48	2868
12- 1 P.M.	-	-	-	-	-	2868

First Hour Intake	182	179	165	187
First 6 Hours Intake	244	273	259	367
First 24 hours Intake	709	665	763	731

24 Hours Deprived   Feeding Begun 1:00 P.M.

Box No.		2	3	4	1		
Animal No.		68	50	61	45	Σ	Cum
1- 2	P.M.	115	130	225	102	572	572
2- 3	"	-	-	-	-	-	572
3- 4	"	23	-	-	37	60	632
4- 5	"	-	70	-	83	153	785
5- 6	"	4	63	-	-	67	852
6- 7	"	44	-	84	-	128	980
7- 8	"	61	86	58	93	298	1278
8- 9	"	18	73	-	-	91	1369
9-10	"	77	-	96	30	203	1572
10-11	"	38	143	132	64	377	1949
11-12	"	33	2	-	-	35	1984
12- 1	A.M.	6	-	-	-	6	1990
1- 2	"	-	4	76	-	80	2070
2- 3	"	31	116	16	76	239	2309
3- 4	"	-	63	-	-	63	2372
4- 5	"	45	-	31	-	76	2448
5- 6	"	30	-	156	12	198	2646
6- 7	"	-	94	-	-	94	2740
7- 8	"	29	2	94	40	165	2905
8- 9	"	-	12	-	-	12	2917
9-10	"	-	-	-	-	-	2917
10-11	"	-	-	-	-	-	2917
11-12	"	19	-	-	-	19	2936
12- 1	"	2	-	-	-	2	2972

First Hour Intake	115	130	225	102
First 6 Hours Intake	186	263	309	222
First 24 Hours Intake	592	824	968	537

BIBLIOGRAPHY

Bibliography

1. Baker, R.A. "The effects of repeated deprivation experience on feeding behavior. J. Comp. Physiol. Psychol. 1955, 48, 37-42.

2. Bare, J.K. "Hunger, deprivation, and the day-night cycle". Study in publication.

3. Bousfield, W.A. and Elliot, M.H. "The effect of fasting on the eating behavior of rats". J. Genet. Psychol. 1934, 45, 227-237.

4. Bousfield, W.A. "Certain quantitative indices of the effects of fasting on eating behavior". J. Genet. Psychol. 1935, 46, 476-479.

5. Bousfield, W.A. and Elliot, M.H. "The experimental control of the hunger drive". J. Genet. Psychol. 1936, 15, 327-334.

6. Cambell, B.A. and Sheffield, F.D. "Relation of random activity to food deprivation". J. Comp. Physiol. Psychol. 1953, 46, 320-322.

7. Deese, J. and Carpenter, J.A. "Drive level and reinforcement". J. Exp. Psychol. 1951, 42, 236-238.

8. Edwards, A.L. Statistical Methods for the Behavioral Sciences. Rhinehart & Co. Inc., New York, 1954.

9. Eisman, E. "An investigation of the parameters defining drive (D)". J. Exp. Psychol. 1956, 52, 85-89.

10. Finan, J.L. "Quantitative studies in motivation. I. Strength of conditioning in rats under varying degrees of hunger". J. Comp. Psychol. 1940, 29, 119-134.

11. Finger, F.W. "The effect of food deprivation and subsequent satiation upon general activity in the rat". J. Comp. Physiol. Psychol. 1951, 44, 557-564.

12. Ghent, L. "The relationship of experience to the development of hunger. Canad. J. Psychol. 1951, 5, 2, 77-81.

13. Ghent, L. "Some effects of deprivation on eating and drinking behavior". J. Comp. Physiol. Psychol. 1957, 50, 172-177.

14. Gilbert, T.F. and James, W.T. "The dependency of cyclical feeding behavior on internal and external cues". J. Comp. Physiol. Psychol. 1956, 49, 342-344.

15. Hall, J.F., Smith, K., Schnitzer, S.B. and Hanford, P.V. "Elevation of activity level in the rat following transition from ad libitum to restricted feeding". J. Comp. Physiol. Psychol. 1953, 46, 429-433.

16. Hall, J.F. "The relationship between external stimulation, food deprivation, and activity". J. Comp. Physiol. Psychol. 1956, 49, 339-341.

17. Hillman, B. Hunter, W.S. and Kimble, G.A. "The effect of drive level on the maze performance of the white rat". J. Comp. Physiol. Psychol. 1953, 46, 87-89.

18. Holden, F. "A study of the effect of starvation upon behavior by means of the obstruction method". Comp. Psychol. Monogr. 1926, 3, 17.

19. Hull, C.L. Principles of Behavior Appleton-Century Press, New York, 1943.

20. Hunt, J.M. and Schlosberg, H. "General activity in the male white rat". J. Comp. Physiol. Psychol. 1939, 28, 23-38.

21. Jenkins, T.N., Warner, L.H., Warden, C.J. "Standard apparatus for the study of animal motivation". J. Comp. Psychol. 1926, 6, 361-382.

22. Kimble, G. "Behavior strength as a function of the intensity of the hunger drive". J. Exp. Psychol. 1951, 41, 341-348.

23. Koch, S. and Daniel, W.J. "The effect of satiation on the behavior mediated by a habit of maximum strength". J. Exp. Psychol. 1945, 35, 167-185.

24. Lawrence, D.H. and Mason, W.A. "Intake and weight adjustments in rats to changes in feeding schedule". J. Comp. Physiol. Psychol. 1955, 48, 43-46.

25. Lawrence, D.H. and Mason, W.A. "Food intake in the rat as a function of deprivation intervals and feeding rhythms". J. Comp. Physiol. Psychol. 1955, 48, 267-271.

26. Ligon, E.M. "A comparative study of certain incentives in the learning of the white rat". Comp. Psychol. Monogr. 1929, 6, 1-95.

27. MacDuff, M.M. "The effect of varying degrees of motivation during learning in rats". J. Comp. Physiol. Psychol. 1946, 39, 207-240.

28. Morgan, J.J.B. "The measurement of instincts". Psychol. Bull. 1923, 20, 94.

29. Moss, F.A. "Study of animal drives" J. Exp. Psychol. 1924, 7, 165-185.

30. Munn, N.L. Handbook of Psychological Research on the Rat. Houghton Mifflin Co., New York, 1950.

31. Perin, C.T. "Behavior potentiality as a joint function of the amount of training and the degree of hunger at the time of extinction". J. Exp. Psychol. 1942, 30, 93-113.

32. Reid, L.S. and Finger, F.W. "The rats adjustment to 23-hour food deprivation cycles". J. Comp. Physiol. Psychol. 1955, 48, 110-113.

33. Reynolds, B. "The relationship between the strength of a habit and the degree of drive present during acquisition". J. Exp. Psychol. 1949, 30, 296-305.

34. Richter, C.P. "A behavioristic study of the activity of the white rat". Comp. Psychol. Monogr. 1922-3, 1, no. 2.

35. Richter, C.P. "Animal behavior and internal drives". Quart. Rev. Biol. 1927, 2, 307-343.

36. Saltzman, I. and Koch, S. "The effect of low intensities of hunger on the behavior mediated by a habit of maximum strength". J. Exp. Psychol. 1948, 38, 347-370.

37. Siegel, P.S. and Stuckey, H.L. "The diurnal course of water and food intake in the normal and mature rat". J. Comp. Physiol. Psychol. 1947, 40, 365-370.

38. Skinner, B.F. The Behavior of Organisms. D. Appleton Century, New York, 1938.

39. Strassburger, R.C. "Resistance to extinction of a conditioned operant as related to drive level at reinforcement". J. Exp. Psychol. 1950, 40, 473-487.

40. Teel, K.S. "Habit strength as a function of motivation during learning". J. Comp. Physiol. Psychol. 1952, 45, 188-191.

41. Verplanck, W.S. and Hayes, J.R. "Eating and drinking as a function of maintenance schedule". J. Comp. Physiol. Psychol. 1953, 46, 327-333.

42. Warner, L.H. "A study of hunger behavior in the white rat by means of the obstruction method". J. Comp. Psychol. 1928, 8, 273-299.

43. Young, P.T. Psychol. Rev. 1949, 56, 2, 98-121. Title: "Food-seeking drive, affective process, and learning".

44. Zeaman, D. and House, B.J. "Response latency at zero drive after varying numbers of reinforcements". J. Exp. Psychol. 1950, 40, 570-583.

VITA

George Anthony Cicala

Born: May 16, 1935, New York, New York

College of William and Mary: 1952-1956

College of William and Mary: 1956-1958