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A comparison of the effects of 23 hour food deprivation and 23 hour water deprivation on the weight and intake of the albino rat

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A Comparison of the Effects of 23 Hour Food Deprivation and 23 Hour Water Deprivation on the Weight and Intake of the Albino Rat

by

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Introduction

Food deprivation and water deprivation have each been used as methods of controlling animals' motivation in behavioral studies. In order to maintain a uniform level of motivation on consecutive days, a frequently used procedure is to deprive animals of either food or water for 23 of every 24 hours. Unless otherwise specified, references to water deprivation or food deprivation as used in the following discussion will refer to a 23 hour deprivation schedule.

On the basis of fairly extensive investigations of these schedules, some conclusions have been drawn about their effects on animals' body weight and consummatory behavior. These investigations have generated some interest in directly comparing the effects of these two types of deprivation. These studies have suggested that the changes produced by a water deprivation schedule may differ from those produced by a food deprivation schedule.

In general, there are two sources from which interest in food and water deprivation derives. One of these sources is the need for knowledge of the effects of these kinds of deprivation by investigators using such deprivation as the motivational condition in studies of learning. Thus, Reid and Finger (1955), and Blick (1960) observe that adjustment to the deprivation schedule must occur before Ss are introduced to the learning task to prevent possible confounding of the effects of the independent variable and the effects of the initial changes in weight and intake that occur when deprivation begins. A factual demonstration of the importance of this has recently been provided by Capaldi and Robinson (1960) who showed differences in learning as a function of degree of adjustment to a food deprivation schedule.

A direct comparison of adjustment to food deprivation and to water deprivation in a single experiment, using homogeneous animals, identical procedures, etc., has apparently not been reported. However, existing studies of each type of deprivation separately have been relatively consistent in their findings. Thus, Reid and Finger (1955, 1957), studying the effects of the 23 hour food deprivation schedule on the body weight of rats, found that body weight decreased steadily for the first 15 deprivation days. There was some indication from the weight tables presented in these studies that body weight might continue to decline, although to a lesser extent, for a longer period of time. They concluded that 15 days was the minimum time required for adjustment. Finger, Reid, and Weasner (1957), using a similar food deprivation schedule, found that body weight declined for 20 days. Kaplan, et al. (1959) found that depending on the S, weight declined for 10 to 15 days for animals on a food deprivation schedule. Raymond, Carlton and McAllister (1955) gave rats food for 50 minutes of each day, instead of the usual 60 minutes, and found weight declining for about 10 days.

Finger and Reid (1952) exposed rats to a single 24 hour deprivation experience. One group was deprived of water, and one group was deprived of food. There was little difference in the amount of weight lost, water deprived animals losing slightly more weight.

Reid and Finger (1955) also measured changes in food intake occurring when the animals were placed on food deprivation. Food intake increased during the first 20 days. Lawrence and Mason (1955), using a 22 hour food deprivation schedule, found that food intake increased throughout the 14 days reported. Baker (1955) reported changes in food consumption for several different food deprivation schedules. He found that intake generally increased for 10 days or more.

Ehrenfruend (1959) kept rats on a schedule in which both food and water were withheld during each 23 hour deprivation period. Mash was the intake substance used. Intake increased for the first 15 days.

Adjustment to a 23 hour water deprivation schedule has been reported by Young, Heyer and Richey (1952) and Blick (1960. The former writers reported that water intake reached a stable level after 6 days on the schedule. Weight gain per intake period failed to show consistent changes after four days. Blick (1960) found that body weight declined for only three days. A stable level of water intake was reached in approximately four days.

The available literature then, is consistent in indicating different effects of deprivation on animals placed on the two types of schedules. Weight changes and intake changes continue for longer periods of time for animals adjusting to the food deprivation schedule than for animals adjusting to the water deprivation schedule. These suggestions about the differences between food and water deprivation must be regarded as somewhat tentative, since they are derived from different experiments using different strains of rats, and having different environmental conditions and procedures.

A second source of interest lies in the direct comparison of the effect on weight and intake of food deprivation with the effect on these measures of water deprivation, independently of adjustment considerations. No significant information is available from a systematic, long-term comparison of these schedules in the same experiment, particularly with regard to daily body weight loss, daily body weight gain during the intake period, and overall weight change.

The need for comparisons between food and water deprivation is emphasized by a number of other studies which suggest that the behavioral effects of the two kinds of deprivation are not the same. Hall (1955) reported a stable activity level only slightly, but significantly higher than that of ad lib controls for rats adjusting to a 23 hour water deprivation schedule. Food deprived animals run under the same schedule and similar conditions showed a negatively accelerated increasing activity level as a function of length of time on the schedule. The level of activity reached by these animals was considerably higher than that of the water deprived Ss. Petrinovich and Bolles (1954) have related water deprivation to stereotypy of behavior and food deprivation to variability of behavior. Using a T maze, these investigators found that water deprived animals were superior to food deprived animals in a problem requiring a constant position response. However, for a T maze problem requiring response alternation, food deprived animals made fewer errors and more quickly reached the criterion. Bolles and Petrinovich (1956) noted that in their 1954 study, food deprived animals lost weight and water deprived animals showed a day to day weight gain. An experiment was therefore done to evaluate the effects of weight loss and weight gain on alternation behavior. Using various improvised deprivation schedules, weight losers and weight gainers were run either hungry or thirsty. Alternation behavior was found to be primarily a function of changes in body weight. No intrinsic correlation between alternation behavior and type of deprivation was noted. Bolles (1959) reports further differences in the types of performance influenced by water and by food deprivation.

The present study is designed to make a direct comparison of food and water deprivation schedules both in terms of the animals' adjustment to the schedules, and the relative effects of the two schedules on several weight and intake measures. The three groups used are: a control group, a 23 hour food deprivation schedule group, and a 23 hour water deprivation schedule group. The groups will be compared over a period of 50 days in terms of body weight, weight loss and gain, and food and water intake.

Method

Subjects. The Ss were 27 experimentally naive male albino rats of the Sprague-Dawley strain. They were 173 days old at the start of the habituation period.

Apparatus. The Ss were housed in individual 11-in. by 8-in. by 8-in. wire mesh cages kept in a small experimental room. External noises were reduced by soundproofing material covering the walls and ceiling of the room. The one window exposed the animals to a natural day-night cycle. Temperature was thermostatically maintained at 78° F. $\pm$ 2° F. No attempt was made to control or measure humidity. A paper lined tray under each cage made it possible to recover food particles which fell through the wire bottom of the cage. All body weight and food (Purina lab chow pellets) measurements were made to the nearest .1 gram on a triple beam balance scale. Water measurements were made to the nearest .5 ml. by using a 150 ml. graduated cylinder; tap water was used throughout the experiment and given to the Ss in 8-oz. bottles attached to each cage.

Procedure. Upon receipt from the supplier, all animals were placed on ad lib. food and water and weighed twice a week for a period of 7 weeks before habituation started.

The habituation phase of the experiment occurred during the period 12/17/60 to 12/23/60. Animals continued to have free access to food and water during this period. Body weight, 24 hour food intake and 24 hour water intake were measured between 12:20 and 1:50 P.M. each day. On the last habituation day (12/23/60) Ss were ranked on the basis of their mean body weights during habituation. Ss were assigned randomly, three at a time, to the three groups - control, 23 hour water deprivation, and 23-hour food deprivation. Thus, nine matched groups (blocks) of three Ss each were formed (Edwards, 1960; Ray, 1960). Animals remained on ad lib. food and water until the next day which started the experimental period.

On 12/24/60 (designated as experimental day 0) at 2:15 P.M. all Ss were weighed. The order in which the Ss were weighed, and in which food and water were presented and taken away from the animals, was held constant; one S from each group was weighed alternately. Thus, one control, one food deprived, and one water deprived animal were handled in that order, this sequence being repeated nine times. Food and water were removed from the animals assigned to the food deprivation and water deprivation groups respectively. Food deprived animals had ad lib. water, and water deprived animals had ad lib. food. The control Ss had ad lib. food and water.

On 12/25/60 and on each of the following 49 experimental days the following procedure was followed:

1) Food and water for the daily one hour intake period were premeasured for all groups. The intake hour was from 1:15 to 2:15 P.M.

2) All Ss were weighed. The intake substances available during the previous 23 hour deprivation period were removed from the animal's cages and discarded. Thus food was removed from the water deprived animals, water from the food deprived animals, and both food and water from the control animals. Food was removed from the papers under the cages.
3) Premeasured food and water were put in each animals cage. The experimenter left the room.
4) One hour later, food and water were removed from each animal's cage and set aside for later measurement. Food which had collected on the trays beneath the cages during the one-hour intake period was added to the food left in the cage for each animal.
5) All Ss were again weighed. The Ss were then provided with the appropriate substance (s) for the next 23 hours.
6) The food and water remaining at the end of the intake period were subtracted from the amounts put in at the beginning of this period to obtain one hour food and water intake. Water intake was corrected for spillage and evaporation by the amount lost during the hour from a control bottle mounted on an empty cage.

The above procedure yielded eight daily measures for analysis: preintake body weight, postintake body weight, weight change during the one hour intake period, weight change during the 23 hour deprivation period, net weight change for the 24 hour period, one-hour food intake, one-hour water intake, and one-hour total intake.

Results

An analysis of variance of habituation body weight for animals assigned to different experimental treatments is presented in Table 1. The analysis indicates that the hypothesis of no differences among the treatment groups in weight during the habituation period can be retained. The significant blocks F was expected as a result of the matching procedure, since assignment to blocks was based on ranked habituation body weight.

__Preintake and Postintake Body Weights.__ The mean preintake and postintake body weights for the three groups as a function of days are presented in Figure 1. Each point on the graph represents the daily mean of the 9 Ss in each group.

Tables 2 and 3 present the analyses of variance for preintake and postintake body weights. The overall differences among groups are significant for both weight measures. Intergroup comparisons by Duncan's test (Edwards, 1960) for individual preintake weight means are presented in Table 4. There it may be seen that each group is significantly different (.01 level) from the other two groups. Table 5 shows the same comparisons for postintake weight. Again, all differences between groups are significant (.01 level).

Tables 2 and 3 also show that significant differences among the blocks, constituted on the basis of habituation weight, persisted in the weight measures taken throughout the experiment. Inspection of

Table 1

Analysis of Variance of Body Weight
During the Habituation Phase

Source	df	ss	ms	F	P
Treatments	2	10.44	5.22	.048	> .05
Blocks	8	57,238.38	7,154.80	65.83	< .001
Residual	16	1,738.88	108.68		
Total	26	58,987.70			

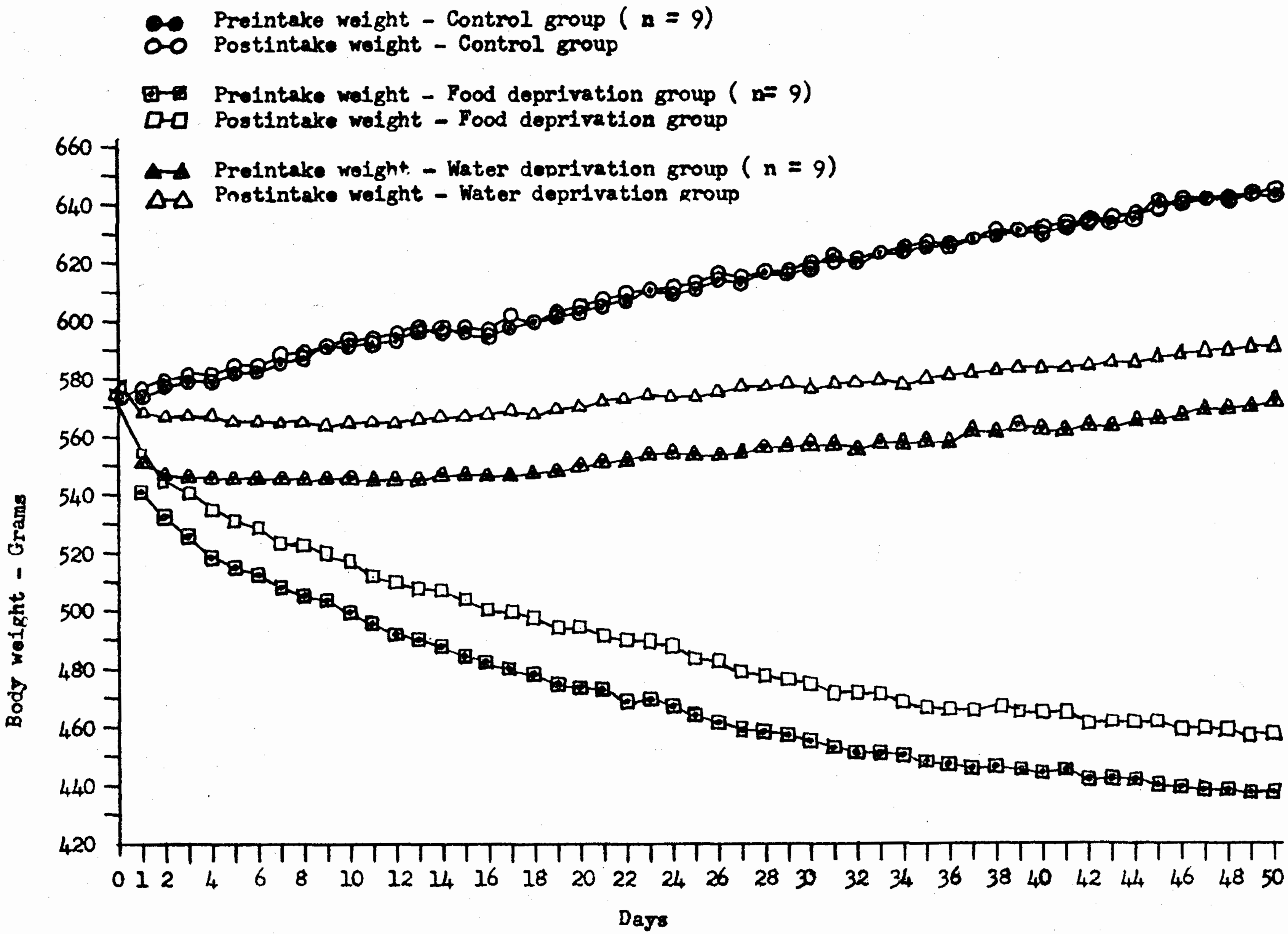

Fig. 1. Mean preintake and postintake body weight as a function of days.

Table 2

Analysis of Variance of
Preintake Body Weight

Source	df	ss	ms	F	P
Treatments	2	90,907.67	45,453.84	130.70	< .001
Blocks	8	64,472.47	8,059.06	23.17	< .001
Residual	16	5,564.15	347.76		
Total	26	160,944.29			

Table 3

Analysis of Variance of
Postintake Body Weight

Source	df	ss	ms	F	P
Treatments	2	72,333.28	36,166.64	83.07	< .001
Blocks	8	69,238.97	8,654.87	19.88	< .001
Residual	16	6,966.25	435.39		
Total	26	148,538.50			

Table 4

Comparison of Individual Group Means for Preintake Weight[1]

Differences in Means

Treatment Means	Food dep. (470.0)	Water dep. (554.6)	Control (611.2)	Shortest Significant Range .01 level
Food dep. (470.0)		84.6	141.2	R_2 = 25.70
Water dep. (554.6)			56.6	R_3 = 26.80

Food dep. Water dep. Control

[1] Lines appearing under the treatment conditions listed across the table indicate the absence of a significant difference between the treatment means. Any two means underscored by the same line are not significantly different. Any two means which are not underscored by the same line are significantly different. In Table 4 all differences are significant; therefore no lines appear.

Table 5

Comparison of Individual Group
Means for Postintake Weight

	Differences in Means			
Treatment Means	Food dep. (488.8)	Water dep. (574.8)	Control (612.4)	Shortest Significant Range .01 level
Food dep. (488.8)		86.0	123.6	R_2 = 28.75
Water dep. (574.8)			37.6	R_3 = 29.99

Food dep. Water dep. Control

the data showed that these differences resulted from the blocks remaining in the same relationship to each other, for preintake and postintake weight, as they were on the habituation weight measure.

Figure 1 shows that the control animals consistently gained weight throughout the experimental period. Water deprived animals showed an initial drop in weight. Beyond approximately the eighth or ninth experimental day, neither preintake nor postintake weights showed any further decline; both weight measures showed a subsequent gradual increase. Postintake weights paralleled preintake weights throughout the 50 day period for this group.

In sharp contrast to the weight loss picture presented by the water deprived group, the weight of food deprived animals showed a sharper initial drop and continued to decline as a negatively accelerated function of days for the entire 50 days. There seemed to be some tendency for the preintake and postintake weight curves of the food deprived group to initially diverge from each other.

Comparing the weight trend of each deprivation group with the control group, a much greater and more rapidly increasing discrepancy between the food deprivation group and control group weights than between the water deprivation group and control group weights may be noted.

A repeated measures t-test shows that the mean postintake weights were significantly higher than mean preintake weights over the 50 day period for the food deprived ($t = 10.50$; $df = 8$; $P < .01$) and water deprived ($t = 22.44$; $df = 10$; $P < .01$) groups. Differences between preintake and postintake weights for the control group were not significant ($P > .05$).

Weight Change During the One Hour Intake Period. Subtraction of each day's preintake weight from the same day's postintake weight yields weight change during the intake period. Figure 2 presents the mean weight change per intake period for the three groups as a function of days. These functions suggest that water deprived animals initially gained more weight per intake period than food deprived animals and more quickly reached a level of weight gain beyond which further consistent increases failed to occur. Food deprived Ss appear to gain increasing amounts of weight for 15 days, while the water deprived Ss show little systematic increase beyond Day 4. Control animals generally appear to have averaged approximately one gram of weight gain per intake period.

Analysis of variance for differences among the groups in one-hour weight change for the 50 day period was significant beyond the .001 level and appears in Table 6. Individual comparisons between group means are presented in Table 7. Both food and water deprived animals gained more weight than the control animals (.01 level). However, the difference between food and water deprived groups in the amount of weight gained, over the 50 day period, was not statistically significant at the .05 level.

Inspection of Figure 2 shows that, while the curves for the two deprived groups are virtually indistinguishable for the last 35 or 40 days, there is a large difference between them for the first 10 days. This fact prompted a separate analysis of variance on mean

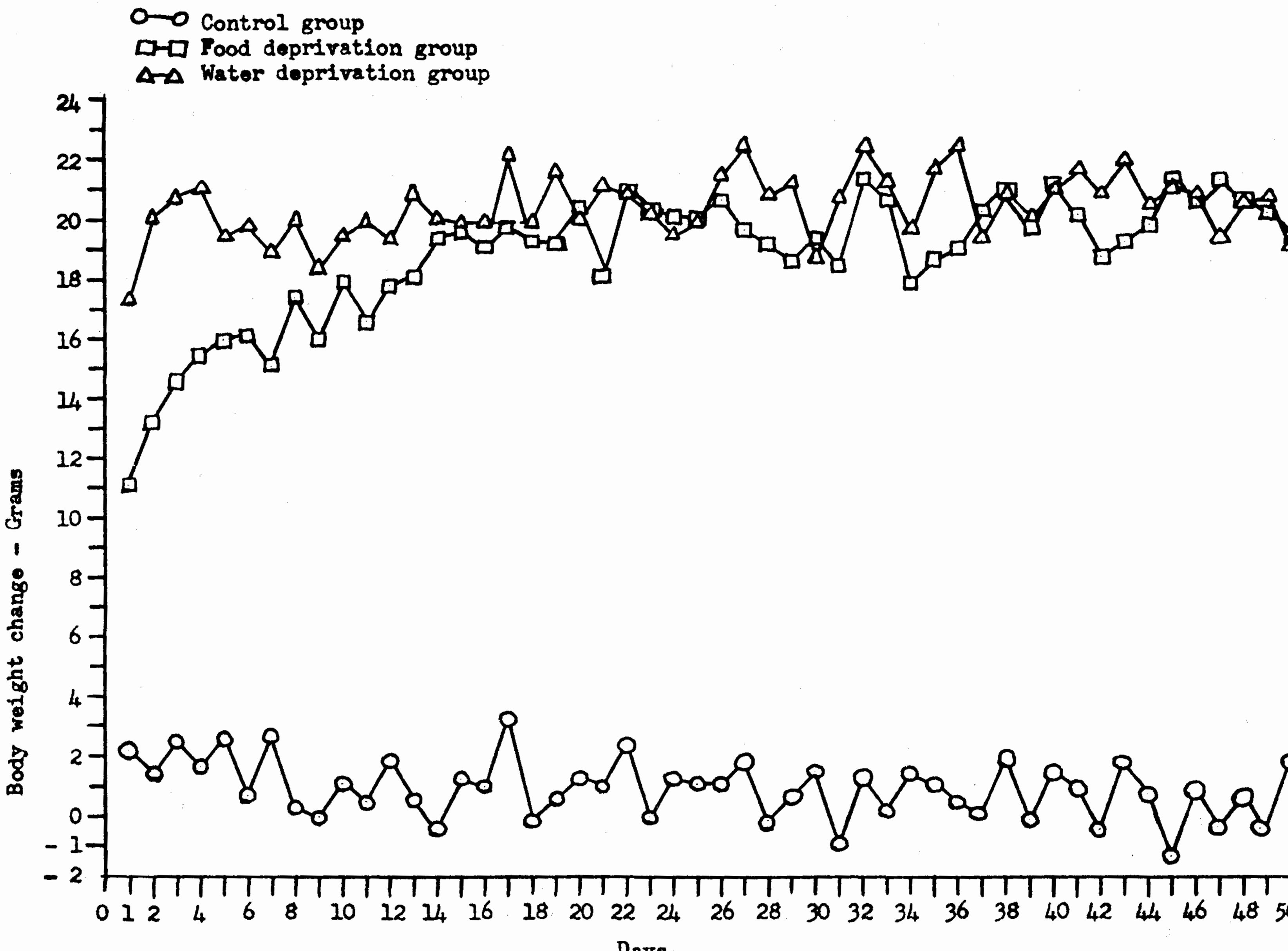

Fig. 2. Mean body weight change during the 1 hour intake period as a function of days.

Table 6

Analysis of Variance of One hour (Intake Period) Weight Change

Source	df	ss	ms	F	P
Treatments	2	2,101.10	1,050.55	83.78	< .001
Blocks	8	121.80	15.22		
Residual	16	200.63	12.54		
Total	26	2,423.53			

Table 7

Comparison of Individual Group Means for One Hour Intake Period Weight Change

Differences in Means					
Treatment Means	Control (0.9)	Food dep. (18.8)	Water dep. (20.4)	Shortest Significant Range .01 level	.05 level
Control (0.9)		17.9	19.5	R_2 = 4.87	3.54
Food dep. (18.8)			1.6	R_3 = 5.08	3.71

Control Food dep. Water dep.

____________________ (.01)

____________________ (.05)

one-hour weight change during Days 1-10. As expected, there were significant differences among the three groups during this period ($F = 56.76$; $df = 2, 16$; $P < .001$). The important finding was that Duncan's test revealed a significant difference at the .05 level between the two deprivation groups, in addition to significant differences between each deprived group and the control group. Thus, the overall 50-day analysis fails to reveal a significant difference between the deprived groups, while an analysis confined to the first 10 days does show such a difference.

Weight Change During the 23 Hour Deprivation Period. Figure 3 presents the mean weight change per 23 hour deprivation period as a function of days for the three groups. These values were derived by subtracting from each day's postintake weight the following day's preintake weight. Negative values were assigned to indicate a loss in weight. The striking feature of Figure 3 is that weight loss per deprivation period remains at approximately the same level for both deprivation groups. The control group values for this measure fluctuate around zero, with a slight tendency to be positive, thus indicating a slight weight gain.

Analysis of variance for differences among the groups in amount of weight change per deprivation period appears in Table 8. Group differences were significant beyond the .001 level. Individual comparisons between groups appear in Table 9 and indicate that both food and water deprived animals differ significantly from

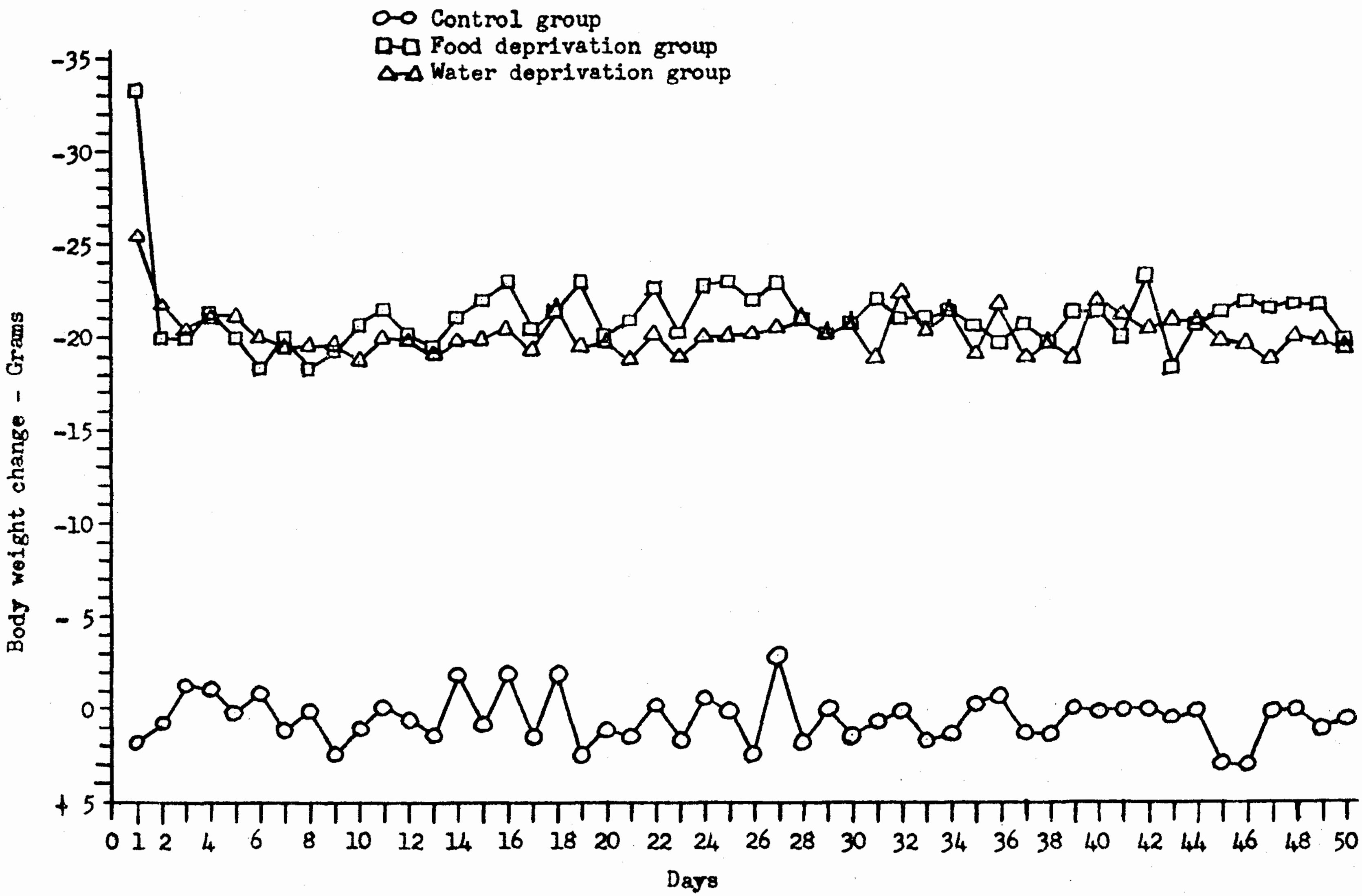

Fig. 3. Mean body weight change during the 23 hour deprivation period as a function of days.

Table 8

Analysis of Variance of 23 Hour
(Deprivation Period) Weight Change

Source	df	ss	ms	F	P
Treatments	2	2,688.34	1,344.17	132.04	< .001
Blocks	8	91.49	11.44		
Residual	16	162.94	10.18		
Total	26	2,942.77			

Table 9

Comparison of Individual Group Means
for 23 Hour Deprivation Period Weight Change

Differences in Means

Treatment Means	Food dep. (-21.1)	Water dep. (-20.1)	Control (+ 0.5)	Shortest Significant Range	.01 level	.05 level
Food dep. (-21.1)		1.0	21.6	R_2 =	4.38	3.18
Water dep. (-20.1)			20.6	R_3 =	4.57	3.33

Food dep. Water dep. Control

__________________ (.01)

__________________ (.05)

the control group in the amount of weight change per deprivation period. There was however, no statistically significant difference between food and water deprived animals on this measure.

Net Weight Change per 24 Hour Intake Period. Addition of each animal's 23 hour deprivation period weight change to the weight change of the animal during the immediately following 1 hour intake period provides a measure of the net weight change for each day. The mean net weight change for the various groups is presented as a function of days in Figure 4. Negative values indicate a net loss in weight.

Analysis of variance in Table 10 indicates a significant overall difference among groups beyond the .001 level. Individual intergroup comparisons in Table 11 revealed that the mean net weight change of each group is significantly different from every other group at the .01 level of significance.

Control animals showed approximately a 1.5 gm. mean net weight gain per day. Water deprived animals, after two days of net weight loss, showed a net weight change fluctuating around zero for a period of time, and a slightly positive net weight change in the later stage of the experiment. This accounts for the slight increase in body weight for this group shown in Figure 1. Food deprived animals show a decreasing net weight loss as a function of days. The decreasing daily net weight loss as time on the schedule increased was particularly apparent during the first 20 days of the experiment. For the entire 50 days, these animals show a mean net

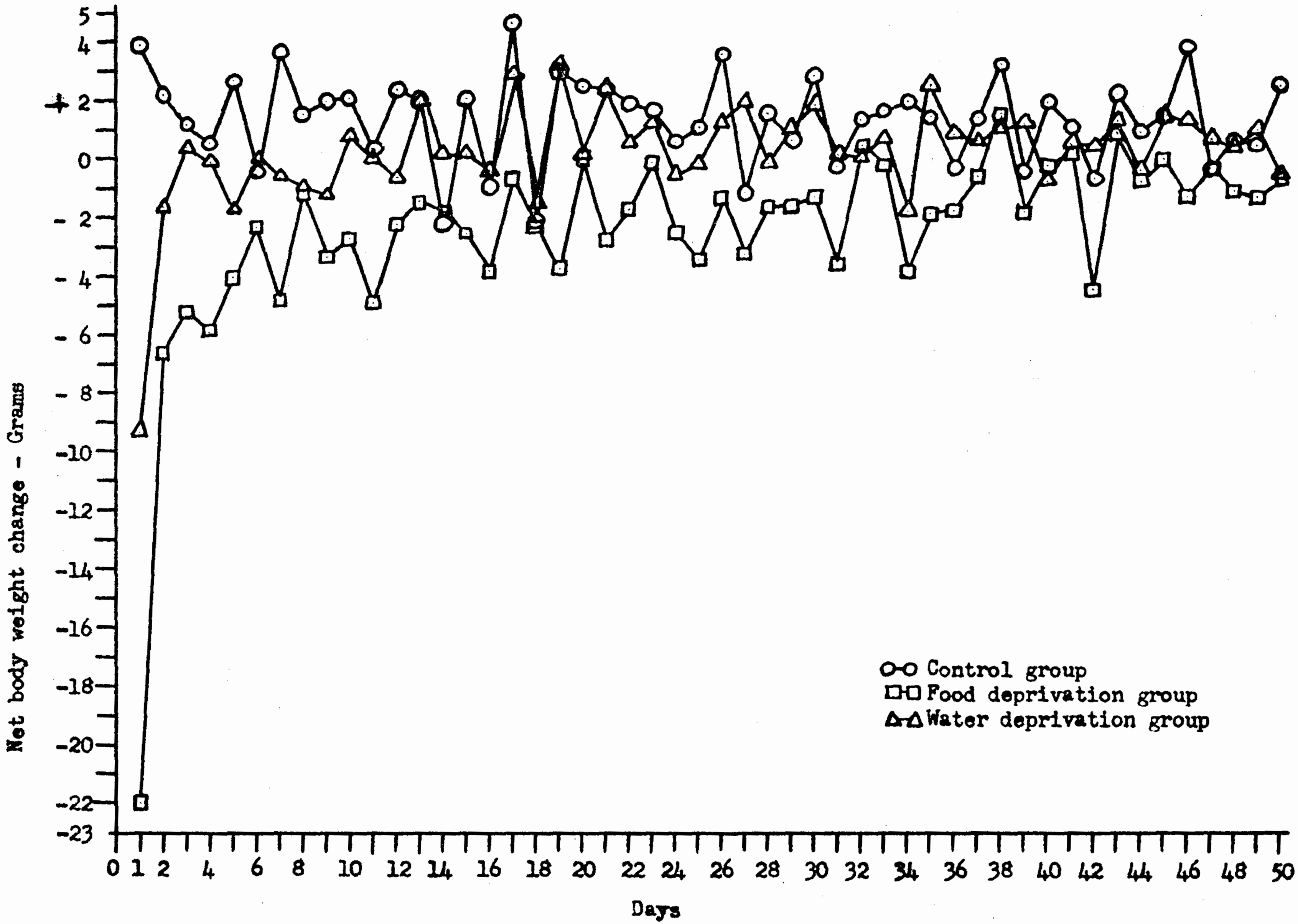

Fig. 4. Mean net weight change for each 24 hour period as a function of days. (See text for details).

Table 10

Analysis of Variance of Net Weight
Change During Each 24 Hour Period

Source	df	ss	ms	F	P
Treatments	2	68.01	34.00	79.07	< .001
Blocks	8	3.10	.39		
Residual	16	6.87	.43		
Total	26	77.98			

Table 11

Comparison of Individual Group
Means for Daily Net Weight Change

Differences in Means				
Treatment Means	Food dep.	Water dep.	Control	Shortest Significant Range
	(- 2.4)	(+ 0.3)	(+ 1.4)	.01 level
Food dep. (- 2.4)		2.7	3.8	R_2 = .90
Water dep. (+ 0.3)			1.1	R_3 = .94

Food dep. Water dep. Control

weight loss of 2.4 grams. Thus, as seen in Figure 1, food deprived Ss continue to lose weight from day to day throughout the experiment.

<u>One Hour Food Intake</u>. The mean food intake during the 1 hour intake period is presented as a function of days for each group in Figure 5. Analysis of variance in Table 12 indicated the difference among groups was highly significant. Individual group comparisons in Table 13 show that water deprived animals ate significantly more food than control animals at the .05 level. Food deprived animals differed significantly from both groups at the .01 level.

Food deprived animals show a generally increasing amount of food eaten per intake period for approximately the first 14-17 days on the schedule. Water deprived animals consistently increase their food intake for a period of only four days. The control group intake of food shows no major trend.

<u>One Hour Water Intake</u>. Figure 6 presents the mean one hour water intake for the treatment groups as a function of days. Analysis of variance in Table 14 was significant for differences among groups on this measure. Intergroup comparisons in Table 15 show that all groups are significantly different from each other at the .01 level.

The water deprived animals show the largest water intake. Their intake increases rapidly for three days and then reaches a level beyond which no consistent increases occur. Food deprived animals drink a lesser amount of water and irregularly increase their intake for a longer period of time than the water deprived

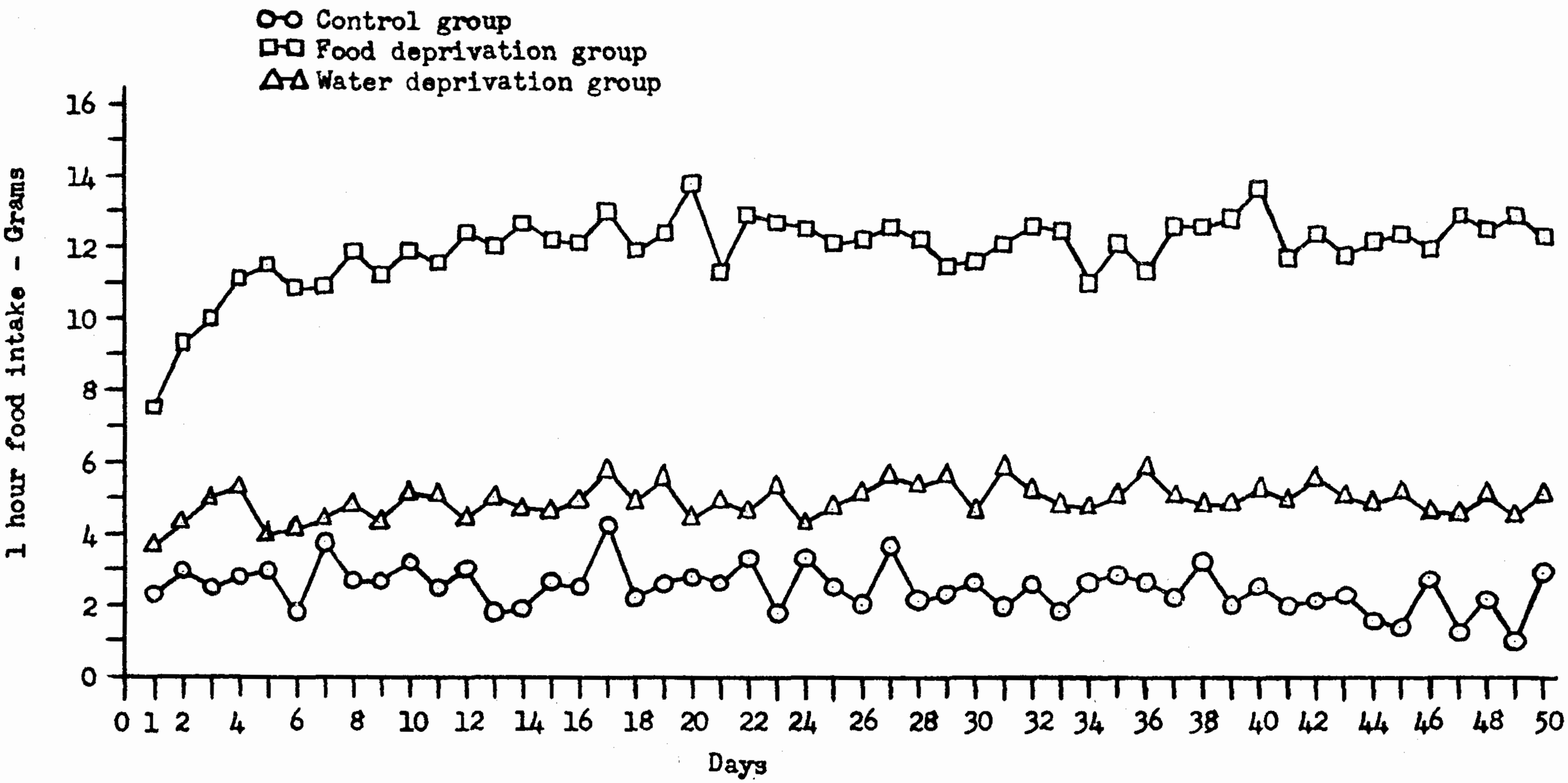

Fig. 5. Mean food intake during the 1 hour intake period as a function of days.

Table 12

Analysis of Variance of
One Hour Food Intake

Source	df	ss	ms	F	P
Treatments	2	437.85	218.92	63.09	< .001
Blocks	8	34.68	4.34		
Residual	16	55.50	3.47		
Total	26	528.03			

Table 13

Comparison of Individual Group Means for One Hour Food Intake

Differences in Means

Treatment Means	Control (2.5)	Water dep. (4.9)	Food dep. (12.0)	Shortest Significant Range	.01 level	.05 level
Control (2.5)		2.4	9.5	R_2 =	2.56	1.86
Water dep. (4.9)			7.1	R_3 =	2.67	1.95

Control Water dep. Food dep.

(.01)

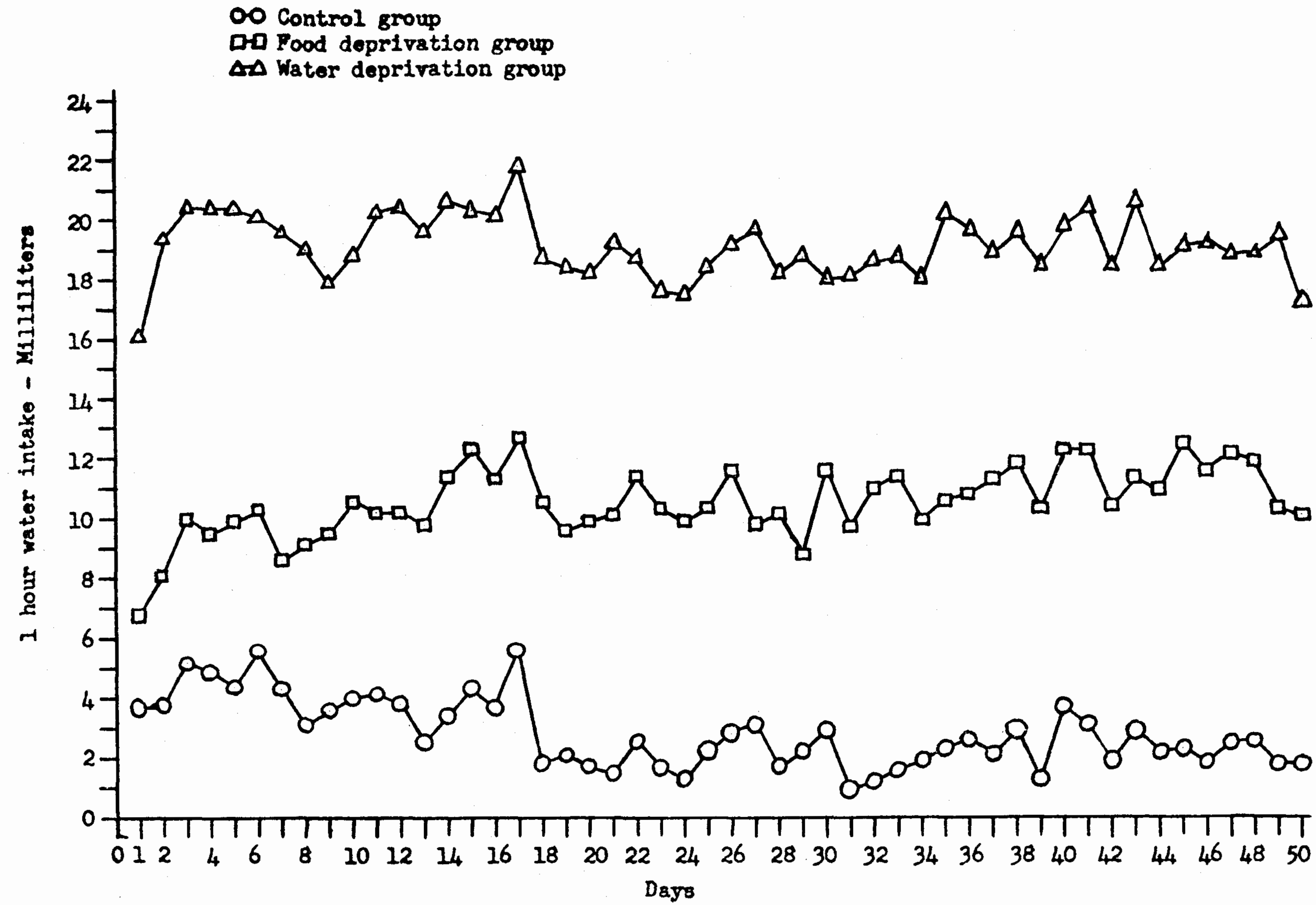

Fig. 6. Mean water intake during the 1 hour intake period as a function of days.

Table 14

Analysis of Variance of
One Hour Water Intake

Source	df	ss	ms	F	P
Treatments	2	1,198.42	599.21	83.11	$<.001$
Blocks	8	69.29	8.66		
Residual	16	115.39	7.21		
Total	26	1,383.10			

Table 15

Comparison of Individual Group Means for One Hour Water Intake

Differences in Means

Treatment Means	Control (2.9)	Food dep. (10.6)	Water dep. (19.2)	Shortest Significant Ranges .01 level
Control (2.9)		7.7	16.3	R_2 = 3.72
Food dep. (10.6)			8.6	R_3 = 3.88

Control Food dep. Water dep.

animals. The control intake shows a slight tendency to decrease over the 50 day period.

__One Hour Total Intake__. Figure 7 presents the mean total intake for the groups as a function of days. Analysis of variance for this measure is shown in Table 16 and indicates an overall significant difference among groups. Table 17 shows that food and water deprived animals did not differ significantly in the amount of total intake. Each of these groups had a total intake significantly higher than that of the control group (.01 level). Food deprived animals more slowly approach a stable level of total intake than water deprived animals. The water deprived animals increase their total intake for four days, and then show a rather sharp temporary drop in intake before returning to the level of the fourth day.

As in the case of one-hour weight change (Figure 2), inspection of Figure 7 reveals a large difference between the deprived groups' curves for the first 10 days, and a subsequent convergence of the curves to about the same level. An analysis of variance was done on total intake for Days 1-10. Differences among the three groups during this period were significant ($F = 36.17$, $df = 2, 16$, $P < .001$). Duncan's test for individual group comparisons showed significant differences between each deprived group and the control group ($P < .01$). However, the difference between the two deprived groups was not significant ($P > .05$).

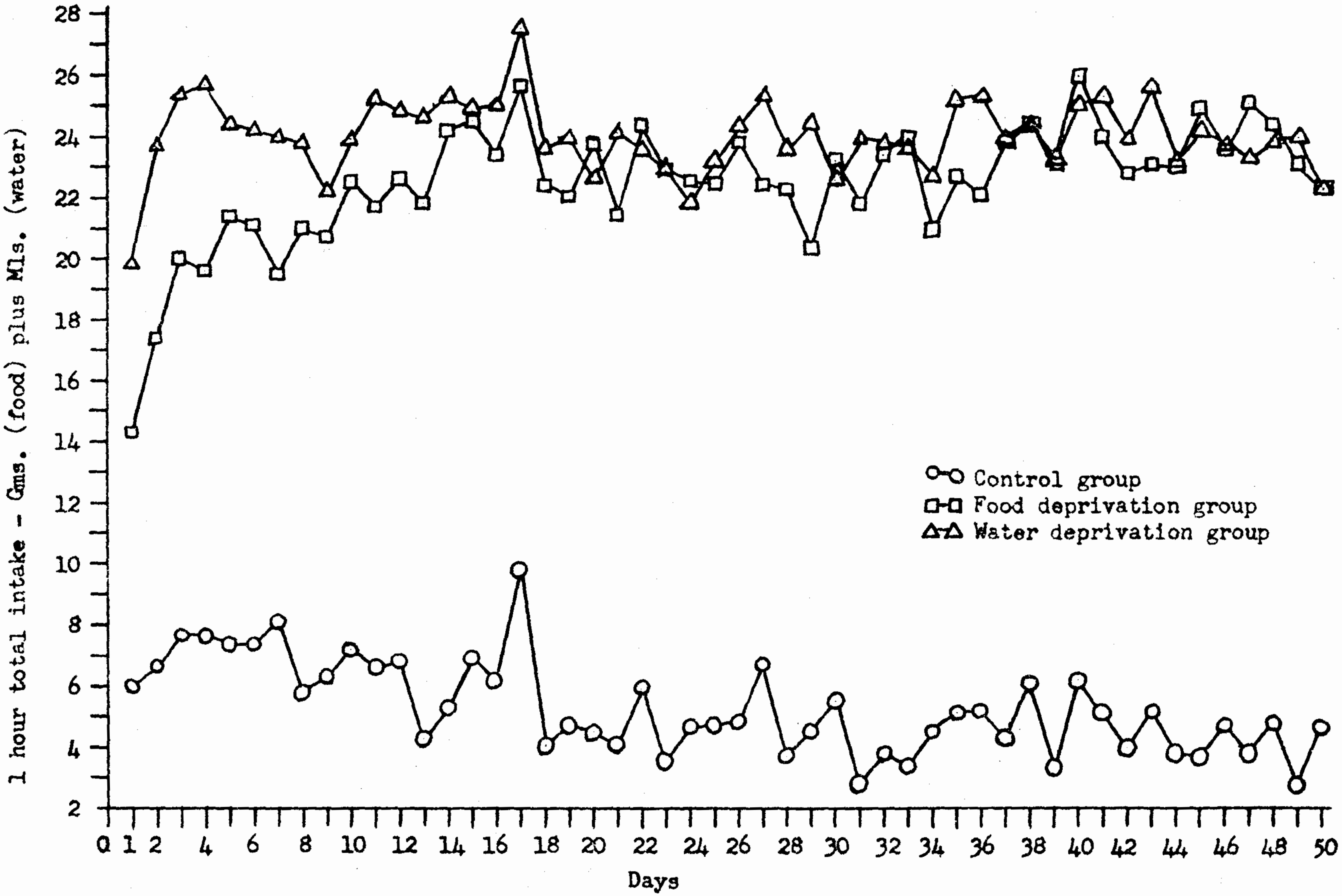

Fig. 7. Mean total intake during the 1 hour intake period as a function of days.

Table 16

Analysis of Variance of
One Hour Total Intake

Source	df	ss	ms	F	P
Treatments	2	1,946.04	973.02	55.29	<.001
Blocks	8	191.15	23.89		
Residual	16	281.63	17.60		
Total	26	2,418.82			

Table 17

Comparison of Individual Group
Means for One Hour Total Intake

Differences in Means

Treatment Means	Control (5.3)	Food dep. (22.5)	Water dep. (24.1)	Shortest Significant Range .01 level	.05 level
Control (5.3)		17.2	18.8	R_2 = 5.78	4.20
Food dep. (22.5)			1.6	R_3 = 6.03	4.40

Control Food dep. Water dep.

(.01)

(.05)

Discussion

The results will be discussed first with respect to a comparison of the effect of deprivation on weight and intake and then with respect to the information provided on the adjustment process.

The effects of type of deprivation on body weight are quite different. Although the groups were equated in weight before the experimental period began, both the mean preintake and mean post-intake body weights of the food deprived Ss were significantly lower for the 50 day period than the same body weight measures of the water deprived Ss. Moreover, the daily body weights of food deprived Ss continued to decrease throughout the experimental period, while the daily weights of water deprived animals quickly stabilized and subsequently increased slightly. Thus, the two types of deprivation produce strikingly different overall weight changes. To the extent that body weight is an index of drive, the weight curves lead one to suspect that a higher drive level is associated with the lower weight level approached by the food deprived animals. Other investigators have reached the same conclusion about the relative strengths of the drives produced by food and water deprivation (Finger and Reid, 1952; Hall, 1955).

A final point concerning body weight is that, while the effect of water deprivation on this measure was relatively mild compared to the effect of food deprivation, both preintake and postintake weight of water deprived animals were significantly below the corresponding control measure. Thus, although there is comparatively little drop in weight for these Ss, their weight is significantly below the ad lib. level.

Food deprived and water deprived animals showed similar weight changes during both the 23 hour deprivation periods and the one hour intake periods. For the one hour intake period, there were no significant differences in the amount of weight gained when the entire 50 day period was considered. However, when the analysis was confined to the first 10 days water deprived Ss did gain significantly more weight than food deprived Ss. The decreasing difference between the weight gain of the two groups during Days 1-10 is consistent with other studies which show extended weight changes for food deprived Ss, but relatively little change for water deprived Ss (Blick, 1960; Reid and Finger, 1955).

The amount of weight lost during the 23 hour deprivation periods was strikingly similar for the two groups; no statistically significant difference was found between food deprived and water deprived Ss.

It has already been noted that the daily body weights of the two deprivation groups showed opposing trends; water deprived Ss showed a slight weight gain in the later stage of the experiment and food deprived Ss consistently lost weight. Yet, considering the entire 50 day period, food deprived and water deprived Ss do not differ significantly in either daily weight gain or loss. A tentative explanation of this seemingly paradoxical result may be offered in terms of intersubject variability. On both of the weight change measures, there was considerable intersubject variability within treatment groups, particularly for the food deprived group. However, net weight change per day, which directly determines the body weight curves in Figure 1, showed much less intersubject variability within treatment groups. Typically, animals losing a large amount of weight during the deprivation period also gained back a large amount during the intake period, and the same was true for animals showing small gains and losses in weight. Thus, the difference between gain and loss, which is the net weight change measure, does not directly reflect the variability found for gain and loss separately. Food deprived animals did show a daily net weight loss, significantly different from the net gain of the water deprived animals. Thus, the different body weight curves in Figure 1 would be expected.

Each deprived group showed greater intake of the substance of which it had been deprived than the other two groups; thus, food deprived Ss ate significantly more food than water deprived Ss and controls, and water deprived Ss drank significantly more water than food deprived Ss and controls. With regard to intake of the non-deprived substance, water deprived Ss ate more food during the intake hour than control Ss and food deprived Ss drank more water during the intake hour than the controls. This latter finding suggests that, during the 23 hour deprivation period, the animals were voluntarily reducing their intake of the available substance and compensating for this reduction during the intake hour when the deprived substance was available. Such a voluntary restriction of intake of available substance has been noted, when either food or water are withheld, by Verplank and Hayes (1953).

Perhaps the most interesting finding from the intake measures is that food deprived and water deprived Ss did not differ significantly in their total intake during the one-hour daily periods. Although each deprived group was different from the other deprived group in intake of each substance separately, total intake of the two groups was comparable. This finding suggests that there is some limiting factor on intake, such as stomach capacity, the operation of which is more or less independent of the kind of substance ingested.

Turning to the question of adjustment to the two deprivation schedules differences are again noted. The important data here are the lengths of time required for weight and intake to decrease and increase respectively before reaching values beyond which consistent changes no longer occur; these data are the commonly accepted criteria of adjustment (Reid and Finger, 1955).

Preintake and postintake body weights of the water deprived group showed no further systematic decrease beyond 8-9 days. Little further decrease was noted after the second day on the schedule. The pattern of weight changes is very similar in all respects to those noted by Blick (1960). The weight gain during the intake period measure increased for 4 days for the water deprived Ss, a finding also reported by Young, Heyer, and Richey (1952). While 23-hour weight loss appears to reach stable values in 5-6 days for both deprivation groups, net weight change for water deprived Ss increases for three days, while for food deprived Ss, it increases steadily for approximately 8 days.

Water intake increases for only three days for the water deprived group. Food intake and total intake showed no consistent tendency to increase after Day 4.

With regard to the adjustment of the food deprived group, preintake and postintake body weights declined as a negatively accelerated function of days for the entire 50 days. The biggest drop in weight occurs during the first 20-25 days. Similar continuous weight losses, for less extended durations, have been noted by Reid and Finger (1955, 1957); Finger, Reid, and Weasner (1957); Kaplan _et al_, (1959); and Raymond, Carlton, and McAllister (1955). Weight gain during the intake period increased for about 15 days for the food deprived Ss.

Food intake of the food deprived Ss increased for approximately 14 days. Similar changes in intake have been reported by others (Reid and Finger, 1955; Lawrence and Mason, 1955; Baker, 1955). Water intake showed an irregular trend upward, reaching the average level for the last half of the experiment on Day 14. Total intake for this group increased irregularly for 14 days.

The general adjustment picture emerging from this analysis is that food deprived Ss require considerably longer than water deprived Ss to complete their adjustment to the deprivation schedule. This is particularly evident in the measures of body weight, weight gain, and intake of the deprived substance, the measures most frequently used in other studies to trace the adjustment process. Blick (1960) has suggested that methodological complications arising from prolonged changes in weight and intake characteristic of a 23-hour food deprivation schedule could be reduced in learning studies by the use of a 23-hour water deprivation schedule as the motivating condition. The results of the present study, directly comparing the adjustment of animals exposed to the two schedules, support this position.

The most impressive and, according to the authors, the first experimental demonstration of the importance of allowing adjustment to occur before undertaking a learning experiment has recently been reported by Capaldi and Robinson (1960). These investigators have shown that learning varies with the duration of time the Ss have been on a food deprivation schedule. In one experiment, runway performance was studied as a function of varying lengths of time on a 23½-hour food deprivation schedule. Ss which had been on the schedule for 10 days ran faster in the runway situation than Ss exposed to the schedule for only one day. In a second experiment, performance in a T maze as a function of the number of days on a 23½-hour food deprivation schedule was studied. A group which had been on the deprivation schedule for 10 days made significantly fewer errors than groups on the schedule for only 3 or 5 days.

It is clear from the Capaldi and Robinson study that time on the deprivation schedule is an important variable in experiments using deprivation of appetitive substances to control Ss motivation. Experiments in which the independent variable is introduced at the time the animals are started on the learning task run the risk of having the effects of this variable contaminated by potential effects of the stage of adjustment to the deprivation schedule. While the Capaldi and Robinson results have not been demonstrated for water deprivation, there is no reason to expect that degree of adjustment to this kind of deprivation would not produce similar effects. In experiments, then, where the choice of type of deprivation schedule is not dictated by the stereotypy or variability of behavior associated with weight gain from water deprivation or weight loss from food deprivation (Petrinovich and Bolles, 1954; Bolles and Petrinovich, 1956), it would seem that water deprivation recommends itself by permitting the investigator to bring the animals' motivational condition more rapidly, and possibly more completely, under control.

Summary

This experiment compared the weight and intake changes occurring when albino rats are placed on a 23-hour food deprivation schedule and on a 23-hour water deprivation schedule. The length of time required for the animals to adjust to the schedules and the relative effects of the two schedules on several weight and intake measures were compared. The experiment employed three groups of animals: a control group, a 23-hour food deprivation group, and a 23-hour water deprivation group. Measures were taken of body weight, weight loss and gain, and food and water intake over a period of 50 days.

The main findings were:

1. There was no significant difference between food deprived and water deprived animals in either the amount of weight lost during the 23-hour deprivation periods or the amount of weight gained during the daily one hour intake periods when the entire 50 day period was considered. Food deprived animals showed a daily net weight loss significantly different from the net weight gain of the water deprived animals. The preintake and postintake body weights of the deprived groups were below the corresponding control measures. The body weights of the food deprived group were lower than the weights of the water deprived group. The daily weights of the food deprived group continued to decrease throughout the experimental period, whereas the daily weights of the water deprived group quickly stabilized and subsequently increased slightly.

2. Food deprived and water deprived animals did not differ significantly in their total intake during one-hour intake periods. Each deprived group showed greater intake of the substance of which it had been deprived than the other two groups. Also, food deprived Ss drank more water during the intake hour than control Ss and water deprived Ss ate more food than control Ss, suggesting that a voluntary reduction of intake of the available substance occurred during the 23-hour deprivation interval.

3. Weight loss during the 23-hour deprivation periods remained at approximately the same level for both deprivation groups. Weight gain per intake period increased for four days for the water deprived group, and continued to increase for about 15 days for the food deprived group.

4. Food intake, water intake, and total intake reached a stable level by the fourth day for the water deprived group. These measures continued to increase for the first 14 days for the food deprived animals.

Considering the more rapid adjustment of the animals to the water deprivation schedule, this method of controlling the animals' motivational condition was seen as avoiding methodological complications arising from prolonged changes in weight and intake characteristic of the 23-hour food deprivation schedule.

Appendix A

Table 18

Mean Habituation Body Weight

		Treatments			
		Control	Food dep.	Water dep.	Mean
Blocks	1	624.6	669.1	661.3	651.7
	2	617.8	620.5	624.1	620.8
	3	607.7	608.3	595.8	603.9
	4	588.4	583.4	579.1	583.6
	5	575.8	552.6	576.4	568.3
	6	542.5	543.8	547.7	544.7
	7	532.6	527.7	529.6	530.0
	8	527.1	517.3	518.6	521.0
	9	509.9	507.1	507.0	508.0
Means		569.6	570.0	571.1	

Table 19

Mean Preintake Body Weight (50 day period)

		Treatments			
		Control	Food dep.	Water dep.	Mean
Blocks	1	668.8	579.7	646.1	631.5
	2	674.3	508.4	608.1	596.9
	3	669.4	469.4	592.6	577.1
	4	642.0	481.1	556.3	559.8
	5	611.3	475.2	550.6	545.7
	6	573.7	458.1	534.1	522.0
	7	585.4	457.0	504.8	515.7
	8	536.8	400.9	510.8	482.8
	9	539.1	400.1	487.9	475.7
Means		611.2	470.0	554.6	

Table 20

Mean Postintake Body Weight (50 day period)

		Treatments			
		Control	Food dep.	Water dep.	Mean
	1	670.0	606.3	669.7	648.7
	2	676.9	525.2	632.0	611.4
	3	672.2	483.7	614.0	590.0
Blocks	4	642.1	500.0	576.8	573.0
	5	611.8	501.0	571.1	561.3
	6	572.7	478.5	554.1	535.1
	7	590.7	477.9	521.5	530.0
	8	535.1	416.2	526.6	492.6
	9	540.3	410.1	507.7	486.0
Means		612.4	488.8	574.8	

Table 21

Mean One Hour (Intake Period) Weight Change (50 day period)

		Treatments			
		Control	Food dep.	Water dep.	Mean
Blocks	1	- 0.9	+ 26.6	+ 23.6	+ 16.4
	2	+ 2.6	+ 16.8	+ 24.0	+ 14.5
	3	+ 2.8	+ 14.4	+ 21.5	+ 12.9
	4	+ 0.1	+ 19.0	+ 20.5	+ 13.2
	5	+ 0.4	+ 25.8	+ 20.5	+ 15.6
	6	- 1.1	+ 20.4	+ 20.0	+ 13.1
	7	+ 5.3	+ 20.9	+ 18.2	+ 14.8
	8	- 1.8	+ 15.3	+ 15.8	+ 9.8
	9	+ 1.1	+ 10.0	+ 19.6	+ 10.2
Means		+ 0.9	+ 18.8	+ 20.4	

Table 22

Mean One Hour (Intake Period) Weight Change (First 10 days)

		Treatments			
		Control	Food dep.	Water dep.	Mean
Blocks	1	+ 0.4	+ 26.8	+ 23.0	+ 16.7
	2	+ 3.3	+ 10.5	+ 23.9	+ 12.6
	3	+ 2.3	+ 12.7	+ 21.1	+ 12.0
	4	+ 0.2	+ 14.2	+ 19.2	+ 11.2
	5	+ 0.1	+ 18.6	+ 18.5	+ 12.4
	6	+ 0.6	+ 15.7	+ 19.4	+ 10.9
	7	+ 6.6	+ 15.7	+ 15.0	+ 12.4
	8	- 2.4	+ 13.8	+ 16.9	+ 9.4
	9	+ 2.3	+ 9.4	+ 17.4	+ 9.7
Means		+ 1.5	+ 15.3	+ 19.4	

Table 23

Mean 23 Hour (Deprivation Period) Weight Change (50 day period)

		Treatments			
		Control	Food dep.	Water dep.	Mean
Blocks	1	+ 2.5	- 28.5	- 23.1	- 16.4
	2	- 0.8	- 19.7	- 23.5	- 14.7
	3	- 0.5	- 18.2	- 21.0	- 13.2
	4	+ 1.9	- 21.2	- 20.3	- 13.2
	5	+ 0.8	- 27.1	- 20.4	- 15.6
	6	+ 2.1	- 21.5	- 20.0	- 13.1
	7	- 3.6	- 22.3	- 17.9	- 14.6
	8	+ 2.7	- 18.5	- 15.4	- 10.4
	9	- 0.5	- 13.2	- 19.7	- 11.1
Means		+ 4.6	- 21.1	- 20.1	

Table 24

Mean Net Weight Change During Each 24 Hour Period (50 day period)

		Treatments			
		Control	Food dep.	Water dep.	Mean
Blocks	1	+ 1.6	- 2.0	+ 0.5	+ 0.0
	2	+ 1.7	- 2.9	+ 0.4	- 0.3
	3	+ 2.2	- 3.8	+ 0.5	- 0.4
	4	+ 2.0	- 2.2	+ 0.2	0.0
	5	+ 1.3	- 1.3	+ 0.1	0.0
	6	+ 1.0	- 1.2	0.0	- 0.1
	7	+ 1.7	- 1.4	+ 0.3	+ 0.2
	8	+ 0.9	- 3.2	+ 0.4	- 0.6
	9	+ 0.6	- 3.2	- 0.1	- 0.9
Means		+ 1.4	- 2.4	+ 0.3	

Appendix B

Table 25

Mean One Hour Food Intake (50 day period)

		Treatments			
		Control	Food dep.	Water dep.	Mean
Blocks	1	1.4	16.8	6.1	8.1
	2	4.2	11.0	5.2	6.8
	3	4.0	10.1	5.0	6.4
	4	1.4	11.3	5.1	5.9
	5	2.7	15.1	5.5	7.8
	6	1.3	12.9	3.4	5.9
	7	5.1	13.4	4.2	7.6
	8	0.6	9.5	4.5	4.9
	9	1.7	7.7	5.1	4.8
Means		2.5	12.0	4.9	

Table 26

Mean One Hour Water Intake (50 day period)

		Treatments			
		Control	Food dep.	Water dep.	Mean
Blocks	1	1.3	14.9	22.7	13.0
	2	4.3	9.4	23.8	12.5
	3	5.2	7.7	21.4	11.4
	4	2.4	11.0	18.3	10.6
	5	2.0	14.9	18.7	11.9
	6	1.5	11.9	19.0	10.8
	7	4.6	11.7	17.5	11.3
	8	1.2	9.2	13.7	8.0
	9	3.2	4.4	17.4	8.3
Means		2.9	10.6	19.2	

Table 27

Mean One Hour Total Intake (50 day period)

		Treatments			
		Control	Food dep.	Water dep.	Mean
	1	2.7	31.7	28.8	21.1
	2	8.5	20.4	29.0	19.3
	3	9.2	17.8	26.4	17.8
Blocks	4	3.8	22.3	23.4	16.5
	5	4.7	30.0	24.2	19.6
	6	2.8	24.8	22.4	16.7
	7	9.7	25.1	21.7	18.8
	8	1.8	18.7	18.2	12.9
	9	4.9	12.1	22.5	13.2
Means		5.3	22.5	24.1	

Table 28

Mean One Hour Total Intake (First 10 days)

		Treatments			
		Control	Food dep.	Water dep.	Mean
Blocks	1	5.3	32.6	30.2	22.7
	2	9.5	14.5	28.6	17.5
	3	9.2	17.8	27.4	18.1
	4	5.7	18.5	22.7	15.6
	5	5.1	23.5	22.9	17.2
	6	5.2	20.3	22.3	15.9
	7	13.2	20.3	18.7	17.4
	8	2.1	18.5	19.5	13.4
	9	8.0	12.7	21.2	14.0
Means		7.0	19.9	23.7	

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