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The Effects of Deprivation Techniques on Body Weight & Propensity to Perform an Operant

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THE EFFECTS OF DEPRIVATION TECHNIQUES ON BODY WEIGHT AND PROPENSITY TO PERFORM AN OPERANT

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Table of Contents

List of Illustrations

THE EFFECTS OF DEPRIVATION TECHNIQUES ON
BODY WEIGHT AND PROPENSITY TO PERFORM AN OPERANT

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Eighteen rats were divided into equal groups which received three different food deprivation procedures: 23 hour deprivation, maintenance at 80% of pre-experimental weights, or fixed daily food allotments of 10 grams. The rats were then given two training sessions with an unearned food source and 15 training sessions earning an identical food source by pressing a lever. Training was followed by three days of choice testing. There were no significant differences between groups in preference for earned rewards during choice testing in degrees of weight loss. However, a correlation comparing propensity to work for pellets with body weight deficit over the last eight training days was significant ($p < .05$). Group correlations of weight loss with propensity to barpress resulted in significance only for the fixed intake animals ($p < .05$). The significant relationship between weight loss and operant performance is consistent with the earlier findings of Bolles (1965). The timed deprivation group had the greatest range in level of weight deficit and the percentage body weight group had the least. These findings indicate that maintaining animals at

a designated percentage of their normal body weight produces less within group variance in the level of weight deficit than the more popular method of timed deprivation.

Chapter 1

Review of the Literature

It has generally been accepted that organisms will choose the method which requires the least effort to reach a desired end (Hull, 1943). Recent findings have provided evidence that animals and children under certain conditions prefer performing an operant task for a reinforcer rather than obtaining identical rewards freely (Jensen, 1963; Neuringer, 1969; Singh, 1970). This phenomenon has been termed the Protestant Ethic Effect (PEE) (Singh, 1972; Stephens, Metze, & Craig, 1975).

Studies Supporting the Existence of the PEE

One of the first to demonstrate the PEE was Jensen (1963). Animals were deprived by limiting daily food intake to a fixed amount (FI) of 10 grams. Following each training or testing session rats were given an amount of food equal to the difference between 10 grams and session consumption. The animals were trained to barpress and given 40, 80, 160, or 1280 rewarded presses on a continuous reinforcement schedule (CRF). When training was completed the rats were placed in a choice situation where they might barpress for pellets or obtain an identical reward freely from a dish. When given a choice a direct relationship was found between

barpress experience and amount of food earned. Jensen suggested "intrinsic appeal" for barpressing as an explanation of this phenomenon.

A later study investigating the PEE was conducted by Neuringer (1969). Food deprived pigeons and rats were taught to perform an operant for a food reward. Following seven days of training the animals were given fifteen sessions in which they might earn the food reward or consume an identical reward from a free cup. Both species preferred to consume more earned rewards. Neuringer then blocked the animal's access to the earned rewards without altering the opportunity to perform the operant. In both species responding dropped. When the operant again produced access to a reward, responding increased. Neuringer's study indicates that the consequences of an instrumental response are an important determining factor in whether the PEE is observed.

Singh (1970) placed rats on 23 hour timed deprivation (TD) and then trained them to work on fixed ratio (FR) schedules of FR1, FR3, or FR11. On alternating days he placed the animals in a no work chamber separated from the work chamber by a removeable barrier. In the no work chamber rats were exposed to free pellets delivered individually at a rate equal to the rate of their prior day's barpressing. When the barrier between the chambers was removed to give the rats a choice, all groups preferred

earned rewards with the FR1 group earning significantly more than the other groups. Singh then made the free-loading more attractive by providing the free food at rates of 12.5, 25, or 50% faster than the rats had previously barpressed. All groups except the 50% group consumed significantly more earned rewards. Singh suggested that preference for barpressing may be related to White's (1959) competency theory that animals possess an intrinsic motivation to actively control their environment.

Studies Supporting the Influence of Deprivation on the PEE

A variable which has been given little attention in the PEE literature is the effect of differences in deprivation procedures. Tarte and Snyder (1972) have provided evidence that preference for earning rewards rather than obtaining them freely is influenced by variation of deprivation. Following training, rats were deprived for 0, 12, 24, 36, 48, 72, or 92 continuous hours prior to choice testing. When given a choice between earning or freeloading for identical rewards, a systematic increase in preference for earned rewards resulted as length of deprivation increased.

Carder and Berkowitz (1970) also used TD when examining the relation of increased work demands with preference for earned rewards. Animals were allowed access to food only during a one hour experimental session with 23 hours of deprivation being maintained between sessions. Rats were

trained to press a bar on a CRF schedule followed by training on a FR2 and then FR10 schedule. When given a choice between earning rewards or freeloading while on a CRF schedule, all rats preferred earned rewards. Preference for working was maintained by 83% of the animals at FR2. An increase in work demands to FR10 resulted in a strong preference for free pellets by all animals. Finally, when a CRF schedule was reintroduced, all rats again displayed a clear propensity for pressing. MacDonald (1970) criticized Carder and Berkowitz's study on the basis of confounding of food deprivation with work demands. Rats had to meet all of their daily food needs within an hour experimental session. MacDonald concluded that at FR10 the rats may have been "hungrier" because they could not earn as much in the same time period and, therefore, they would be more eager to eat free pellets.

A replication of Carder and Berkowitz's study was conducted by Davidson (1971) who initially employed a deprivation procedure different from that of Carder and Berkowitz. Rats were maintained at 80% of their initial body weight (PW) and trained to press a lever in a choice situation with work demands set at FR10. Following training the animals were placed in a choice situation. A preference for earned rewards was displayed with almost all free consumption occurring during "time out" periods when a discrimination cue signalled that the lever was inoperative.

After the initial testing session the animal's access to food was limited to one hour daily test session with 23 hour deprivation being otherwise maintained. Preference for earned rewards remained stable through 87 successive sessions. If the rats were fed prior to choice testing, 75% maintained equally high or higher preference for earned rewards during choice testing. When given continuous access to food, 50% maintained equally high or higher preference for earned rewards during choice testing. Differences in initial deprivation methodology between Davidson's study and that of Carder and Berkowitz may have been an influential factor accounting for the discrepancies between the results of the two studies. Carder and Berkowitz, using timed deprivation, found that animals lost their preference for earned rewards at FR10 while in Davidson's study, which used percentage body weight, the animals preferred earned rewards at FR10.

Another study where different types of deprivation may have confounded the results was conducted by Knutson and Carlson (1973). They compared differences in the preference of rats for earned food or water when presented with a choice of earning rewards or obtaining them freely. Animals on food deprivation were maintained at PW 80% while the water deprived group was maintained on a 23 hour TD schedule. When placed in a choice situation, the water group displayed more responses during each session yet showed a decline in

the number of presses across sessions. The food group preferred freeloading throughout. Knutson and Carlson attributed differences between food and water groups to the greater consumption time required of food. They also acknowledged that differences in deprivation methodology may have been a confounding factor.

Such differences as those between Carder and Berkowitz (1970) and Davidson (1971) or differences within an experiment such as found by Knutson and Carlson (1973), may be influenced by variations in deprivation methodology. In light of the existing discrepancies in the PEE literature and the findings of Tarte and Snyder (1972) which indicate that deprivation factors might significantly influence PEE behavior, direct investigation assessing what, if any, affect deprivation methodology has on PEE choice behavior is warranted.

Studies on the Influence of Variations in Deprivation

In a study similar to that of Tarte and Snyder (1972) the effects of length of preceding deprivation time on rats' running wheel activity was examined by Duda and Bolles (1963). Rats were given running wheel access following 0, 24, 48, 72, or 96 hours of continuous deprivation. Half of the animals in each group had experienced 10 days of 23 hour TD immediately prior to the pre-test deprivation exposure. The exposure to the 10 days of prior deprivation resulted in various degrees of weight loss so that after

undergoing the additional pre-test deprivation, weight losses were more severe than the weight deficits of animals who were not deprived earlier. Running wheel activity level was predominantly a function of weight loss, independent of how the weight was lost. Animals at equal percentage body weights performed similarly in the activity wheel with no relation to differences in the rate of weight loss. Duda and Bolles concluded that weight loss is the crucial factor in determining an animal's activity level with speed of loss or length of deprivation being relatively unimportant.

Further research investigating the importance of weight loss was conducted by Bolles (1965). He examined the effect of a-periodic TD on consummatory behavior. Deprivation periods of 7, 14, 21, 28, 35, and 42 hours were randomly presented twice to each rat in the study. The use of testing intervals which were multiples of seven resulted in each animal being tested at many stages of his diurnal cycle. The dependent measure was the amount of food consumed during one hour of free access to food. Food consumption gradually rose over test days and there was a corresponding continual drop in subjects' body weights. Bolles agreed with the earlier conclusions of Duda and Bolles that rats' consumption was more related to their overall deficit in body weight than to immediately preceding length of test deprivation.

In a second experiment, Bolles (1965) compared the effects of a-periodic versus regular deprivation intervals

on lever pressing. One group was randomly subjected to deprivation intervals which ranged from three to forty-seven hours with no interval lengths falling between twenty-one and twenty-eight hours. At the end of each session the animals were given a 60 minute test session. A second group was given 90 minute test sessions on a constant 23 hour TD schedule. Animals tended to consume more food when required to obtain it by lever pressing than when given free access, as in Bolles' prior experiment. The greater consumption resulted in body weights remaining stable throughout the study. Response rates across test days were equally stable in both the regular and a-periodic interval groups. Bolles concluded that his results were consistent with prior findings suggesting that length of deprivation interval was not a very important factor in determining a rat's consummatory behavior--at least in comparison with the importance of weight loss.

Since weight deficit has been implicated as an influential performance variable, comparison of different deprivation methodologies is warranted. In one such study, Moskowitz (1959) compared the effects of different methods of deprivation on body weight and activity level. Following 10 days adaptation to an activity wheel, rats were matched on the basis of body weights and measured activity level into three groups. Group one was maintained on a FI of 40% of the amount which they regularly consumed each day. Group

two was maintained on 23 hour TD. The third group was maintained at PW 80% of their predeprivation body weight. The FI 40% group continually had weight decrements throughout the 25 days of the experiment. The TD animals' weights dropped sharply before leveling off at about the tenth day. The PW group's weight quickly dropped to the designated level at which it remained throughout the experiment. There were no significant group differences on activity measures. Trends did indicate that the FI group's activity continued to increase relative to weight loss. The PW group had a slow steady rise in activity level until about the fifteenth day at which time it leveled off. The TD group had the overall highest activity level. Moskowitz interpreted the data as indicating that body weight deficit was the most significant controlling factor. He conducted a second experiment to test the relation of body weight deficit to activity level. Body weights were gradually reduced from 100% to 60% of the rat's estimated normal weight. Normal weight was estimated by matching rats given continuous access to food to the experimental rats by age and pre-experimental weight. The activity curve rose as the weight curve decreased ($r = -.99$). It was also found that weight loss did not become a significant factor until reaching a deficit level of 85% to 90% normal weight.

Another study comparing three methods of deprivation and using barpressing as the dependent variable was conducted

by Davenport and Goulet (1964). Deprivation procedures were TD 23.5 hours, PW 80% pre-experimental weight, and PW 80% adjusted to rats matched by age and weight who were given continuous access to food. Body weight was found to be highly correlated to barpress performance. Subjects at PW 80% normal had response curves taking the form of a flat gradient over time. The weights of rats maintained at a constant fraction of their initial weight were continually losing weight as compared to the controls and displayed a corresponding rise in operant responding. Davenport and Goulet confirmed the importance of body weight and further concluded that researchers must make allowance for normal growth or misinterpretation might occur.

The results of studies such as Moskowitz (1959), Bolles (1965), and Davenport and Goulet (1964) led Weinstock (1972) to conclude that different feeding procedures are not equivalent and that weight loss is probably the most crucial factor in determining subsequent behavior. In view of the findings of deprivation studies the wide variation of deprivation methods found in the PEE literature limits comparisons across studies until research directly examines deprivation in relation to the PEE.

Chapter 2

Statement of the Problem

Review of the PEE literature reveals contradictory findings which may partially be explicable by the variation of deprivation procedures employed. The available evidence indicates that variations in deprivation methodology result in performance differences on subsequent measures (Moskowitz, 1959; Davenport & Goulet, 1964). These performance differences appear related to variant body weight deficits. It was predicted that the different deprivation procedures of timed deprivation, percentage body weight, and fixed intake would produce different degrees of weight loss. It was also expected that groups with the greater weight deficits would display a greater preference for earned rewards in the presence of identical free rewards.

Chapter 3

Method

Subjects

Subjects were 18 male experimentally naive Max hooded rats from the Western Kentucky University animal colony. Age at the onset of the study was approximately 110 days.

Equipment

The apparati were three Skinner boxes with plexiglass sides. At one end of the box was a lever activating a Noyes pellet dispenser which was connected to a delivery tray. An identical tray containing nine grams of free pellets was placed at the opposite end of the box. Quantity of pellets consumed was measured at the end of each session. During bar training sessions the free food tray was empty, and during free food training sessions the lever was removed. A continuous reinforcement schedule was used. Rats were weighed with a beam balance scale each day prior to being placed in the box. The same scale was used for weighing food.

Experimental Groups

Three experimental groups of six rats each were placed on different deprivation schedules. Subject order and box assignment were determined by Latin Squares. Group one was

placed on a 23 hour deprivation schedule, with an hour food access being permitted following the 15 minute training or testing session. A second group was maintained on approximately 10 grams of food daily by giving an unlimited amount of time to consume an amount of food equal to the difference between 10 grams and session consumption. The third experimental group was maintained at 80% of their initial body weight by regulating food intake on the basis of their pre-session weight. Allotted daily consumption was estimated so that the following day's pre-session weight would approximate 80% of the animals pre-experimental weight. Animals in all conditions were weighed daily prior to training or testing.

Procedure

Following seven days maintenance on their respective deprivation schedule the rats were taught to barpress by being placed for four continuous hours in the Skinner box in which they were to be tested. Since the number of rats that might be shaped per day was limited by the number of Skinner boxes used, the introduction of deprivation was staggered. This held constant the seven days of initial deprivation prior to any training.

On the three days following auto-shaping rats were exposed daily to 15 minute bar training sessions. During the next two days 15 minute free food training occurred. Twelve additional bar training sessions of 15 minutes each

followed before three days of choice testing. During choice testing the animals were presented with the opportunity to either consume the free food or consume pellets earned by barpressing.

Chapter 4

Results

The different deprivation procedures of TD, FI, and PW did not produce different degrees of weight loss. A one way analysis of variance conducted to compare weight changes in the three groups from initial weight to the weight on the last training day was not significant, $F(2,15) = .54$, $p > .05$. A one way analysis of variance conducted from the first to last training days, $F(2,15) = 2.22$, $p > .05$, and from the eighth to last training days, $F(2,15) = 1.88$, $p > .05$, were also not significant despite trends in the expected direction (see Figure 1). The PW and TD groups maintained relatively stable body weights across training days while the FI animals were continually, but not significantly, losing weight.

Support for the second hypothesis was also not found. Table 1 indicates that no group differences existed in the preference for earned rewards in the presence of identical free rewards. Correlations were conducted to determine if preference for earned rewards during choice testing was related to body weight deficits and are presented in Table 2. All correlations were not significant ($p > .05$).

Mean Percentage Body Weight Across Training Days for Timed Deprivation, Fixed Intake, and Percentage Weight Deprivation Groups

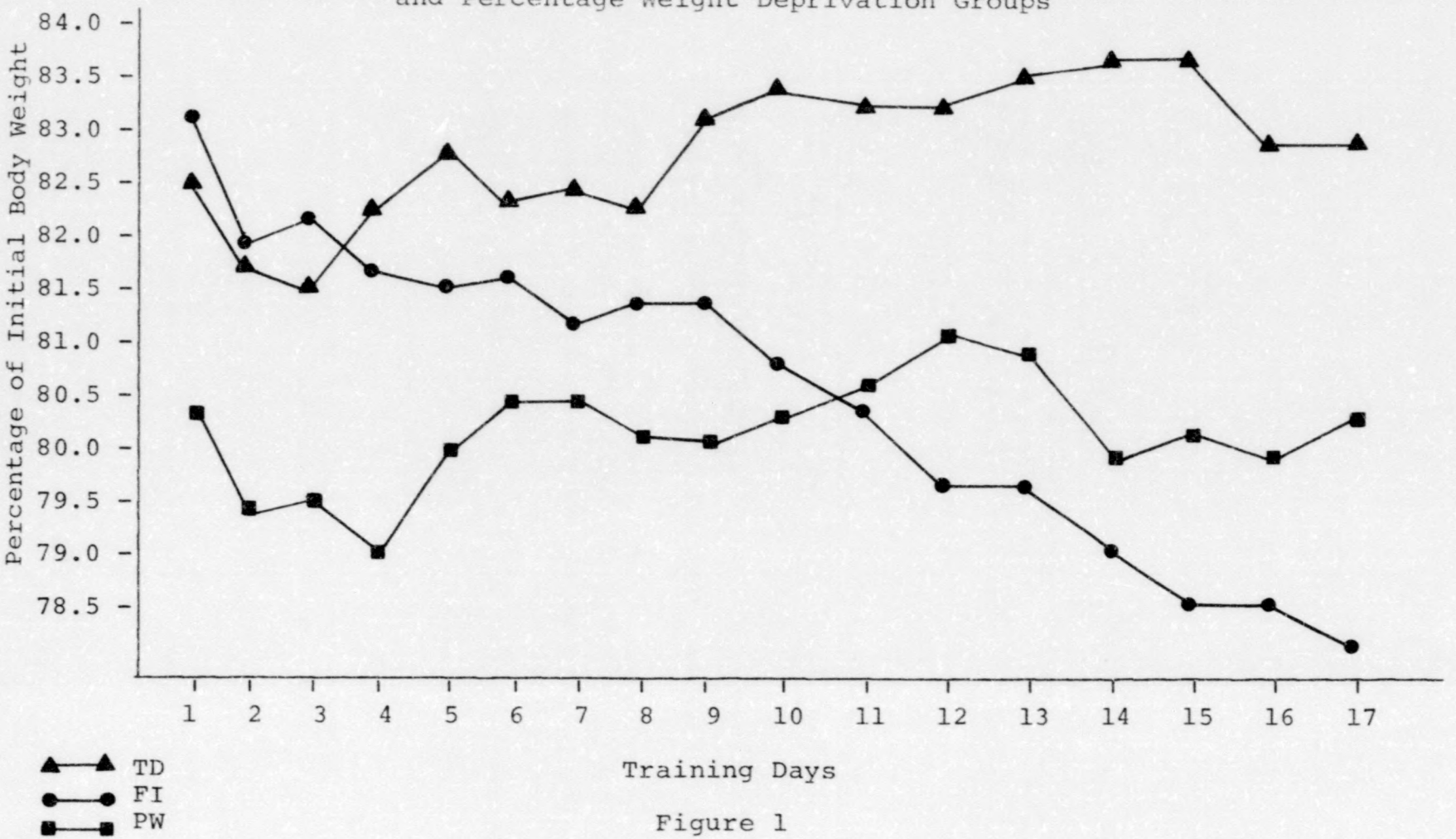

Figure 1

Table 1

Frequency Count of Preference for Earned or Freeloaded Rewards for Timed Deprivation (TD), Fixed Intake (FI), and Percentage Weight (PW) Deprivation Groups

Preference	Deprivation Group		
	TD	FI	PW
Earned	1	1	1
Freeloaded	5	5	5

Table 2

Correlations of Body Weight to Barpressing during Last 8 Training Days and during Choice Testing for Timed Deprivation (TD), Fixed Intake (FI), Percentage Weight (PW), and All Subjects

Group	Training Days	Choice Testing
TD	.44	.63
FI	-.91*	.13
PW	-.77	.07
All	-.75**	.34

*Significant at the .05 level for an N of 6

**Significant at the .05 level for an N of 18

Correlations were also computed between body weight deficit and propensity to barpress during the last eight training days and are reported in Table 2. Only the last eight training days were used because the first week tended to be a habit strength acquisition phase during which all rats tended to increase barpressing. At the end of one training week barpress curves tended to become more level for the PW and TD groups, who had the more stable weight levels. Of the group correlations a significant relationship ($p < .05$) between weight loss and barpressing was found only for the FI animals. When correlations were computed using all 18 animals a significant relationship was found ($p < .05$).

Finally, during testing days major differences were observed in the range of percentage body weights. The TD group displayed the greatest variance as it had a range of 26 percentage points. The FI group's weight deficit ranged across eight percentage points. And as expected, the PW group's relative weight deficit ranged across only three percentage points.

Chapter 5

Discussion

The lack of significant differences between groups indicates that method of deprivation is not an important factor in determining weight loss. The differences in weight deficit trends occurring between groups appears to be the result of differences in total daily consumption rather than deprivation methodology. Specifically, the FI group's daily consumption was less than that of the other groups. Had the amount eaten daily been closer to consumption of the other animals the trends probably would not have occurred.

Similarly, deprivation methodology does not appear to be a significant factor influencing a rat's preference for earned rewards over identical free rewards. However, since the majority of animals preferred freeloading the hypothesis may not have been accurately tested. Also, had there not been great individual variance of preference for earned rewards within groups, tests of significance may have been more sensitive. A replication examining the relationship of relative weight deficit to preference for earnings should prove beneficial in answering this question. The relationship of weight loss to choice of earned rewards might be

studied with the method used by Moskowitz (1959) in which animal's weight was gradually reduced from 100% to 60%.

Group correlations of body weight to barpressing were significant for only the FI animals. They were the only animals with continued increases in barpress rate after the initial training week. They were also the only group with continued weight loss across training days. The findings of a significant relationship for only those animals who both continued to lose weight and increase performance rate supports the conclusions of Bolles (1965) that weight deficit is the most crucial factor in determing operant performance.

When weight loss was correlated with propensity to barpress during training for all animals with no group differentiation, a significant relationship consistent with earlier findings for barpressing (Bolles, 1965; Davenport & Goulet, 1964), activity wheel performance (Duda & Bolles, 1963; Moskowitz, 1959), and consummatory behavior (Bolles, 1965) was found. Since weight loss has proved to be an important factor in determining such a wide variety of behaviors and considering the results of Tarte and Snyder (1972) which implicate weight loss as relevant to PEE behavior, further research is necessary before ruling out weight deficit as an influential factor on the PEE phenomenon.

The final finding was the existence of large between group differences in the range of percentage body weight deficit. Evidence indicates that body weight loss may be

the most important factor in determining activity level or operant performance (Bolles, 1965; Davenport & Goulet, 1964; Duda & Bolles, 1963; Moskowitz, 1959). Greater within group variance on important variables should result in greater within group variance on dependent performance measures. This lends support to Moskowitz's conclusions that conclusions that PW deprivation methods produce a more stable level of performance, and recommends PW as the preferred technique with research where deprivation is supposedly a constant factor for all individual subjects.

It is perplexing that the Max hooded rats used in the current study preferred to freeload. A study by Hanel (1975) found that Max hooded rats tended to prefer earned rewards. Therefore, a replication of the present study is recommended. Future research might also examine the effects of several levels of pre-determined weights on choice behavior to determine if weight deficits are an important factor, and if so to discover that level most enhancing to PEE earnings. An extension of the present study examining the effects of different water deprivation methods on choice performance to investigate possible similar trends with water as a reinforcer is also suggested.

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