LAKEHEAD UNIVERSITY

QUALITATIVE DIFFERENCES IN THE EFFECTS OF

FOOD AND WATER ON LEARNED BEHAVIOR

by

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A THESIS

SUBMITTED TO THE FACULTY OF ARTS

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF ARTS

DEPARTMENT OF PSYCHOLOGY

THUNDER BAY, ONTARIO
CANADA

WINTER, 1973

ACKNOWLEDGEMENTS

I would like to sincerely thank my head supervisor, Dr. Steve R. Goldstein, for his consistent help and encouragement throughout the preparation of this thesis. His insightful and constructive comments were truly invaluable and greatly appreciated.

Furthermore, I am indebted to Dr. J. Jamieson for his helpful contributions towards the refinement of all comments within.

ABSTRACT

Experimental interest for the present research stemmed from the traditionally accepted notion that qualitatively different reinforcers, such as food and water, have similar effects on learning. The present investigation examined the rat's ability to learn an alternation and a position habit for food or water reward by using an incentive-oriented approach. It was found that food rewarded animals were superior to the water rewarded on the alternation habit but inferior on the position habit. This finding replicates an earlier result by Petrinovich and Bolles (1954) and, since only a moderate level of water and food deprivation was used in which all animals continued to gain weight throughout the experiment, Bolles and Petrinovich's (1956) later interpretation of their earlier study is questioned. The present results support the above authors' original hypothesis that food deprivation is conducive to alternation behavior and water deprivation is conducive to stereotyped behavior, and do not support their later position that alternation behavior is simply elicited by body-weight loss. The present results suggest that a strong relationship exists between food and water seeking behavior and the motivational states aroused by their respective reinforcers.

A third experiment was conducted in which it was found that animals rewarded in both arms of a T-maze with food showed more alternation than animals finding water in both arms. This finding

further supports a basic difference in the kind of behavior elicited by food and water reinforcement.

The behavioral differences between hungry and thirsty animals were discussed from the viewpoint that these responses were a manifestation of behavior patterns resulting from the evolutionary process of natural selection. These differences were also discussed in terms of Oatley's suggestion that an appropriate behavioral response to any environment stems from the fact that the brain contains a model of the external world. Furthermore, the results were considered in view of the notion that the knowledge of a species' feeding habits and natural habitat could predict an animal's potential ability to respond in certain experimentally induced or natural situations.

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INTRODUCTION

Each species of animal has an internal structure, a unique functional inter-relationship with the environment, and a particular developmental history and, therefore, by virtue of its structure, function and history, each species is able to live in a given region of the world. An active selection by animals of those habitats and niches in which they can live most successfully can be observed on every hand. These habitats are extremely varied and the differences include the existing physical and chemical factors such as temperature, humidity, salinity, oxygen content and light availability. Equally important, these habitats also differ in biological factors such as potential food and water sources and their locations, predators and prey, and density of numbers of members of the same species. The measurable success of an animal in its niche within a particular habitat is determined by its overall adaptation to that niche and the relative number of offspring that it leaves as a result of the adaptation. This adaptation of an organism is expressed in a multitude of ways including a variety of reproductive, morphological, physiological and behavioral mechanisms necessary to cope with the environment.

While adaptation to the environment is by and large determined genetically and embryologically for lower organisms, it becomes

abundantly clear that for higher organisms evolution shifts its dependence to learning as the mechanism most capable of dealing with an increasingly variable and complex environment. Although it is relatively easy to see how learning is of immense selective advantage to man, it becomes difficult to understand the role and scope of this adaptive mechanism when viewed from within a deluge of fixed sequences of behavior so characteristic of lower organisms. To speculate more profitably about learning, one must know more about the nature of learning mechanisms and the laws that govern them. In an attempt to do this, early psychologists developed the S-R or behaviorist approach whereby learning was described as an association among stimuli and responses. Denying any reference to consciousness or mentalistic constructs, animal learning was thought to represent an acquired tendency to respond in a specific way when confronted with a particular stimulus situation. Out of behaviorism have grown three great schools of learning: Tolman's purposive behavior, Hull's behavior system and Skinner's descriptive behaviorism all of which have tried to construct a system of behavioral laws which will predict and explain exactly under what conditions learning will occur. Discussion of their respective merits will not be dealt with here at any length; accounts of these learning theories can be found in Munn's classic textbook on the rat (1950), in Broadbent (1961) and in Deese and Hulse (1967).

One criticized feature of S-R principles, however, is that they are quite indifferent to the type of behavior being considered. Due to this indifference, behaviorists have tended to direct their attention towards the general properties of learning as witnessed in the

experiments by Pavlov (1927) where dogs could be conditioned to salivate to _any_ of a wide variety of visual, auditory and tactile stimuli. Even today some authors conclude or imply that one can shape an animal's behavior in any fashion; such learning or performance being a direct function of simple theoretical manipulations. Teitelbaum (1966) asserts that "...in any operant situation, the stimulus, the response, and the reinforcement, are completely arbitrary and interchangeable. No one of them bears any biological built-in fixed connection to the others..." Hall (1966), Deese and Hulse (1967), and Kimble (1961), have endorsed a similar position sacrificing as it were, the possible limitations of the S-R approach for the integration of the many learning experiments which have been performed. Logan (1971), in his textbook on the fundamentals of learning and motivation, reasons that his utilization of S-R language is based on the fact that "...it is most likely to force the student to think objectively about behavior..." One might question whether the behavioral objectives of this attitude, from an educational standpoint, are valid. Should one aim at leaving the student of animal behavior with an objective attitude at the possible expense of a more precise approach?

Comparative learning studies further question the interchangeability and equality of various stimuli and responses. In view of the fact that animals differ so widely in their sensory capacities and their manipulative ability, the procedures needed to measure discriminative conditioning in a variety of animals, for example, have been found to be very different and no longer can one be sure that problems are of equal difficulty or that all animals perceive stimuli

in the same way. The counter-productive behavior of such unconventional laboratory animals as pigs and racoons (Breland and Breland, 1966) have already shown that generalizations derived by behaviorists from their studies of rats, and a few other vertebrates, may be limited in their applicability.

With the rise of ethologists such as Lorenz (1937, 1965) and Tinbergen (1951) attention towards behavior has been drawn to the limitations of animal learning and the questionable validity of existing learning paradigms. From emphasizing the adaptive significance of behavior and observing the varying stimulus, response and reinforcing elements prevalent in natural conditions, it soon became evident that learning abilities might be as species-specific as any characteristic of morphology or physiology. Although some experimental psychologists such as Thorndike (1931) did stress the notion that certain stimuli naturally go together and are therefore more easily learned than those which are merely juxtaposed without regard to their relationship to each other, only recently has such reasoning been heavily invoked. Authors such as Seligman (1970), Hinde (1970) and Rozin and Kalat (1971) have investigated or encouraged the investigation of learning as influenced by the nature of the stimulus, the response, and the reinforcer.

Although contemporary authors such as Hinde (1970) provide a comprehensive exploration of different grades of stimuli, responses and reinforcers involved in a variety of learning situations, the focus of attention of the literature presented here will be placed on qualitatively different reinforcers and their relationship to behavioral responses. More specifically, a comparison of the classic positive

reinforcers, food and water, and their relationship to motivational states and learning abilities in the rat will be reviewed. This review should expand the support of the following propositions: first, that the "equipotentiality premise" may be wrong, that the interchangeability and equality of food and water reward for the rat in various learning situations is questionable; second, that traditional deprivational schedules, where subjects are deprived of food or water and lose or maintain a subsistence weight, may in some instances produce a distorted perspective of animal learning in general; third, that the relationship between food and water reward and specific behavioral responses may be due to specific evolutionary selection pressures.

REINFORCERS AND BEHAVIORAL RESPONSES

Although a substantial amount of evidence has been gathered on behavioral effects due to quantitative differences of reinforcers, relatively little has been accumulated with differences due to quality. Such studies as those of Thompson (1964), Stevenson (1969) and Hogan (1967), however, do provide evidence for the latter as well as for Oatley's suggestion that different reinforcers probably tax different regulatory mechanisms (1970). As a single illustration, Hogan, in a comparison of the effects of reinforcing male Betta splendens with food or with the opportunity to display at a mirror, found that the fishes' initial rates of acquisition of alley-swimming were similar for food and display, but the asymptotic rate of swimming for display

was lower and more variable than the rate for food. Moreover, swimming for display was extinguished almost as soon as the reinforcement was withdrawn, whereas the food-reinforced swimming showed the gradual decline typical of extinction in other situations. However, various aspects of the fishes' behavior, such as the fact that they sometimes swam for display faster than they ever swam for food, suggest that display is not simply a weak reinforcer but rather that food and mirror display depend on different mechanisms for their effects. Food and display, therefore, may not be regarded as "equal" reinforcers just as a reward of sexual behavior for the rat may not be an equal substitute for food in the reinforcement of bar-pressing behavior. In effect, growing evidence suggests that reinforcers necessary for the maintenance of internal homeostasis cannot be arbitrarily interchanged with variables that have no relationship to internal survival value. Of more importance to the present study, however, is the appearance of existing differences between the traditional reinforcers of food and water.

A study by Bolles (1965), on the effects of deprivation conditions upon the home cage behavior of the rat indicates a difference between food and water. Subjects were observed in their home cages by sampling their behavior across time to determine how the pattern of behavior changes as a function of deprivation experience. Relative to satiated controls, he found that the hungry groups showed a marked increase in activity while thirsty subjects showed little change. Similar differences were obtained by Collier and Levitsky (1968). They trained adult male rats to run in a treadmill while

subjected to a series of food and water deprivations. Although they found that total log running time per session was a linear function of log percentage of body weight loss under both conditions, they noted that food deprivation produced more running per gram of body weight loss than water deprivation. Further support was obtained from the unexpected results of Levy and Seward (1969). Four groups of rats were deprived of both food and water and then trained in a double runway to anticipate either food in both goal boxes, water in both, or food in one and water in the other. On 50% of the test trials, the first goal box contained no reward. In addition to the typical frustration reaction caused by nonreward, the authors also predicted a larger frustration effect for groups expecting homogeneous reward. Unfortunately, testing of the prediction was vitiated by the unequal reward values of food and water. By comparing the position of the food variable across groups, it was found that only food produced an apparent frustration effect. It was concluded that food was a stronger incentive, that is, a more effective reinforcer.

In a closely related study, Mischey (1970) examined whether or not the partial reinforcement effect could be sustained through changed motivation. In phase I of this study, rats were trained in a running response under water deprivation. Subjects were then switched to food deprivation in phase II and randomly assigned to either 50% or 100% reinforcement groups. In phase III, motivation was changed back to thirst and both groups extinguished. Although these results confirmed the fact that frustrative effects do transfer from food to water, a second study was conducted to demonstrate

whether a transfer could also occur from water to food. Surprisingly, both the partial <u>and</u> the continuous groups exhibited a partial reinforcement effect. The results indicated a confounding of the frustration effect and the difference in incentive value of food and water.

Further examples of differences between water and food reinforcement can be found in experiments by Logan and Spanier (1970) and Macdonald and de Toledo (in preparation).* The latter reinforced hungry or thirsty rats with food or water respectively for bar-pressing on continuous reinforcement (CRF) or a variable interval one minute (VI I-minute) schedule and extinguished them when they had reached asymptotic performance. A comparison of the two food-reinforced groups revealed the usual partial reinforcement effect on the speed of extinction as well as the usual increase in rate at the beginning of extinction. However, although water reinforcement is commonly believed to be equivalent to food reinforcement, the water reinforced groups showed neither of these effects. Moreover, Logan and Spanier (1970) trained hungry or thirsty rats to run for food or water under conditions of immediate or delayed reward in an effort to reveal whether delay of reward interacted with the nature of the motivating conditions. Although the principle of the gradient of delay of reinforcement should apply for thirsty as well as hungry animals, they observed that the parameters of these gradients were not the same; delay of water reward was relatively less detrimental to performance than delay of food reward.

* Macdonald and de Toledo are presently involved in replicating a study similar to that of Mischey (1970) which, in conjunction with the above mentioned study will also be presented for publication.

Although evidence of this kind is quite scanty, it appears that the withholding of food reward has a different and possibly a more substantial effect on the behavior of rats than the withholding of water. This absence of research appears to be due to the fact that such differences have not been explicitly looked for rather than because they may not exist.

The above performance differences engendered by food and water complement the notion that reinforcers may interact with internal factors to facilitate or restrict behavioral responses in particular ways. Motivational states, aroused by some form of deprivation may alter the probability of certain responses occurring. Sachs (1965) observed that for animals deprived of food, food-searching behavior was prepotent while sexual behavior was suppressed. Cotton (1953) and Cicala (1961) found that increased food deprivation for rats running in an alley decreased competing responses such as sniffing and exploratory behavior. Brown and Jenkins (1968) observed that pigeons learned to peck keys even when this behavior did not produce grain. By confronting the birds with an illuminated key, and giving them enough grain to start them pecking, the authors observed that the pigeons continued to peck even when the probability of getting food did not increase - in fact, even when the probability decreased. Moreover, when the pigeons were auto-shaped for water reward, their "pecks" clearly exhibited drinking movements of the beak and throat. Miley and Baenninger (1971), focusing on the interaction of motivational states with behavioral responses, studied the roles of hunger and thirst in the initiation and maintenance of mouse killing by rats. By maintaining rats on a

food or water deprivation schedule for a two week period, the authors
noticed that hunger induced killing in most rats regardless of sex or
strain whereas water deprivation had no effect on the initiation of
killing. Studies by Breland and Breland (1966) and Sidman and Fletcher
(1968) further suggest the emergence of food or water-related behaviors
when the respective motivational states are induced; in both of these
cases the behavioral patterns which emerged were similar to those in-
volved in collecting or consumming the food reinforcer.

Consequently, in view of the fact that food and water elicit
differences in performance, the general conclusion that food and water
produce similar effects on learning is open to question. Further
support for such a conclusion stems from the studies dealing with the
summation, substitution, and discrimination of different sources of mo-
tivation.

Hayes (1949) observed that learning occurs more readily
when training is carried out under hunger than when rats are trained
under thirst. Hayes found that rats trained under 18 hours of water
deprivation failed to respond appropriately to food in a straight-way
when tested hungry, whereas rats trained under 23 hours food deprivation
responded appropriately to water when made thirsty. Grice and Davis
(1957) in a "substitution" study, in which rats were trained to press
a panel for food, found that groups which were switched from hunger to
thirst showed somewhat inferior performance to the control group.
Similarily, studies on the energizing effects of irrelevant drive
have shown inhibitory effects of irrelevant deprivation on instru-
mental responses. Levine (1956), and Bolles and Morlock (1960), have

concluded that inhibitory effects appear to be particularily strong
in the case of irrelevant hunger and relevant thirst. It seems
apparent that the effects of irrelevant hunger are different from
those of irrelevant thirst. In addition, drive-discrimination studies
by Hull (1933), as well as those subsequent to him (see Thistlethwaite,
1951), have verified the rat's capability of discriminating a food
motivational state from that of water. Eninger's (1951) studies on
the role of irrelevant drive stimuli in learning theory and Tapp's
(1968) experiments on the effects of deprivational states on the re-
inforcing properties of light onset give further support to the
hypothesis that food and water affect learning in different ways. In
short, these differences in performance and learning supplement the
notion that the emphasis that behaviorists place on arbitrary events
does not ensure laws that are general; in fact, it only produces laws
that are specific to arbitrary events, arbitrarily paired. Furthermore,
these differences seem to support the conclusion that it may be ex-
tremely misleading to attribute a nondirective or general motivating
effect to either hunger or thirst.

A logical explanation of why qualitatively different rein-
forcers such as food and water elicit subsequent differences in per-
formance could be based on the fact that these differences in perform-
ance represent different learning adaptations. If one treats food and
water seeking behavior as any other biological characteristic subject
to natural selection, then one would expect that these environmental
problems would represent specific modifications of learning. Past
studies in animal behavior have already focused on two special adaptations

of learning. Imprinting has been viewed as an adaptation to limit the probability of errors in species recognition, while Rozin and Kalat (1971) have focused on feeding (specific hungers) as a "survival system" showing adaptive specialization in learning. Rozin and Kalat have argued that basic features of learning as applied to food selection in the rat are different from features characterizing the rat's learning in traditional laboratory situations. They reason that these differences make sense in terms of evolutionary adaptation and that learning in food selection is a manifestation of specifically adapted learning mechanisms. It is interesting to note here that both feeding and imprinting have been considered exceptions to the "general laws of learning" (Rozin and Kalat, 1971; Shettleworth, 1971; Staddon and Simmelhag, 1971).

A most appropriate explanation for the evolution of adaptive mechanisms based on hunger and thirst exploration in the rat stems from an experiment by Petrinovich and Bolles (1954). In this particular experiment, hungry and thirsty rats were run in a T-maze on two problems. In one, animals were required to learn the simple location of a reward which was placed in a constant position (one arm of the T-maze). In the second problem, animals were required to acquire a response-alternation habit. The authors observed that thirsty rats learned to find water always in one place in the maze more easily than hungry rats. On the other hand, hungry rats were superior in a task in which reward was placed on alternate sides of the maze on successive trials. Presumably, the results indicated that the brain mechanisms of rats had evolved in such a way as to match

the tendencies of the environment to maintain a source of water in a constant place while varying the location of food. Moreover, it was concluded that this sort of hunger exploration might be more evident in carnivores, and less evident in herbivores who have a more stable food supply.

The essence of this study supports the position that potential food and water sources can be important factors in moulding an animal's performance dimension. After millions of years these environmental factors could result in specific adaptations. Such adaptations would undoubtably influence an animal's learning ability and could manifest themselves in the existence of certain brain mechanisms capable of generating specific food and water behavioral patterns. Although this latter statement is quite speculative in nature, it is extremely difficult to fully discuss the motivational "roots" of food and water deprivation during performance without delving into the understanding of the physiological mechanisms involved in hunger and thirst. The physiological approach will not be investigated at this time but it must be noted, however, that the results of a number of experiments involving lesions and stimulation of certain brain areas do give credence to this speculation. Studies by Hess (1954), Stellar (1954), Grossman (1962), as well as others, have shown that drinking and eating responses as well as a variety of other instinctive patterns can be elicited in many species. These experiments further refute a nondirectional conception of hunger and thirst. In retrospect, it seems that some incentive mechanism appears to be necessary to substantiate the results obtained by Petrinovich and Bolles (1954).

THE SPECIFIC PROBLEM

The conclusion drawn by Petrinovich and Bolles (1954),
that different kinds of behavior could be facilitated in the rat
by using different kinds of deprivation conditions, was, in effect,
a result that a simple drive hypothesis could not account for. If,
in fact, these traditional reinforcers could have been arbitrarily
interchanged, then these different responses should have been
learned with equal difficulty. But, in reality, different degrees
of difficulty seemed to reflect the incompatibility between spe-
cific neural traces of adaptive behavior and those problems posed
by the experimenter. The authors, however, felt that the crucial
factor producing these observed differences could not truly be de-
termined since their experimental groups differed not only in re-
gard to such variables as goal object (food versus water), but also
consummatory activity (eating versus drinking) and body-weight (the
hungry animals lost weight while the thirsty ones gained). As a re-
sult, Bolles and Petrinovich (1956) replicated their first study in
an effort to control for these variables.

Rather than using a standard 24 - hr. deprivation schedule
as was the case in their first study, the authors induced motivation
by using a Verplanck-Hayes schedule (1953). By utilizing this
type of schedule Bolles and Petrinovich asserted that "maximum"
thirst was apparently achieved when a subject was given water for 23
hours and then only food for one hour: this maintenance schedule pre-
sumably provided for a "pure" water deprivation state. Similarily, a sub-
ject was made hungry when food was followed by water in a similar fashion.

Aware of the fact that in their initial study hungry animals lost weight while thirsty ones gained, Petrinovich and Bolles were now able to observe the performances of thirsty animals while losing weight and hungry ones while gaining: this latter condition was achieved because no ad lib feeding period was given to any of the subjects after running. In view of this procedure Petrinovich and Bolles observed that the alternation response was exhibited by thirsty animals provided they had a large enough food deficit, whereas stereotypy of behavior was exhibited by hungry animals provided they had a small enough food deficit. As a result, the authors rejected their initial interpretation and concluded that there was no intrinsic correlation between behavior patterns and reinforcers; this view was based on the observation that food and water variables accounted for only 13% of the variation in alternation whereas the body-weight variable accounted for 78% (9% of the total variation was attributable to other factors in the design). Consequently, the results indicated that body-weight changes were the crucial factors controlling the variability of behavior. The results of this study now implied that food and water had similar effects on performance and that a drive hypothesis was applicable: animal behavior was once again viewed without biological consideration.

When the results of Petrinovich and Bolles' initial study are juxtaposed with those obtained in the second, the problem seems resolved as to whether body-weight, and consequently, a nondirective drive hypothesis, is a more appropriate interpretation of variability than a viewpoint based on evolutionary selection pressures; however,

one must seriously question the general methodology that characterizes

the second study. Although the design of the latter study permits a

greater control of variables that may possibly affect performance,

two issues raise the problem of validity in the 1956 study; namely,

first, the precise nature of the motivation of an animal on a

Verplanck-Hayes schedule and second, the omission of control groups.

In reference to the first problem, evidence strongly sug-

gests that there are different mechanisms involved in food and water

motivated behavior and that there is, in general, a fairly constant

interdependence between food and water intake (Siegel and Stuckey,

1947; Collier, 1969; Fitzsimmons and Le Magnen, 1969); this fact, cou-

pled with the observations that food has an overall greater effect

on performance than water, suggests the dominance of the former in

their interactions. Consequently, although given access to food one

hour prior to running, an animal, having been deprived of food for

23 hours previous, may "anticipate" water reward but his variable

behavior may be "governed" by the food mechanism. Collier (1969),

as well as Stellar and Hill (1952), have viewed motivation induced

by body-weight to reflect the animal's tendency to recover weight

back to its genetic potential for size. In brief, although an animal

on a Verplanck-Hayes schedule "wants" or is willing to consume water

after one hour of feeding, the behavior (variability) corresponds to

his predominating motivational state (tissue deficit). The variab-

ility exhibited by the thirsty rats of Petrinovich and Bolles' se-

cond study may indeed be a direct function of body-weight loss, but

its occurrence might be governed by the mechanism associated with

food deprivation. It seems doubtful then, that an animal placed on a Verplanck-Hayes schedule could exhibit behavior based on a "pure" motivational state; moreover, one must seriously question whether this schedule would enable one to isolate the correct deter- miner of variable behavior especially if the mechanisms underlying the conditions of hunger and thirst are subtle in nature.

In addition to the possibility that body-weight loss cam- ouflaged a correct interpretation of variable behavior, a second problem exists as to the specific role played by the reinforcer in the learning situation. This problem was created by the fact that Petrinovich and Bolles did not form control groups in order to ex- amine to what degree performance differences depended, that is, e- merged as a result of a particular response being simply reinforced as opposed to a particular response being facilitated. Behavioral differences in both the alternation and position habit problems only appeared after some reinforcements had been given implying indirectly that the responses made by all subjects were solely reinforced. And yet, if these traditional motivational states do induce different dom- inant behavior patterns, then it appears that the correct reward would have facilitated rather than caused the learning of these different abilities. By omitting the formation of a group of hungry and thirsty animals given food or water in the apparatus regardless of response, a standard for "amount of variability" to which the experimental groups could be compared was not established. As a result, Petrin- ovich and Bolles removed the possibility of attributing any facilita- tive effect on performance due to quality of reward. By not

establishing these control groups and observing their spontaneous
alternation habits as a direct function of motivational states, a
standard for behavioral comparison could not be provided and con-
sequently the specific role of the reinforcer could not be deter-
mined.

THE PRESENT STUDY

By concluding that body weight represents the crucial
factor in the learning of different responses, Petrinovich and Bolles
place their explanations of behavior along side those of Hull (1951)
and Hebb (1955) in that, long-term environmental factors are either
rejected or ignored. Thus behavior is viewed as undirected at first
but eventually, via certain learning mechanisms, becomes directed.
However, if one accepts the basic premise that in many instances,
an animal's motivation in a given situation is very largely specific to
that situation then one must concede the fact that a variety of specific
learning adaptations could be displayed if the correct experimental de-
sign is employed by the experimenter. The possibility of observing
learning adaptations based on hunger and thirst has been expressed
by Oatley, (1970) as well as Petrinovich and Bolles (1954). They argue
for the genetic transmission of behavioral patterns based on biological
survival value: in the wild, rats continually explore their environ-
ment for food whereas their water supply is presumably more fixed.
Consequently, returning to the place where water was previously found

is adaptive, but returning to where they last found food is not; this is due to the lower probability of always finding food in the same place. It seems then, that a deprived laboratory rat may bring to the experimental setting a historical model of the environment. Hence, if in fact, a pure motivational state is experimentally induced, the "genetic anticipation" of a particular response should facilitate the learning of a particular ability only if the problem possesses characteristics common to the animal's natural environment.

In view of these criticisms and suggestions, the present problem centers around the notion that although the weight loss variable analyzed by Bolles and Petrinovich (1956) is an indication of general instrumental behavior, it may not necessarily be the underlying cause of specific behavior patterns. It is argued here that the conclusions of Bolles and Petrinovich's second study may be incorrect. In order to permit clear conclusions the author feels that, if in the study of alternation and position habit, animals are allowed to gain weight, thereby being subjected to moderate metabolic needs, and furthermore, if they are trained to expect a specific reward, then the animals' general anticipation of reinforcement may reflect an exploratory search for food or water characteristic of their 'historical' behavior. By not implementing either a deprivational schedule whereby subjects lose weight or a schedule where they are maintained at a certain percentage of their initial body weight, the nondirective driving force usually experienced by animals in these situations is minimized and any gain in weight during the learning periods would mean that generally their needs are being satisfied more

naturally — their motivational state during testing at a 'purer'
level.

In order to control the body weights of all subjects, it
was proposed that they be forced to eat and drink at restricted times
during the day. Since it was presumed that the subjects would quickly
learn to consume the same amount of food and water as they would under ad
lib conditions (Fitzsimmons and Le Magnen, 1969) it was reasoned that
they would gain weight: it should be noted at this point, that since
all subjects were expected to gain weight, the concept, "deprivation",
throughout the present study was not used in its traditional sense.
It was also presumed that during the restricted feeding session the
organisms would come to anticipate food and water and that when placed
in the apparatus at the time of testing they would come to anticipate
the particular reward from which they were briefly deprived. Placing
the animals in the apparatus at the time of anticipated reward could,
therefore, provide evidence for specific behavioral responses without
the interaction of the weight loss variable. It was assumed that al-
though the intensity of the motivational states would be at a lower
level than in the study of Bolles and Petrinovich (1956), the op-
portunity to observe biologically-orientated, behavioral differences
would be increased because a less confounded motivational state would
be produced, thereby permitting more clear cut conclusions.

In order to provide for a more precise interpretation of
any behavioral differences that might occur in the present study, it
seemed necessary to clarify the specific role of food and water reward
in relation to the different learning situations. By forming

additional hungry and thirsty groups, subjecting them to the same maintenance schedule as experienced by subjects encountering the alternation and position habit problems, and then observing their behavior during spontaneous alternation, it could then be clarified whether these traditional reinforcers cause or facilitate the observed responses: by comparing the frequency of alternating responses between the hungry and thirsty control groups, any behavioral differences observed in the other experimental situations could then be viewed from a comparative standpoint. The addition of control groups then, anticipating and continually receiving rewards, could therefore provide more knowledge about the role of rewards in different learning situations.

It was predicted, therefore, that under strict weight control conditions, an incentive type of approach to the study of alternation and position habit would provide evidence that traditional motivational states exhibit unique, biological organization and affect subsequent behavior in a qualitatively distinct fashion.

EXPERIMENT I: POSITION HABIT

The specific purpose of Experiment I was to test the ability of food deprived and water deprived rats to learn a stereotyped response. Since the relevant reward for each group was to be found in only one arm of the T-maze, the index of a stereotyped response was taken as the continuous, uniform choice of entering the reinforced arm only.

METHOD

SUBJECTS: The subjects for this experiment consisted of 10 naive, male, CBL Long-Evans hooded rats weighing approximately 175 gm upon their arrival at Lakehead University. All subjects were then individually housed and placed on ad lib. food and water schedules; two hyperemotional animals were discarded and replaced by others from the same population before any preliminary training had begun.

APPARATUS AND TESTING AREA: A T-maze was constructed of 3/4 in plywood and painted flat black. Runways measured 4 in wide, 6 in high and were covered with 1/4 in Plexiglas. The main stem of the maze was 60 in long, and each arm 25 in long; the floor of the maze was covered with a clear protective coating of acrylic which aided in the elimination

of odour trails as well as in the cleaning of the maze. The goal boxes measured 10 in by 4 in by 6 in and were separated from the rest of the arm by guillotine doors. The first 8 in of the main alley constituted the start box, and it also was separated from the rest of the maze by a guillotine door. The maze was placed on a large table which was situated approximately 3 ft from the walls of the laboratory. The light source consisted of four - 40 w. flourescent light tubes located directly over the choice point of the maze.

GENERAL PROCEDURE - MAINTENANCE SCHEDULE AND PRELIMINARY TRAINING:

For 6 days during initial training, subjects were allowed to eat and drink ad lib. During this time, the daily food and water intake for each subject as well as individual weight gain was measured; calibrated drinking bottles and petrie dishes were used to obtain these calculations. At the end of the 6th day, a standard ration (the average amount of food and water consumed per day) and a personal weight score (base weight) was computed for each animal. Subjects were then weighed each day until the termination of the experiment in order to check weight fluctuation. Seven days prior to T-maze training, all animals were deprived of food and water for a 24-hr. period and then forced to receive their respective standard ration in two equal portions. Subjects were given access to their rations for approximately two periods of 2 hr. each day, once in the morning and once in the late afternoon, with a time interval of about 4 hr. (see Figure 1). It was presumed that subjects would quickly learn to consume

FIG. 1: Restricted feeding and testing schedule for Experiments 1, 2, and 3.

	FOOD DEPRIVED GROUP	WATER DEPRIVED GROUP
9 am	Subjects receive irrelevant incentive (water) for 1 hr.	
10 am	Subjects weighed and tested for food reward.	Subjects receive irrelevant incentive (food) for 1 hr.
11 am	Balance of first food portion and water portion given.	Subjects weighed and tested for water reward.
12 am		Balance of first water portion and food portion given.
1 pm		
4 pm	Second portion of the standard ration given. Since subjects do not have a full 2 hr. access to food in the morning, any remainder of the first food portion is added to the second.	
5 pm		Second portion of the standard ration given. Since subjects do not have a full 2 hr. access to water in the morning, any remainder of the first water portion is added to the second.
6 pm		
7 pm		

ROXIMATE TIMES

the same amount of food and water under these specified conditions as they would under ad lib conditions (Fitzsimmons and Le Magnen, 1969).

During the restricted feeding session, all animals were handled for approximately 20 min. per day. Group A, the randomly formed food deprived group, consisting of 5 subjects, received its initial portion of water for 1 hr. but not food. These subjects were then placed in the T-maze where food reward was available in both arms. During this time, it was expected that subjects would gradually habituate to the apparatus as well as grow to anticipate the deprived reward. After the alotted 20 min. had elapsed, the food deprived subjects were placed back in their home cages where the remainder of the first food portion (water included) was given. The second portion of the standard ration followed in the late after-noon. Group B, the randomly formed water deprived group, consisting of 5 subjects, experienced similar proceedings. After receiving its initial portion of food for 1 hr., but not water, the water deprived subjects were placed in the T-maze where water reward was available in both arms. Again, it was expected that these subjects would gradually habituate to the apparatus as well as grow to anticipate the relevant reward. After the assigned 20 min. had elapsed, subjects in Group B were placed back in their home cages where the balance of the first water portion was given (food included). The second, re-maining share of the standard ration followed in the late afternoon.

T-MAZE TRAINING: After the preliminary training had been concluded,

subjects were run through 60 trials (10 trials per day). Prior to each testing time, however, each animal was weighed in an attempt to compare weight gain or loss during T-maze training with the average weight gain computed from the ad lib session. Subjects were run immediately after receiving access to the irrelevant incentive for 1 hr. On the first day, the first four trials were forced (trials 1 and 3 rewarded, 2 and 4 unrewarded) to give the animals further equal experience with the contents of the goal boxes. One goal box contained the appropriate incentive while the other contained nothing. The position of the correct goal box was right for all animals. Subjects were run using the noncorrection method, that is, they were not permitted to correct their responses after making an error. There was a time interval of approximately 1 min. between trials; subjects remained in the chosen goal box for 10 sec. whether the response was correct or incorrect. The subjects were then removed to their home cages where the remainder of the appropriate reward was given followed by the customary second portion of the standard ration in the late afternoon.

R E S U L T S

ANALYSIS OF DATA: The ability to learn this uniform mode of behavior was judged on the basis of the number of errors for the learning period for both groups. A two-factor mixed design with repeated measures on one factor was used in the analysis of this data: type of reward (food or water) and blocks of trials (days) were the factors examined. In

addition, trials to criterion (18 correct choices over 2 successive days - 20 trials) were also computed; trials to criterion for both groups were compared by means of the Mann-Whitney U test. The average response time for each individual subject was also computed. The same two-factor mixed design with repeated measures on one factor was also used in the analysis of the average response times.

WEIGHT TREND: The data presented in Table 1 represents the weight trends of both the hungry and thirsty groups. It should be noted that most of the subjects exhibited a fluctuating weight trend during the restricted feeding session which eventually stabilized permitting complete adaptation to this schedule by approximately the 5th day. It can be seen that all subjects adapted to this restricted feeding session and surpassed their base weight scores; these events were observed in this experiment as well as in those subsequent. Although both groups gained less weight during the testing period, a comparison of the average weight gain of both the ad lib feeding session and the testing period for the thirsty and hungry subjects resulted in insignificant differences (t=1.000, df=4, N.S.) and (t=2.139, df=4, N.S.) respectively. This result, coupled with the fact that nine out of ten subjects surpassed their base weight scores before reaching the set criterion, indicate that performance was not determined by body-weight loss. In addition, insignificant differences were obtained in a comparison of the average weight gain during the testing period between the hungry and thirsty groups (t=1.415, df=8, N.S.).

TABLE 1: Weight trend (position habit)

Calculations of the average weight gain of each animal for the ad lib. feeding session and testing period are rounded off to the nearest gram. The base weight scores represent the weight attained at the end of the ad lib. feeding session and the point at which the animals are deprived for a 24 - hr. period and thus subjected to a weight loss. The difference between the base weight and the final weight of each animal represents the weight gain occurring over a period of 12 days (preceded by the 24 - hr. period of deprivation). These 12 days involve a period of adaptation before any weight gain occurs. The last two columns represent the block of trials on which the base weight is surpassed and the block of trials on which the set criterion is reached.

	AVERAGE WEIGHT GAIN DURING AD LIB FEEDING SESSION (GM)	BASE WEIGHT (GM)	AVERAGE WEIGHT GAIN DURING TESTING PERIOD (GM)	FINAL WEIGHT (GM)	BLOCK OF TRIALS ON WHICH BASE WEIGHT SURPASSED	BLOCK OF TRIALS ON WHICH CRITERION WAS REACHED
(THIRSTY)						
A1	5	227	4	241	3	4
A2	5	212	5	230	3	4
A3	5	239	5	266	-*	5
A4	5	244	5	246	6	5
A5	5	219	5	234	3	5
(HUNGRY)						
B6	5	193	5	218	3	6
B7	5	211	3	222	4	5
B8	5	229	4	232	5	6
B9	5	215	5	230	3	6
B10	5	240	4	242	6	6

* Base weight surpassed before testing period.

PERFORMANCE: The ability to learn the stereotyped response was described in terms of the number of errors exhibited by both groups. The number of errors for each subject was blocked into six blocks of 10 trials each, thus the scores used in the analysis represent the number of errors for each successive block of 10 trials. Learning curves for both groups are shown in Figure 2. Each point on the curve represents the total number of errors for each respective group for a given block of trials: the performance curves disclose the superiority of the thirsty group in mastering the constancy problem.

The results of the analysis of variance conducted for the between groups and blocks of trials (within groups) factors can be seen in Table 2 below. Results indicated that there was a significant difference in the number of errors between the food reinforced and water reinforced groups (F= 9.79, df=1/8). This difference is significant at better than the .05 level of confidence. Hence, it was concluded that the quality of the reinforcer significantly affected the overall amount learned in terms of total number of errors over the learning period. Analysis of the number of errors over blocks (days) 1 - 6 showed significance (F=35.02, df=5/40). This difference is significant at better than the .001 level of confidence and denotes the fact that both groups had learned the stereotyped response as a function of practice trials. The interaction effect between groups and trial blocks was insignificant (F=.79, df=5/40, N.S.). This indicated that there was no significant difference in the rate
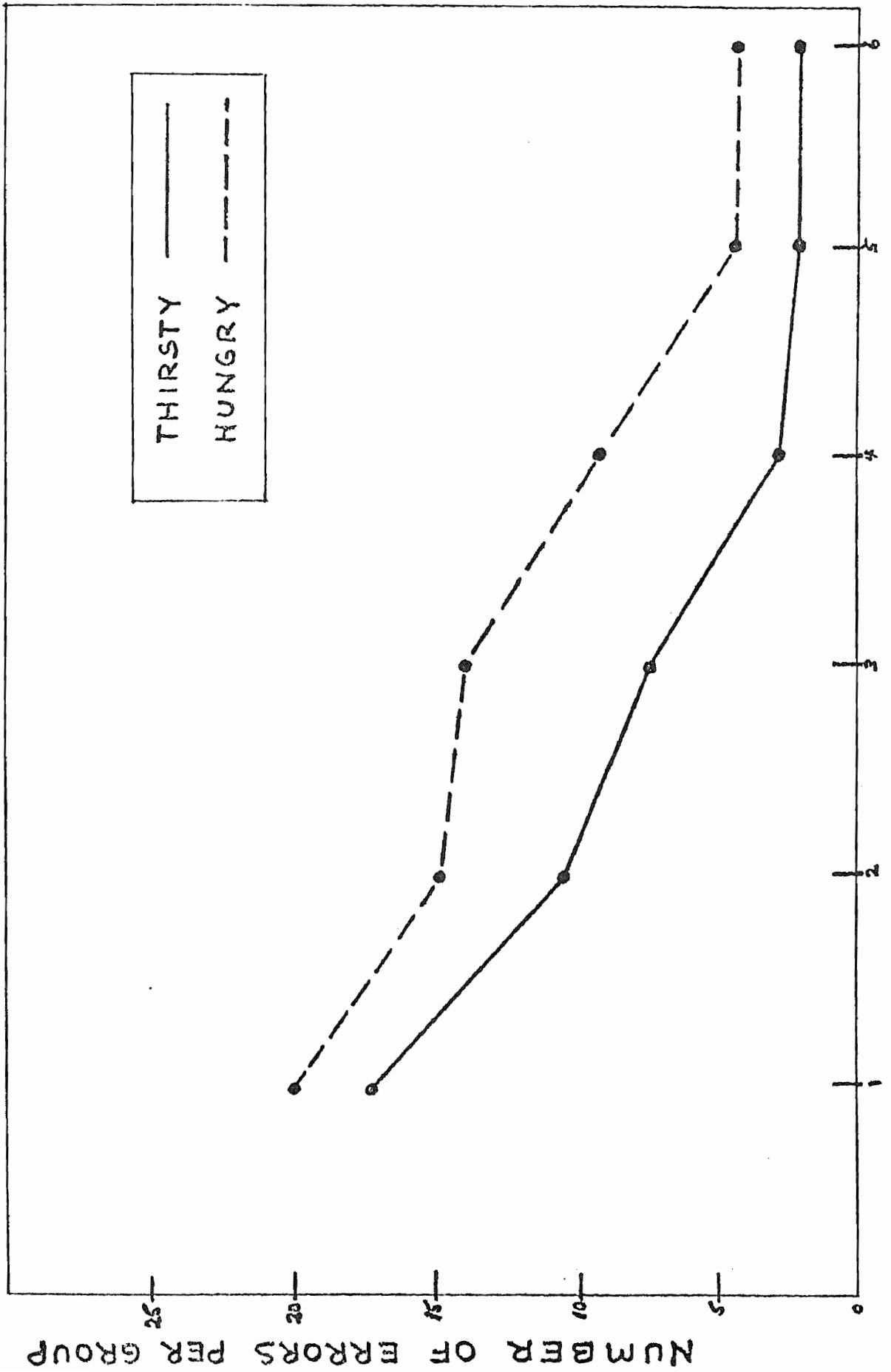
FIG. 2: Performance curves for position habit

TABLE   2: Analysis of variance for position habit
(number of errors)

SOURCE	SS	df	MS	F	P
TOTAL	110.18	59	–	–	–
BETWEEN SUBJECTS	16.01	9	–	–	–
CONDITIONS	8.81	1	8.81	9.79	.025
ERROR between	7.20	8	.90	–	–
WITHIN SUBJECTS	94.17	50	–	–	–
BLOCKS (DAYS)	75.28	5	15.06	35.02	.001
BLOCKS X CONDITIONS	1.69	5	.34	.79	INSIG.
ERROR within	17.20	40	.43	–	–

of acquisition for both groups across blocks of trials; the rate of
learning was the same regardless of whether subjects received food or
water, an effect clearly seen in the parallel slopes of Figure 2.

The data in Table 3 below shows that the thirsty animals
were also significantly superior to the hungry ones in terms of trials
to criterion (18 correct choices over 2 successive days - 20 trials).
The thirsty group required a mean of 46 trials to reach criterion
whereas the hungry group needed a mean of 58 trials. One of the five
hungry animals failed to reach the set criterion before the experiment
was terminated and consequently received an arbitrary score of 60. Trials
to criterion for both groups were compared by means of the Mann-Whitney U test.

Results indicated that there was a significant difference
in the number of trials required to reach criterion in the hungry
and thirsty animals ($P < .004$).

An analysis of variance was also conducted on the mean re-
sponse times of both groups. It can be seen from Table 4 that there
was a highly significant difference in the response times of both the
hungry and thirsty subjects ($F=79.34$, $df=1/8$): the mean running times
for the hungry and thirsty groups were 4.40 and 8.73 sec. respectively.
This difference was significant at better than the .001 level of con-
fidence. Analysis over blocks 1 - 6 showed insignificant ($F=1.54$, $df=5/40$,
N.S.) designating that these response times were not a function of
practice. Similarily, the interaction effect was found to be insignifi-
cant signifying the fact that the response differences occurred at a
similar rate throughout the learning period ($F=1.17$, $df=5/40$, N.S.).

TABLE 3: Trials to criterion (position habit)

GROUP	TOTAL NUMBER OF RESPONSES	MEAN	NUMBER OF CASES	P
Thirsty	230	46	$n_1 = 5$	.004
Hungry	290	58	$n_2 = 5$	

TABLE   4: Analysis of variance for position habit
(mean response time)

SOURCE	SS	df	MS	F	P
TOTAL	550.73	59	-	-	-
BETWEEN SUBJECTS	310.06	9	-	-	-
CONDITIONS	281.66	1	281.66	79.34	.001
ERROR between	28.40	8	3.55	-	-
WITHIN SUBJECTS	240.67	50	-	-	-
BLOCKS (DAYS)	34.53	5	6.91	1.54	INSIG.
BLOCKS X CONDITIONS	26.34	5	5.27	1.17	INSIG.
ERROR within	179.80	40	4.50	-	-

SPECIFIC CONCLUSIONS: In view of the above results, it seems
reasonable to conclude that water deprivation produces an "antici-
patory state of the organism" which seems to facilitate the learning
of a stereotyped response. Although food deprived subjects can also
learn this response, their performance is inferior to that of the
water deprived group. Moreover, it may be concluded that body-
weight loss is not the crucial factor that governs performance dif-
ferences since these discrepancies occurred while both groups were
gaining weight at a similar rate. In addition to the differences
between the two groups in the trials to criterion and number of
errors, there was an orderliness in the distribution of these errors
similar to the one obtained by Petrinovich and Bolles (1954). Hun-
gry subjects made nearly twice as many errors on the second trial
of each day than did the water subjects although this was not evi-
dent on the first and third trials: such an observation seems
logical if one reasons that hungry animals show a strong tendency
towards variable behavior. Moreover, the fact that the hungry
subjects ran faster than the thirsty ones suggests that the perfor-
mance of the hungry group was not the result of lower motivation.

Although the intensity of both motivational states was
presumably at a lower level due to the fact that subjects were not
subjected to a traditional deprivational schedule but rather to a
schedule that allowed them to gain weight, performance, no doubt,
was energized by the anticipation of reinforcement. Consequently,
one might reason that the present study accentuated the exploratory

phases of thirst and hunger rather than the drive aspects.

EXPERIMENT 2: ALTERNATION RESPONSE

The specific purpose of Experiment 2 was to test the ability of food deprived and water deprived rats to learn an alternating response. Since the location of the relevant reward for each group was continually changing from one arm of the T-maze to the other, the index of an alternating response was noted as the proper change in direction in order to enter the reinforced arm only.

METHOD

SUBJECTS: The subjects for this experiment consisted of 10 naive, male, CBL Long-Evans hooded rats weighing approximately 175 gm upon their arrival at Lakehead University. All subjects were then individually housed and placed on ad lib food and water schedules; one hyperemotional animal was discarded before training procedures began and replaced by another animal from the same population.

APPARATUS: The apparatus used in Experiment 2 was the same as that of Experiment 1.

GENERAL PROCEDURE - MAINTENANCE SCHEDULE AND PRELIMINARY TRAINING:

The schedule and pre-training employed in this experiment was the same as in Experiment 1.

T-MAZE TRAINING: Following preliminary training, each subject was run through a total of 99 trials (90 test trials plus 9 pre-training trials — 11 trials per day). Prior to each testing time, each animal was weighed in an attempt to compare weight gain or loss during T-maze training with the average weight gain computed from the ad lib session. Subjects were run immediately after receiving access to the irrelevant incentive for 1 hr. (a reward was referred to as irrelevant if it did not appear in the test situation). The first trial was viewed as an 'extra' trial in that all subjects were rewarded no matter which side of the maze they chose. On the second trial, however, the appropriate reward was placed on the side opposite that chosen on the first trial. On the third trial, the reward was located on the side opposite that which the animal chose on the second trial regardless of whether trial two was correct or not. This procedure continued for the next eight trials. Subjects were run using the noncorrection method with approximately 1 min. between trials; they remained in the chosen goal box for 10 sec. whether the response was correct or incorrect.   The subjects were then removed to their home cages where the remainder of the appropriate reward was given followed by the customary second portion of the standard

ration in the late afternoon.

R E S U L T S

ANALYSIS OF DATA: Due to the fact that subjects were rewarded on their first trial regardless of response, analysis dealt with the last 10 trials per day only.   The ability to learn an alternating response was assessed on the basis of the number of errors for the learning period for both groups.   A two-factor mixed design with repeated measures on one factor was used in the analysis of this data: type of reward (food or water) and blocks of trials (days) were the factors examined.   Trials to criterion (9 correct choices in one day - 10 trials) were also computed; trials to criterion for both groups were compared by means of the Mann-Whitney U test.   Average response time for each subject was also calculated.   The same two-factor mixed design with repeated measures on one factor was also used in the analysis of the average response times.

WEIGHT TREND: Table 5 represents the weight trends of both the hungry and thirsty groups.   As was found in Experiment 1, both groups gained less weight during the testing period.   Similarily, a comparison of the average weight gain of both the ad lib feeding session and the testing period for the hungry and thirsty subjects provided insignificant differences: for the thirsty group ($t=1.639$, $df=4$, N.S.) and for the hungry group ($t=1.000$, $df=4$, N.S.).   Not only did the

TABLE 5: Weight trend (alternation)

Calculations of the average weight gain of each animal for the ad lib feeding session and testing period are rounded off to the nearest gram. The base weight scores represent the weight attained at the end of the ad lib feeding session and the point at which the animals are deprived for a 24 - hr. period and thus subjected to a weight loss. The difference between the base weight and the final weight of each animal represents the weight gain occurring over a period of 15 days (preceded by the 24 - hr. period of deprivation). These 15 days involve a period of adaptation before any weight gain occurs. The last two columns represent the block of trials on which the base weight is surpassed and the block of trials on which the set criterion is reached.

	AVERAGE WEIGHT GAIN DURING AD LIB FEEDING SESSION (GM)	BASE WEIGHT (GM)	AVERAGE WEIGHT GAIN DURING TESTING PERIOD (GM)	FINAL WEIGHT (GM)	BLOCK OF TRIALS ON WHICH BASE WEIGHT SURPASSED	BLOCK OF TRIALS ON WHICH CRITERION WAS REACHED
IRSTY)						
A1	5	201	5	235	2	9
A2	5	194	4	220	3	9
A3	5	212	5	250	2	9
A4	4	207	3	223	4	9
A5	5	220	5	258	3	9
JNGRY)						
B6	5	202	5	236	2	9
B7	5	207	5	240	3	8
B8	5	214	5	251	1	7
B9	4	210	4	236	2	7
B10	6	222	5	257	2	7

restricted feeding sessions have an insignificant effect on the
weight gain of both groups, but learning of the correct response
occurred while subjects' weight gain approximated that of the ad lib
standard.   This fact, paired with the observation that all 10 subjects
surpassed their base weight scores before reaching their respective
criterions supports the conclusion that learning performance was not
determined by body-weight loss.   Insignificant differences were also
obtained in a comparison of the average weight gain during the test-
ing period between thirsty and hungry groups (t=.8948, df=8, N.S.).

PERFORMANCE: The ability to learn the alternation response was
specified in terms of the number of errors exhibited by both groups.
The number of errors for each subject were blocked into nine blocks
of 10 trials each, thus the scores used in the analysis represent
the number of errors for each successive block of 10 trials.   Learn-
ing curves for both groups are shown in Figure 3.   Each point on the
curve represents the total number of errors for each respective group
for a given block of trials: these performance curves display the
superiority of the hungry group in solving the alternation problem.

The results of the analysis are shown in Table 6.   It can
be seen that there is a significant difference in the number of errors
between the food reinforced and water reinforced groups (F=17.47,
df=1/8).   This difference is significant at better than the .01 level
of confidence.   The quality of the reinforcer, therefore, significantly
affected the overall amount learned.   Analysis of the number of errors
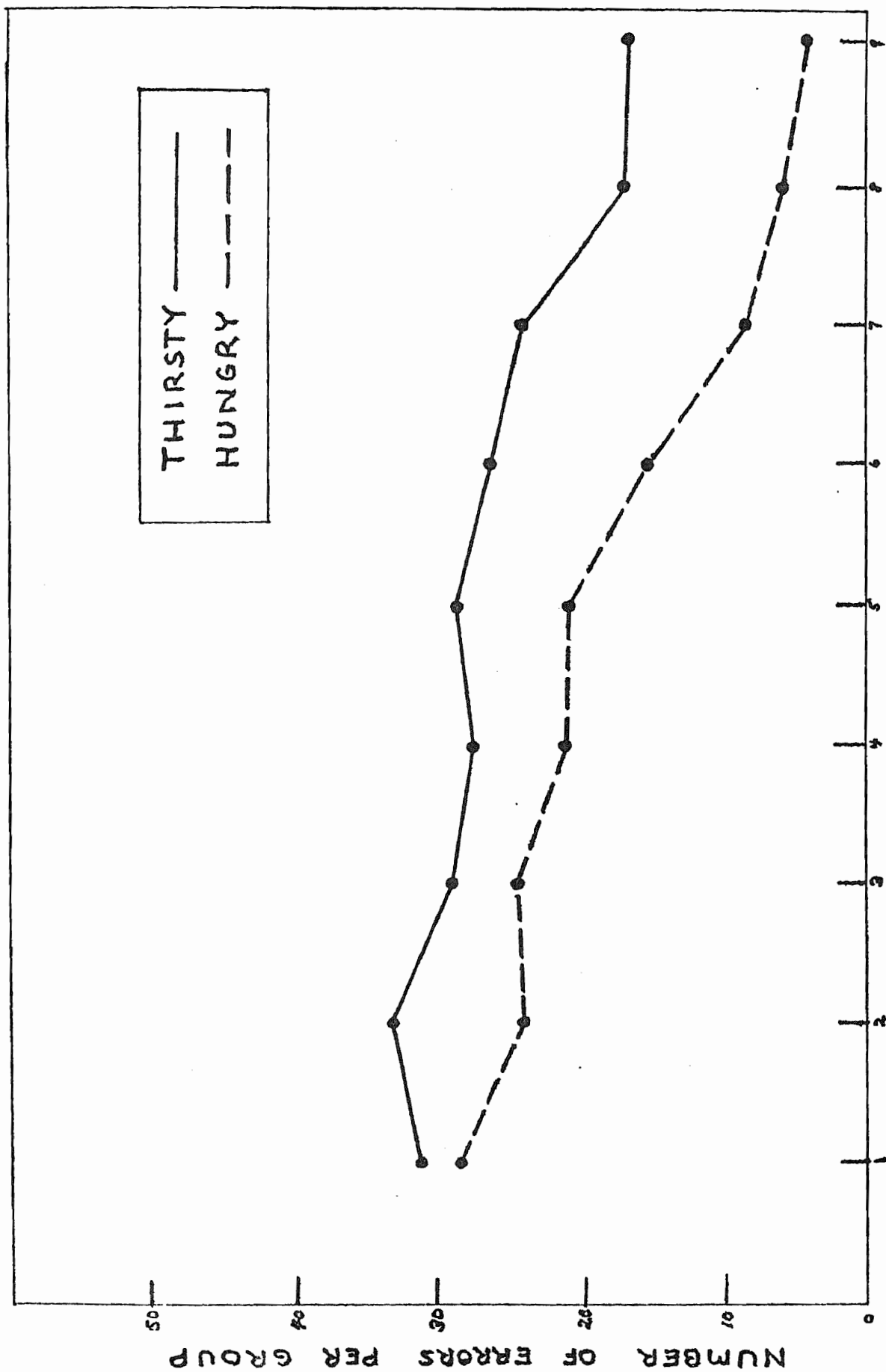
FIG.3: Performance curves for alternation habit

TABLE 6: Analysis of variance for alternation habit
(number of errors)

SOURCE	SS	df	MS	F	P
TOTAL	336.32	89	–	–	–
BETWEEN SUBJECTS	86.32	9	–	–	–
CONDITIONS	59.21	1	59.21	17.47	.01
ERROR between	27.11	8	3.39	–	–
WITHIN SUBJECTS	250.00	80	–	–	–
BLOCKS (DAYS)	163.02	8	20.38	18.04	.001
BLOCKS X CONDITIONS	14.49	8	1.81	1.60	INSIG.
ERROR within	72.49	64	1.13	–	–

over blocks 1 - 9 showed significance at better than the .001 level of confidence (F=18.04, df=8/64). This shows that both groups learned the alternation response. The interaction effect between groups and trial blocks was nonsignificant (F=1.60, df=8/64, N.S.), indicating that the rate of learning was the same regardless of whether subjects received food or water.

The data in Table 7 below shows that the hungry animals were also significantly superior to the thirsty ones in terms of trials to criterion (9 correct choices in one day - 10 trials). The hungry group required a mean of 76 trials to reach criterion whereas none of the thirsty subjects reached the set standard before the experiment was terminated: one thirsty subject did succeed however, in scoring eight correct choices on the final day of testing. All the thirsty subjects received an arbitrary score of 90.

Trials to criterion for both groups were compared by means of the Mann-Whitney U test. Results indicated that there was a significant difference in the number of trials required to reach criterion between the hungry and thirsty animals (P<.004).

The analysis of variance for the mean response times can be seen in Table 8. As was the case in Experiment 1, there was a highly significant difference in the response times between the hungry and thirsty subjects (F=68.59, df=1/8): the mean running times for the hungry and thirsty groups were 4.16 and 6.38 sec. respectively. This difference was significant at better than the .001 level of confidence. Analysis of the mean response time over blocks 1 - 9 showed insignificance (F=1.10, df=8/64, N.S.) indicating that these response times were not a function of trials. The interaction effect was also insignificant indicating

TABLE 7 : Trials to criterion (alternation)

GROUP	TOTAL NUMBER OF RESPONSES	MEAN	NUMBER OF CASES	P
Thirsty	450	90	$n_1 = 5$	
				.004
Hungry	380	76	$n_2 = 5$	

TABLE 8: Analysis of variance for alternation habit
(mean response time)

SOURCE	SS	df	MS	F	P
TOTAL	383.60	89	-	-	-
BETWEEN SUBJECTS	124.04	9	-	-	-
CONDITIONS	111.11	1	111.11	68.59	.001
ERROR between	12.93	8	1.62	-	-
WITHIN SUBJECTS	259.56	80	-	-	-
BLOCKS (DAYS)	30.40	8	3.80	1.10	INSIG.
BLOCKS X CONDITIONS	9.29	8	1.16	.34	INSIG.
ERROR within	219.87	64	3.44	-	-

that the time differences occurred at a similar rate throughout the learning period (F=.34, df=64/8, N.S.).

SPECIFIC CONCLUSIONS: The above results indicate that food deprivation seems to facilitate the learning of an alternation response. Since the present study takes advantage of response variability by the nature of its design, in that the position of the reward is constantly being changed from one arm of the maze to the other, it seems logical to expect hungry subjects to make fewer errors in this instance while making more errors in a situation that demands a "constant" response pattern as was the case in Experiment 1.   Conversely, it was expected that the present design should hinder the thirsty group in acquiring an alternation response since water deprivation seems to facilitate stereotyped behavior;   this was found to be the case.   Since none of the thirsty animals reached the set criterion, one might conclude that the alternation response is a more difficult problem for thirsty subjects to learn than a position habit is for hungry ones.   Petrinovich and Bolles (1954) also obtained such results although in their study, three out of 10 thirsty animals did reach criterion before the experiment was terminated.   Similar to Experiment 1, it may again be concluded that body-weight loss is not the crucial factor that governs performance differences since these differences occurred while both groups were gaining weight at similar rates.   The hypothesis that alternation behavior is primarily a function of body-weight loss seems unjustified in view of these results.

EXPERIMENT 3: SPONTANEOUS BEHAVIOR

The specific purpose of Experiment 3 was to show the frequency of alternating responses exhibited by food deprived and water deprived rats. In this study, the focus of attention was placed on the spontaneous alternation of rats when reward was available in both arms of the T-maze. Experiment 3, therefore, became a control study to determine whether qualitatively different rewards produce differences in spontaneous alternation.

METHOD

SUBJECTS: Subjects for this experiment were 10 naive, male CBL Long-Evans hooded rats weighing approximately 175 gm upon their arrival at Lakehead University. Subjects were then individually housed and placed on ad lib food and water schedules.

APPARATUS: The apparatus used in Experiment 3 was the same as that of Experiments 1 and 2.

GENERAL PROCEDURE - MAINTENANCE SCHEDULE AND PRELIMINARY TRAINING:

The schedule and pre-training employed in this experiment was the same as in Experiments 1 and 2.

T-MAZE TRAINING: T-maze training was the same as in Experiment 1 except in the following respect: all subjects, after receiving access to the irrelevant incentive for 1 hr., did not experience any forced trials. Subjects received the relevant reward regardless of the response since both goal boxes contained the appropriate incentive. The time interval between trials for all subjects was about 1 min.

RESULTS

ANALYSIS OF DATA: The frequency of alternating responses was analyzed by a series of One-Sample Runs Tests in an effort to determine the randomness of such behavior. The total number of runs over six successive days - 60 trials, was computed for each subject. In addition, the number of runs for both food deprived and water deprived groups were compared by means of a t-test for independent groups. The average response time for each subject was also computed. A two-factor mixed design with repeated measures on one factor was used in the analysis of the average response times: type of reward (food or water) and blocks of trials (days) were the factors examined.

WEIGHT TREND: The data in Table 9 represents the weight trends of both the hungry and thirsty groups. The restricted feeding session had no significant effect on the weight gain of all subjects since a comparison of the average weight gain of both the ad lib session and

TABLE 9: Weight trend - spontaneous behavior

Calculations of the average weight gain of each animal for the ad lib feeding session and testing period are rounded off to the nearest gram. The base weight scores represent the weight attained at the end of the ad lib feeding session and the point at which the animals are deprived for a 24 - hr. period and thus subjected to a weight loss. The difference between the base weight and the final weight of each animal represents the weight gain occurring over a period of 12 days (preceded by the 24 - hr. period of deprivation). These 12 days involve a period of adaptation before any weight gain occurs. The last two columns represent the block of trials on which the base weight is surpassed and the block of trials on which the set criterion is reached.

	AVERAGE WEIGHT GAIN DURING AD LIB FEEDING SESSION	BASE WEIGHT	AVERAGE WEIGHT GAIN DURING TESTING PERIOD	FINAL WEIGHT	BLOCK OF TRIALS ON WHICH BASE WEIGHT SURPASSED
	(GM)	(GM)	(GM)	(GM)	
IRSTY)					
A1	5	236	4	250	3
A2	4	224	4	242	2
A3	5	240	5	268	-*
A4	5	244	5	273	-*
A5	5	220	5	239	2
JNGRY)					
B6	5	225	4	248	-*
B7	4.	238	4	251	3
B8	4	230	4	241	3
B9	4	226	3	230	5
B10	5	242	5	261	2

* Base weight surpassed before testing period.

the testing period for the thirsty and hungry subjects resulted in in-
significant differences (t=1.000, df=4, N.S.) and (t=1.634, df=4, N.S.)
respectively. The frequency of alternating responses therefore, was
observed while subjects' weight gain approximated that of the ad lib
standard. Body-weight loss was not a factor in performance. Insig-
nificant differences were obtained in a comparison of the average weight
gain during the testing period between the thirsty and hungry groups
(t=1.500, df=8, N.S.).

PERFORMANCE: In order to determine the randomness of alternating
responses exhibited by food or water deprived rats, the total number
of runs over six successive days, 60 trials, were computed for each
subject; individual runs reflected the order and succession of left
and right choices. The results of the series of analysis can be
seen in Table 10. Results indicate that for the thirsty group, three
out of five subjects displayed a nonrandom series of left and right
turns A1; Pr $(z \geq -1.72)$ = .0427 A3; Pr $(z \geq -2.06)$ = .0197 A4; Pr
$(z \geq -2.03)$ = .0212. Since the direction of the deviation from random-
ness was predicted to exhibit fewer runs than would probably occur in
a random sample, a one-tailed test was utilized. This direction of
deviation was reflected by the negative z scores obtained by four out
of five thirsty subjects. Results for the hungry group also signified
that four out of five subjects revealed a nonrandom series of left or
right choices: B7; Pr $(z \geq +2.61)$ = .0045 B8; Pr $(z \geq +2.10)$ = .0179

TABLE 10: Spontaneous behavior

SUBJECTS	RESPONSES (LEFT OR RIGHT)	RUNS	TEST OF SIGNIFICANCE	PROBABILITY (C.R. = .05)	DECISION
(THIRSTY)					
A1	$34L = N_1$ $26R = N_2^1$	24	z -1.72	.0427	NOT RANDOM
A2	$30L = N_1$ $30R = N_2^1$	27	z -1.04	.1492	RANDOM
A 3	$32L = N_1$ $28R = N_2^1$	23	z -2.06	.0197	NOT RANDOM
A 4	$33L = N_1$ $27R = N_2^1$	23	z -2.03	.0212	NOT RANDOM
A 5	$24L = N_1$ $36R = N_2^1$	31	z $+ .33$	.3707	RANDOM
(HUNGRY)					
B6	$27L = N_1$ $33R = N_2^1$	29	z $- .45$	.3264	RANDOM
B7	$30L = N_1$ $30R = N_2^1$	41	z $+2.61$	.0045	NOT RANDOM
B8	$23L = N_1$ $37R = N_2^1$	37	z $+2.10$	.0179	NOT RANDOM
B9	$28L = N_1$ $32R = N_2^1$	39	z $+2.13$	.0166	NOT RANDOM
B10	$36L = N_1$ $24R = N_2^1$	36	z $+1.68$	.0465	NOT RANDOM

B9; Pr $(z \geq +2.13) = .0166$ B10; Pr $(z \geq +1.68) = .0465$. The direction of deviation for the hungry group was characterized by the positive z scores which indicated that four out of the five hungry subjects displayed more runs than would probably occur in a random sample. The number of runs for both groups were compared by means of a t-test for independent groups. A significant difference at better than the .01 level of confidence was found ($t=4.24$, $df=8$). The frequency of alternating responses, therefore, occurred at different rates under differing reinforcement.

An analysis of variance was conducted for the mean response times of both groups and the results of this analysis can be seen in Table 11. Results revealed that there was no significant difference in times between the food and water reinforced groups ($F=4.21$, $df=1/8$, N.S.): the mean running times for the hungry and thirsty groups were 4.07 and 5.10 sec. respectively. Analysis of the mean response times over blocks 1 - 6 showed significance at better than the .001 level of confidence indicating that the response times were a function of practice trials ($F=19.36$, $df=5/40$). The interaction effect was insignificant signifying the fact that there was no significant difference in response times for the hungry and thirsty groups across blocks of trials ($F=1.41$, $df=5/40$, N.S.).

SPECIFIC CONCLUSIONS: Although hungry subjects ran faster than thirsty ones in Experiments 1 and 2, it was quite evident in view of the weight trends that the quality of performance was not based on higher or lower motivational states. In Experiment 3, the

TABLE 11: Analysis of variance for spontaneous behavior
(mean response time)

SOURCE	SS	df	MS	F	P
TOTAL	158.58	59	–	–	–
BETWEEN SUBJECTS	46.41	9	–	–	–
CONDITIONS	16.01	1	16.01	4.21	INSIG.
ERROR between	30.40	8	3.80		–
WITHIN SUBJECTS	112.17	50	–	–	–
BLOCKS (DAYS)	75.48	5	15.10	19.36	.001
BLOCKS X CONDITIONS	5.49	5	1.10	1.41	INSIG.
ERROR within	31.20	40	.78	–	–

response times for both groups were similar, however, giving further support to the notion that performance differences are not necessarily a function of the quantitative aspects of motivation. Of more importance, the present study gives an indication of the specific role played by the reinforcer in the learning of a position habit or alternation response. Since hungry animals tend to alternate more frequently than thirsty ones regardless of the fact that all choice-point behavior is reinforced, it appears that the relevant reward facilitates rather than causes the learning of certain abilities. Consequently, it is concluded that different motivational states "prepare" the animal for different behavior patterns while the specific reinforcer facilitates and increases the probability of its occurrence. Although Petrinovich and Bolles (1954) found that differences in the learning of both problems only appear after some reinforcements have been given (see Figure 4), the present experiment provides evidence to the contrary and supports the initial performance differences that occurred in Experiments 1 and 2.

In brief, the data from the three experiments demonstrates that the quality or type of reinforcer engenders qualitatively different effects on behavior in different learning situations.
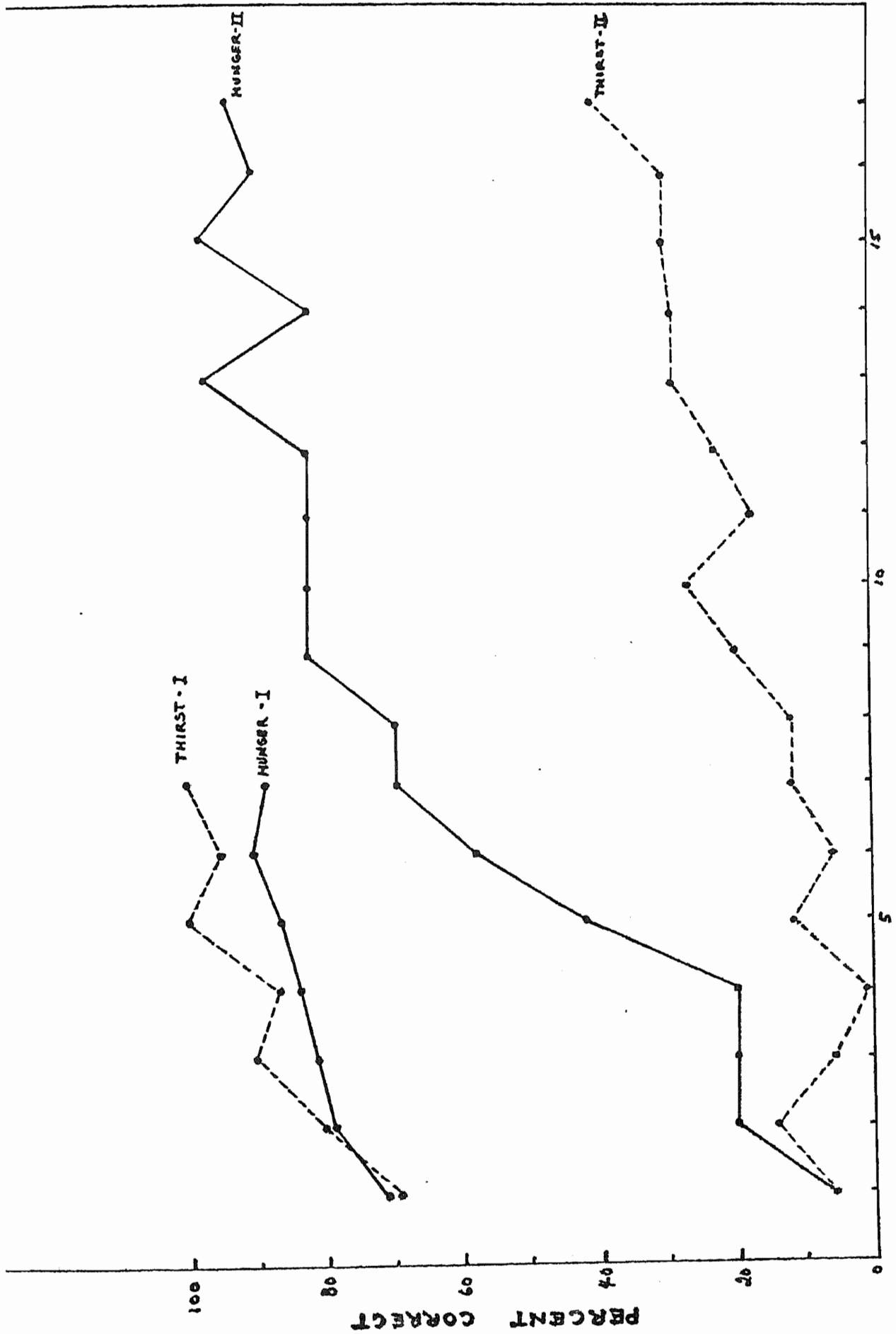
FIG.4: Performance curves for problem I (position habit) and problem II (alternation) from Petrinovich and Bolles (1954)

GENERAL DISCUSSION

The format presented in these experiments is conspicuous
in its attempt to stay clear of the general drive idea that has
played such a large part in past theoretical treatments of motiva-
tion. By controlling the body-weight loss variable, emphasis has
been turned away from drive factors that push behavior from behind,
towards incentive components that draw behavior forward. The pre-
sent results provide evidence contrary to the hypothesis set forth
by Bolles and Petrinovich (1956), that alternation behavior is
primarily a function of body-weight loss since a correspondence be-
tween specific response and motivation occurred during body-weight
gain. Moreover, such studies as those of Campbell, Smith, Misanin
and Jaynes (1966), and Glickman and Hartz (1964), show that different
patterns of deprivation-induced activity exist among different species
of animals even though these activities occur with similar weight-
loss functions.

The present issues give impetus to the premise that per-
formance while gaining weight provides for a more "natural" motiva-
tional state characterized by a moderate metabolic need. These nat-
ural states seem capable of circumventing subtle motivational pro-
blems as usually exemplified in experiments where traditional
schedules of deprivation are utilized and water deprived rats become
both hungry and thirsty and hence, capable of eliciting behavioral

responses based on hunger rather than thirst. It is professed
that the irrelevant drive of hunger became greater than that of
thirst in the second study by Bolles and Petrinovich (1956), con-
sequently inviting a behavioral interpretation based on body-weight
loss. An incentive approach, whereby animals are induced to expect
or anticipate a specific reinforcer, therefore, might be a more
sensitive means by which to isolate the correct determiner of pos-
sible behavioral differences based on qualitatively different mo-
tivational states. Such an approach here, has provided evidence for
the correlation between hunger and variability, and thirst and constancy,
thereby inviting a behavioral explanation based on biological sur-
vival value. Despite the assertion of authors such as Lorenz (1965)
and Lockard (1968), who argue that phylogenetically established
behaviors essential to survival in the wild are no longer kept in
peak condition due to the process of domestication, the present re-
sults support the proposition that certain learning processes based on
food and water exploration are still present even though the laboratory
rat has received its food in a fixed location for generations. In
view of the fact that the more stable a given environment is, the
slower is the evolution of animals living in it (Weisz, 1966), one
must assume that these learning processes have not yet been signi-
ficantly subjected to the genetic changes accompanying domestication.

Although issues in the methodology were the basis for
questioning the results obtained by Bolles and Petrinovich in their
second study, one may in turn question the present author's

interpretation of the behavioral differences observed in the present study. There is no doubt that in the comparison of different rein- forcers it is particularily important to separate effects due to dif- ferences in the quality of reinforcers from effects which may be due to other factors. One might seriously question whether the present results indicate anything beyond a quantitative difference in learning of both experimental groups or that differences merely reflect some quantitative variable outside the realm of learning such as equality of reward value.

In reference to the quantitative alternative in learning, it might be contended that in the position habit problem, the hungry group could have caught up and surpassed the performance abilities of the thirsty group had the number of trials been extended. One might assert that learning of position habit in the hungry group simply "evolves" more slowly: this argument seems feasible since the hungry subjects did in fact learn this response although their performance was inferior to that of the water group up and until the point at which the experiment was terminated. Opposing this alterna- tive explanation is the fact that behavior exhibited during the spon- taneous behavior study clearly indicated the facilitative effect that food and water seem to have on variability and constancy respectively. Although it was concluded that water facilitated the learning of position habit whereas food did not, any future increase in learning ability by the hungry group might only expose a change in the fun- ction of food reward; that is, food may now come to cause or reinforce

the position habit response. Similarily, the thirsty group might
come to parallel or surpass the hungry group in variability. Although
none of the thirsty subjects reached the set criterion in Experiment 2,
three out of 10 thirsty subjects did so in the initial study of
Petrinovich and Bolles. In any event, one must still contend with the
fact that the learning of different responses goes on more slowly or
quickly and this seems to depend on the deprivational state induced.

Effects present in this study may also be due to quantitative
differences in reward value, in that one reinforcer may produce the
same effects as might be produced by a smaller or larger magnitude
of another. The question arises as to whether an X amount of food
reward is equal in reward value to a Y amount of water reward in
both experimental problems. In dealing with this alternative,
the present author must concede the fact that during the present
testings a pellet of food may not have been equal in value to a
drop of water and yet, one must admit that in studies of this
comparative nature, it would be quite rare if (in addition to reward)
both groups experienced all potentially important factors exactly
equally. It should be noted, however, that all subjects in all
three experiments did gain weight; consequently, one might ration-
alize that the "amount factor" of their respective rewards dimin-
ished to the point that the equality variable was not a significant
one. Furthermore, studies dealing with differential incentive effects
due to amount of reinforcement (Lawson, 1957; Morrison and Porter,
1965) have found that if separate groups of animals are trained on

various discrimination problems with each group receiving <u>either</u> a large or a small amount of reinforcement, relatively small differences attributable to amount are found. Although animals, when given more reinforcement, tend to run faster, maze learning problems are not necessarily learned sooner. The "equation" variable then, may indeed have affected the results of this study but one must seriously question the probability of a significant interaction.

One possible method of discovering whether two reinforcers differ qualitatively or simply quantitatively has been suggested by Steiner (1968). Steiner feels that this problem can be overcome by comparing the effects of varying the parameters of one reinforcer with the effects of varying the parameters of another using several measures of reinforcement strength. This approach is basically the same as Bitterman's (1965) method of systematic variation which is suggested for comparing the learning abilities of different species. Steiner, however, focuses on the comparison of functional relationships across reinforcers rather than across species. One might, in effect, apply the above approach to the present studies to clarify any skepticism surrounding the results. However, in view of the maintenance schedule employed in the present studies, the probability of obtaining significantly different results and rejecting an explanation based on biological survival value is questionable.

Another possible interpretation of the present results

may in effect be explained by the Yerkes-Dodson law (1908) which
maintains that for various tasks there is an optimal motivational
level for learning, and that levels higher or lower than the op-
timum, result in impaired performance. Consequently, in view of
the mean response times, the food deprived subjects in Experiment
1 may have been subjected to a level of motivation whose intensity
interfered with their main response tendencies resulting in perfor-
mances inferior to the water deprived group. Similarily, the water
deprived subjects in Experiment 2 may have been exposed to a level
of motivation too weak to express an optimal level of performance
on the alternation problem. In response to these possibilities
two issues must be kept in mind. First, the Yerkes-Dodson law im-
plies that an optimal level of motivation is lower for complex tasks
and higher for simple tasks. If one assumes that alternation is a
more complex task than position habit, then the food deprived sub-
jects in Experiment 1 should have been superior on the position
habit whereas the water deprived subjects should have been superior
on the alternation problem: the present results, however, show a
completely opposite effect. Second, the results of Experiment 3 ex-
hibit a behavioral difference between the food and water deprived
groups even though a learning task is not prevalent and, moreover,
the mean response times of both groups relatively similar. If be-
havioral differences during spontaneous alternation exist, then one
must accept the possibility that differences in various learning sit-
uations could also occur. Although it is clearly erroneous to

presume that animals in the present study were tested during the
optimal level of motivation, one must challenge the hypothesis
that the present results are solely attributable to the Yerkes-
Dodson effect.

SITUATION - SPECIFIC COMPATIBILITY: It follows from the results
presented here, that an organism may have abilities that manifest
themselves in only a limited number of possible situations. De-
pending on the motivational state that is induced, an animal's an-
ticipation of a particular response seems to facilitate the learning
of a particular ability only if the laboratory problem exhibits
characteristics common to the animal's natural environment.

In an effort to explore the environmental aspects of
purposeful behavior, Oatley (1970) proposes that certain motivation-
al mechanisms have features appropriate to the nature of the environ-
ment and that in order to generate behavior appropriate to the envi-
ronment, the brain must itself contain a model of the external world.
In view of the fact that behavior must have been shaped during ev-
olution to take account of and represent these environmental features
relevant for eating, breeding, etc., it seems logical that certain
aspects of the external world are reflected in the logical construc-
tion and framework of the model contained in the brain: it seems
highly probable that an organism possesses a historical model of the
environment.

It appears necessary, however, to extend Oatley's

implications. If the brain is truly a symbolic representation of the external world then an understanding of behavior in the laboratory setting demands the discovery of what objects, events and relationships are relevant to the problem posed by the experimenter. If the animal's "biological model" of the environment is compatible with the "experimental model", that is, the problem posed by the experimenter, the opportunity to learn a specific response would be enhanced, whereas their incompatibility would lead to a decrease in the probability of the response occurring. Gleitman and Rozin (in press) accentuate this form of reasoning in their general review on the learning abilities of different species of fish. They argue that the failure of a few fish species to demonstrate certain learning abilities such as a progressive improvement in habit reversal in a few laboratory situations, does not adhere to a biological argument; a species should be tested only in those situations that demand a type of behavior that is of the greatest survival value. One might speculate, therefore, that the water deprived animals of Experiment 1 bring to the experimental setting a historical construction of water seeking behavior which in view of natural selection is congruent with the stereotyped response demanded. The food deprived animals, on the other hand, possessing a model of food-seeking behavior, exhibit a greater occurrence of incompatible responses since variability does not coincide with the experimental problem. A similar interpretation can also be applied to the results of Experiment 2 even though the problem is changed.

In this case, however, the model of food-seeking behavior is consonant with the alternation response whereas the water-deprived model stands in disagreement with the experimentally induced situation. A fundamental method of reaching an understanding of behavior in the traditional laboratory situation does not lie solely on the discovery of what objects, events and relationships are relevant to some category of behavior but also on the degree of compatibility between biological ability and experimental design. The present observations lend support to the generalization that certain situations seem to call forth specific responses which are often typical of the species rather than the individual and tend not to rely on any general laws of learning.

Further examples of situation-specific compatibility are seen in the training of pigeons to avoid or escape shock, (Rachlin and Hineline, 1967; Rachlin, 1969) and escape and avoidance learning in rats, (Bolles, 1970). Although previous experimentation had shown that pigeons could be shaped to raise their heads to avoid shock, they could not be shaped to key-peck in similar situations. Only after laborious shaping procedures did Rachlin and Hineline (1967) succeed in training them to avoid by pecking. Rachlin (1969) reasoned that this training difficulty was due to the fact that the operant level of key-pecking was much lower in pigeons when they were being shocked than when they were hungry and/ or being fed in the experimental situation. Bolles (1970), found that rats could easily learn to run out of situations where they

received shock but had great difficulty in learning to press a lever to escape or avoid shock. Relating learning in the laboratory to behavior in the wild, he suggests that shock qualifies an animal's behavior by eliciting species-specific defense reactions (SSDR's) only. Consequently, all other responses, including those SSDR's not appropriate or effective for the situation, will occur only with extreme difficulty. Both these studies further exemplify the fact that specific responses appear only if the experimental situation becomes appropriate for their occurrence.

An unexpected but interesting factor that arises in the comparison of the average response rates of both groups in Experiments 1 and 2 is the higher latency of response that the water deprived group exhibits after experiencing a nonreinforced trial. Quite frequently, after a nonreinforced trial, a thirsty subject would engage in sniffing and grooming responses whereas the nonreinforced hungry subject continued to respond at an approximately similar rate.

One might explain these results in terms of frustration theory by hypothesizing that a nonreinforced, hungry rat possesses a stronger S_F component, that is a feedback stimulus that becomes associated with approach behavior (Amsel, 1962), than does a nonreinforced, thirsty rat. This can be explained on the grounds that a stronger S_F has evolved through the experience of partial reinforcement caused by the uncertainties of food sources while the S_F of thirsty rats has remained weak in light of the fact that water

reinforcement has always been available at a fixed location. Consequently, nonreinforcement for a hungry animal would result in similar or greater persistence, whereas a thirsty animal would show a decrease or lack of persistence. Theoretically speaking, it seems that different S_F components are "naturally" set to a different degree in each of these motivational states.

FEEDING HABITS AND BEHAVIORAL RESPONSES: In order to generate behavior appropriate to the environment, it seems inevitable that the initiation for such activity would be the gaining and refining of species-survival information. Such information, no doubt, would be achieved by exploratory behavior and refined by natural selection in the form of specific behavior patterns and special motor skills. One might reason that exploratory behavior is the means by which organisms attempt to free themselves from the restriction of a limited environment where any sudden external change might lead to extinction; and yet, certain predetermined activities such as feeding, mating and predator-prey relationships confine and "force" organisms to display species-specific movement. In light of this natural correlation, it seems highly possible that feeding patterns may be quantitatively related to exploratory behavior.

A study by Glickman and Sroges (1966), on the curiosity of zoo animals, catches the spirit of the exploratory-feeding relationship. These authors studied the reactions of more than

200 zoo animals to a standardized set of novel objects in an attempt to find possible differences among various taxonomic groups both in the quantity and form of object manipulation: whether the animals observed, sniffed, chewed, used their forepaws, etc.. They hypothesized that feeding patterns which required extensive manipulation of the environment, coupled with moderate metabolic requirements, would favour the development of sustained investigatory activity. On the other hand, the ready availability of food, which requires only the simplest kind of stereotyped manipulatory responses for its acquisition, would not favour intensive manipulation in a particular species. The results definitely indicated the existence of systematic differences in reactivity among various groups of mammals. An example of such differences occurred within the family of the Old World monkeys. One group, the Ceropithecinae, are known to be omnivorous, eating berries and insects as well as other small animals. Although ranging widely through the trees, the members of this subfamily have adapted to life on the ground. The Colobinae, on the other hand, are consistent tree-dwellers and are entirely herbivorous. In view of these differences in habitats and food sources, the Ceropithecinae proved to be significantly more reactive than the Colobinae. Moreover, the carnivore group (eg: ocelot, lion, fox) showed a vigorous, fearless approach to the objects which approximated the patterns used in the capture and consumption of prey. The responses of the rodent section (eg: american woodchuck, flying squirrel, kangaroo rat) were

generally limited to passive exploratory manipulation (eg: gnawing) although here again, differences in aggressiveness of approach among the three suborders emerged as a function of the food source of the species. A recent study by Russell and Pearce (1971), provides further evidence of this sort. They examined the exploratory reactivity of the diverse marsupial fauna of Australia occupying an appropriate carnivorous-herbivorous niche. Using the same test objects as those of Glickman and Sroges (1966) the authors found that the highest level of reactivity was exhibited by the carnivorous Dasyuroides and this was contrasted with low levels of reactivity in the herbivorous Megaleia rufa and Macropus eugenii.

It appears, therefore, that one can predict the sheer quantity of exploratory reactivity from the knowledge of habits and environment. This form of reasoning seems applicable to the behavioral differences found in the present study. The "generally omnivorous nature" of the rat is exhibited when the animals become hungry during which time a greater magnitude of hunger exploration in the form of alternation occurs. The thirsty group, in comtrast, shows a "herbivorous approach" by acting in a stereotyped fashion: a form analogous to the behavioral patterns of animals living amongst a readily available and constant food supply.

Relative to ethologists who fundamentally investigate unlearned behavior in a variety of species, learning remains almost exclusively the possession of psychologists. In view of the

present results, however, the general laws of learning seem inappropriate and the facts demand an interpretation within the context of adaptive behavior as a whole. The research presented here demands a unifying principle that can explain laboratory learning in rats in terms of the interaction of feeding activities, hunger exploration and experimental design. In view of the common denominator that must underlie both learned and unlearned behavior as well as the subject matter of biology and comparative psychology, it seems highly probable that the principles of evolution by natural selection provide this unifying framework. The observation here, that type of reward must be considered as a relevant variable in any experiment where variability or stereotypy of behavior is a dependent variable, exemplifies the value of this regulation. With further experimentation, other pairs of positive as well as negative reinforcers might prove to facilitate the learning of certain responses in a qualitatively different fashion.

Although recent authors such as Skinner (1969), Breland and Breland (1966), Staddon and Simmelhag (1971) have drawn attention to the similarities between evolution and learning, no general method of approach has been able to fuse both aspects in order to explain situation-specific learning. As far as animal behavior in general is concerned, the time seems appropriate for the assimilation of divergent pieces of knowledge advocated by different disciplines. Associative learning within the realm of natural

selection might provide the appropriate structure from which a more precise understanding of behavior can emerge.

S U M M A R Y   A N D   C O N C L U S I O N S

Three experiments were undertaken in an effort to determine: first, whether 'moderately' hungry or thirsty rats, anticipating food or water reinforcement, would differ in their abilities to learn certain responses. Second, to investigate the relationship of food and water reward to these different learning situations. In Experiment I, animals were required to learn the location of a reward which was in a constant position. Although food-deprived animals could learn this response, it was found that water-deprived animals excelled in performance. In Experiment 2, animals were required to acquire a response-alternation habit. Although none of the water-deprived animals reached the set criterion, all of the food-deprived subjects were successful in their attempts. The frequency of alternating responses exhibited by hungry and thirsty rats was observed in Experiment 3. Since hungry animals tended to alternate more frequently than thirsty ones regardless of the fact that all choice-point behavior was reinforced, it appeared that the relevant reward facilitated rather than caused the learning of the problems in Experiments I and 2.

By way of summary, the present studies support the following conclusions: (1) In the study of alternation and position habit in the rat, body-weight loss is not the crucial factor responsible for performance differences between thirsty and hungry animals, since learning differences can occur while both groups are

gaining weight at a similar rate.

(2) There appears to be an intrinsic correl-
ation between food and water seeking behavior and the motivational
states aroused by their respective reinforcers.

(3) It appears that different motivational
states may prepare an animal for different behavior patterns while the
respective reinforcers facilitate and increase the probability of
their occurrence.

(4) An incentive approach may be a more sen-
sitive means by which to isolate the correct determiner of possible
behavioral differences based on qualitatively different motivational
states.

A discussion of the results obtained from these three
experiments emphasized the probability that the learning abilities of
different species of animals may be just as evolutionarily specialized
as perceptual and motor apparatus. The suggestion was made that an
organism may possess behavioral abilities that manifest themselves in
only a limited number of situations. Depending on the motivational
state, an animal's anticipation of a particular response seems to
facilitate the learning of a particular ability only if the labor-
atory problem exhibits characteristics common to the animal's natural
environment; an understanding of behavior in the laboratory setting
seems to demand the discovery of what elements and relationships are
relevant to the problem posed by the experimenter. The degree of sit-
uation-specific compatibility was considered an extremely important

gaining weight at a similar rate.

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(3) It appears that different motivational states may prepare an animal for different behavior patterns while the respective reinforcers facilitate and increase the probability of their occurrence.

(4) An incentive approach may be a more sensitive means by which to isolate the correct determiner of possible behavioral differences based on qualitatively different motivational states.

A discussion of the results obtained from these three experiments emphasized the probability that the learning abilities of different species of animals may be just as evolutionarily specialized as perceptual and motor apparatus. The suggestion was made that an organism may possess behavioral abilities that manifest themselves in only a limited number of situations. Depending on the motivational state, an animal's anticipation of a particular response seems to facilitate the learning of a particular ability only if the laboratory problem exhibits characteristics common to the animal's natural environment; an understanding of behavior in the laboratory setting seems to demand the discovery of what elements and relationships are relevant to the problem posed by the experimenter. The degree of situation-specific compatibility was considered an extremely important

variable in the understanding of purposeful behavior in animals.

Moreover, a knowledge of the feeding habits of a species and natural

habitat seems valuable in discerning an animal's potential to respond

in certain situations. It was proposed that learning theory within

the guidelines of natural selection might provide for the foundation

of a precise understanding of animal behavior.

A P P E N D I X

TABLE A: Number of errors for position habit.

DAYS

		1	2	3	4	5	6
THIRSTY	A1	4	2	0	0	0	0
	A2	3	2	1	1	0	1
	A3	3	4	2	0	1	0
	A4	4	2	2	1	0	0
	A5	3	1	2	1	1	1
HUNGRY	B6	4	3	3	2	0	1
	B7	3	3	2	1	0	0
	B8	5	4	3	2	2	1
	B9	3	3	2	2	1	1
	B10	5	2	3	2	1	1

TABLE B: Number of errors for alternation response.

		DAYS								
		1	2	3	4	5	6	7	8	9
TY	A1	7	7	6	6	6	6	5	4	4
	A2	7	7	6	7	4	7	4	3	4
	A3	6	5	6	4	7	4	7	5	4
	A4	6	6	5	4	5	4	3	2	3
	A5	5	7	6	6	6	6	5	3	2
RY	B6	5	6	6	6	5	2	5	3	1
	B7	6	6	6	5	5	4	3	0	0
	B8	7	5	4	5	4	4	0	2	1
	B9	5	4	5	2	3	2	0	0	2
	B10	5	5	4	4	5	4	1	2	0

TABLE C: Mean response times for position habit (in sec.).

DAYS

	1	2	3	4	5	6
A1	10	7	12	8	8	10
A2	9	11	12	7	10	9
A3	5	9	7	10	8	3
A4	7	14	11	10	3	7
A5	6	8	10	15	8	8
B6	7	4	3	4	3	4
B7	4	4	3	7	7	5
B8	4	7	6	3	3	3
B9	5	3	4	6	4	4
B10	5	6	4	4	3	3

THIRSTY (rows A1–A5)

HUNGRY (rows B6–B10)

TABLE D: Mean response times for alternation response (in sec.).

DAYS

	1	2	3	4	5	6	7	8	9
A1	8	6	8	9	5	3	4	9	7
A2	10	5	3	6	6	7	8	9	7
A3	7	7	6	4	5	8	10	6	3
A4	6	6	5	8	3	6	6	4	6
A5	7	11	4	4	12	5	4	5	9
B6	7	3	4	6	4	4	6	5	3
B7	4	4	5	3	5	3	5	4	3
B8	7	5	3	3	5	3	3	3	4
B9	4	3	4	5	5	3	3	4	4
B10	6	4	3	6	5	4	4	3	3

THIRSTY (A1–A5)

HUNGRY (B6–B10)

TABLE E: Mean response times for spontaneous behavior (in sec.).

DAYS

		1	2	3	4	5	6
THIRSTY	A1	10	7	7	8	5	5
	A2	6	4	4	5	3	5
	A3	5	4	5	3	4	6
	A4	7	5	3	5	4	6
	A5	8	5	4	4	3	3
HUNGRY	B6	7	5	5	3	3	3
	B7	8	3	4	4	3	4
	B8	6	4	4	3	3	3
	B9	6	3	4	3	3	3
	B10	7	4	4	3	4	3

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