An Attempt to Demonstrate a Learned Drive Based on Saline Induced Thirst

Born

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AN ATTEMPT TO DEMONSTRATE
A LEARNED DRIVE
BASED ON SALINE INDUCED THIRST

by

DAVID G. BORN

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Arts

School of Graduate Studies
Western Michigan University
Kalamazoo, Michigan
July, 1959
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The monotony of converting latencies into running speeds, and the statistical analysis that followed, was alleviated a great deal by the assistance of Miss Mary Demas who patiently checked and cross-checked the data as it was processed. Thanks also go the Upjohn Company for donating the subjects and permitting the writer to discuss a number of injection procedures with Dr. Douglas Anger and his associates during working hours.

Finally, the writer wishes to acknowledge Dr. Donald Meyer of Ohio State University, and Dr. K. J. Asher, for their helpful suggestions and/or criticism offered in the evaluation and interpretation of the results. Thanks, also, to Dr. Stanley Kuffel for serving on the thesis committee.
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An attempt to demonstrate a learned drive based on saline induced thirst.

INTRODUCTION

While the importance of motivational phenomena has been recognized for many years, advances in this area have not been as rapid as those in such areas as learning or sensation and perception. The reasons for this are partly conceptual and partly methodological.

Many theorists have attempted to postulate motives for all objects for which human beings or animals strive. The practice has resulted in such concepts as a "poker-chip-drive" in chimpanzees in the chimp-o-mat studies, a "money-drive" in humans, "competitive drives", "prestige drives", et cetera. The writer suggests that much of this confusion has resulted from a failure to distinguish between the incentive properties of goal objects on the one hand, and motivational (drive) states of the individual on the other. As used by most contemporary writers in the field (and in the remainder of this paper), a drive refers to a condition of the organism present prior to and/or simultaneous with the occurrence of some behavioral sequence; an
incentive refers to some object or event which does not occur until the termination of the behavioral sequence. For example, a hungry (drive state) rat is placed in a runway and runs (behavioral sequence) to the end where he finds food (incentive). Judson S. Brown (Brown, 1953) has suggested three functional properties of drives which should aid us in drawing future distinctions between these two concepts.

1. "Drives function in combination with existing reaction tendencies to produce overt behavior." (p. 3).

2. "A reduction in drive following a response will function under special conditions to increase the probability that the response will occur again in the same situation." (p. 5).

3. "An abrupt increase in drive following a response will function under special conditions to reduce the probability that the response will occur again in the same situation." (p. 5).

The role which the primary drive states (hunger, thirst, pain, sex, etc.) play in motivating the behavior of lower organisms has been adequately demonstrated in behavioral research centers throughout the country. At the human level, however, in well developed societies, such primary drive states usually do not attain a sufficient intensity
to motivate the intense behavior of human beings. What, then, motivates them?

Most theorists feel that human behavior is driven by a complex interaction of learned rewards and learned drive(s). Under the present conceptualization money is an example of such an incentive substance or learned reward; anxiety is classified as an acquired drive.

The way in which learned drives and learned goal objects acquire their values is not well understood as the following section will testify. We shall see, however, that theorists have long recognized the importance of these notions and have employed them freely in attempting to explain the behavior of living organisms.
1. Review of Relevant Literature.

The Zeitgeist of 1890 found William James (In Mowrer, 1939) advancing the notion that anxiety was an instinctive reaction to objects or situations that the organism perceived as potentially dangerous. Such reactions were thought to be psychogenetically fixed, unlearned products of the evolutionary struggle for survival.

Ivan Pavlov expressed a very similar view in 1903.

"It is pretty evident that under natural conditions the normal animal must respond not only to stimuli which themselves bring immediate benefit or harm, but also to other physical or chemical agencies -- waves of sound, light, or the like -- which in themselves only signal the approach of these stimuli..."

"The stronger carnivorous animal preys on weaker animals, and these if they waited to defend themselves until the teeth of the foe were in their flesh would speedily be exterminated. The case takes on a different aspect when the defense reflex is called into play by the sights and sounds of the enemy's approach. Then the prey has a chance to save itself by hiding or by flight" (Pavlov, 1927, p. 556).

Meanwhile, in the area of personality development, Sigmund Freud was hypothesizing that, "Anxiety arose to a situation of danger; it will be regularly reproduced thenceforward whenever such a situation recurs" (Freud, 1936, p. 72). Freud felt that anxiety served as a signal intended by the ego for the purpose of influencing the pleasure-pain mechanism. "Since we have reduced the
development of anxiety to a response to situations of danger, we shall prefer to say that the symptoms are created in order to remove or rescue the ego from the situation of danger. (pp. 85-86). In modern terminology, Freud's proposition might be expressed as: Anxiety, developed in the danger situation, functions as a drive which produces symptomatc behavioral patterns directed toward the goal of anxiety-reduction.

We have seen in the preceding paragraphs that James, Pavlov, and Freud have all assigned similar interpretations to the role of anxiety and stimulus cues. Each of these men, in his own way, had recognized the biological utility of anticipatory reactions to danger signals.

The experimental work of John B. Watson (In Mowrer, 1939) provided him with some insight into the manner in which the human organism acquires fear or anxiety. Employing the conditioning paradigm of Pavlov, Watson concluded that most human fears are related to and a function of individual experiences. In experimenting with the reactions of infants to loud sounds and loss of physical support, Watson found that a multitude of neutral stimuli, when properly paired with either of these two variables, could be made to acquire the capacity to elicit definitely fearful behavior.
In the years that were to follow something resembling a general drive to understand was suggested by a few theorists to account for the hitherto unexplained behavior of the human being. Woodworth (1918) found this position untenable as the following quotation bears out.

"The point at issue is very well brought out in the case of a game of skill. The motive that drives the chess player to his chess, or the golf player to his golf, is not at all adequately accounted for by referring to an undifferentiated reservoir of curiosity or manipulations. The one is driven precisely by an interest in chess and the other by an interest in golf. The driving forces are specific, and acquired in the learning of these games. In the same way, while a man may enter a certain line of business from a purely external economic motive, he develops an interest in the business for its own sake (unless he is entirely out of his element), as he acquires mastery of its problems and processes; and the motive force that drives him in the daily task, provided of course this does not degenerate into mere automatic routine, is precisely an interest in the problems confronting him and in the process by which he is able to deal with those problems. The end furnishes the motive force for the search for the means, but once the means are found, they are apt to become interesting on their own account.

In short, the power of acquiring new mechanisms possessed by the human mind is at the same time a power of acquiring new drives; for every mechanism, when at that stage of its development when it has reached a degree of effectiveness without having yet become entirely automatic, is itself a drive and capable of motivating activities that lie beyond its immediate scope. The primal forces of hunger, fear, sex, and the rest, continue in force, but do not by any means, even with their combinations, account for the sum total of drives activating the experienced individual." (p. 104).
Woodworth's basic notion of habits becoming drives has recently been elaborated by Allport into his concept of "functional autonomy". Allport has severely criticized the view that all human conduct is to be accounted for in terms of trial and error striving to eliminate immediately felt organic needs. As he points out, much of the most energetic behavior of contemporary man takes place when his organic needs are fairly well satisfied. In an attempt to account for this state of affairs, Allport has proposed the notion that habits have an on-going character, independent of the motivation existent at the time they were formed, and that this "habit-momentum" is a form of self motivation. Allport's functional autonomy is summed up by Peter Bertocci (1940) in the following quotation:

"Functional autonomy is 'a substantive designation' for a psychological process underlying the observable facts (a) that the manifold potentialities and dispositions of childhood coalesce into sharper, more distinctive motivational systems' and (b) that these systems, as they emerge, 'take upon themselves effective driving power, operating as mature, autonomous motives quite different in aim and in character from the motivational systems of juvenile years, and very different indeed from the crude organic tensions of infancy'. Briefly, the mechanisms or means used to satisfy certain needs themselves become drives which are not mere 'changes rung on universal themes'" (pp. 96-97).

This position has been severely criticized by McClelland (1942) and Rethlingschaefer (1943) as ignoring the facts of experimental extinction, among other things.
Before proceeding with other interpretations of the manner in which acquired drives become established it is necessary to introduce the classical demonstration of acquired fear by Neal E. Miller (1948). Miller's apparatus was a box consisting of two compartments; one white with a grid as a floor, the other black with a smooth floor. The compartments were separated by a door which could be opened by the experimenter, or by pressing a bar or turning a wheel located in the box. Albino rats showed no preference for either side prior to conditioning.

At this point subjects were given ten trials in which they were placed in the white compartment, an electric shock was administered, and they were allowed to escape to black. Shock was omitted on all trials that followed.

Miller found that his subjects continued to run from the white compartment to the black. The test of the motivating properties of the conditioning which had occurred came when Miller changed the door between the compartments so that it opened only when a wheel in the white compartment was turned. Subjects rapidly learned this response to escape from white to black.

As a final test of acquired motivation, the controls were again changed so that pressing the bar in the box opened the door and wheel turning did not. Miller found that the
wheel-turning response rapidly extinguished in favor of bar-pressing. The interpretation which he provided was in terms of a secondary drive. Briefly, the interpretation revolves around the question of the motivation for the learning of the wheel-turning and bar-pressing responses. In the presumed absence of primary drives, the assumption of a learned fear motivating the learning of these behaviors appears warranted.

Miller and Dollard (1941) and more recently Judson S. Brown (1953) have extended the implications of such studies to the human situation. Brown has suggested that many of the so-called drives for money, prestige, praise, etc., are non-existent. He proposes the notion that, "...the important motivating component of many of the supposed acquired drives for specific goal objects is actually a learned tendency to be discontented or distressed or anxious in the absence of these goal objects." (p. 12). Illustratively, during the early years of childhood there are innumerable occasions when the child gets bumped or burned or scratched etc., and in each case normal parents show great concern and behave in a correspondingly anxious manner. Such an idea provides us with the classical conditioning paradigm for the anxiety reaction. If the child's pain (UCS), which produces anxiety is repeatedly and contiguously associated in time and space with the anxiety reaction of the parents (CS), we should expect their anxiety to later produce a similar
reaction in the child. If, on later occasions, the parents were to exhibit anxiety over a lack of money, the child's anxiety, paired with the concern over financial matters (CS), would provide a higher-order-conditioning situation. Once such conditioning has taken place all verbalizations associated with a lack of money could be expected to elicit anxiety via stimulus generalization. Money thus becomes a reward which serves to reduce the anxiety and reinforce the behavior which preceded its acquisition.

Similarly, Miller and Dollard express the following view: "Any cue which acquires the ability to elicit the anxiety or fear responses and hence to produce the anxiety stimuli acquires drive value. Conversely, any cue that acquires the ability to stop the fear responses and hence to reduce the fear stimuli acquires reward value for the frightened individual." (p. 60). "Drive value is acquired by attaching to weak cues responses to strong stimuli." (p. 66).

The concept of a learned drive (fear or anxiety) based upon the aversive drive pain is now widely accepted. Unfortunately, acquired motivation based upon the appetitive drives (hunger, thirst, sex, etc.) has not attained the same status. Anderson (1941) and Calvin et al (1953) have reported studies purporting to demonstrate an acquired
drive based upon hunger. Myers and Miller (1954), attempting to replicate Anderson's study with slight modifications, obtained negative results and suggested that the positive findings of these two studies may be due to "chance" factors or artifacts of the experimental design.

Miller (1951), in noting the relative ease with which learned aversive drives may be demonstrated as contrasted to the learned homeostatic drives, has suggested that this may be due to the time interval involved in the pairing of the CS and UCS. To be conditioned, a response must be evoked in the presence of the CS. Aversive drives can be aroused rapidly (throwing a switch in the case of shock) which permits immediate pairing of CS and UCS; hunger and thirst, on the other hand, develop very slowly.

Seward (1953) attributes a large part of the failure to demonstrate secondary motivation to experimental technique. To demonstrate an acquired drive, Seward suggests, the influence of a primary need state must be ruled out. In aversions one need only turn off the shock but in the case of the appetitive drives their elimination is not as rapid or as clear cut and probably involves some complex physiological mechanism.

Considering the available evidence for learned drives Seward proposes a "theory of motive-learning" which requires that learned drives fall into two categories, secondary and
tertiary, depending upon how they are acquired.

"Secondary drives result from the conditioning of primary drive components to external stimuli. Tertiary drives result from the blocking of learned responses, especially responses by which primary or secondary drives have been reduced. Which kind of drive is acquired depends on whether circumstances favor the conditioning of drives or the learning of goal responses. There is no necessary connection between this classification and that of primary drives into aversions and appetites. As Miller has pointed out, however, the onset of aversions is typically sudden; that of appetites is gradual. It seems reasonable to suppose that in order to be learned, a response must involve a somewhat abrupt change of excitation. We should, therefore, expect aversion to yield secondary drives supplemented by tertiary, while appetites, unless their onset is sudden, should lead almost exclusively to tertiary drives" (p. 102).

Clark L. Hull (1943, 1951) is perhaps the first theorist to state explicitly the conditions involved in establishing a learned drive. Corollary 4 in his theoretical schema reads as follows:

"When neutral stimuli are repeatedly and consistently associated with the evocation of a primary or secondary drive and this drive stimulus undergoes an abrupt diminution, the hitherto neutral stimuli acquire the capacity to bring about the drive stimuli (S_D) which thereby become the condition (C_D) of a secondary drive or motivation" (p. 25).

Such a statement of the manner in which secondary motivations are established, it will be noted, implies the familiar paradigm of classical conditioning. Furthermore, by stating the antecedent conditions, Hull provides us with a means for testing the utility of part of his theory of mammalian behavior. This theoretical proposition provides the conceptual basis for the present research.
2. Statement of the Problem

We have seen in the foregoing discussion a very brief treatment of the history and current status of a very important theoretical issue. How are we to account for the intense striving for money, praise, prestige, etc., in the human organism? Is Allport's functional autonomy a reality? Can Brown account for all of these phenomena in terms of anxiety? And last, is it methodologically possible to demonstrate acquired drives based upon primary drives other than pain? The following study is designed to shed further light upon the latter question. It proposes to do this by pairing a neutral stimulus (a black box) with the relatively rapid onset of a primary drive (thirst). (How this is done will be explained below.) Following such pairing, subjects will be required to perform an instrumental response in the absence of the primary drive but in the presence of the previously neutral stimulus. The elicitation of the secondary drive by the previously neutral stimulus should, according to Brown's first functional criterion of a drive (c.f., p. 2), enhance the performance of the instrumental response.

The problem of inducing rapid onset of appetitional drives appears partially resolved by a number of investigators (Holmes and Gregerson, 1950a; Holmes and Gregerson, 1950b; Wayner and Remanis, 1958; O'Kelley and Falk, 1958) who have reported success in the artificial induction of thirst by
means of hypertonic saline solution. Wayner and Remanis (1958), employing subcutaneous injections of hypertonic saline, have reported a median drinking latency of seven and one-half minutes for a group of rats injected with high concentrations of salt solution. This does a great deal to circumvent one of the supposed barriers in demonstrating an acquired drive based on thirst.

Personal communication with Dr. Douglas Anger and his associates at the Behavioral Research Laboratory of the Upjohn Company, Kalamazoo, Michigan, revealed that five different types of saline injections could be used to develop a thirst condition in the white rat. Two of these procedures, subcutaneous injections and oral injections, were selected for use in a pilot study (See Appendix A) to determine the relative latencies of the thirst condition following these two different types of injections. Wayner and Remanis reported making as many as fifteen subcutaneous injections on fifteen consecutive days. Their experiment was terminated at this point because the animals showed painful reactions to the injections and deleterious effects due to repeated exposure to saline were noted.

The present study, then, shall employ the use of hypertonic saline in attempting to bring about a thirst
condition in a period of time short enough to permit its pairing with neutral stimuli. Introducing a foreign substance such as saline into an experimental design naturally introduces a number of variables which must be controlled for. The following is a brief outline of the purpose served by each of the groups employed.

**Experimental Group (SE)**

Each animal in the experimental group shall receive an injection of a five percent solution of hypertonic saline (1cc/100 grams of rat wt.), a five minute delay while the thirst threshold is approached, and will then be placed in a smooth, dark, black box. It is expected that this procedure will permit some conditioning of the dark and black of the box to the onset of intense thirst. This conditioning will then serve to motivate the animals in this group from a smooth, dark, black start box to a neutral white goal box in a straight alley runway situation.

**Ringer's Group (RB)**

Because of the possibility of pain from the injections becoming conditioned to the black box, a second group of subjects will be injected with an equal volume of Ringer's solution. This solution was chosen because its chemical composition very closely approximates that of the fluids found in the cells of living organisms. As such, it might produce as much pain as saline, but does not produce
thirst. Other treatment of this group will parallel that of SB.

**Black Box Group (B)**

In order to evaluate any conditioning of pain to the black box in groups SB and RB, a third group will be run which will be treated identically to groups SB and RB but will receive no injection.

**Saline Group (S)**

The last group of subjects employed in the study will receive an injection of saline (again the same relative volume as SB—1cc/100 grams of rat wt.) but no experience with the black boxes. This group will serve as a control for possible behavioral changes resulting from the fifteen minute confinement in the black boxes and also for the possibility of peculiar physiological effects stemming from repeated saline injections.

Each night, prior to injections and/or black box treatment, subjects will run in a black, straight alley runway to a pellet of food in a white goal box. A twenty-two hour food deprivation will serve as the relevant motivating condition in the runway; the acquired drive, therefore, will serve as an irrelevant drive in the instrumental reward situation. Hull (1943, 1951) has postulated that relevant and irrelevant drives summate
in a behavioral fashion to produce effective drive (D). This notion has considerable experimental support and the principle is utilized in the present study. It is hypothesized that group SB will excel over all other groups in both starting and running speeds. This hypothesis is based upon the assumption that the learned drive conditioned in the black boxes will generalize to the runway situation and will function as an irrelevant drive in enhancing speed measures to a neutral goal box and a pellet of food. No basis exists for predicting differences among the various control groups.
METHODOLOGY

Subjects

The subjects were forty albino rats (sixteen males and twenty-four females) of the Sprague-Dawley strain donated by the Upjohn Drug Company of Kalamazoo, Michigan. At the start of the experiment the mean weights of the males and females were 270.2 grams and 209.1 grams respectively. The females were housed in groups of three per cage and the males were housed in groups of four per cage. Ten subjects were randomly assigned to each of four groups with the restriction that six females and four males would appear in each group.

Apparatus

Two apparatuses were employed in the experiment. The first apparatus consisted of twelve adjacent boxes, each box being four and one-half inches deep by three and three-fourths inches wide by ten inches long. The boxes were constructed of three-fourths inch boards with one-fourth inch hardware cloth serving as a floor. Each box was equipped with a hinged, one-fourth inch thick opaque top which could be hooked shut when a subject was placed in the box. The entire apparatus was painted a flat black and was located in a dimly lit experimental room.
The second piece of apparatus was a forty-eight inch straight-alley runway which separated a ten inch start box from a ten inch goal box. The goal box, start box, and runway were all three and three-fourths inches wide by four and one-half inches deep (inside dimensions). The entire apparatus was painted a flat black with the exception of the goal box which was a flat white. A glass furniture coaster which had been painted white served as the food cup.

The start box was equipped with double guillotine doors: one was opaque and painted flat black; the other, transparent plexiglas. At the end of the runway there was a single transparent plexiglas guillotine door which prevented the animal from retracing once he had entered the goal box. Both the runway and the goal box were covered by transparent plexiglas; the start box was covered by plexiglas which had been painted with several coats of flat black, thus making it opaque. A single fifteen watt bulb located three feet above the goal box provided the only illumination in the experimental setting.

At each end of the runway, six inches from both the start and goal boxes, were photoelectric cells which controlled the operation of two standard electric timers. Latencies were thus measured over six inch and thirty-six inch distances. Raising the second start box door (plexiglas)
tripped a microswitch which activated the first clock. The time which elapsed between raising the start box door and breaking the first light beam (starting latency) and elapsed time between the two beams (running latency) was measured to the nearest .01 second.

Procedure

Pre-experimental Training. One week prior to the onset of training, the subjects were placed on a twenty-two and one-half hour food deprivation schedule. Feeding was permitted in solitary cubicles three and one-half inches wide by eleven inches long by five and one-half inches deep where the subjects had access to Purina Laboratory Chow and water for one and one-half hours. On the last day of experimental training, the subjects were fed wet mash in place of the laboratory chow they had previously received. After each feeding the subjects were returned to the home cages. Subjects had access to water at all times in the home cages.

On each of the last four days prior to training, each subject was handled for approximately three minutes per day. Subjects were habituated to experimental apparatus by permitting them to roam about for one and one-half hours in a neutral grey Y-maze with both a white and a black goal box.
Runway Procedure. On each day of training, subjects first received four acquisition trials in the runway to a one-third gram pellet of wet mash. After they were placed in the start box, a ten second delay was imposed before the first of the two start box doors was opened. Two seconds after the opaque door was raised, the plexiglas door was raised allowing the animal to run to the goal box. Animals which remained in the start box longer than sixty seconds were given both a sixty second starting latency and a sixty second running latency for that trial. If, however, an animal broke the first beam in less than sixty seconds, but failed to break the second beam in sixty seconds, he was given the starting latency he obtained and a sixty second running latency. Subjects which took considerably longer than the sixty second maximum imposed on each of the two measures were pushed gently down the runway and into the goal box. All subjects were left in the goal box until the food pellet was consumed and were removed immediately thereafter.

Solutions. Two solutions were employed in the experiment. The first solution was a Ringer's solution made up in accordance with the following formula:

1. NaCl - 0.7 grams
2. CaCl₂ - 0.0026 grams
3. KCl - 0.035 grams
4. Distilled water - 100 cc.

(Todd et al., 1957, p. 931)
The second solution was one Normal NaCl (58.6 grams/liter distilled water). This solution was chosen because it enabled the Experimenter to readily measure the size of the injection for each animal (1cc = meq NaCl).

**Injection Procedure.** Approximately fifteen minutes after a group of subjects had received their four acquisition trials, they were removed from their home cages and transferred into a brightly lit office. Subjects were weighed each night as the size of the injection was based upon the body weight of the rat (1cc/100 grams body weight).

The following procedure was used in making injections: Subjects were rolled, head and shoulders inside, in a heavy opaque cloth. The animal was held firmly on the table with one hand and the other hand was used to start a stop watch as soon as the injection was completed. A second experimenter pulled up the loose skin of the back with a thumb and forefinger, thus producing a natural "pocket" at the base of the skin. Injections were made into this pocket with a No. 23 hypodermic needle.

**Experimental Procedure.** Table I summarizes the experimental conditions imposed upon the various groups. Subjects which received injections were immediately placed upon a table twenty-three inches by forty-nine inches and allowed to roam about for 300±5 seconds.
Following the five minute delay, animals were placed in the black boxes where they remained for 15 minutes ± 10 seconds before they were returned to the home cages. Approximately ten minutes later they were allowed to eat for one and one-half hours in the feeding cubicles.

Acquisition trials were continued for thirty-seven consecutive days, experimental conditions beginning on day two and running, unchanged, through day thirty-one. On day thirty-two, injections were omitted from the experimental conditions. The last five days thus provided extinction data for any drive conditioning which might have occurred.

**TABLE I**

<table>
<thead>
<tr>
<th>Group</th>
<th>Injection</th>
<th>Delay on Table</th>
<th>Time in Black Box</th>
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<tbody>
<tr>
<td>B</td>
<td>None</td>
<td>None</td>
<td>15 min.</td>
</tr>
<tr>
<td>S</td>
<td>NaCl</td>
<td>20 min.</td>
<td>None</td>
</tr>
<tr>
<td>SB</td>
<td>NaCl</td>
<td>5 min.</td>
<td>15 min.</td>
</tr>
<tr>
<td>RB</td>
<td>Ringer's Solution</td>
<td>5 min.</td>
<td>15 min.</td>
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RESULTS

Qualitative Results

Perhaps one of the more unusual findings lies in the comparatively large number of injections which the Experimenter was able to administer. Wayner and Kemanis (1958), it will be remembered, had reported discontinuing their study of repeated injections of saline after the fifteenth trial because of painful reactions and deleterious effects of saline. In the present study the Experimenter was able to give thirty such injections without observing any extremely painful reactions on the part of the subjects. This finding would suggest that injection procedure may play a large part in establishing the limit of subcutaneous saline injections. Additional research on the subject would certainly seem "apropos".

In regard to the physiological effects of repeated injections, the Experimenter observed that a considerable amount of scar tissue developed as a result of the repeated exposure to hypertonic saline and no such reaction occurred with Ringer's solution.
Quantitative Results

Because Hullian theory (Hull, 1952) linearly relates running speed to the concept of excitatory potential (which, other things equal, is directly related to the strength of drive) it was necessary to convert the obtained latencies into speed measures. This was done by multiplying the reciprocal of each obtained latency by ten (10/t). An average of these reciprocals for each subject over groups of six trials (last three trials on each of two consecutive days) was computed to yield mean starting (running) speed scores for each subject for each block of trials. These scores were those used in the statistical analyses.

Graphic representations of the group means of the above scores appear in Figures 1 and 2. Figure 1 is a plot of group mean starting speeds over blocks of trials; Figure 2 is a similar plot of running speeds. Inspection of these two figures reveals a marked split between the four groups. Group RB and S perform at a higher level than groups SB and B.

For purposes of statistical analysis an asymptotic portion of the curves (blocks 13-16) was chosen for an analysis of variance. The first step prior to this analysis involved a homogeneity of variance test which yields a $p > .05$, thus satisfying the assumption of homogeneity. Following this the analysis of variance was run and an F-ratio of 4.45 was obtained. This is found
to be highly significant (p .01 for 3, 36 degrees of freedom).

A series of \( t \)-tests were run over all possible combinations of groups. The resulting \( t \)'s for starting and running speeds, and the corresponding significance of each are reported in Table II.

**TABLE II**

Computed \( t \) values for mean starting speed differences (\( t_s \)) and mean running speed differences (\( t_r \)) between groups (blocks of trials 13-16).

<table>
<thead>
<tr>
<th>pair</th>
<th>( t_s )</th>
<th>( t_r )</th>
<th>degrees of freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-S</td>
<td>2.10*</td>
<td>0.93</td>
<td>18</td>
</tr>
<tr>
<td>B-SB</td>
<td>0.35</td>
<td>0.81</td>
<td>18</td>
</tr>
<tr>
<td>B-RB</td>
<td>2.95**</td>
<td>1.82</td>
<td>18</td>
</tr>
<tr>
<td>S-SB</td>
<td>1.69</td>
<td>2.29*</td>
<td>18</td>
</tr>
<tr>
<td>S-RB</td>
<td>0.75</td>
<td>1.16</td>
<td>18</td>
</tr>
<tr>
<td>SB-RB</td>
<td>2.50*</td>
<td>3.61**</td>
<td>18</td>
</tr>
</tbody>
</table>

* p .05  
** p .01
Figure 1. Mean Starting Speed from Runway in Blocks of Six Trials (last three trials on each of two consecutive days).
Figure 2. Mean Running Speed from Runway in Blocks of Six Trials (last three trials on each of two consecutive days).
DISCUSSION AND CONCLUSION

The nature of the experimental design would suggest that the starting speed measure would be the most sensitive index of the conditioned drive. Both the black boxes and the start box were smooth black cubicles, and we would expect to get the most stimulus generalization between these two. For this reason, and because running speeds and starting speeds have fallen in the same relative positions, the following discussion shall be confined to starting speeds under the assumption that the same interpretations shall apply in both cases.

First, the failure of group SB to perform at a higher level than did the remaining groups clearly does not lend support to the prediction formulated earlier. The fact that group SB performed at approximately the same level as did group B, which received no injections, argues against the assumption that any drive conditioning occurred.

The superior performance of groups RB and S was not expected and, since their performances were higher than groups SB and B, requires explanation. A number of such explanations are possible. The first, and most parsimonious, is that the observed differences are
due to sampling errors. It could be that groups S and RB were composed of faster animals. The random assignment of subjects to groups and the lack of clear cut differences on the first block of trials argues against such an explanation, but the possibility does remain, especially with the relatively small number of subjects in each group.

A second possible interpretation involves ignoring the data of group RB. If this is done, it can be seen that the two inferior-performance groups, SB and B, both had daily sessions in the black boxes while the superior performance group, S, did not. It is possible that extensive experience with the black box resulted in the conditioning to the black boxes of behaviors (e.g. sitting quietly) which would interfere with the performance of the instrumental response (running). Such conditioning could not have occurred in group S. The application of this interpretation to group RB, however, clearly does not account for their data. Actually, very little is known of the behavioral effects of Ringer's solution other than that it does not produce thirst as rapidly as does hypertonic saline. It could be that this solution produces behavioral effects that would preclude the conditioning of competing responses to the black boxes. It is obvious that much research effort could and should be directed at delineating the non-thirst effects of these and other solutions.
Whatever the explanation of the unexpected results of the present study, the fact remains that no evidence suggestive of drive-conditioning was obtained. Thus, we are left with a serious gap in the empirical verification of part of one of psychology's most influential theories. The parsimony and "elegance" of the Hullian formulation of learned drives, plus its abundant verification with aversive primary drives, has made the formulation one of the most widely accepted in the field of motivation in recent years. Yet, the repeated failure to verify the proposition with primary appetitive drives poses a serious problem, theoretically and/or empirically.

Briefly, it would appear that there are three alternative answers to the state of affairs outlined above: (a) There is no such thing as a learned drive based upon appetitional primary drives. (b) There are learned drives based upon appetitional primary drives, but the Hullian type of formulation of how they develop is incorrect. (c) There are such learned drives, and the Hullian type of formulation is accurate, but inadequate experimental methodology has prevented an adequate empirical demonstration.

If one accepts the first of these alternatives, then one is placed into the position defended so ably in recent years by Judson Brown (1953), that of interpreting complex human activities primarily in terms of the single learned drive of anxiety (c.f. p. 9). While it would
appear that such a position cannot be attacked successfully on formal grounds, a priori considerations of the complexities of human behavior would argue against such a parsimonious conceptual scheme. At the same time, if one prefers to use the Hullian theoretical approach, then a restricted motivational scheme such as that employed by Brown appears preferable as it does not go very far beyond the evidence.

Acceptance of the second alternative places one in the position of providing an alternative theoretical scheme. While a consideration of various behavior theories is beyond the scope of this paper, it is the writer's opinion that rival theories have not presented more adequate conceptualizations of the phenomena (and the lack of phenomena) in the field of learned drives. This may be due to the fact that rival theorists to a large extent, have not yet addressed themselves to this problem.

The third alternative is attractive insofar as it suggests that the resolution of this problem depends, in considerable part, upon the accumulation of more data than exists at present. If, as has been suggested, the major methodological problem involved here is that of the rapid evocation of appetitional drives, then an adequate demonstration of learned drives in this area may wait upon the development of adequate techniques for drive evocation.
The induction of thirst via saline injections would appear to be the only such technique widely available at the present time. Until new techniques for rapid appetitional drive evocation become available, the writer would strongly urge that further attempts be made to demonstrate a learned drive based upon saline-induced thirst. As we have seen, certain factors in the present experiment may have operated to prevent a demonstration of drive-conditioning. It is to be hoped that such factors can be circumvented in future studies.

The equivocal results of the present study might be partially resolved by incorporating the following procedure in a future study. Subjects could be trained, in the runway, to run to a pellet of food. After performance had reached asymptote the animals could be assigned to the various groups in a manner which permitted equating group mean speeds. This procedure would eliminate the possibility of assigning several high performance subjects to the same group. After subjects had been designated to the various groups, the experimental conditions could be imposed. With the performance of each group equal, any changes which occurred could be attributed directly to the conditions and not to possible chance factors resulting from the random assignment to groups.
In conclusion, it appears that two summary statements may be drawn from the present study. 1. The present experiment failed to demonstrate a learned drive based upon thirst. 2. The theoretical assumption that learned drives develop simply through the association of previously neutral stimuli with the evocation of primary drives does not appear warranted at the present time in the field of primary appetitional drives such as hunger and thirst.
SUMMARY

This investigation was an attempt to demonstrate an acquired or learned drive based on the primary drive, thirst. Neal Miller (1951) has suggested that a major part of the difficulty involved in demonstrating such phenomena (learned drives based upon primary homeostatic drives) is due to a lack of contiguity between the conditioned stimulus and the rapid onset of the primary need state; i.e., appetitive drives typically develop very slowly.

To circumvent this problem the Experimenter attempted to induce thirst artificially by means of subcutaneous injections of hypertonic saline. Following injections, subjects were placed in black boxes where they remained until a state of intense thirst had developed. In adopting this procedure the Experimenter had hoped to condition the state of thirst to the dark, black environment of these boxes. It was assumed that any conditioning which occurred would function as an irrelevant drive in a black runway when hungry subjects ran to a pellet of food. Consequently, it was hypothesized that both starting speeds and running speeds of the experimental group, in the runway situation, would exceed those of the
appropriate control groups.

The experimental findings did not support the hypothesis; i.e., the experimental group ran slower than two of the control groups. Various alternative interpretations were proposed and their implications for current motivational theories were considered. Additional research was suggested.
REFERENCES


APPENDIX A

Pilot Study I

The purpose of this study was to determine the relative abruptness of the onset of a thirst condition following subcutaneous injections of a one normal (5.62%) solution of hypertonic saline or an oral (stomach-loading) injection of a fifteen per cent solution. The one normal solution was used because it permitted the Experimenter to transform the volumes of solution injected, directly into milliequivalents (meq's) of sodium chloride (1 meq = 10c). This made it possible to compare the results of this study with those of other experimenters who have tended to report saline injections in terms of meq's/100 grams of rat wt. The fifteen per cent solution was also used for purposes of comparison with other research.

It was assumed that latency to onset of drinking following the injection would be a good index of the time involved in reaching the thirst threshold. The following procedure was employed.

Procedure

Seven albino rats (three males and four females) were placed on a twenty-two hour deprivation schedule with ad lib access to water. The males and females were
housed in cages of three and four respectively. For four consecutive nights subjects received saline injections; subcutaneous or oral injections the first night, and subcutaneous injections on the remaining nights. (See Results for explanation.) As soon as the injection was completed a stop watch was started and the subject was immediately placed in a small solitary cubicle equipped with a water bottle. The Experimenter recorded the time that elapsed between the completion of injection and onset of drinking. Additional behavioral observations were made and will be discussed below.

Results

The mean drinking latencies for the subcutaneous and oral injections are six minutes and eighteen seconds and twenty-eight minutes and thirty-two seconds, respectively. As previously stated the oral injections were discontinued after the first night. Following an injection of fifteen per cent saline subjects typically went into a state which we came to refer to as "saline shock." In this condition the animals appeared to be dead; i.e., they laid on the injection table motionless, many times on their side or back depending upon the position they were in when the Experimenter released them. Whether this effect was due to an overload of saline or the trauma of having the catheter forced down their throats is not known. The
injections were discontinued because of the long latency to onset of drink and the possible behavioral variables which might accompany "saline shock", if this procedure was employed in the major study.

The first night of subcutaneous injections found the subjects reacting violently to the needle and accompanying pain. By the time the fourth injection had been completed, however, subjects were found to be much easier to handle. This fact, coupled with the relatively short latency and ease of injections, caused the Experimenter to select the subcutaneous injection for the attempted acquired drive demonstration.

To reduce the possibility of conditioning pain to the black boxes, the Experimenter decided to impose a five minute delay on the experimental group before placement in the boxes. This procedure also reduced time in the box before the thirst condition developed.