RUNNING SPEED IN THE LONG PATH OF A SINGLE CHOICE MAZE
AS A FUNCTION OF FRUSTRATION
IN THE SHORT PATH

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CHAPTER I

INTRODUCTION

The investigation of effort and its effects has, for the most part, been limited. This is due probably to the belief stemming from Hull's theory that work is an aversive stimulus to be avoided, given the choice, and that it results in decrements in response strength when applied. Recent investigations, however, have caused both assumptions to be questioned and indicate that effort may even enhance the effect of stimuli associated with it.

The literature on effort or work can be divided into two main issues: (a) What are the effects of an organism's expenditure of effort upon the next effortful response? and (b) once an effortful response has been made and effort is no longer present, what are the effects of that effortful response?

The concept of effort was first introduced by Hull as the input variable of work in his Principles of Behavior (7). One of Hull's hypotheses concerning work was called the "least effort hypothesis" which stated:

If two or more behavioral sequences, each involving a different amount of energy consumption of work, have been equally well reinforced an equal number of times, the organism will gradually learn to choose the less laborious behavior sequence leading to the attainment of the reinforcing state of affairs (7, p. 294).
Later, Hull restated the hypothesis as follows: "Other things being equal, organisms which are presented with alternate paths in detouring about a barrier to an adjacent object will learn to prefer the one involving the shorter distance" (8, p. 257).

Hull's view of effort has been open to two kinds of tests. The first examines whether, if two responses are followed by the same reinforcement, the organism will tend to choose the less effortful of the two. De Camp (3), Gengerelli (6), and Kuo (9) have demonstrated that rats will learn to traverse the shorter of two paths leading to the same goal. Thompson (14) studied the functional relationship between the rate of learning and the absolute value of the amount of "work" involved in making a response. Rats were run in a learning situation consisting of a T-maze and involving the operation of levers which required differential amounts of pressure to obtain a similar reward. The results showed that the animals learned to prefer the arm containing the lever easiest to press. In the conclusion, Thompson stated:

...the data appear to support Hull's deduction that in a situation involving the alternative responses animals will develop a preference for the one involving the lesser amount of effort when the temporal factor is equalized, but they indicate further that the development of this preference will proceed more rapidly when the absolute amount of work involved in the two responses is increased while the work ratio of the two responses is held constant (14, p. 515).

The previous experiments had little bearing on the value of the goal or of the reinforcer itself. They related primarily
to the choice of paths to a goal. The following experiments are interested in the consequences of effort on a stimulus event once effort is expended. That is, does the expenditure of effort enhance a stimulus event associated with the effortful experience? The value of a stimulus event, either a primary or secondary reward, was tested either by choice or by the strength of the instrumental response necessary to obtain the reward. In any test of the value of the reward, the original effort conditions were not present.

Wright (15) argued that the presence of a barrier between a subject and a desired goal increased the positive valence of that goal. In a series of experiments with children, Wright reported their preference for an object that was less accessible than when it was easy to reach. He had the children indicate their preference both by their action (choice) as well as by their verbal report and used these as measures of the valence of the object. His experiment may be interpreted as indicating that anticipated effort enhances the preference or incentive value of a goal. It does not indicate, however, the effect of actually making the effortful response. Child and Adelsheim (2) repeated Wright's experiment and reported that there was no uniform tendency to choose a barred object but the greater generality was an opposite tendency to choose the more available of two objects. The authors gave several reasons why a child might choose a barred object. First, the individual might have become satiated with respect to the easily available goal.
Second, the barrier itself or the activity of overcoming it has a goal value. Third, the belief that an object that is difficult to attain is better than an object more easily obtained. Next, previous learning sequences may lead a child to prefer a barred object. Finally, a certain amount of social reward is received for choosing the more difficult route to a goal.

Festinger's (4) theory of cognitive dissonance is also relevant to the problem of effort and value. Festinger defined cognitive dissonance as occurring when two cognitive elements are not in agreement. When dissonance occurs, the organism is motivated to reduce the dissonance by changing one or both elements until they agree. Festinger (5), specifically discussed the theory's relevance to effort and value. He contended that when an organism obtains an "insufficient reward" relative to a particular expenditure of energy, there will be a tendency to discontinue the effortful activity or to attribute additional value to the activity or to its goal consequences. The development of an "extra preference" for the activity or its goal consequence is conceived as resulting from an internal process of dissonance resolution; that is, the receipt of a reward incommensurate with the effort expended in its attainment leads to a state of cognitive dissonance that the organism is motivated to reduce.

In a study by Aronson (1), preference was directly assessed following a series of unrewarded trials on tasks which required "considerable expenditure of energy" for one group and were
"almost effortless" for another group. Aronson hypothesized that as effort increased, stimuli associated with a lack of reward would become more attractive. He also stated that since any effects due to secondary reinforcement should remain constant regardless of effort, stimuli associated with a lack of reward would become more attractive as effort increased. The results of the experiment demonstrated that the degree of effort a person expended in attempting to achieve a reward had an effect on the relative attractiveness of stimuli associated with rewarded trials and stimuli associated with nonrewarded trials. In the Easy condition, there was an increase in the relative attractiveness of the rewarded color. In the Effortful condition, however, there was no change in the relative attractiveness of the two colors. The Effortful group showed a clear preference over that shown by the Easy group for irrelevant aspects (secondary reinforcement) of the goal situation. The results, therefore, were interpreted in terms of an interaction between the effects of cognitive dissonance and those of secondary reinforcement.

Olds (13) used children in an experiment attempting to show that "wanting-practice" affects the value of a secondary reinforcer. Practice in "wanting" was varied by using a task in which differences in expended effort could be introduced. This was done by varying the number of turns of a crank necessary to attain a reinforcer. In Experiment I, fourteen children were habituated to a stimulus response sequence of the form
by long over-learning. Then, during delay treatment, the sequence was repeated except that, by reference to the habituation sequences, the $R^1-S^r$ interval was four times for Group A, 2.5 times for Group B, the same for Group C, and one-third for Group D in relation to what it had been during habituation. Measures before and after the delay treatment showed that the groups which experienced the delay in $S^r$ (A and B) increased their valuation of $S^r$ significantly as compared with control Group C. Group D showed a slight and nonsignificant decline in valuation of $S^r$ as compared with the control group.

In Experiment II, twelve subjects of Experiment I were divided into two groups and treated like Groups B and C of Experiment I. Two measures were taken before the delay treatment and two measures were taken after the delay treatment. One (prior-post) pair was taken when $S^r$ had small instrumental value, the other when $S^r$ had high instrumental value. Group B showed significant value gains (as compared to control Group C) only when the instrumental value of $S^r$ was low. However, the difference between the differences was not significant.

The results were interpreted as indicating that "wanting-practice" increased the reward value of $S^r$. While the results may be interpreted as indicating that effort directly affects the value of $S^r$, they may also be interpreted as indicating that the $S^r$ value is constant, but that the children in Groups A and B turned with greater pressure simply because they experienced an increment of drive attributable to frustration.
Three recent and related experiments have been directly concerned with the problem of whether a stimulus event undergoes changes in value as a function of the effort expended during the response it reinforced.

Lewis (10) used first- and sixth-grade boys subjected to either a high- or low-effort procedure to obtain twenty poker chips. The experiment was designed to investigate whether a stimulus event used as a positive reinforcer undergoes changes in value as a function of the effort expended during the response that it reinforced. Effort was varied by altering the number of turns of a crank handle necessary to obtain a single chip. Two measures of value were used: (a) preference or incentive value—the tendency of the cue aspects of the stimulus event to elicit approach responses resulting in its attainment—was assessed by determining the number of alternative chips (differing in color from the training chip) the child would exchange for the training chips; and (b) reinforcement value—the effect of presentation of the stimulus event (training chip) upon the probability of occurrence of a subsequent new response—was assessed in a binary choice problem where the chips were used as reinforcers for a correct response. While the preference value failed to show the effects of effort, the reinforcement value of the chips was affected so that those associated with high effort were more effective in increasing the probability of the occurrence of the desired response than were those associated with low effort. These results, therefore,
lend support to the hypothesis that effort can increase the value of a stimulus event used as a positive reinforcer.

In a second study using animals as subjects, Lewis (11) again tested whether the reward value of an object is functionally related to the amount of effort required to obtain that object. Three experiments were used to test the hypothesis. The rats were required to pull weights in order to obtain a minimal amount of a food reward. Four weight groups were used: five, thirty, fifty-five, and eighty grams. The weight that the subject pulled was constant from trial to trial.

After the training periods the weights were removed and not used during the testing procedure. During the test phase of the experiments, value was assessed in three ways: the running speed to the food in the straight alley maze, the speed with which the animal consumed the food, and the amount of food consumed in a free eating situation when the animal was satiated on another food.

The results of all three experiments were consistent and tended to occur for all measures in the direction predicted by the hypothesis. The hypothesis that effort can affect the value of a goal object as a reinforcer during the initial effort experience was supported. The subjects expending the greatest effort in the training series developed the strongest preference for the food. The subjects in this group had a faster eating rate, and consumed a greater amount of food than the subjects in the less effort groups.
In a final experiment, Lewis (12) tested the hypothesis that a secondary reinforcer associated with high effort would be preferred to the same secondary reinforcer associated with low effort. Preference was measured in two ways: (a) subject's choice in a T-maze, and (b) time spent in the presence of the secondary reinforcer. Each animal experienced both high and low effort conditions associated with either a vertically or horizontally striped area. Half of the subjects experienced high effort with vertical and low effort with horizontal stripes. The other half experienced high effort with horizontal and low effort with vertical stripes. During the test phase, the animal, without weights, was given a choice between the striped areas and the total time spent in each arm was recorded. There was no reinforcement given during the test trials. The results demonstrated that effort is effective in influencing the value of a secondary reinforcer.

From the above experimental data it has been shown that animals when given a choice learn to make the least effortful response leading to a goal. Other experimental data has also shown that the reward value of an object is functionally related to the amount of effort required to obtain that object. On the basis of this empirical evidence it was assumed that the subjects in this investigation would also learn to make the least effortful response and the reward value of an object would increase as effort was increased.
Lewis (11) has listed four theoretical positions that could account for the reward value of an object being functionally related to the amount of effort required to obtain that object. They were (a) cognitive dissonance theory, (b) frustration, (c) proprioceptive stimuli, and (d) attentional factor. According to the concept of frustration, high effort is seen as interfering with a goal directed response and therefore results in frustration which increases the general drive level of the organism. The effort does not directly affect the value of the external reinforcement but affects the drive level and any consequent reinforcement of drive reduction. Therefore, any reinforcer associated with this increased drive acquires a higher value because it is associated with the reduction of a higher drive state. The purpose of the present study was to further investigate the effects of frustration on the reward value of a goal object.

Under the assumption that animals will learn to take the shortest path to a goal and that the reward value of an object will increase as effort increases, the following hypothesis was proposed:

If rats are frustrated in the short path of a single choice maze (experimental group) then the experimental group's running time for the long path will be less than that of a control group not frustrated in the short path.
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CHAPTER II

METHOD

Subjects

The subjects consisted of twenty-three male, naive, Sprague-Dawley albino rats approximately sixty days old, from Ferguson Laboratory Animal Supply. The original sample consisted of twenty-four subjects but one subject in the experimental group died after five days of training.

Apparatus

As shown in Figure 1, a single choice maze with a long and short path leading to the goal was used.

![Diagram of experimental apparatus]

Fig. 1—Diagram of experimental apparatus
The maze was constructed so that both the right and left side could serve as either the long or short path. The short path was six feet long and the long path twelve feet long. The alleys were two and seven-eighths inches wide and three and five-eighths inches high and covered by one-fourth inch square hardware cloth. The dimensions of the start and goal boxes were identical. They were seven and one-half inches long, six and five-eighths inches wide, and three and five-eighths inches high. The entire maze was painted flat black except the goal box, which was gray. All doors in the maze were of the guillotine type and were operated remotely by the experimenter.

As shown in Figure 1, a delay box was located midway in each of the short paths. A standard stop watch was used to record running time.

Design

A two group design was used. Each subject was assigned a number before training began. A table of random numbers (1) was then used to assign the subjects to groups. After the subjects were assigned to groups a coin was flipped to determine which group was to be the experimental and which the control group. The experimental group was frustrated in the short path, while the control group was not frustrated in the short path.

Running speed for the long path was defined as the total time in seconds a subject took to traverse the maze from start to goal box. For the purpose of this experiment, frustration was defined as a ten second delay in the short path of the maze.
Procedure

All subjects were maintained on a thirty-hour food deprivation schedule and ad libitum water schedule.

A pretraining program was conducted in a ten-foot straight alley. Each subject ran four trials a day until three out of four successive trials were run within twenty seconds.

The training trials were not begun until all subjects completed pretraining. On the first training trial both the right and left paths were made long. The path chosen by the subject on this trial became the long path for that subject for the remainder of the experiment. On the second trial, the subject was forced to take the opposite, shorter path. Each subject was given four trials daily, two long and two short, for fifteen days, totaling sixty trials. Since the order of presentation of the trials had six possible combinations, the combination for each day was assigned randomly. A table of random numbers (1) was used to make this assignment.

The Experimental Group was delayed in the short path for ten seconds and then allowed to continue to the goal box. The Control Group was not delayed in either path.

The subjects were allowed to eat in the goal box for one minute after each trial. The intertrial interval was thirty seconds. The running time required for the long path for each subject was recorded.
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CHAPTER III

RESULTS

Figure 2 represents the mean running time of the experimental and control group for the long path during training. The means were computed for each block of five trials.

Fig. 2--Mean running time for control and experimental groups in the long path during training.
A $t$ test for matched groups was applied to the mean time for the first and last five trials for the experimental and control groups. The control group showed a significant decrease in running times ($t = 2.96$, d.f. = 11, $P < 0.02$) as did the experimental group ($t = 5.06$, d.f. = 10, $P < 0.001$).

A $t$ test for randomized groups was then used to test the overall difference between the means of the experimental and control groups. The resulting $t$ was $0.771$ ($P > 0.1$). Since the 0.05 level of significance was used, this $t$ value was not significant. It is therefore not possible to reject the null hypothesis. As a result, the empirical hypothesis is not accepted. Table I represents a summary of the $t$ test for randomized groups.

**TABLE I**

**SUMMARY OF $t$ TEST FOR THE DIFFERENCE BETWEEN THE MEAN RUNNING TIMES OF THE EXPERIMENTAL AND CONTROL GROUPS**

<table>
<thead>
<tr>
<th>$\bar{X}_C$</th>
<th>S.D.</th>
<th>$\bar{X}_E$</th>
<th>S.D.</th>
<th>$t$</th>
<th>$P$</th>
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<tr>
<td>29.07</td>
<td>20.57</td>
<td>23.75</td>
<td>8.25</td>
<td>.771</td>
<td>N.S.</td>
</tr>
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The results in Table I, as presented in Chapter III, reveal no significant difference in the running times for the experimental and control groups although the difference was in the direction predicted. Therefore, the results do not support the empirical hypothesis.

DeCamp (2), Gangerelli (3), and Kuo (5) have demonstrated that rats will learn to traverse the shorter of two paths leading to the same goal. For the purpose of this study it was assumed that the subjects in the control group would also learn to prefer the shortest of the two paths.

Brown and Farber (1) have defined frustration as a hypothetical state or condition of an organism. As for the operations required to produce frustration, the authors felt that the common assumption among experimenters was that frustration developed under any conditions that hindered or prevented the occurrence of a response to which there was a supraliminal excitatory potential. They also delineated a number of manipulable conditions which could be defined as antecedents to frustration. Among these conditions were (a) the introduction of partial or complete barriers, (b) a delay period between the initiation and completion of a response sequence, (c) the omission or reduction of a customary reward or one
or more trials, and (d) other variations in the organism's condition, environment, or training leading to evocation of a response tendency that is incompatible with an ongoing one.

Since all trials were forced, the control subjects were not allowed to choose the path they preferred. Having assumed the control subjects would have preferred the short path, it is suggested that frustration was induced when the short path was blocked. It is further suggested that this increment of frustration served to enhance the value of the goal object when the subjects in the control group were forced to run the long path.

As for the experimental group, no evidence of a greater preference for the short path was observed during the course of the experiment. This can be explained by Hull's (4) goal gradient hypothesis. The goal gradient hypothesis as Hull originally formulated it is as follows:

The mechanism . . . depended upon as an explanatory and integrating principle is that the goal reaction gets conditioned the most strongly to the stimuli preceding it, and the other reactions of the behavior sequence get conditioned to their stimuli progressively weaker as they are more remote (in time or space) from the goal reaction (4, p. 25-26).

Since the subjects in the experimental group were delayed in the short path, it is suggested that their responses in the short path were not as strongly conditioned as those in the long path.

It is therefore concluded that both groups experienced an increment of frustration, increasing the value of the goal object for both groups. Because of this confounding of the
independent variable, the results cannot be generalized to any larger population, nor can the results be interpreted as refuting the findings of previous experimental studies in this area.
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CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

Twenty-three male, naive, Sprague-Dawley albino rats were used as subjects in the present study. This study was an attempt to further investigate the effects of frustration on the reward value of a goal object.

The following hypothesis was tested: If rats are frustrated in the short path of a single choice maze (experimental group) then the experimental group's running time for the long path will be less than that of a control group not frustrated in the short path.

The subjects were run in a single choice maze for sixty trials. The experimental group was blocked in the short path for ten seconds, inducing frustration. The running time for the long path was recorded for both experimental and control group.

No significant difference was found to exist between the running times for the two groups. However, the difference between the two groups was in the direction predicted. It was concluded that the experimental procedure produced an increment of frustration in both groups, thereby increasing the reward value of the goal object for both groups.
Recommendations

On the basis of the results and conclusions of this investigation a modification of the experimental design seems appropriate. It is suggested that instead of forcing all four trials a day, the last two trials be free runs in which the subject could choose the path to the goal. After all subjects had reached some criterion of performance, extinction trials could be administered to test for the reward value of the goal.
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