A GESTALT VERSUS A STIMULUS RESPONSE ANALYSIS OF REASONING IN THE RAT

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By

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I. HISTORY

> The psychology of animal learning . . . has been and still is primarily a matter of agreeing or disagreeing with Throndike, or trying in minor ways to improve upon him. Gestalt psychologists, conditioned--reflex psychologists, sign--gestalt psychologists--all of us here in America seem to have taken Thorndike, overtly or covertly, as our starting point. (1, pg. 19)

At the end of the last century, on the basis of the puzzle-box experiments and others, Thorndike established a theoretical position of trial and error learning. He summarized his experiments in Animal Intelligence (7), and contended that in the random movements of the cat in the puzzle-box the correct response is eventually made by chance alone. Then, through a trial and error process of "stamping in" and "stamping out," the correct response is strengthened, and the incorrect responses are weakened.

This strengthening and weakening was, in part, referred to by Thorndike as the law of exercise. This includes the law of use, which is the strengthening of connections with practice; and the law of disuse, which refers to the weakening of connections when practice is discontinued.

Another of Thorndike's major formulations is the law of effect, which states that the consequences of a response have an effect upon the strengthening or weakening of that response. The strength of the response is increased when that response is followed by a satisfying state of affairs. Hilgard (1, p. 24) quotes Thorndike as writing:

> By a satisfying state of affairs is meant one which the animal does nothing to avoid, often doing things which maintain or renew it. By an annoying state of affairs is meant one which the animal does nothing to preserve, often doing things which put an end to it.

Thus, the correct response occurs by chance and is strengthened through repetition and the satisfying state of affairs following it. The incorrect responses are weakened because of the annoying state of affairs which follow them and are further weakened by disuse. Hilgard (1, p. 47) wrote:

> The flavor of Thorndike's theory has all along been that of the automatic strengthening of specific connections--directly without intervening ideas or conscious influences.

At least one constructive result, indirectly, came out of World war I, when Kohler was confined on the British controlled island of Tenerife. There, with his assistants and a cooperative colony of chimpanzees, he studied the problem solving behavior of chimps, and applied gestalt theory to the field of learning.

Kohler (4) described the intelligent problem solving behavior of his animals, and criticized Thorndike's trial and error position, and his conclusion that animals are not capable of reasoning or insight. Kohler felt that since cats are not ordinarily confined to boxes and required to push buttons in order to escape, the entire problem situation utilized by Thorndike was an unnatural one. The correct response in this situation, therefore, could be attained

in no other way but by chance, since the response was not within the animal's usual repertoire of responses.

The puzzle-box situation was also one in which the animal could not see all of the necessary components for the solution of the problem. Kohler (4, p. 3) wrote:

> As experience shows, we do not speak of behavior as being intelligent when human beings or animals attain their objective by a direct unquestionable route which clearly arises naturally out of their organization. But we tend to speak of "intelligence" when, circumstances having blocked the obvious course, the human being or animal takes a round-about path, so meeting the situation.

He then conducted experiments with chimpanzees in which the "direct way" was blocked and the animal had to utilize a "round-about way" in order to overcome the block and attain the objective. Kohler also required that the objective, the obstruction, and also the total field of round-about routes be in plain sight, and the required acts be within the normal repertoire of the animal.

One of Kohler's most quoted experiments, and one which illustrates the occurrence of insight and intelligent behavior by a chimpanzee, is the double-stick problem; which has, incidentally, also immortalized Sultan. Kohler (4, p. 125) described this situation thus:

> This time Sultan is the subject . . . his sticks are two hollow, but firm, bamboo rods . . . the one is so much smaller than the other, that it can be pushed in at either end of the other quite easily. Beyond the bars lies the objective, just so far away that the animal cannot reach it with either rod. Nevertheless he takes great pains to try to reach it with one stick or the other, even pushing his right shoulder through the bars.

Sultan continued to try to reach the fruit, making bad errors, and some "good errors;" (4, p. 125) such as when he:

> . . . pushes one of the sticks out as far as it will go, then takes the second, and with it pokes the first one cautiously towards the objective, pushing it carefully from the nearer end and thus slowly urging it toward the fruit. . . . thus, all of a sudden, for the first time, the contact "animal-objective" has been established, and Sultan visibly feels (we humans can sympathize) a certain satisfaction in having so much power over the fruit that he can touch and slightly move it by pushing the stick.

After watching Sultan's failures for over an hour, Kohler understandably left the task of observing to a keeper, who reported: (4, p. 126)

> Sultan first of all squats indifferently on the box . . . then he gets up, picks up the two sticks, sits down again on the box and plays carelessly with them. While doing this it happens that he finds himself holding one rod in either hand in such a way that they lie in a straight line; he pushes the thinner one in a little way into the opening of the thicker, jumps up and is already on the run towards the railings, to which he has up to now half turned his back, and began to draw the banana towards him with the double stick.

The conditions under which Sultan solved his problem illustrate insight and the use of a round-about path to an objective. In this instance, the direct path to the objective (fruit) was blocked by cage bars, and an indirect path of first putting two sticks together, and then combining this behavior with that of reaching for the fruit with the longer double stick had to be taken.

In Kohler's experiments, although he does not explicitly set up a theoretical framework complete with postulates, cer-

tain consistent underlying notions become evident. Kohler (4, p. 11) wrote:

> When any of these higher animals, which make use of vision, notice food (or any other objective) somewhere in their field of vision they tend--so long as no complications arise--to go after it in a straight line.

When this direct path is blocked, there is a tension created in the organism's psychological field, and this tension varies with the need for the goal and its distinctiveness from the background. Unresolved tension creates conductive forces, tempered by the physical barriers, or restraining forces of the geographical field. Thus Sultan persisted for over an hour, hovering near the cage bars with his two sticks, in futile attempts to reach the fruit.

In his discussion of the gestalt interpretation of problem solving, Osgood (6, p. 607) wrote:

> The unstable, fluctuating pattern of tensions in the psychological field tends to be minimized through sudden reorganizations, involving the perceptions of new paths to the goal.
>
> This sudden reorganization of forces in the psychological field is the occurrence of insight.

In describing the characteristics of insight, Osgood listed suddenness as the most obvious characteristic of an insightful solution. This differs from trial and error solutions, or usual conditioning, which are ". . . a gradual and irregular accretion."

Smoothness is another characteristic, and was illustrated by Sultan's quick, smooth transition from sitting on

the box to being ". . . already on the run toward the railing." Once the solution was apparent to the animal, there was no longer ambivalence or bad errors, but a smooth flow of behavior which resulted in success.

In the occurrence of insight, the solution preceded the execution of behavior; as contrasted with Thorndike's cats, which first, by chance, released the door-opening mechanism before learning the solution.

This seemed to be the most important characteristic of insightful behavior, as demonstrated by Kohler's animals, and was illustrated many times over with dogs, as well as with chimpanzees.

Here lies the primary difference between the approaches of Thorndike and Kohler. In the first, the animal's random movements bring about success, and are gradually narrowed through exercise and effect to the most effective behavior. The solution is the mechanical association, which is strenthened by the succeeding satisfying state of affairs.

In Kohler's formulation, however, even though he describes considerable trial and error behavior, this behavior does not seem to be completely random, and the recognition and solution of the problem precedes the experience of success. Arriving at the solution, then, does not depend upon what follows the behavior; but rather the solution precedes, in temporal sequence, the experience of success.

II. INTRODUCTION TO THE PROBLEM

In 1929, Maier (5) reported his work on the problem-solving behavior of white rats, from which he concluded that the "round-about-way" problems involved the formation of Gestalten. Maier constructed situations in which the animal could become familiar with a variety of paths; some of which led to the goal, and some of which did not. Then the primary path to the goal was blocked, and the problem for the animal was to utilize these experiences and arrive at the goal.

One of these mazes is shown in Figure 1, page 8. In this experiment, the animal was allowed to become familiar with the table top, and given practice in scaling the wall and exploring the various alleys, including the correct path. The animal then learned to run correctly from a box at point b, to the goal, F; which was inaccessible by any other means. The wire cage extended around it, but was open at the juncture of the alley and F. In the test situation, the animal was placed next to the wire cage at point A. Maier reported that after unsuccessfully attempting to get through, over, or around the wire cage, the animals all eventually solved the problem by leaving the area around A, scaling the wall, going directly to box b, and then taking the correct path to F.

After a number of experiments similar to this, Maier concluded that the solution of the problem illustrated the formation of patterns or Gestalten. In the experiment here

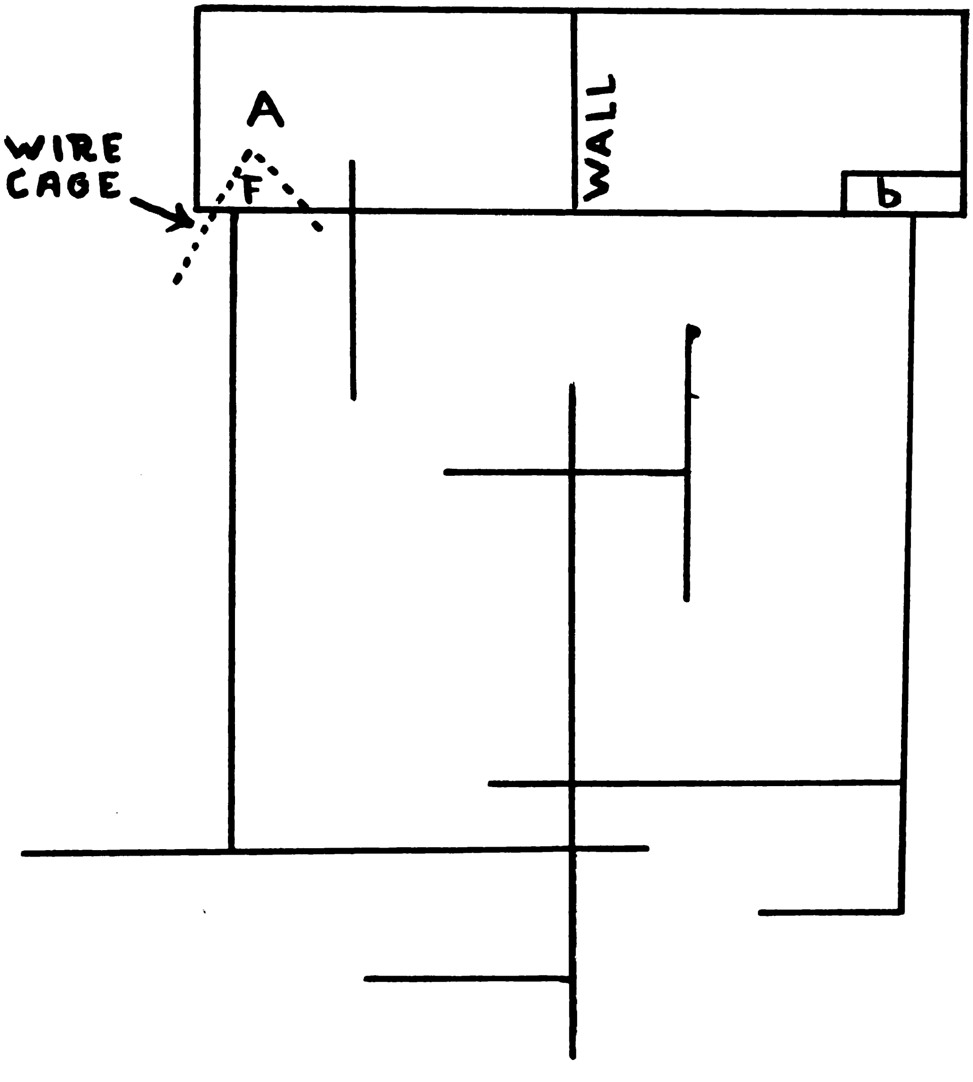

Figure 1. One of the mazes used in Maier's "reasoning" experiment. Animals were allowed to explore the maze and to approach food at F, without the barriers of the wall and wire cage. Then with the cage and wall in position the animal was placed at A. Unable to go directly from A to F, the animals showed "reasoning" by scaling the wall, entering box b, and taking the correct path to the goal, F. Maier, Comparative Psychology Monographs, 1929, 29: 11.

described, for example, the solution did not depend upon trial and error since the solution seemed already to have been arrived at when the animal left point A, scaled the wall and entered box b. Also, if we were to base an explanation on simple association, we would have to assume that point A is equally well associated with all other points on the maze. An explanation based on pure association, then, cannot account for the fact that the animals correctly chose the A to b run, rather than A to any other point.

Maier explained his results on the basis of the animals having experienced the following patterns: (1) A to F; (2) the pattern of the maze in general from exploring it; and (3) b to F. To solve the problem, a new path, A-b-F, must be formed through combining parts of the other patterns. This is a new combination of separate experiences and is not formed merely by repetition. Insight is the formation of this pattern, which is the solution, and does not depend upon trial and error, or simple association. Maier (5, p. 92) wrote:

> The concept of patterns or Gestalten thus seems to be a necessary assumption to explain these complex types of behavior. The fact that a rat can choose the shorter means to an end without previously having reached this end by any of these means, seems to make a pattern concept almost a necessity. A temporal chain is not sufficient, it must be an immediate whole.

Hull agreed that the solution of such problems depends upon more than simple association, or trial and error. He wrote: (2, p. 220, 21)

> . . . the genuinely creative and novelty-producing portions of the reasoning process take place in advance of the emergence of the substance of materials of the syllogism; i.e., the solution consists in the assembly, from the considerable store of such materials presumably possessed by the more versatile and adaptive organisms, of the particular set of premises which are relevent to the problem situation in question.
>
> . . . .
>
> Chance is evidently an element in intelligent behavior but, clearly, the dice of chance must be loaded in some way or problems would never get solved. In short, any adequate theory of higher adaptive behavior must show how the dice are loaded; i.e., how the characteristics of the problem situation are able to evoke the particular combination of acts which alone will serve to extricate the organism from its difficulty.

However, Hull felt that, although Maier had properly rejected the simple association explanation, his utilization of Gestalten was not explanatory. Maier had not demonstrated how these patterns were formed to bring about the solution. The real problem was to deduce the formation of the solution by the combination of behavior segments from more basic principles.

Hull then set up a conventionalized form of Maier's "reasoning" experiments; Figure 2, page 11. R is the starting box; while U, X, and H are goal boxes, each with its own distinctive stimuli. Animals would be taught, through forced trials, to run from R to X, and from U to X for food reward. After this is learned, they are taught to run, food satiated, but thirsty, from R to U, and R to H for water reward. In the test trials the animals are placed hungry at R, with the

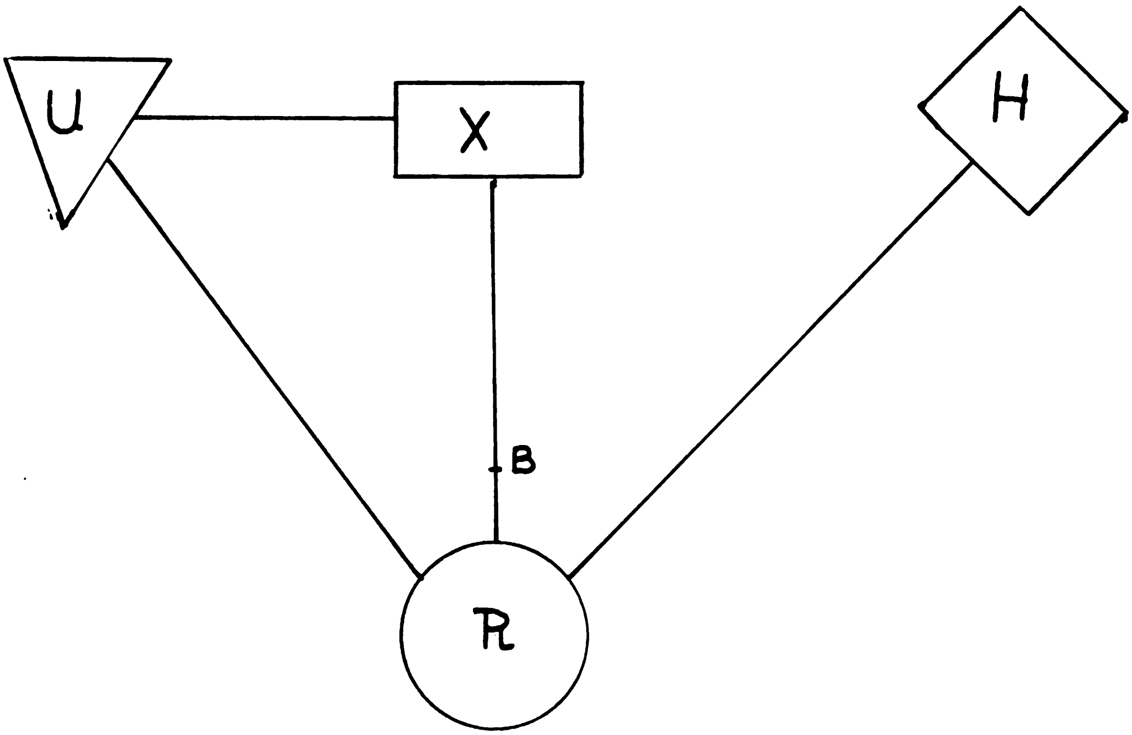

Figure 2. A conventionalized form of a maze used in Maier's "reasoning" experiments. Hull, Psychological Review, 1935, 42: 222.

previously-learned direct path, R-X, blocked at point B. The problem is for the animal to reach X, and the solution, of course, is to run the sequence R-U-X. That the animals do solve this type of problem is illustrated by Maier's experiments.

The essence of the problem as Hull views it is to show that the stimulus complex of R is more closely associated with the R-U response than with the R-H response. In learning the U to X path for food reward, the stimulus complex at U comes to elicit anticipatory food-taking responses, which are strengthened with each repetition of the U-X run. Thus, each time the animal is placed in the U goal box, it will respond to these distinctive stimuli by making the anticipatory goal responses and then the "correct" response of running the U to X path. Then, when running under water deprivation along the R-U path, the anticipatory food-taking responses, elicited in the past by the stimuli of the U goal box, are again elicited when the animal enters this goal box and are strengthened by the abatement of the water drive. Through repetition of reinforced R-U trials, the anticipatory food-taking responses become associated with alley I, and eventually with the R-U choice point in the starting box, R.

In contrast, with this, goal box H has never been associated with food. Anticipatory food-taking responses will then not be elicited by the stimulus complex of goal box H and, of course, will not become associated either with alley III, or with the R-H choice point in the starting box. Then, when the animal is placed hungry in the starting box, the proprioceptive cues contingent upon food deprivation will elicit anticipatory food-taking responses; and since these are already differentially associated with the R-U choice point, the animal will tend to make this response rather than the R-H response. Once in goal box U, the problem is solved and the animal quickly runs the previously learned U-X path and arrives at the goal.

In this way Hull explained the solution of the problem by the animals without referring to any higher mental processes as reasoning or insight, but by deducing the operation of intermediary S-R mechanisms as representational processes.

III. STATEMENT OF THE PROBLEM

Osgood (6), in his discussion of Hull's treatment of the problem, points out that this explanation depends upon a certain sequence of training. That is, the anticipatory food-taking responses must be already associated with the stimuli of box U in order for them to be reinforced on the water trials to U and then to become associated with alley I (see Figure 3, page 17) and then chained back to the R-U choice in the starting box. If the training sequence were reversed, if the water acquision trials preceded the food acquisition trials, then the fractional anticipatory goal responses elicited by the stimuli at box U would not become associated with alley I, and the R-U choice in the starting box. There would be, then, no loading in favor of the R-U choice, and in the test situation the animals should make the correct choice with no better than chance success.

According to Maier's explanation, however, the sequence should have no effect upon the test choice, since the formation of gestalten does not depend upon the sequence, but upon the combination of parts of separate experiences into a new and correct pattern.

Utilizing Hull's conventionalized form of Maier's reasoning experiment, the experiment described by Osgood and reported above, will be performed. This experiment is so designed as to test the explanations of both Hull and Maier. All groups, according to Maier's explanation, should solve the problem through the formation of gestalten, while Hull would predict that only the group trained in the food-water sequence will be able to solve it. Thus, if neither of the two groups, or, if only one of the two groups makes the correct choice with significantly better than chance success, then we would have to reject Maier's gestalt interpretation and conclude that there is no reasoning or insight evident in the animals' behavior.

Results supporting Hull's view would be that the group trained in the food-water sequence makes the correct choice with significantly better than chance success, while the other groups do not. Any departure from these results would lead us to reject the efficacy of the fractional anticipatory goal responses in bringing about the solution.

If, of course, none of the groups solve the problem, the conclusion will be that neither the formation of gestalten nor the mediation of the fractional anticipatory goal responses were operative.

IV. METHOD

Apparatus

The apparatus used in this study was a four-alley wooden maze as shown in Figure 3, page 17. The maze was constructed as a single stationary unit with no interchangeable parts, and included a starting box (R), with openings into three straight alleys (I, II, and III); three distinctive goal boxes (U, X, and H); and a straight alley (IV), which connected the U and X goal boxes. A small platform (A), with enclosed sides, was constructed which led into the starting box so as to insure the animal's entering the starting box with essentially the same position orientation on each trial. The dimensions of the maze are as follows:

R = 13 in. wide by 7 in. long by 12 in. high

A = 5 in. wide by 8 in. long by 6 in. high

I = 5 in. wide by 30 in. long by 12 in. high

II = 5 in. wide by 23 in. long by 12 in. high

III = 5 in. wide by 30 in. long by 12 in. high

IV = 5 in. wide by 14 in. long by 12 in. high

U = 5 in. wide by 12 in. long by 10 in. high

X = 7 in. wide by 13 in. long by 12 in. high

H = 5 in. wide at the entrance and 12 in. wide at the rear by 8 in. long by 12 in. high

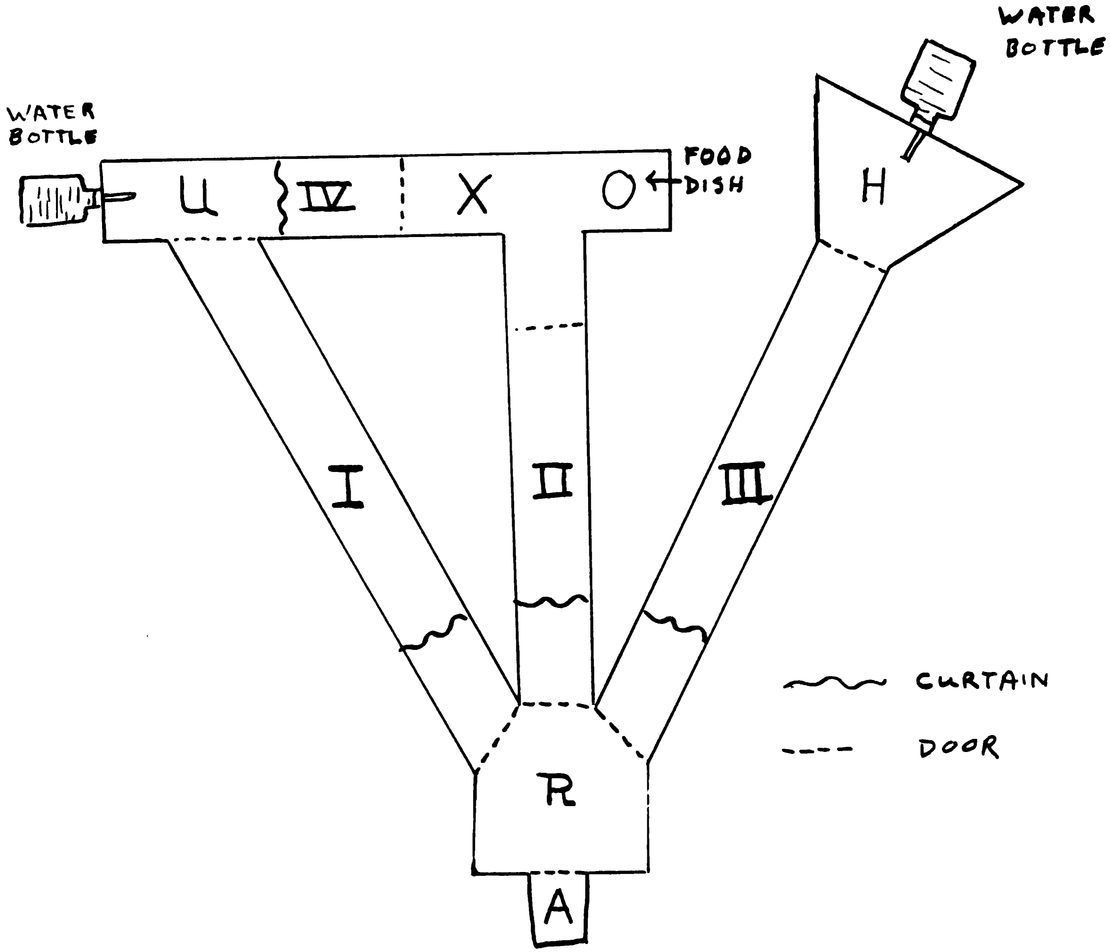

Figure 3. The maze used in this study. Animals were trained to run R-X and U-X for food reward, and then R-U and R-H for water reward. Another group of animals was trained in the same manner but with the water trials first. On the test trials for all groups, the animals were placed hungry at R, with alleys I and III open. Entering alley I constituted a correct choice, and alley III an incorrect choice.

The reason for the high sides on the maze was to eliminate extra-maze cues and the learning of simple approach responses by the animals.

The sides and the bottom of the maze were constructed of three-fourth inch plywood. The top of the maze was covered with one-fourth inch hardward cloth hinged along one side to facilitate easy access to the running animal in case the necessity should arise. Guillotine doors were located as shown in Figure 3, page 17, at the entrance of each different section of the maze. A system of strings and counterweights was connected to the doors and attached to overhead slats so that opening and closing the doors could be accomplished from one central position.

The entrance platform and starting box were of untinted natural wood sanded smooth and the sides and the bottoms of the straight alleys were painted a uniform flat grey. The entrance platform extended two inches into the starting box and a wire fence was placed as shown in Figure 3, page 17, to prevent the animal's doubling back past the end of the starting platform within the starting box.

Each curtain was a single piece of grey cloth of the same shade as the sides of the alleys and was placed in each alley eight inches from the starting box. An attempt was made to have the portions of the alleys between the starting box and the curtains as homogeneous and as similar to each other

as possible to prevent the interference of extraneous cues which may have affected the animal's behavior.

An essential condition of this study was to maximize the distinctiveness of the goal boxes so as to provide for a clear association of the cues of the stimulus complex of each goal box with the particular appropriate reward. To provide this condition, goal box U was rectangular in shape, painted white and had a floor of soft, perforated fiber-board material. Goal box X was also rectangular in shape, but larger than U, was painted the same flat grey as the running alleys, and had a hard, wooden floor. Goal box H was trapezoidal in shape, being narrower by seven inches at the entrance than at the rear, was painted black and had a sheet of tin covering the floor.

In goal box X a metal dish was attached to the floor to prevent the animals from dragging the dish out of the goal box. Holes were drilled into and wire supports were attached to the sides of goal boxes U and H to provide for the insertion of the water bottles and drinking tubes. The exact position of these is shown in Figure 3, page 17.

The maze was securely attached to the top of a table of such a height as to facilitate easy access and observation by the experimenter. Constant illumination was provided throughout the experiment by fixed overhead lights.

Subjects

The subjects for this experiment consisted of 37 experimentally naive albino and hooded male and female rats from the colony maintained by the Department of Psychology of Michigan State University, East Lansing, Michigan. The ages of the subjects at the beginning of the experiment ranged from 82 to 208 days, with a mean age of 109 days.

Procedure

The procedure falls into four main categories: (A) handling; (B) acquisition series, food-water sequence; (C) acquisition series, water-food sequence; and (D) test trials.

Handling. Seven days before the initial trials, each group was handled by the experimenter. They were picked up and stroked and generally manipulated so as to reduce the emotionality of subjects and experimenter to insure the successful functioning of both during the experiment.

During this seven-day period, the animals became relatively docile and the marked aversive responses to the experimenter diminished considerably.

Acquisition series, food-water sequence. At the beginning of the seven-day handling period, experimental Group I was given forty-eight hours of food deprivation. For the remaining five days each of the ten animals received eight grams of Purina Dog Chow, mixed with an equal volume of water at the hour of the day in which it was to be run in the maze. This procedure maintained a controlled hunger rhythm of about twenty-four hours.

The acquisition series for experimental Group I extended over an eighteen day period. The subjects were given four trials apiece each day for seven days, with no trials on the fourth day. The trials were spaced so that all the subjects were run before the first animal was run a second time. The animals were water satiated during the acquisition trials in which food served as reward.

On the first day, the animals were given four forced, spaced trials from R to goal box X with food reward. The doors, located as shown in Figure 3, page 17, were closed as soon as the animal had passed them to prevent retracing. The animals were allowed thirty seconds of eating time in the goal box. The food reward consisted of ground Purina Dog Chow, mixed with an equal volume of water.

On the second day of the acquisition series, the animals were given four spaced trials apiece on the U to X alley, with the food reward and the eating time the same as on the previous day.

On the succeeding five days, the animals were given two trials from R to X and two trials from U to X. All trials were spaced and the reward and feeding time remained the same. Each animal ran these alleys in alternate order.

After seven days of this learning, the animals were fed to satiation, put on twenty-four hour water deprivation, and then were run on the R-U and R-H alleys for water reward. After ten days of this training, the animals were water satiated, put on twenty-four hour food deprivation and given two more U-X trials for food reward.

This group began to show marked aversive behavior to goal box H on the water reward trials. This persisted over a period of four days and reached a point where the animals would not enter alley III which led to goal box H. This situation was corrected when the animals were well satiated with food before making the water runs.

The reason for this differential behavior to goal box H was not fully determined, but it was felt that it might have an effect upon the subsequent test trials. For this reason, we added a control group which was treated exactly the same way as experimental Group I, except that all animals were well satiated for food before making the water runs.

<u>Acquisition series, water-food sequence</u>. Experimental Group II, which consisted of thirteen animals, was trained first to run for water reward, and then trained to run for food reward.

They were food-satiated, but thirsty and were given two forced, spaced trials on R-U and two on R-H, each day for ten days. They were rewarded with sixty seconds of drinking in each goal box.

After ten days of this training, they were allowed to become water satiated and were then put on forty-eight hour food deprivation. The acquisition trials for food reward for this group are the same as those described for experimental Group I.

Test trials. Each group was given a test trial twenty-four hours after the last food trial of the learning series. For each group, the test trials consisted of having both R-U and R-H alleys open with R-X blocked. Each animal was placed hungry at the entrance alley A and was faced with a choice between R-U and R-H. After all animals in a group had been given one test trial, they were given another. On the next day, each animal was again tested once. The animals were allowed fifteen seconds of feeding time upon reaching goal box X, to avoid extinguishing the response. They were also allowed to retrace from the incorrect H goal box to the correct goal box, X. Thus, each animal was fed for fifteen seconds in the X box on each test trial.

V. RESULTS

Experimental Group I

As can be seen from Table I, nine of the ten animals in this group made the correct choice on each of the three test trials. On the first test trial, all of the animals approached both of the open alleys, and all but one showed marked recoil from the R-H alley. Progress along the R-U alley was rapid, the only pause occuring once in the U goal box. There, each of the animals which had made the correct choice approached the end of the goal box where the water tube had been previously, investigated the hole in the side of the box and then turned and went to goal box X. The behavior of the animals in test trials two and three was essentially the same as in the first, but with a decrease in the time required to reach goal box X.

Utilizing a chi square design with expected frequencies of five correct, and five incorrect choices, it was found that chi square, for one degree of freedom, equalled 4.90, with a probability less than .05 but greater than .02. Thus, in each of the three test trials, Group I made the correct choice with significantly better than chance success.

Experimental Group II

This group, trained on the water-food sequence, did not make the correct choice with significantly better than

TABLE I

FREQUENCY OF RESPONSE AND CHI SQUARE VALUES AND PROBABILITIES FOR ALL GROUPS ON EACH TEST TRIAL

Trial Number	Group I	Group II	Control Group
One	R W 0 9 1 E 5 5 X^2 = 4.90 d. f. = 1 .05>P>.02	R W 0 8 7 E 7.5 7.5 X^2 = 0 P = .50	R W 0 7 5 E 6 6 X^2 = .042 d. f. = 1 .45>P>.40
Two	R W 0 9 1 E 5 5 X^2 = 4.90 d. f. = 1 .05>P>.02	R W 0 10 5 E 7.5 7.5 X^2 = 1.066 d. f. = 1 .25>P>.15	R W 0 9 3 E 6 6 X^2 = 2.08 d. f. = 1 .10>P>.05
Three	R W 0 9 1 E 5 5 X^2 = 4.90 c. f. = 1 .05>P>.02	R W 0 11 4 E 7.5 7.5 X^2 = 2.40 d. f. = 1 .10>P>.05	R W 0 10 2 E 6 6 X^2 = 4.08 d. f. = 1 .05>P>.02

R = right (to U)
W = wrong (to H)

O = observed frequencies
E = expected frequencies

chance success on any of the test trials. On the first test trial eight of the fifteen animals made the correct choice, ten of the fifteen on the second, and eleven of the fifteen on the third. From the probabilities given in Table I, page 25, it can be seen that none of these results are significant.

The behavior of this group was different from that of Group I in that they did not show the marked recoil from the R-H alley as did the first group. Whereas most of the animals in the first group approached the R-H alley, recoiled from it and then went directly to the R-U entrance, those of Group II either entered the starting box, paused about midway between the two alleys and then went directly to one of them, or they came off the entrance alley and without any pauses went directly to one or the other of the alleys.

Control Group

The Control Group, which was trained on the food-water sequence as was Group II, did not make the correct choice with significantly better than chance success on test trials one and two, with seven out of twelve, and nine out of twelve correct choices respectively. From Table I, page 25, it can be seen that for trial one, a chi square of zero gives a probability of .50, and for trial two, the probability is between .25 and .15. On the third test trial, however, ten of the twelve made the correct choice. Chi square equals

4.08, and with one degree of freedom the probability lies between .05. and .02.

The behavior of this group was essentially the same as that of Group II, again differing from Group I in the absence of the recoil behavior from the R-H alley.

Since the correct choices of trial three of the Control Group showed significance, the question was asked whether this group made the correct choice significantly more than did Group II. The two groups were compared directly on each of the three test trials, and as seen from Table II, page 28, there are no significant differences between the two groups.

TABLE II

COMPARISON OF GROUP II AND CONTROL GROUP
ON EACH OF THE THREE TEST TRIALS

	Trial One		Trial Two		Trial Three	
	R	W	R	W	R	W
Group II	8	7	10	5	11	4
Control Group	7	5	9	3	10	2
	X^2 = .017 d. f. = 1 .45>P>.40		d. f. = 1 p = .4421*		d. f. = 1 p = .4841*	

*Fisher's exact text.

VI. DISCUSSION

The results of this study, as reported in the previous section, do not support either Maier's or Hull's position. According to Maier's analysis, all groups used in this study should solve the problem through the formation of gestalten. That is, the emergence of new "wholes" in an insightful solution depends upon the experiencing of all the necessary sections of the maze and not upon the order of these experiences. Thus, all groups used in this study should have solved the problem if the formation of gestalten was truly operative, since the animals did traverse all the alleys. That Group II and the Control Group did not solve the problem is evidence against Maier's gestalt position. There was no evidence of insightful solution and Maier's analysis in terms of the formation of gestalten in such problem-solving behavior must be rejected.

These results clearly contradict those reported by Maier, and it may be well to conjecture as to the reason for this. In Maier's study, open-alley mazes were used. They were raised, narrow strips of wood connecting various table-tops, and with this apparatus, extra-maze cues may have been important variables. The animals may have been learning a simple approach response to some extra-maze cue, or to cues on the open maze itself.

In the present study a closed-alley maze was used, with high walls and a wire mesh top. Simple approach responses were minimized by the structure of the maze and by the use of curtains and choice points which were made as similar as possible. Under these conditions the animals were unable to solve the problem, and the formation of patterns or gestalten was not evident.

A further study is suggested by the discrepancy in results between this study and Maier's study. By repeating this study, and then running another group of animals in a maze of identical floor plan, but with raised, open alleys, a comparison can be made between conditions approaching those of minimum and maximum conditions for the learning of simple approach responses to gross cues. It may be found that open alleys provide sufficient cues for the solution of the problem, and Maier's gestalten may actually be the learning of simple approach responses.

Hull predicts problem solution for those groups trained on the food-water sequence and not for those trained on the water-food sequence. He discards both a simple association explanation and Maier's concept of gestalten as emergent new "wholes." Hull's analysis is based on the operation of anticipatory responses as a mediating S-R mechanism which brings about the solution. According to Hull these mediating S-R mechanisms are central to the solution of problems and to higher adaptive behavior in general. He accepts chance as a factor in learning and in problem solution, but contends that chance is tempered by a behavioral "loading" of one behavior sequence over another, which depends upon the animal's store of previous learning.

In the context of the present study, prediction of problem solution for the Control Group, but not for Group II follows from Hull's analysis. This prediction is based on the "loading" of the R-U choice over the R-H choice through the mediation of fractional anticipatory food-taking responses. These are first elicited in goal box X on the food trials, and then become associated with the cues of box U. On subsequent water trials they are elicited by the cues of box U and become associated with alley I. In the test situation when a hungry animal is placed at R, with alleys I and III open and alley II blocked, there will be two excitatory tendencies to alley I. That is, the cues of the starting box, R, will elicit an approach response to both alley I and alley III, but the anticipatory responses elicited by the proprioceptive hunger cues are associated only with alley I. Thus, the cues of the starting box, plus the r_g, constitute two excitory tendencies to alley I. On the other hand, there is only one excitatory tendency to alley III which is produced by the cues of the starting box. Thus the two excitory tendencies to alley I are prepotent over the single tendency to alley III, and the animal makes the correct choice and "solves" the problem. The group trained on water trials first, and then food trials, will have equal excitatory tendencies to both alley I and alley III on the test trials because no r_g will have chained back from X to U to R. Thus with the two responses having equal exictatory tendencies, the animals in this group should choose one alley equally as often as the other, and should do no better than chance on the test trials.

However, the results show that the Control Group did not solve the problem and did not differ significantly from Group II on any of the test trials. On the basis of these results, we must conclude that fractional anticipatory goal responses did not mediate sufficiently to bring about the solution. Hull's analysis of the central role of r_g in problem solving and higher adaptive behavior in general, is not supported.

It is apparent that Hull intended his analysis to be applied also to the behavior of organisms higher in the phylogenetic scale than the white rat. Kendler (3) reports a study on the Inferential Behavior in Preschool Children, in which he utilized an apparatus analagous to the maze in this study. From Hull's analysis of the role of r_g in problem solving, Kendler reasoned that inferential behavior is mediated by the mechanism of the anticipatory goal response. However, his results showed that the sequence of training most conducive to the successfull mediation of r_g according to Hull's analysis, did not produce a significant amount of inference, as did other training sequences. Thus Kendler's results also failed to support Hull's hypothesis, and does cast doubt upon the efficacy of r_g as a mediating representational process.

Of the three groups used in this study, only Group I made the correct choice with significantly better than chance success. On each of the three test trials, nine of the ten animals made the correct choice and "solved" the problem. As explained in the section on procedure, this initial food-water sequence group began to show marked aversive behavior to goal box H. It was felt that this behavior might constitute an uncontrolled variable operating in the subsequent test trials. For this reason, the Control Group--also trained on the food-water sequence--was added.

Comparison of the results of Group II and the Control Group shows that the positions of neither Maier nor Hull were supported, since neither group was able to solve the problem. However, the success of Group I is consistent with both theoretical positions, and cannot be used as a test between the two. The question still remains, then, as to how this group solved the problem and the other two did not.

Group I and the Control Group were both trained on the food-water sequence, and ostensibly received the same treatment. However, the aversive behavior to goal box H manifested by Group I was not evident in the Control Group, and this is

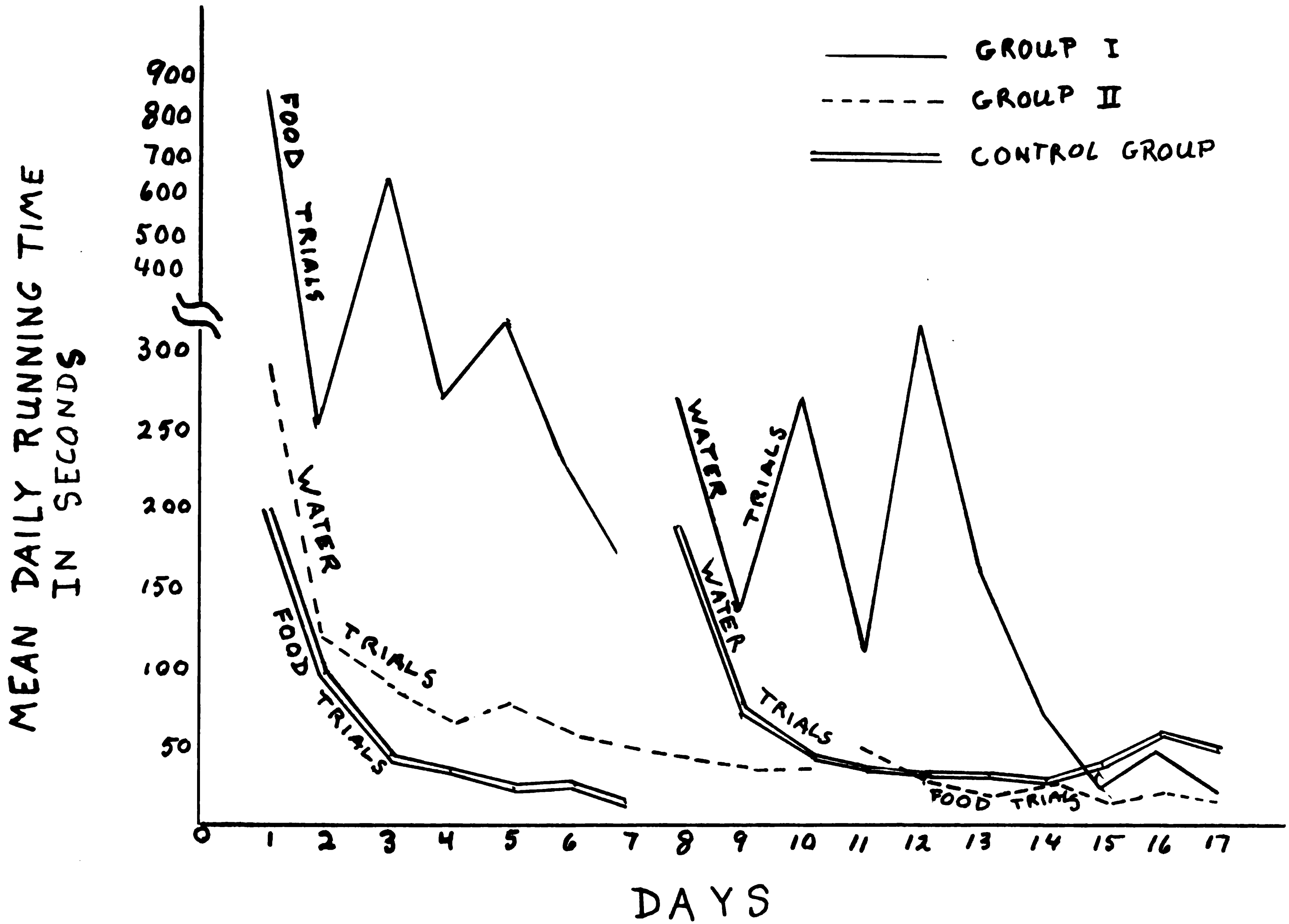

Figure 4. The mean daily response time for each group on both water and food acquisition trials.

the primary difference between the two. This aversive behavior was first noted on the second day of the water trials and continued to the sixth day. From the graph of Figure 4, page 34, the daily fluctuations in performance can be seen, and this curve differs considerably from those water acquisition curves of the other two groups. This aversive behavior was marked at first by a recoil from the H goal box, and eventually by a recoil from alley III. It was realized then that the animals were both hungry and thirsty, being on twenty-four hour water and food deprivation, and it was suggested that this double deprivation may have been the reason for the aversive behavior. When the animals were fed to satiation after the sixth day the aversive behavior ceased. As seen on the graph, the curve for the remaining days shows a relatively steady decline and is similar to the curves for the other groups.

Thus the animals responded negatively to the H goal box when they were hungry, and positively when they were thirsty only. On the subsequent test trials, when they were again put on food deprivation, the negative response to alley III was again elicited and the animals entered alley I, the only other possible choice, as a negative response to alley III. Once in alley I they continued to goal box U, and then to X and the "solution" of the problem.

The Control Group, on the other hand, was well satiated with food on the water trials, and consequently did not learn to avoid alley III. In the test trials this group did no better than chance. It should be pointed out here that the mean running times differ for the two groups. As can be seen from Figure 4, page 34, the Control Group performed much better than Group I, with regard to mean running time and consistency in reduction of running times on subsequent days. It might be expected, then, that the Control Group learned the maze much better than did Group I. Then, consistent with the positions of both Maier and Hull, this group should have solved the problem with less difficulty than Group I. The fact that on the test trials Group I performed with significantly better than chance success while the Control Group did not, seems to be further evidence that the avoidant responses learned by the first group were instrumental in the "solution" of the problem by that group.

VII. SUMMARY AND CONCLUSIONS

From different theoretical orientations, Maier and Hull have both analyzed the problem-solving behavior of white rats. Maier, from a gestalt orientation, explains the correct choice of an indirect path to a goal when the direct path is blocked, as the emergence of new wholes, the insightful reorganization of previous learning into new and successful wholes. This organization of new patterns is referred to as gestalten by Maier.

Hull, rejecting such ambiguous concepts as insight and reasoning as not explanatory, analyzed the problem-solving in terms of fractional anticipatory goal responses. He sees the "solution" as a behavioral "loading" of one path over another through the mediation of r_g. The r_g, according to Hull, is central for animal problem-solving, and even higher adaptive behavior. Reasoning or insight is thus reduced to behavioral chains linked together by the anticipatory responses.

Since neither of the two experimental groups set up to test the two positions were successful in solving the problem, the predictions stemming from the two analyses were not borne out. There was neither evidence of insightful solution, nor of the successful mediation of the r_g, and the two analyses are rejected.

A third group, for which success was predicted by each of the two opposing views, did "solve" the problem. But it is felt that the solution came about inadvertantly through the learning of an avoidant response to the incorrect alley, and not through the formation of gestalten or through the mediating function of r_g.

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