STUDIES IN SPATIAL LEARNING. II. PLACE LEARNING VERSUS RESPONSE LEARNING

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A. Introduction

Consider the case in which normal rats (i.e., those deprived of no sense capacities) have been trained to find food on a simple T-maze. After several days of such training we observe that whenever the rats are put at the starting place, they run quickly to the choice point and without hesitation turn down the path which leads to the food box. We then say that the rats have learned. But what is it that they have learned? There are at least three different answers which have been given to this question.

1. Such training may have produced a disposition in the rats to run on a path which has certain specific characteristics (e.g., knot-holes of such and such a pattern, or the like) and to avoid running on all paths which have certain other specific characteristics. 2. Such training may have produced a disposition to turn right whenever they come to the choice point. 3. Finally, such training may have produced a disposition to orient towards the place where the food is located (e.g., under the window, to the left of the radiator, etc.).

Each of these answers has at one time or another been defended by some psychologist as the only way in which rats learn mazes. Today, however, the first hypothesis has few supporters. The experiments of Honzik (1, pp. 17-19) and others on the sensory control of maze learning have demonstrated clearly that learning in terms of intra-maze cues alone (i.e., when extra-maze stimuli are changed from trial to trial) is extremely difficult for the rat. Thus we must conclude that the rapid learning exhibited by rats in most maze problems is probably based on other cues than intra-maze ones.

There is, however, no direct evidence which enables us to choose between the last two hypotheses. So far no experiment has been performed which has separated these two dispositions. In all T-mazes, as they have usually been constructed, running to a given place in the environment is always accomplished by a certain response (e.g., a right turn at the choice point) or set of responses. From such behavior it is obviously impossible to determine whether the training
has produced a disposition to turn right or a disposition to go to a certain place.

In the first paper of this series (2) we presented evidence that training on a particular path, which requires specific right and left responses, produces a disposition in the rat to take the shortest route to the food place when the original path is blocked. It is clear from this fact that the disposition which is acquired involves more than the tendency merely to make the original trained response. This fact by itself strongly suggests that what is learned in T-mazes where choices must be made is not a disposition to make certain responses (e.g., right turns) but rather a disposition to orient towards, or go towards the location of the goal.

The purpose of the present paper is to present direct evidence for this latter hypothesis. In order to do this it is necessary, as we have pointed out, to construct a situation in which we can separate and distinguish the disposition to turn right from the disposition to go to the location of the goal. With this end in mind we have constructed a simple maze problem which can be arranged in two different ways. The only difference between these two is that in one arrangement the maze can be learned only if the rats acquire a disposition to run right, whereas in the other arrangement the maze can be learned only if the rats acquire a disposition to go to a constant food location. One group of rats will be run on each of these two arrangements of the maze and their learning will be compared. The group run in the first arrangement will be called 'The Response-Learning Group'; the other will be called 'The Place-Learning Group.'

Let us consider three possible results to such an experiment. 1. The Response-Learning Group may learn but not the Place-Learning Group. Such a result would indicate that rats do not acquire dispositions to orient towards the location of the goal. 2. The Place-Learning Group may learn but not the Response-Learning Group. This would indicate that rats do not acquire dispositions to make specific response (e.g., right turns). And 3. Both groups may learn, but one of them may learn more rapidly than the other. Such a result would indicate that rats can acquire both dispositions, but that one of them is more native or primitive than the other (in the sense that brightness discrimination is more native for the rat than pattern discrimination). Such a result would also indicate that probably most of the rapid spatial learning exhibited by normal rats in other analogous situations consists in the acquisition of the more primitive kind of disposition.

B. Animals

Two groups of eight male M x M pigmented rats from the Tryon 'bright' and 'dull' stocks were used in this experiment. They were all approximately 90 days old, and had been on a 24-hour wet food maintenance diet throughout the experiment.
hour wet food maintenance schedule for three days before the beginning of the training. During the experiment they were run and fed every evening at 9:00 p.m.

C. Apparatus

The apparatus was an elevated maze (see Fig. 1) made of two-in. wide gray painted pine paths. The center path running from the food boxes at $F_1$ to those at $F_2$ was eight feet long, while the paths $S_1$ and $S_2$ were each two feet long. On the center path, $F_1F_2$, four in. from each end were wire frames from which were suspended black curtains eight in. square. The food boxes contained four compartments which were six in. high, four in. wide, and 10 in. deep. In each compartment was a glass bird bath, and on the rim of each of these bird baths was 1/2 teaspoon of wet food.

![Elevated maze](image)

Fig. 1. Elevated maze. $S_1$ and $S_2$: starting points; $F_1$ and $F_2$: food boxes; $C$: center point.

D. Method

**Preliminary training.**—The Place-Learning and the Response-Learning Groups were given the same preliminary training. During this period the eight-foot $F_1F_2$ path was located in another part of the room (see Fig. 2) 20 feet away from the location where it was later used. Further, this path was placed at right angles to its later position. On the first day each rat was put by hand into one of the food boxes and allowed to feed for five min. Next it was put in the opposite food box and allowed to feed for another five min. Next each rat was put back in the home cages and half an hour later fed their daily ration.

On the second day the rats were again started from the middle of the $F_1F_2$ path and allowed to run to one of the two food boxes. Next they were started in the same fashion but when they began to run towards, say $F_2$, a block was placed in front of the food box. A similar block was placed at $F_1$ if they started in that direction. Thus, no matter which direction they chose they met a block and were forced to turn around and run towards the food box at the opposite end of the path. This procedure was repeated three more times before the rats were returned to their home cages.

**The Response-Learning Group, ($N=8$).**—On the third day the experiment proper began. The maze illustrated in Fig. 1 was used. Each of the rats in the Response-Learning Group was given six daily trials on this maze. On half of these trials the rats started from $S_1$ and on the other half from $S_2$. The order of these starting positions was $S_1S_2S_1S_2S_1$ and on alternate days $S_2S_1S_2S_1$. Whenever an animal in this group was started at $S_1$, the food box at $F_2$ was blocked, and the food box at $F_1$ was open. Conversely, when started at $S_2$ the food box at $F_2$ was blocked and that at $F_1$ was open. Thus the animals in this group were required to learn always to turn right at the choice point $C$, whether started from $S_1$ or from $S_2$. 

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**Notes:**

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Conversely, if the rat turned left this day, the rat in this group would reach a plateaud for the Place-Learning Group we have given the name of F1. The four rats in this group were required to go to F2 for the Place-Learning Group to be required to go from S1 or from S2. Errors as the result of hesitation between these points were recorded.

Both groups were given a period of preliminary training by the same method as used for the initial test trial. The rats in the Place-Learning Group were required to go from S1 to F1 or from S2. The rats in the Initial Group reached two plateaus in their performance. The time elapsing between the instant at which the rat was put on the maze and the instant at which it made a choice was also recorded.

The rats in the Place-Learning Group (N = 20) were first given two test trials to determine their position habits. The procedure of this test trial was as follows: Each rat was started at S1. If a rat turned right towards F1, then a block was placed behind the curtain at F1 so that the rat was forced to turn and go into F2 at the opposite end of the path.

An error was recorded whenever a rat turned and ran more than 12 in. toward the incorrect food box. The time elapsing between the instant at which the rat was put on the maze and the instant at which it made a choice was also recorded.

The Place-Learning Group (N = 8).—On the third day of this group were given one test trial to determine their position habits. The procedure of this test trial was as follows: Each rat was started at S1. If a rat turned right towards F1, then a block was placed behind the curtain at F1 so that the rat was forced to turn and go into F2 at the opposite end of the path.

**Fig. 2.** Maze in its environment

Despite the error in the rat's performance, there was little evidence of hesitation that the rat would move to the 10th trial to make their choice.

On the 13th trial,
Conversely, if the rat turned left, a block was placed at \( F_2 \) and the rat was forced to go to \( F_1 \). After this initial test trial the apparatus was arranged for the experimental trials so that each rat in this group would have to go against its original position habit. Thus, within the Place-Learning Group we had 5 rats with initial biases for going to \( F_2 \) and 3 with initial biases for going to \( F_1 \). The former were required to go to \( F_2 \) on all experimental trials, while the latter were required to go to \( F_1 \) on all experimental trials.

Each of these rats was given six daily trials, and the order of the starting positions was the same as that used for the Response-Learning Group. Thus the animals in the Place-Learning Group were required to learn to go always to the same place in the room whether started from \( S_1 \) or from \( S_2 \). Errors and times were recorded.

Both groups were run to a criterion of 10 successive errorless trials.

E. Results

The rats in the Response-Learning Group were run for 12 days or 72 trials. During this time only three of the eight rats in this group reached the criterion of 10 successive errorless trials (see Table I). The rest of the rats in the Response-Learning Group developed habits of always going to the same place (either \( F_1 \) or \( F_2 \)), and thus their performance remained at chance. All of the rats in the Place-Learning Group reached the criterion within eight trials or less (see Table II) and the mean number of trials to reach the criterion for this group was 3.5 trials.

The differences between the two groups can also be seen in their error curves (see Fig. 3). The error curve for the Response-Learning Group comes down very slowly and finally after the 22nd trial reached a plateau at a value between four and five errors. The error curve for the Place-Learning Group, on the other hand, comes down rapidly and reaches a plateau at zero errors on the 10th trial.

Despite the great difference in the error curves for the two groups, there was little if any difference between the two groups in the amount of hesitation they exhibited before making a choice (see Fig. 4). By the 10th trial the rats of both groups were taking about four sec. to make their choices.

On the 13th trial for the Place-Learning Group, the center path,
F. Discussion

R. S. Woodworth (3) after summarizing the results of the early experiments on the sensory control of maze learning concludes:

Since neither chain reflex nor motor pattern accounts for the rat's behavior in the maze, we ask once more what it is that the animal learns. The most obvious answer, which has been given repeatedly by investigators in describing the rat's concrete behavior, though avoided in their theories, is simply that the rat learns the place. By place we mean a concrete situation containing the open food box, the dead-end box, the dead-end location of these parts, etc. We need not credit the rat with the simpler power of recognizing the power of perception, orientation, or the motor pattern, and different parts of the maze. We could experimentally block them before training, or avoid them in a number of abnormally threatening situations, of course, a repetition of the above is not a problem to be investigated any further.

In this statement of what we made certain we made absolutely clear what Woodworth means by a disposition to go to a place. He is talking about a certain set of reasonably well-defined parameters for avoidance situations. This statement, however, quite fairly characterizes the disorientations in unambiguous dead-end boxes as "the food" or "x experiences," etc. It is quite clear and certainly showed Woodworth did not employ the term "place" as this was not the meaning which we made clear.

In this first mentioned definition of "place," which makes it certain that points directly to the open food box, the dead-end box, the dead-end location of these parts, and the location of these parts in definable parts of a configuration, was such a test, a test which makes it certain that what Woodworth was talking about when he said "what is learned is what will be expected in the future, in short, to expect," although the definition included such orientations, really does not indicate that the rat "made a T-maze where choice was blocked," in short, this latter hypothesis.

1. We could block them before training by, for example, a number of abnormally threatening situations, etc. Of course, a repetition of the above is not a problem to be investigated any further.

2. It was assumed that Woodworth meant the opposite of the given statement.
crete situation containing objects in spatial relations. By learning the place we do not imply that the animal acquires a memory image which he can call up in the absence of the place; we need not credit him with any power of ideational recall. We do credit him with the simpler power of recognizing a presented object or situation. We credit him with some power of perception or observation, so that he can discover the character of different objects and different parts of the maze. He observes the food-containing character of the food box, the dead-end character of the blind alley, the particular odor of a bit of floor—and the location of these parts in relation to each other. The maze, at first a vague total, comes to have parts in definite location and with definite characters (3, p. 135).

In this statement, Woodworth seems to make the same distinction which we made in the introduction to this article. In our terms, what Woodworth is saying is that training in a maze produces a disposition to go to certain places rather than a disposition to make a certain set of responses. Woodworth's criticism of former experimenters for avoiding this 'obvious' conclusion in their theories is not, however, quite fair. At the time that he was writing there was no unambiguous definition for the matrix "x learns the place of the food" or "x expects food at location L." This fact may have been, and certainly should have been, the reason why these experimenters did not employ this explanation in their theories.

In this first article of our present series (2) we presented a conditioned definition for the matrix "x expects food at location L," which makes it equivalent to the matrix "x runs down the path which points directly towards location L" when certain conditions are fulfilled. Furthermore, we presented evidence in the same article that training over a specific route produces such a disposition in many rats. Thus, if one accepts this definition, one can make an interpretation of Woodworth's place-learning hypothesis which can be experimentally tested. The experiment reported in the first article was such a test, and its results indicated that under some conditions what is learned is a disposition to orient towards the location of the goal; in short, to expect food at that location.

Although the evidence presented in the first article indicated that such orientational dispositions were sometimes acquired by rats, it did not indicate that the rat acquired such dispositions when trained upon a T-maze where choices were required. Two alternative ways of testing this latter hypothesis suggested themselves.

1. We could train a group of rats on a simple T-maze, and then block them before they reached the choice point and discover which of a number of alternative paths they would choose. This would be, of course, a repetition of the experiment reported in the first paper of this series and would differ from it only in the fact that the original

2. It was assumed that with more training almost all the rats would have acquired this disposition. Evidence for this assumption will be presented in a later paper in this series.

3. Just what conditions are necessary and sufficient for the rats to acquire such dispositions is a problem to be investigated.
training would involve a choice rather than a single path. Such an experiment would enable us to decide whether such dispositions were acquired in T-mazes, but it would not enable us to determine (A) whether there were other kinds of dispositions which might also be acquired in such situations, or (B) should there be such another kind of disposition, which of the two kinds was the simpler and more primitive for the rat. Because of these considerations we decided upon another way of testing this hypothesis.

2. We constructed a simple maze which could be arranged in two ways. One arrangement could be learned only if the rats acquired a disposition to turn right. The other could be learned only if the rats acquired a disposition to go to a constant food location. By comparing the behavior of the rats in these two situations we could answer all the questions raised above.

The results of this experiment indicate that both kinds of dispositions may be acquired by the rat, but that the disposition to orient towards the goal is simpler and more primitive than the disposition to make right turns. This is confirmed not only by the fact that all of the Place-Learning Group learned more rapidly than any of the Response-Learning Group, but also by the fact that five of the latter group developed habits of consistently going to the same place, despite the fact that food was there only 50 percent of the time.

Finally, one criticism is likely to be raised against our interpretation of these results. Someone may argue that the Place-Learning Group learned more quickly than the Response-Learning Group because they merely had to learn to take the path which led from C to the food box no matter where they were started, while the Response-Learning Group had to learn to take different paths from different starting positions. Such a criticism assumes that spatial learning consists in the acquisition of dispositions to run on a path which has certain specific characteristics (e.g., knotholes of such and such a pattern, and the like). We said in the introduction to the present article that there is a great deal of evidence against this hypothesis and that as a consequence it is no longer widely held. However, in order to demonstrate that our rats did not acquire a disposition to take a particular path, we rotated the center path, $F_1F_2$, on the 13th trial for the Place-Learning Group. After this rotation the path which had led to the food box now led to the blind and vice versa. This rotation produced no change in the rats' behavior.


4. This is an interesting fact in itself, since most experimenters having observed 'position habits' in the usual T-maze, have interpreted them as habits of turning in the same direction (e.g., either always right or always left). The position habits exhibited by our rats, however, were 'fixations' on a particular end of the room. Thus, our rats who failed to solve the problem 'fixed' in a way that involved 50 percent right and 50 percent left turns.
behavior. They continued without hesitation to go to the end of the room which was correct. This fact indicates that their performance was completely independent of intra-maze cues, that is, that they had not acquired a disposition to take a particular path.

G. Summary

1. The results of a previously reported experiment (2) suggested the hypothesis that what is learned in T-mazes, where choices must be made, is not a disposition to make certain responses (e.g., right turns) but rather is a disposition to orient towards the location of the goal.

2. The experiment reported in the presented paper tests this hypothesis. Two groups of rats were trained on a single unit maze, in which the starting path led into the choice point sometimes from the east and sometimes from the west. The Response-Learning Group \((N = 8)\) was required to learn to turn always right. The Place-Learning Group \((N = 8)\) was required to learn to go always to the same place, half the time turning left and half the time turning right.

3. Only three rats in the Response-Learning Group reached the criterion \((10\) successive errorless runs) while the rest developed consistent habits of going always to the same place. All of the rats in the Place-Learning Group reached the criterion within eight trials or less.

4. We conclude that in situations where there are marked extra-maze cues, place-learning is simpler than response-learning.

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Bibliography

