JOURNAL OF ANIMAL BEHAVIOR

Vol. 5 MAY-JUNE 1915 No. 3

THE WHITE RAT AND THE MAZE PROBLEM: III. THE INTRODUCTION OF A TACTUAL CONTROL

STELLA B. VINCENT
Chicago Normal College

In two papers, appearing in preceding numbers of this Journal, I have attempted to show that vision and olfaction can be introduced as controls into the maze problem and to demonstrate some of the effects of such an introduction upon the learning process of the white rat. In this article I wish to review, briefly, in the light of the previous discussions, some work on the maze problem where the conditions for tactual and cutaneous control were emphasized and to add some experimentation not previously reported. For the full details of the earlier work see my monograph, " The Function of the Vibrissae in the Behavior of the White Rat."[1]

While this paper, the third of a series, attempts to show how tactual elements enter into and modify the maze reactions, it must be understood that the sensory experience is always a complex. Yerkes has sounded the warning clearly when he says: "An animal responds to a situation, not to any one independent and isolated stimulus. Every situation, to be sure, may be analyzed into its component simple stimuli, but the influence of each is conditioned by the situation."[2] The difficulty of isolating the tactual element is the chief reason why there has been so little work done with it in studies of labyrinth

[1] Vincent, S. B. The Function of the Vibrissae in the Behavior of the White Rat. *Behavior Mon.*, vol. 1, no. 5.

[2] Yerkes, R. M. Relations of Stimuli in the Frog. *Harvard Studies*, vol. 2, p. 546.

learning The experimentation which has been undertaken up to this time has consisted mainly in moving the labyrinth to a different base, covering the floor path with different substances, interposing hurdles, and the use of anesthetics on the feet of the animals.

Opinions as to the value of the sense in such problems have been based upon observation and voiced in general statements like this: "The longer one observes the behavior of the dancing mouse the more he comes to believe in the importance of touch and motor tendencies."[3] Or the assumption was perhaps a specific one and yet unsupported by any evidence, as: "Tactual-motor sensations furnish the essential data for the recognition and discrimination involved in forming the special associations at critical points."[4] One investigator has made apparently contradictory statements, as: "The indications point to the fact that the rat in no way uses his cutaneous sensations as a basis for 'sensing' the correct turns in the maze as distinguished from the incorrect."[5] In this case the feet of the animal were anaesthetized with ethyl chloride. Reporting some experiments with blind animals he said: "Runs squarely down the middle of the galleries, makes his turns into the various entries as boldly and with as much sureness as do the normal rats. The vibrissae undoubtedly play a large part (though not an indispensable one) in the early reactions of these rats to the maze."[6] Of normal animals he remarks: "In all probability the rat does not discriminate his turns by means of any data contributed by the vibrissae." "Vibrissae undoubtedly warn him of the presence of solid objects. . . The function of the vibrissae to some extent at least may be dispensed with once the path is learned."[7] These seeming contradictions, however, are due to the confusion in the report of those activities involved in the formation of the habit and those essential to its control when established. The conclusions are those drawn from one type of maze and one form of motor habit and while possibly valid in this particular problem cannot be carried over to all such co-ordinations.

[3] Ibid, Dancing Mouse. p. 178.
[4] Small, W. S. Mental Processes of the Rat. *Amer. Jour. Psy.*, vol. 12, p. 237.
[5] Watson, J. B. Kinaesthetic and Organic Sensations. *Psy. Rev. Mon. Sup.*, vol. 8, no 2, p. 78.
[6] Ibid, p. 58.
[7] Ibid, p. 69.

Miss Richardson makes some definite statements though not in connection with labyrinth problems. "Slight contact (with plane) seemed to give her immediate orientation."[8] "The basis seemed to be that afforded by touch. Contact with the plane was doubtless evidence of its presence." . . "It was only when they came in contact with the plane that some sensory impulse connected with its fall set off the old association and they would dash to the door of the box."[9] "There was no indication that any of the rats located the door by means of vision for each rat passed the door while 'searching' for it without reaching to it. Yet when the door was touched there followed the examination of the latch and the requisite movements to open the door." . "Locating the door as before probably with the snout."[10] "The normal rats like the blind rats seemed to discover the latch by contact."[11]

A layman would scarcely question the importance of the tactual experience in the life of animals, yet in experimental work its function had been called in question even in such problems as Miss Richardson mentions and kinaesthesis had barred all rival contestants in labyrinth learning. It was in order to test the control in the maze that this work was undertaken.

DESCRIPTION OF MAZE

The method used in testing this tactual control was not quite the same as that employed in the work with vision and olfaction. In those experiments the stimulating values of the true path and the blind alleys were made to differ in as pronounced a manner as possible. In this case there was no attempt made either to accentuate the contact values of the floor or walls of the maze or to offer contrasting standards in the true path and the false. Another maze was built on a new plan where the conditions, it was hoped, were such that not only could the tactual functioning of feet and vibrissae be seen but also that such functioning would be a necessary part of the learning process. (Figure 1.)

[8] Richardson, Florence. A Study of Sensory Control in the Rat. *Psy. Rev. Mon. Sup.*, vol. 12, no. 1, p. 39.
[9] Ibid, p. 40.
[10] Ibid, p. 55.
[11] Ibid, p 56.

The runways to this maze had sides which could be detached. When this was done there was left a maze pattern of open, elevated paths but these paths had sufficient space between them so that the animals did not try to jump from one to the other. It was found that on this open maze, where the whole pattern was exposed, the visual control was not sufficient to prevent there being just as real a problem as was seen in mazes with enclosed sides. The situation forced the use of the feet and the vibrissae in a way that the other mazes did not and this fact accounts for the title at the head of this paper. Other sensory elements contributed to the learning, without doubt,

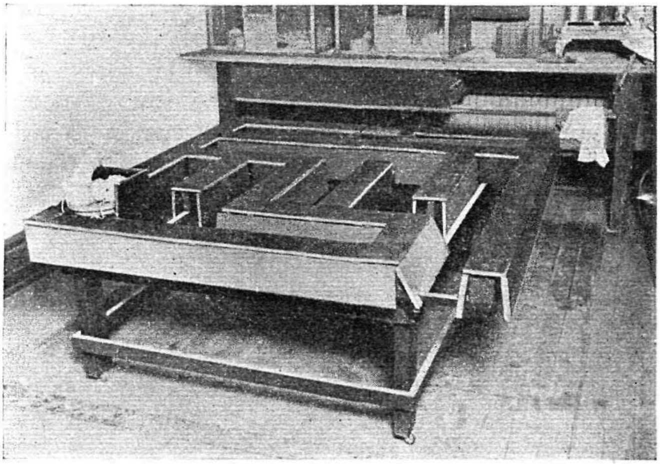

Fig. 1—The maze as used with sides down

but the tactual-cutaneous factors were the prominent ones and the ones which we wished to throw into relief. As it is desired to compare the results obtained in this work with those secured where vision and olfaction were emphasized in the Hampton Court maze, let us compare the two labyrinths.

COMPARISON OF HAMPTON COURT AND X MAZES

The length of the true path in the Hampton Court maze is 40 feet, in this 17 feet. There is one more blind alley in the H.C. maze than in this. The *cul de sacs* have a total length of 30 feet in the one and 9 feet in the other. The paths, both true and false, of the H C. maze are more complex in nature. The results obtained from the H.C. maze and those given by the smaller maze, which we will call the X maze, when the sides are on are very similar. In table 1 they are given in tabular form together with the dimensions of each maze.

To make these results comparable it is necessary to multiply the errors of the X maze by 7/6, since the H.C. maze has 7 errors while the X maze has only 6. The time taken to run the maze should be directly proportional to the length of the path. In the first trial in any maze the *cul de sacs* are explored rather thoroughly; therefore the time of the first trial in the X maze should be multiplied by 40/17 x 30/9, the ratios between the lengths of the true paths and the *cul de sacs* in the two mazes. In the final trials, however, the errors are cut out and to get the comparative speed we multiply the figures for the X maze by 40/17 to correct the speed for the true path. By comparing the corrected results of the X maze with those of the H.C. maze we can see that the statement of similarity is substantiated.

The X maze took an average of four more trials to learn than the H.C. maze. The slower learning time for the X maze is doubtless a result of the character of the *cul de sacs*. There are three pairs of blind alleys in this maze. One and three are exactly of the same length and character and so are two and six and likewise four and five. The two latter pairs differ only four inches in length while after the turns the distances in 1, 2, 3 and 5 are identical. (See figure 1.) The distances on the true path between the turns are also comparable If, after the habit is formed, the running under these conditions is carried on largely in kinaesthetic terms, as we believe, then differences between the kinaesthetic elements in the series should favor such an accomplishment. Such differences in kinaesthetic elements are differences in complexity, differences in the distances between the turns as well as in the direction of the turns, and differences in the lengths of the *cul de sacs*, etc. Too great a similarity between such kinaesthetic units would hinder the learning. The plan of the H.C. maze, according to this conception, is more favorable for learning and hence the slower learning time of the X maze. The corrected figures for the X maze show a greater average number of errors in the first trial and in the last five trials but looking at the average number of errors for the first five trials and the total errors per animal we see that the balance is in favor of X maze.

Thus the error balance in the figures of the two mazes now leans to one side and now to the other. These differences, also, probably spring from the form and character of the *cul de sacs*.

The lower final speed in the X maze is caused by one slow animal. If we take the time for all of the runs in which there were no errors in both series and from these records compute the speed per foot for each maze we find it to be exactly the same, 2.5 feet per second. This is not the final speed, however.

The object here is not to go over these details item by item but merely to show that, in general, these mazes are alike in type and the reactions made in them are therefore approximate.

COMPARISON OF EXPERIMENTS ON X AND Y MAZES

We will now turn to a consideration of the experimentation on the X maze, where the sides to the runways were on, and the same maze, which we will call the Y maze, the open maze, where the runways had no sides.

The behavior in the X maze needs no description but that in the Y maze showed essential differences. When the sides were taken from the runways and the rats put on the maze they showed a marked tendency to follow the edges of the paths. They did this either by turning their vibrissae down against the sides or by curling their toes over the edges of the board. That this was a real control was shown by using rats whose vibrissae had been cut on one or both sides of the head, by using blind rats with and without vibrissae and rats in which the branch of the fifth nerve which innervates the upper lip and snout had been cut. The learning in all of these cases was made more difficult except in one instance. In this case the vibrissae were cut on one side only. As a result, the animals were forced to keep to one side of the maze and by following this side they made their way around the labyrinth almost immediately. It is impossible here to go into all of the evidence and readers are referred to the original monograph.[12] The work conclusively showed that the tactual-cutaneous experience had

[12] Op. cit.

a vital part in the solution of the problem. In the end the rats ran this maze with as much boldness and confidence as the other, with heads up, almost leaping corners, etc. The one exception was the group of blind rats without vibrissae.

Let us compare the results of the two mazes as to accuracy and speed. We find that the time of learning was the same but in the Y maze the errors were less by one-half in the first trial and one-third in the first five trials, and the total number of errors was decreased about one-third although the final accuracy of the two mazes was practically the same. The beginning time was shorter because of the fewer errors but the average time of the first five trials was about the same in both. The final speed in the Y maze was slightly better. The most noticeable difference, then, was the decrease in errors The open maze, from the beginning, favored accuracy and it should be noted that this accuracy was not attained at the expense of speed.

In a maze, where the paths are enclosed by restraining walls, there is little need of fine bodily adjustments. The turns in the H.C. maze and in this maze are always 90 degrees but the place of the turn in the H.C. maze is always marked by some corner or projecting wall against which the body of the rat brushes or his vibrissae drag as he runs. A railway engineer does not have to keep his train on a straight course by the fraction of an inch, he has only to develop speed, his track is laid for him. The analogy is not perfect but in the enclosed maze the rat is comparatively "safe" He does not have to control, as on the open maze, the finer postural and positional adjustments and as a result of this looseness of running he makes more errors. On the open maze the control of these finer adjustments is necessary in order to avoid slips and falls and hence there is greater initial and final accuracy.

The nose, feet and vibrissae were constantly used at the different places of turning. The direction of the turn seemed a much easier thing to conquer than the exact place. The operated animals were at a great disadvantage. Vision aided these finer adjustments but the nose and feet and vibrissae seemed to be of greater help to the rat than sight. However, either sight or the touch of nose or vibrissae seemed to be a vital necessity to the learning. The animals could not well dispense with both in such a problem as was here presented.

THE X MAZE RE-LEARNED AS THE Y MAZE

That the habits set up in the two mazes were inherently of different type was shown by the following experiment: After the group of animals whose records are given for the X maze in table 1 had learned the maze the sides were removed and the rats were tried again. Kinaesthesis had apparently been firmly established during the first experiment and while some disturbance was to be expected, it was thought that it might affect the runs of but one day. The outcome shows the danger of supposing anything about animals. These rats had to relearn the maze almost as if it were a new problem. The old habits did not meet the situation. The animals went out upon the maze with flattened, crawling bodies; they clung to the edges with their toes, they followed these edges with their vibrissae; they used apparently every tactual-cutaneous help possible. While the fewer initial and total errors seem rather good evidence that something was carried over from one maze to the other, the fact that it took over eleven trials on an average for the relearning, as well as the evidence of the observed behavior, indicates that the habit had to be re-established through new sensory aids. A summary of the numerical data may be seen in the last column of table 1.

The maze pattern was the same. The kinaesthetic series was the same: the distances, turns, all that goes to form what Professor Watson calls a kinaesthetic element, but the other sensory elements, always present in the kinaesthetic complex, light, possibly odor and sound but chiefly touch had greatly changed. Always, as the rat ran in the X maze, his sides and vibrissae brushed the walls, the projecting partitions and the angles of the box. All at once this part of the sensory experience was gone. It could be and it was replaced but with a tactual experience of another sort requiring very different adjustments. In addition there was the necessity for the finer adjustments previously mentioned. Thus the problem became a new one. The position which I desire to maintain here and upon which I desire to lay emphasis is that, while in a fully formed habit kinaesthesis probably predominates as a control, the sensory experience is never purely kinaesthesis but always a complex and the finer are the adjustments which need to be made the more necessary the associated sense qualities of vision and touch become.

TABLE 1

Comparison of Mazes—Dimensions, Records

	Hampton Court Maze	X Maze	Y Maze	X Maze Corrected	X Maze re-learned as Y Maze
Total length of true path	49 ft.	17 ft.			
Length of *cul de sacs* .	30 ft.	9 ft.			
Number of *cul de sacs* . .	17	8			
Number of turns, true path.	19	7			
Time of learning . .	12.1 ± 3 6 trial	16 5 ± 3 7 trial	16 5 ± 6 6 trial		11.8 ± 9 2 trial
Average errors first trial .	14 7 ± 7 7	18 ± 8 8	9 5 ± 4 05	(x 7/6) 21	4 6 ± 1 3
Average errors first five trials . .	48 7 ±17 7	30 ±12 8	21 ± 5 2	" 35	11.4 ± 3 3
Average errors last five trials . .	1 ± 14	18 ± 2 7	09 ± 11	" 42	0
Total average errors per animal	66 6 ±16	51 ±23	37 3 ± 5 1	" 59	22 ± 7 6
Time first trial		7 2 ± 3 8	5 1 ± 2 5		2 9 ± 1 2
Average time first five trials.	16 3 ± 6 7 min	1 8 ± 2 7 min.	1 9 ± 7 min.	(x 40/17 x 30/9) 14 1 min	1 19 ± 4 min.
Speed last five trials .	31 ± 05 min.	.18 ± .06 min.	15 ± 03 min.	(40/17) .42 min	1 ± 01 min.
Average speed in trials without error . .	2 5 ft. per sec.	2 5 ft. per sec.	1 8 ft. per sec.		1 8 ft. per sec
Total surplus time	93 9 min.	15 3 ± 6 min.	13 9 ± 4 3 min.		8 93 ± 2 38 min.

CONCLUSIONS

The conclusions from this study are that, given conditions which favor or necessitate the use of vibrissae or the tactual use of nose or feet, the maze habit is not more quickly established but that during the setting up of the habit fewer errors are made and because of this the time per trial is lessened and time is gained. The conclusion is also drawn that these conditions make, within the limits of the experiments, for greater final speed as well as for greater final accuracy.