A FURTHER CONSIDERATION OF THE SENSORY CONTROL OF THE MAZE HABIT IN THE WHITE RAT

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INTRODUCTION

The present paper reports an experiment on the behavior of the white rat in the maze which justifies the conclusion that after mastery the maze response of blind rats is partially controlled by stimuli peculiar to the different segments of the maze. In dealing with the problem of the sensory control of the maze habit in a previous paper (3), I have pointed out that the rat encounters new stimuli from the units of the maze and from the environment as it runs through the maze. Experiments on the rotation of the maze have particularly emphasized the influence of these environmental stimuli, and the present work shows the importance of the intra-maze stimuli. No experiments are recorded in the literature which rule out the possibility that the behavior of running a spatial maze is controlled in part by exteroceptive stimuli from the various maze units and from the environment. In the double alternation temporal maze, so I have argued (3, p. 533), the differential effect of such stimuli is ruled out, inasmuch as such stimuli are constant from unit to unit of the response. The explanation of the double-alternation–temporal-maze habit thus requires the assumption that the stimuli involved in running such a maze are supplemented by some symbolic process or by some central neural engram. Of the two possibilities, I favor the first, partly because such a factor is known to exist in some animals and partly because it seems scientifically sounder to exhaust the peripheral possibilities of explanation before resorting to central possibilities. There is no reason to question the validity of the assumption that as a result of training some modification of nervous functions is brought about and that these modifications persist for varying intervals of time. No one, however, has ever proved that these neural engrams can function independently of stimuli, although Lashley and Ball (6) would seem to favor such an hypothesis. Psychologists have often adopted this hypothesis in the form of "brain set" and *"Aufgabe,"* but they have neglected the possibility that peripheral factors may be adequate to account for the various phenomena of behavior concerned. They have said, for example, if a subject is instructed to respond with the opposites of a list of words, that while each individual response is set up by the specific words on the list, nevertheless the original instruction stimulus, although absent as a stimulus, still controls the general pattern of response through the medium of a "brain or cortical set." Although such a "cortical set" is not open to direct observation, the assumption of its presence might be justified if it could be shown that the instruction stimulus could exert its influence over the series of responses in no other way than through such a medium. There is, however, no reason for believing this to be the case. The subject may himself repeat the instruction stimulus at intervals during the series of responses. Thus, in place of a central "brain set," a recurring and self-administered instruction stimulus may control the sequence of responses.

As the above comments indicate, the problem of the sensory control of the maze habit is not interesting for itself alone. The maze habit is a typical act of skill, a typical instance of serial action, to be contrasted with such forms of behavior as are found in simple discrimination. Experiments have revealed the character of the sensory control of the pupillary reflex, the knee-jerk, brightness discrimination, and numerous other similar forms of behavior; but no detailed and adequate account has ever been given of the sensory control of an act of skill, such as typewriting, dancing, or maze-running. On the basis of what I regard as an inadequate analysis of behavior data, Lashley (6) has adopted the view that the maze habit is controlled by a central neural engram, and he has elsewhere defended a closely related view, viz., that of the equipotentiality of cerebral action (5). I have offered a detailed criticism of this latter view in another paper (4), and in the present article an experiment will be described whose results furnish additional reasons making unnecessary the assumption that the perfected maze response is controlled by a neural engram rather than by specific stimuli.

SUBJECTS, METHOD, AND APPARATUS

Figure 1 shows the ground plan of the double alternation elevated maze used in the present experiment. This was the same

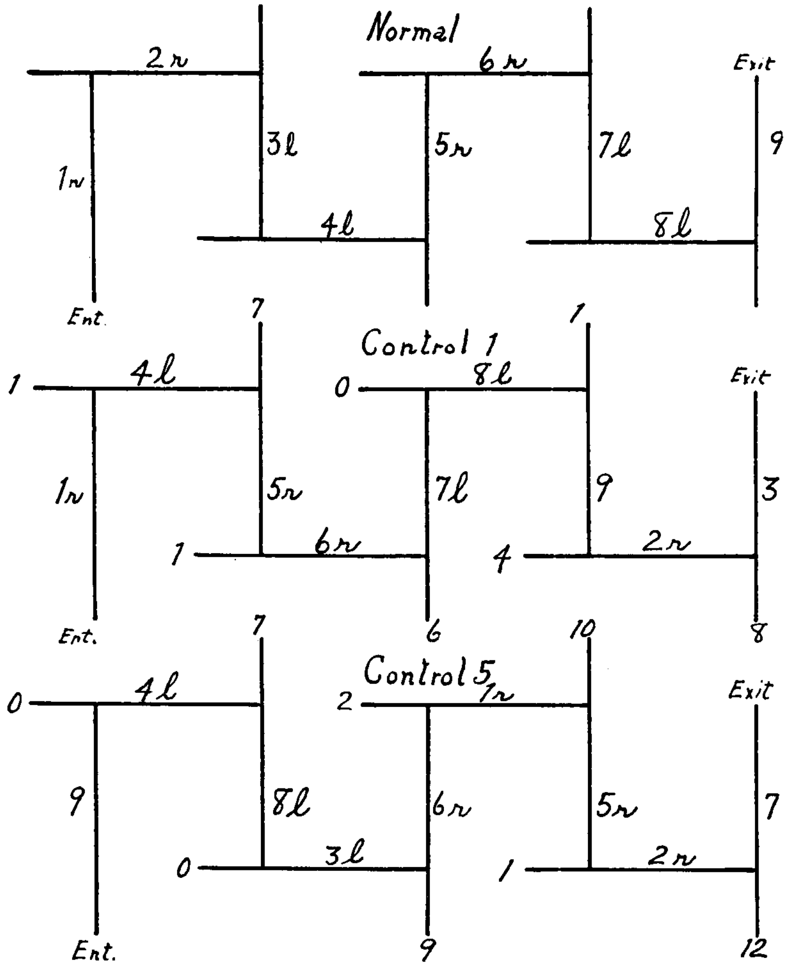

FIGURE 1

ARRANGEMENTS OF THE UNITS IN THE NORMAL MAZE, IN CONTROL 1, AND IN CONTROL 5

In the normal maze the units are numbered from 1 to 9, and each number is accompanied by a letter which designates the character of the turn to be made in leaving the unit. In Controls 1 and 5 the units are re-arranged, but they are still designated by their original numbers and letters. At the end of each cul-de-sac in the drawings for Controls 1 and 5 a number has been placed indicating the number of entrances made to that cul-de-sac.

apparatus used in a previously described experiment (3, p. 508), except that in the present instance no brass strips were laid along the top of the units. These were made of carefully machined wood, and each unit offered the rat a running surface 35½ inches long and ¾ inch wide. Each cul-de-sac was 10 inches long, and each segment of the true pathway was 24¾ inches long. The maze contained no food box. When the rats reached the exit, they were lifted from the maze to a chair on which they ate their daily rations. A buzzer, located near the entrance of the maze, was sounded continuously during the experiment except during certain controls to be described later. The noise of the buzzer was introduced in order to have a dominating auditory stimulation in the environment of the maze. The noise was of a medium intensity, and did not disturb or otherwise excite the rat so far as could be observed. The maze was never cleaned during the course of these experiments, nor was the upper surface ever touched by the experimenter. The surface on which the rats ran was so narrow that no deposits, save urine, would remain upon it. The result was that the runways remained apparently clean throughout the work.

The rats were brought from the living-room to the maze room one at a time and were given one trial per day. The same route from cage to maze was followed each day. The living cages were never cleaned just before an experiment. The feeding time per rat was carefully regulated. The time of day during which the experiments were performed varied but little. In other words, care was taken, in these and other ways which need not be specified, to secure uniform working conditions in order that differences between normal and control records might be as significant as possible.

Fourteen untrained rats were used. Of these, 5 were 3 months old, and the remainder were 4 months old at the beginning of the experiment. All animals were blinded by extirpation of the eyeballs one week before the experiments began. Except where the control tests required otherwise, the rats were run in the same order each day. Males and females were kept segregated.

Results

Table 1 shows for each rat the number of trials required before three perfect runs in succession were made. Rat 12 never made a perfect run in 171 trials, a period of 5 months and 21 days. Rat 5 acquired the correct behavior after 170 trials. (No control tests were made with Rat 5). If we exclude Rats 5 and 12, the average number of trials required before 3 correct runs in succession were made is 17.5. After the subjects had mastered the maze, by satisfying the criterion above stated, training was continued until each subject had run the maze correctly at least 9 times in 10 successive trials. Control experiments were then begun.

Each control test was preceded by three perfect runs under normal conditions. This means that, if a control were introduced and if some error were then made by the rat, the normal maze situation was again used until three perfect runs in succession were made. Only after this was another control test given. Inasmuch as errors may be made due to chance, i.e., due to uncontrolled factors rather than to the conditions set up in a control test, it is important to have some standard other than perfection in terms of which to evaluate the effects of control tests. Such a standard I have derived as follows: Each rat's normal records were examined for cases where three perfect runs in succession were made. In each such case the record for the trial following the three runs was tabulated as perfect or imperfect. The total array of such cases was subdivided into groups containing about 40 cases each, making them comparable in size with the control groups. On the basis of such data it is possible to say, for example, that of such 40 normal trials x % contained errors. I have called this percentage the normal error score and have entered it for each rat in Table 1. Since each control test was preceded by three perfect runs, the percentage of control runs which were imperfect can be compared with the normal error score in order to determine the influence of the control test.

TABLE 1

DATA ON NORMAL PERFORMANCE

	Rats													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trials prior to 3 correct in succession	21	12	14	16	170	22	23	17	15	26	24	not in 171	7	14
Trials prior to first correct run	12	8	14	11	63	19	15	4	13	11	18	—	7	8
Normal error score in %	15	0	18	7	—	14	20	0	7	0	12	—	23	12
Average normal error score		10%												

Before passing to a consideration of the control tests, let us comment briefly upon the types of errors made prior to mastery. Table 2 shows the number of forward-going errors made in each of the 8 culs-de-sac during the last 10 trials prior to 3 perfect runs in succession. The table thus shows which culs-de-sac were holding up the final mastery of the maze. The results are in accord with our previous findings (3, p. 510), a summary of which is added to Table 2. Excluding the first cul-de-sac, which proved difficult to master, the greatest difficulties were encountered with those culs-de-sac (2, 4, 6, 8) which were at right angles to the general path of progression from entrance to exit. This is not a proof of the functional presence of some factor of orientation, and yet it is the type of result which such a factor should produce.

Of the 14 rats used in the present experiment only one failed to master the maze whereas in the 1929 experiment 3 of 6 rats failed. The difference may be due to variations in individuals or to the fact that the brass topped maze of the earlier experiment was rendered more difficult by the greater care taken to eliminate cutaneous differences and by the fact that it was washed daily.

As we have pointed out above, the problem of the present experi-

TABLE 2

FORWARD-GOING ERRORS FOR EACH CUL-DE-SAC DURING THE LAST 10 TRIALS PRIOR TO 3 CORRECT RUNS IN SUCCESSION

(Last 5 Trials for Rat 13)

	Culs-de-sac							
Rat	1	2	3	4	5	6	7	8
1	0	1	0	6	0	0	0	1
2	4	5	1	5	2	6	0	3
3	2	2	0	2	0	3	1	3
4	0	3	0	2	0	0	0	6
5	3	1	1	4	1	3	0	5
6	3	1	2	7	0	1	0	3
7	1	2	0	3	0	2	0	2
8	0	1	0	1	0	3	0	2
9	5	4	1	3	0	1	3	5
10	1	2	0	0	0	2	0	0
11	1	3	0	0	0	1	0	2
13	2	3	1	4	0	1	3	3
14	2	2	0	0	0	3	1	1
Total	24	30	6	37	3	26	8	36
Previous experiment*	21	33	12	40	6	33	8	—

*6 rats only.

ment was to determine whether or not the rat's behavior after mastery of the maze was controlled by exteroceptive stimuli from the various units of the maze. After the rats had been trained until they could make at least 9 runs without error out of 10 successive ones, the controls now to be described were made. It was the intention to test each rat three times on each control. This, however, was not always possible. Some of the rats were markedly unstable in their behavior. By this I do not mean that they were in poor health, timid, or were made irregular by a poor control of the feeding. I mean that for undetermined reasons they could not run the maze correctly, even under normal conditions, for many trials in succession. (This is well illustrated by the normal error scores of Table 1.) It therefore happened with these rats that many trials would be necessary before the normal response was sufficiently automatic to justify the re-introduction of a control. This behavior, coupled with the fact that two rats could not master the maze, would seem definitely to indicate that the present maze, with its double-alternation pattern and its units of equal length, offered a more difficult problem to blind rats than is the case in the usual maze.

Controls

1) The normal order of units in the maze (Units 1, 2, 3, to 9) was changed by placing the units in the order 1, 5, 6, 7, 8, 9, 2, 3, 4. The portion of each unit that had been cul-de-sac in the normal maze was kept as cul-de-sac in the new arrangement. The pattern of the maze was unchanged as were all other factors save that of the order of the units. Figure 1 shows a plan of the normal maze and of the maze of Control 1.

2) The only change made in the normal maze was a 180° rotation of Unit 1.

3) The normal maze was used but the buzzer was not sounded.

4) Controls 1 and 2 were combined, but each unit was rotated 180°. This does not mean that the maze as a whole was rotated with reference to the environment. It only means that those portions of the units which were normally culs-de-sac were now parts of the true pathway.

5) The units of the normal maze were arranged in the order 9, 4, 8, 3, 6, 1, 5, 2, 7, and all old culs-de-sac were included in the true pathway. (See Figure 1.)

6) This control was the same as No. 5 except that the buzzer was not sounded.

7) All units were in their normal serial position, but each cul-de-sac was made 4 inches longer, a change which necessarily made each section of the true pathway 4 inches shorter. (See Figure 2.)

8) The maze as a whole was rotated 180°. The serial order of the units remained normal. The buzzer was not sounded.

9) Controls 6 and 7 were combined for Control 9.

10) The buzzer was placed near the exit of the maze rather than near the entrance where it was normally, i.e., the buzzer was rotated 180°.

11) The normal serial order of the units was maintained, but the culs-de-sac were changed in length as indicated in Figure 2. Cul-de-sac 1 was 4 inches shorter; Cul-de-sac 2, 8 inches longer; Culs-de-sac 3 and 4, normal; Cul-de-sac 5, 8 inches longer; Cul-de-sac 6, 4 inches shorter; and Culs-de-sac 7 and 8, normal.

12) Figure 2 shows the arrangement of the units in this control. The rats were trained in this maze until they made at least 9 errorless runs in 10 successive trials, one trial per day. They were then tested on the two following controls. Each test on Controls 13 and 14 was immediately preceded by at least 3 correct runs in succession on Control 12.

13) Each cul-de-sac was 4 inches longer than was the case in Control 12.

14) The lengths of the individual culs-de-sac were those listed under Control 11.

Table 3 summarizes the results secured with these controls. An examination of the data reveals the following: The animals as a group were disturbed (*a*) by an interchange of the maze units (Controls 1, 4, 5, 6, 7, 9), and (*b*) by a rotation of the maze through 180° (Control 8). As a group, the animals were possibly disturbed by (*a*) the absence of the buzzer (Control 3 and Controls 5 *vs.* 6); (*b*) the rotation of Unit 1 by 180° (Control 2); (*c*) the uniform lengthening of all culs-de-sac in the maze of Control 12 (Control 13). The animals as a group were not disturbed by (*a*) rotation of the buzzer by 180° (Control 10); (*b*) the uniform lengthening of all culs-de-sac in the original maze (Control 7); (*c*) the irregular lengthening and shortening of culs-de-sac in either maze (Controls 11 and 14).

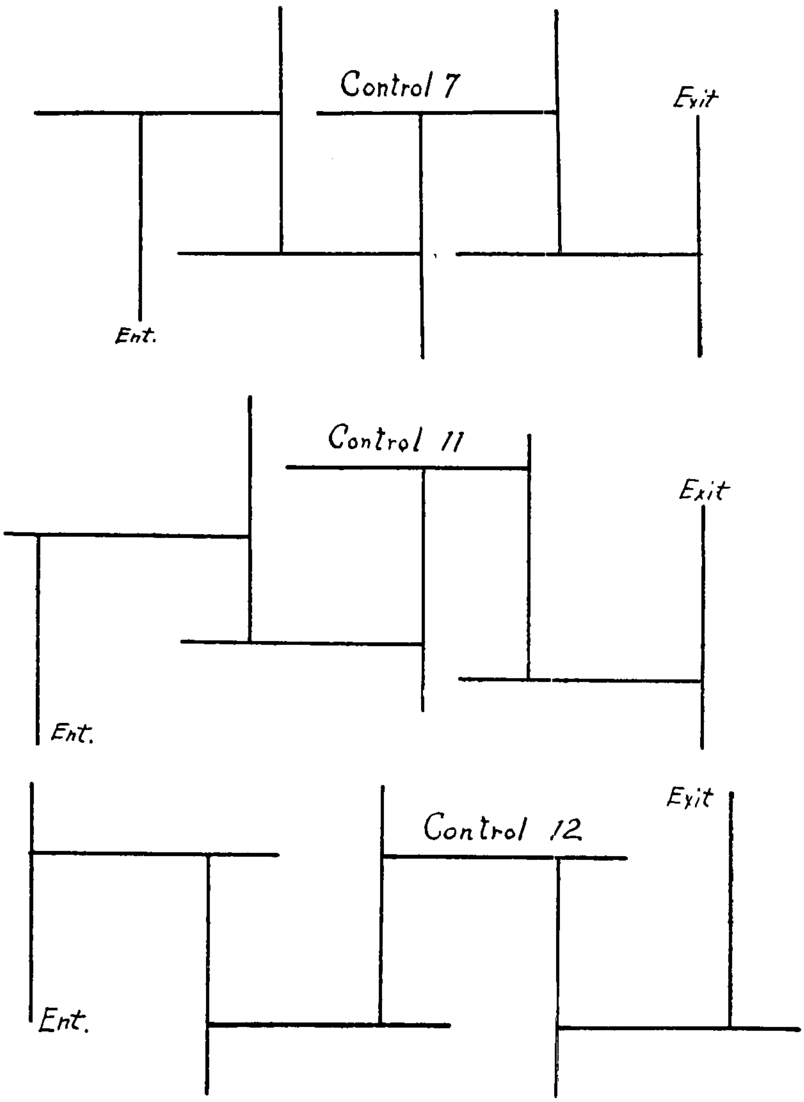

FIGURE 2
THE GROUND PLAN OF THE MAZE FOR CONTROLS 7, 11, AND 12

TABLE 3

RECORDS ON THE CONTROL TESTS

Conditions	Responses	Percentage of tests containing errors
Normal error score (based on the records of 12 rats on 3 sets of 40 tests each, where the percentages of runs with errors were 14, 13, and 4%)		10
Control 1 12 rats, 37 tests (units in order, 1, 4, 5, 6, 7, 8, 9, 2, 3)	1 rat perfect 4 others, 2 of 3 trials correct	45
Control 2 11 rats, 30 tests (Unit 1 rotated 180°)	5 rats perfect 3 others, 2 of 3 trials correct	23
Control 3 12 rats, 35 tests (buzzer not sounded)	6 rats perfect 5 others, 2 of 3 trials correct	20
Control 4 12 rats, 34 tests (Control 1 plus Control 2. All old culs-de-sac now in true path.)	2 rats perfect 4 others, 2 of 3 trials correct	44
Control 5 12 rats, 36 tests (units in order 9, 4, 8, 3, 6, 1, 5, 2, 7)	2 rats perfect 3 others, 2 of 3 trials correct	52
Control 6 12 rats, 34 tests (same as Control 5, but no buzzer)	1 rat perfect 2 others, 2 of 3 trials correct	70
Control 7 10 rats, 32 tests (each cul-de-sac 4 inches longer)	9 rats perfect 1 other, 2 of 3 trials correct	3
Control 8 12 rats, 34 tests (maze rotated 180°, buzzer silent)	only 1 correct trial in the 34	97
Control 9 12 rats, 35 tests (Control 6 plus Control 7)	no rat perfect 3 made 2 of 3 trials correct	62
Control 10 8 rats, 24 tests (buzzer rotated 180°)	6 rats perfect 2 others, 2 of 3 trials correct	4
Control 11 10 rats, 29 tests (culs-de-sac varied irregularly in length, see text)	7 rats perfect 2 others, 2 of 3 trials correct	13

TABLE 3 (*continued*)

RECORDS ON THE CONTROL TESTS

Conditions	Responses	Percentage of tests containing errors
Control 12 9 rats, 27 tests (maze arranged with culs-de-sac straight ahead)	only 1 correct trial in the 27	97
Control 13 9 rats, 26 tests (each cul-de-sac 4 inches longer)	5 rats perfect 2 others, 2 of 3 trials correct	19
Control 14 9 rats, 27 tests (culs-de-sac varied irregularly in length as in Control 11)	5 rats perfect 4 others, 2 of 3 trials correct	14

The disturbance in behavior which resulted when the maze units were interchanged indicates clearly that the animals' responses were partially controlled by stimuli peculiar to the various units of the maze. The mere fact that the units were moved and then replaced might theoretically result in the introduction of new stimuli. It is to be noted, however, that the tops of the units were never touched, that great care was taken to fit the units together exactly, and that such a control as No. 7 led to no disturbance of behavior, although the units were manipulated for this control as well. Since no new stimuli were introduced when the units were interchanged, the term "distraction" has no significant application anymore than it has in a visual discrimination problem when the animal's behavior is upset by a change in some aspect of the light, for example, its intensity. No effort was made to determine what the stimuli were which were peculiar to the various units, but it seems reasonable to assume that they were olfactory or tactual, or both. No dependable evidence was secured indicating that the animals were following an olfactory trail, although in many cases their behavior was in harmony with such an hypothesis.

In addition to the stimuli from the units of the maze, stimuli from the environment of the maze were present and may have aided in the control of behavior. There is reason to believe that the auditory stimulation from the buzzer was effective (Controls 3 and 5 *vs.* 6), but its influence was probably not directive (Control 10).

The absence of the buzzer stimulation may have allowed other fainter sounds to distract the subjects. The effect of the 180° rotation of the maze is similar to that usually found where the living cage is not in connection with the maze and so rotated with it. The disturbance of behavior by this control is further evidence of the dependence of the maze habit upon stimuli from the environment.

Table 3 also contains data on the number of rats who were perfect under each control. Thus in Control 1, 4 rats each made 2 perfect runs in the 3 trials given. One rat made all three trials perfect. The remaining 7 rats made errors on either 2 or 3 of the 3 trials given each animal. The table does not show the number of errors per trial on the incorrect trials. Such data, however, were calculated, and they were found to tell the same story given by the figures in the table, i.e., the average errors per incorrect trial were greatest in Controls 6 and 8 and least in Controls 7 and 10. In Control 1 the rats who made imperfect runs made an average of 2 forward-going errors on each such run. In Control 6, the average number of such errors per imperfect trial was 3. In Control 8 where all rats were disturbed and where only one perfect trial was made, an average of 3.6 such errors was made per imperfect trial. There were 8 possible forward errors in the maze; retracing occurred but seldom. The percentage of error in these three controls thus ranges from 25 to nearly 50% of the possible error. When it is recalled that Table 2 shows that Culs-de-sac 3, 5, and 7 were seldom entered under normal conditions, it will be seen that, instead of 8 culs-de-sac, the maze practically contains but 5. Calculated on such a basis, the percentage of culs-de-sac entered in the controls is much higher than that indicated above.

It was said above that certain controls show that the rats were responding to specific exteroceptive cues from the individual units of the maze. It is not to be assumed, however, that each unit of the maze was a separate problem for the rat and that the stimuli from Unit 1 led to a response to the right, the stimuli from Unit 2 led to a response to the right, etc. It is to be remembered that stimuli from the maze environment were effective and that the response of running the maze was a highly automatic and well-integrated response. One should therefore not expect to find in such controls as 1 and 5 that the rats made the same response to the various maze units when interchanged that they had made when the units were in the normal order. Figure 1 presents the arrangement of the units in the normal maze, in Control 1, and in Control 5. In each case the units bear their original serial numbers plus a letter, *r* or *l*, indicating the direction of the turn which originally followed each unit. Thus Unit 1 was normally followed by a turn to the right; Unit 7, by a turn to the left, etc. Will the rat when placed in Control 1 turn left on leaving Unit 7, right on leaving Unit 1, right on leaving Unit 6, etc.? No such clear-cut results were secured, nor should they have been expected. Culs-de-sac 1, 3, 5, and 7 are seldom entered in the normal maze, perhaps because of the influence of some orientation factor. If, therefore, in Control 1, Unit 5 called for a response to the right which would take the animal into the third cul-de-sac, the fact that this cul-de-sac pointed away from the main line of progression through the maze might well be sufficient to inhibit the response normally called forth by Unit 5. Furthermore, once a rat had entered a cul-de-sac on a control test, the normal stimulating effect of a succeeding unit might well be disturbed. Thus if, in Control 1, a rat entered Cul-de-sac 4, the consequences of this fact itself might lead the animal not to turn left, i.e., not to enter Cul-de-sac 5, upon leaving Unit 7.

In order that the reader may see which culs-de-sac were entered and how often each was entered during Controls 1 and 5, I have entered in Figure 1, at the end of each cul-de-sac, a number indicating how many times that cul-de-sac was entered during the control in question. It will be seen that Culs-de-sac 2, 4, 6, and 8 were entered more frequently than were the others. Sometimes such an entry was in accordance with the turn normally called for by the preceding alley, and sometimes it was not. We have just seen some of the reasons why the rat could not be expected to respond to each unit as to an isolated discrimination test. We should now add the further point that if the rat's behavior were solely determined by the stimuli peculiar to each unit he should never leave Unit 9 in Control 5, since, in the normal maze, this was the last unit, and the rat had never learned to pass beyond it.

During the initial learning of the maze, no rat ever fell from the maze. During Controls 1 and 4, six falls occurred. These were all at the ends of Culs-de-sac 2, 3, 4, and 6. These falls occurred because the rats simply ran off the ends of the culs-de-sac. An inspection of the diagram for Control 1 in Figure 1 will reveal that each of these four culs-de-sac would be entered by rats who responded in the normal manner to the stimuli specific to the units preceding the culs-de-sac in question. Occasional falls also occurred during Control 5 on Culs-de-sac 2 and 6; and mention should also be made of the fact that, after controls had been begun, occasional falls from the ends of culs-de-sac also occurred on the normal maze.

Was the disturbance in the behavior of the rats as seen, for example, in Controls 1, 5, and 6, due to the interchange of stimuli which had been controlling the behavior, or was it due to the distracting influence of the new arrangement of stimuli? The term "distraction" would seem applicable only to disturbances in behavior resulting from the introduction of new stimuli into a behavior situation. Thus if, in a visual discrimination problem, sudden noises are introduced and if the subject fails to maintain his normal accuracy of response, it is sometimes said that the noises are distractive factors. If, however, no new stimuli are presented, but if the old stimuli are rearranged or varied, the resulting disturbances in behavior are said to follow from the change in those aspects of the stimulus which have been controlling the behavior. Thus if a subject is trained to discriminate two lights differing in wave length and in intensity, we control the situation by varying the intensities. If the discrimination is disturbed, it is said not that the subject is distracted but that his behavior has been partially if not wholly controlled by intensity differences. In the present experiment no stimuli were introduced into Controls 1, 5, and 6 which were not present in the normal maze. The term distraction is therefore not applicable here, even if the term is significant under other conditions, which I am inclined to doubt.

The suggestion for Control 7 came from comments which Köhler had made to me concerning the *Gestalt* aspect of maze running. If the maze response is a *Gestalt,* it was said, then a uniform condensation of the maze which left the pattern constant should not affect the subject's performance. Carr and Watson (1), it is true, had found that the rat's behavior was disturbed by lengthening and shortening certain pathways in the maze, but these investigators did not alter all pathways in a like manner. The results with Control 7 show that the rats were unaffected by the uniform shortening of all units of the true pathway by 4 inches. However, Control 11 gave the same results, although in this control some sections of the true pathway were lengthened, some shortened, and others left with their normal lengths. There is thus no evidence here that maze running is controlled by a *Gestalt* or that this term has any essential significance in maze problems. Two possible explanations of the results are suggested: (*a*) The changes in the lengths of alleys may have been subliminal for the proprioceptive discrimination of distance. This, however, does not seem probable since both DeCamp (2) and Yoshioka (7) found the limen for distance discrimination to be .10, whereas the present difference between the normal true pathway and the shortened pathway is .16. (*b*) Since the units of the true pathway were of equal length and since the turns were arranged in the order of double alternation, I have argued that proprioception could not play the deciding rôle in the present maze. (See 3, p. 511.) If proprioception did not determine the behavior of the rats, then an alteration of the proprioceptive aspects of the straight sections could not be expected to disturb the behavior. It is, however, not at all improbable that a disturbance would have been found had some of the sections been altered to three or four times their normal length or reduced to some such size as one-tenth the normal length.

An inspection of Figures 1 and 2 will reveal that in the normal maze and also in Controls 7 and 11 the rat could not run past the entrance to the correct unit as had been possible in the Carr and Watson experiment. It might have been, therefore, that this was the reason for the lack of disturbance in Controls 7 and 11. In order to test this possibility, the rats were trained on the maze of Control 12, Figure 2, until they could make 9 correct runs in 10 successive trials. They were then given Controls 13 and 14. (Only 9 rats reached this degree of proficiency during the period of time available for experimentation.) In Control 13, 19% of the runs contained errors. This may indicate a slight disturbance of behavior. In Control 14, 14% of the runs contained errors. There is thus only a slight degree of disturbance, if any, when the sections of the true pathway are altered under conditions which permit the rat to run past the proper turn. This is not, of course, to deny that Carr and Watson found the contrary results. It merely indicates that the form of behavior in question is not the invariable consequent of changes in the lengths of maze alleys and that in a maze of the present pattern disturbances of behavior were not clearly in evidence.

Conclusion

Utilizing a double alternation elevated maze, I have shown that the perfected maze response of blind rats is partially dependent upon exteroceptive stimuli received from the various units of the maze.

These results, in addition to enlarging our conception of the multiple-stimulus control of maze behavior and hence, probably, of all acts of skill, reveal the inadequacy of the experimental data gathered by Lashley and Ball to demonstrate that the maze habit is controlled by a "wholly central mechanism."

References

1. Carr, H. A., & Watson, J. B. Orientation in the white rat. *J. Comp. Psychol. & Neur.*, 1908, **18**, 27-44.
2. DeCamp, J. E. Relatve distance as a factor in the white rat's selection of a path. *Psychobiol.*, 1920, **2**, 245-253.
3. Hunter, W. S. The sensory control of the maze habit in the white rat. *J. Genet. Psychol.*, 1929, **36**, 505-537.
4. ———. A consideration of Lashley's theory of the equipotentiality of cerebral action. *J. Gen. Psychol.*, 1930, **3**, 455-468.
5. Lashley, K. S. Brain mechanisms and intelligence. Chicago: Univ. Chicago Press, 1929. Pp. 186.
6. Lashley, K. S., & Ball, J. Spinal conduction and kinaesthetic sensitivity in the maze habit. *J. Comp. Psychol.*, 1929, **9**, 71-106.
7. Yoshioka, J. G. Weber's law in the discrimination of maze distance by the white rat. *Univ. Calif. Publ. Psychol.*, 1929, **4**, 155-184.

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UNE NOUVELLE CONSIDÉRATION DU CONTRÔLE SENSORIAL DE L'HABITUDE DU LABYRINTHE CHEZ LE RAT BLANC

(Résumé)

On a fait cette expérience dans le but de déterminer si l'habitude perfectionnée du labyrinthe est contrôlée par les stimuli extéroceptifs propres aux différentes unités du labyrinthe. On a employé un labyrinthe élevé à double alternation, les sujets étant des rats aveugles. On a trouvé que les rats, après avoir appris le labyrinthe, ont été confus quand on a échangé les unité du labyrinthe sans changer la forme du labyrinthe. Puisque ce contrôle n'a pas introduit de nouveaux stimuli mais n'a fait que changer l'ordre des stimuli extéroceptifs que le rat aurait pu obtenir des unités individuelles du labyrinthe, la conclusion semble justifiée que la réponse normale du labyrinthe a été contrôlée en partie par ces stimuli. Cette conclusion est importante parce qu'elle appuie plus l'opinion que les actes habiles sont contrôlés par une multiplicité de stimuli et parce qu'elle montre l'insuffisance de l'évidence selon laquelle Lashley et Ball tirent la conclusion que l'habitude du labyrinthe est contrôlée par un engramme neural entièrement central.

Hunter

EINE WEITERE BETRACHTUNG ÜBER DIE SINNESBEHERRSCHUNG IN DER LABYRINTGEWÖHNUNG DER WEISSEN RATTEN

(Referat)

Das Problem des Experiments bestand darin, zubestimmen, ob eine Vervollkommnung der Labyrintgewöhnung durch exterozeptive Reize beherrscht werde, die den verschiedenen Einheiten des Labyrints eigen sind.

Man gebrauchte ein erhöhtes Labyrint mit recht, rechts, links, links Wendungen (a double alternation elevated maze) und blinde Ratten. Nachdem die Ratten das Labyrint beherrscht hatten, ergab sich, dass sie dadurch beunruhigt wurden, dass die Einheiten des Labyrints, und zwar ohne das Modell des Labyrints zu ändern, ausgewechslt wurden. Da diese Vorrichtung keine neue Reize einführte, sondern nur solche exterzeptive Reize neu ordnete, die die Ratte von den einzelnen Labyrinteinheiten bekommen haben kann, scheint die Folgerung gerechtfertigt, dass die normale Labyrintreaktion teilweise durch solche Reize beherrscht werde. Dieses Ergebnis ist wichtig, indem es von Neuem die Ansicht unterstützt, dass Fertigkeiten durch eine Vielheit von Reizen beherrscht werden, und also die Unzulänglichkeit von Lashley und Balls Beweisführung aufdecken, deren Ergebnis aussagt, dass die Labyrintgewöhnung durch ein zentrales Nervenengramm beherrscht sei.

HUNTER