THE SENSORY CONTROL OF THE WHITE RAT IN THE MAZE HABIT*1

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I. INTRODUCTION

Despite long continued investigation the problem of the sensory control of the maze habit of the white rat is still in an unsatisfactory condition. The present paper seeks a further clarification of the situation through a series of experiments upon the following problems:

1) Can the rat run the maze by means of proprioceptive stimuli alone?

2) If not, what supplementary stimuli are necessary?

3) Does maze running depend upon the reception of identical stimuli from run to run?

The plan adopted in the present experimental work was to use one and two alleys 9" wide, which, while they did not bring in the changed conditions of Vincent's elevated maze, threw into relief the rôles of contact and vision. A complete record of contacts was kept. These contacts show the importance of cutaneous control and they also help reveal the variability of the pathway followed by the rat from trial to trial.

As a check upon proprioception, supplementary to that of recording touches, the maze was so constructed that the wall or walls could be lifted, i.e., removed, without further disturbance to the maze. If the habit be strictly proprioceptive, it will continue, in the absence of the walls.

II. EXPERIMENTAL SECTION A

A. Apparatus

The apparatus used in this experiment was a simple maze of rec-

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tangular design, $3' \ge 4\frac{1}{2}'$, with two removable cross-walls running the width of the maze. Figure 1 is a perspective view and Figure 2 a floor plan of the maze used.

During what is called the First Period the maze had the first cross-wall and no punishment device; during the Second Period the apparatus for giving an electric shock for each contact with the cross-

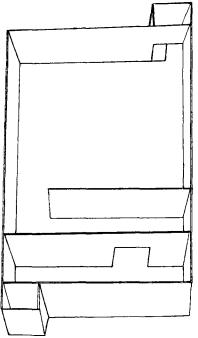


FIGURE 1

PERSPECTIVE VIEW OF THE MAZE, NOT SHOWING THE PUNISHMENT DEVICE wall was added; during the Third Period, a second cross-wall with an additional accompanying punishment system was added.

The box was made of 3-ply veneer wood, $\frac{1}{4}$ " thick, painted a uniform black. The inside measurements were 36" x 54" x 7". The first cross-wall was placed 9", and the second cross-wall 18", from the wall through which the rats entered the maze. The opening in the first cross-wall was 5" high and $8\frac{1}{2}$ " wide, occurring $18\frac{1}{4}$ " and $9\frac{1}{4}$ " from the left and right sides respectively. The second cross-wall was $27\frac{1}{4}$ " long, leaving an opening of $8\frac{3}{4}$ " next to the left

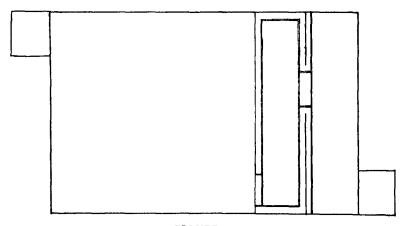


FIGURE 2

FLOOR PLAN, INCLUDING THE PUNISHMENT DEVICE OF THE THIRD PERIOD

side. The cross-walls were firmly held in place by 5 small nails fitted into 1/16'' holes in the floor, and by nails which fitted slits in the sidewalls. Either cross-wall could be lifted without otherwise altering the maze.

There was a *camera lucida* attachment for the tracing of pathways.

The punishment device used during the Third Period is shown in Figure 2. It consisted of a sheet of 5/1000" brass in the middle portion of each alley and of strips 15/16" wide of the same brass, which extended around the walls as indicated in the diagram. The strips protruded 15/16" into the cross-wall openings. The space between the sheets and the strips was 1/16". The cross-walls themselves were covered with brass to a height of 5". The brass was fastened smoothly with escutcheon nails. The narrow strips and the two sheets were wired to form opposite poles of a circuit. They were connected in parallel with a 1850-ohms, .4-ampere rheostat in a 115-volt alternating circuit. The rheostat could be adjusted easily to give any intensity of shock desired.

During the Second Period there was no second alley, and consequently no punishment device except in the first alley. The strips extended into the cross-wall opening only $\frac{1}{2}$.

During the First Period there was no punishment device.

During punishment periods every effort was made to secure the

punishment most effective in eliminating contacts. As will be seen, the rats did not appear to get a shock every time they touched the cross-walls and the narrow strips, probably because of the difference in the strength of contacts made. If the rheostat were placed at a point such that punishment followed the slightest contact, a heavy contact caused a shock so strong that a fear reaction to the whole maze followed. To the strength of current used, the rat's hair and tail were perfect insulation, only the bare nose and the feet mediating punishment. Furthermore, the rats showed individual differences in electric sensitivity, and the experimenter therefore regulated the rheostat for each rat at what seemed to be its learning optimum, that is, such that it would seldom be made to squeal, and such that it could make few touches without getting punishment.

The rats of Group A had their eyes enucleated November 28 and began running December 1. They were given three trials daily throughout the experiment. The rats of Group B were blinded December 7 and began work December 10. They were given five trials daily until December 30 and thereafter three daily. No rats were run on February 29 and March 1 and 2.

All had apparently recovered from the effects of enucleation when training began. All were fed in the food-box for three days before beginning training. The rats' vibrissæ were trimmed closely at intervals of from two to four days.

Until January 8 the doors of both the entrance- and food-boxes were restricted by nails so that they opened only $4\frac{1}{2}$ ". Thereafter the entrance door opened only $1\frac{1}{2}$ " in order to force the rats to take the same orientation at the beginning of all runs. The openings in each case adjoined the side walls.

The apparatus was set up in a small room heated uniformly at ordinary room temperature; it was closed to exclude air currents, and very few sounds came in from the outside. The only illumination came from lamps directly over the maze.

B. Method

1) Rats. Ten vibrissæless blind rats were used, Group A consisting of rats 1-5 and Group B of rats 6-10. These rats, which were of the Experimental Colony Strain of the Wistar Institute, were slightly over a month old at the beginning of the experiment. The rats were active, worked well, used the exercisers in their cages, and appeared vigorous and healthy.

2) Procedure. The daily hour of experimentation was from

3 to 4 P.M. The rats were always given their trials in the order of their numbers. Each rat in its turn was taken from its cage and placed in the entrance-box. After a few seconds, during which the rat usually took up a position near the door, the entrance door was opened. As the rat ran, its pathway was traced by means of the *camera lucida*. While the rat ate, the experimenter indicated by a pointer where the rat had touched or had received a shock, and the person who did the tracing recorded this data on his record. The rat was then returned by hand to the entrance-box for its next trial. The manner of carrying and of placing in the entrance-box was as invariable as possible, and the experimenter was the only person to handle the rats. After their runs the rats were permitted to eat all they would before being replaced in their cages; they were fed at no other time of day.

The experimenter wishes to mention the fact that it was often difficult to observe contacts; but he feels that when there was error it was toward an underestimation. The excess of cut-runs over touch-runs (defined later) corroborates this.

The cross-walls were lifted at various times to study the effect of the removal of the contacts that were persistently made on them.

During the First Period only the first cross-wall was inserted, and no punishment apparatus was used. The natural rôle of cutaneous processes was studied. During the Second Period, by means of punishment, every effort was made to reduce the amount of contact. During the Third Period the same methods as in the Second Period were used but with an additional cross-wall. The effects of greater maze complexity upon the rôle of the cutaneous processes were studied.

In order to compare the final performances of the rats under the three conditions, a Constant Period in each of the three periods was chosen for the tabulation of results. Each of these Constant Periods shows no learning (except possibly the first) and a minimum of variability in the responses.

The limits of the periods by days and runs are given in Table 1.

Periods	Days	Runs				
First	Dec. 1- Jan. 3	A 1-102; B 1-115				
Constant First	Dec. 20-29	A 58-87; B 51-100				
Second	Jan. 4- Feb. 3	A 103-195; B 116-208				
Constant Second	Tan. 17-31	A 141-185; B 154-198				
Third	Feb. 4- Mar. 13	A 196-393; B 209-316				
Constant Third	Feb. 12- Mar. 5	A 219-278; B 232-291				

TABLE 1

3) Definitions. When there was no punishment device, touches were defined as any contacts with the walls. When the punishment apparatus was installed, a *touch* was any contact, including those resulting in shocks, which the rat made with the walls, and any contact or any passing of the body, other than the tips of the hairs, over the narrow strips along the walls. In some cases, the rats did not necessarily touch the strips with their feet when they passed above a corner of them, but it was impossible for the experimenter, being above the rats, to observe this. The bodily position was adopted as the only practical criterion.

A shock was an observed start or jump at contact with the brass. A touch-run for any part of the maze was a run during the course

of which one or more touches were made on the part indicated.

A shock-run was one during the course of which a shock was received; shocks, of course, could be received only in the alleys.

Cut-runs were those in which, the cross-walls being lifted, the rat cut across the former position of the cross-walls.

Perfect runs were those during which no touches at all were made.

C. Results

1) First Period. Group A reached a minimum and fairly constant distance and time in about 25 trials; Group B, in about 40. Complete time and distance records are on file in the Clark University Library.

The following was noticed concerning the early nature of the habit: the rats as a rule touched the left corner of the cross-wall opening and the right side-wall (see Figure 4). The touch on the right side-wall was made with the right side of the head and served to deflect the rats a little to the left and into the food-box entrance. However, once in a while during the first week the deflection was too great, and the rats touched again on the right side of the head by hitting the rear wall; or sometimes the rats did not touch the right side but wandered from the true path so as to touch the rear wall with the right side of the head. In either case the rat usually responded by the customary response of deflecting to the left when he touched on the right. This response, and the succeeding ones similar to it, led the rat in a circular path about the larger end of the maze; the rat found the food-box at the completion of the circle. With repetition, a touch on the rear wall led to a continuance of the wrong direction for only a short distance before turning, and

finally the rats came to orient toward the food-box from a touch almost anywhere in the maze.

While this circular behavior was not as prominent here as in Experimental Part B, some traces of it were found in all of the rats, with the exception of Rat 7, which consistently followed closely the left parts of the maze.

In touching either the cross-wall or the rear wall, the faster rats usually ran into the walls with full force. The slower rats were more cautious and often approached the walls in a hesitating manner.

Table 2 gives the cross-wall touch-runs, and shows that the rats touched on the cross-wall on 58% of their runs during the Constant First Period, the period of final attainment. Table 2, with all similar tables, is to be read as follows: On December 20, Rat 1 touched the cross-wall (one or more times) on one of its three runs, Rat 2 touched on two of its three, etc. It will be remembered that Rats 6-10 are represented by five runs daily in this table, but by three in all other tables.

	TABL	E 2		
CROSS-WALL	Touch-Runs,	Constant	First	Period

	Rats:	1	2	3	4	5	6	7	8	9	10	Total
Dec	20	1	2	1	3	2	2	4	3	2	3	23
"	21	3	3	3	2	0	2	5	2	3	2	25
"	22	1	2	2	1	2	3	5	4	1	2	23
£1	23	1	3	2	2	2	2	4	4	2	3	25
**	24	2	3	1	1	1	1	5	3	2	3	22
**	25	3	1	3	2	2	1	5	1	3	2	23
**	26	2	2	2	3	3	1	5	3	2	1	24
"	27	0	2	3	1	2	2	5	3	1	3	22
"	28	1	3	2	2	2	1	4	3	2	4	24
"	29	1	1	3	0	3	4	4	5	2	4	27
Total	cross	-v	va	11	to	uc	:h-	ru	ns	,—	231	
Total	runs	_	40	0								
Perce	ntage	o	f	ere	oss	- 74	/al	1	to	uc	h-ru	ins . 58

The general nature of the paths followed during the Constant First Period is shown in the tracings of Figure 3. These tracings were made by following the path described by the base of the tail, and consequently *do not show the touches*. Because of a slight distortion in the outer edge of the lens used in the *camera lucida*, the beginning and end of these tracings, when copied upon a diagram of the maze, do not quite correspond to the positions of the entranceand food-box doors.

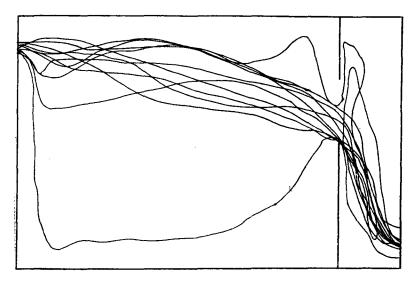


FIGURE 3

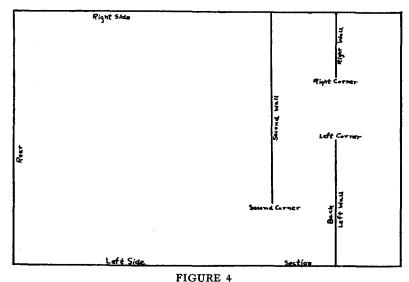
TEN TYPICAL TRACINGS FROM THE CONSTANT FIRST PERIOD Constructed by taking the first run of Rat 1 on the first day, the second of Rat 2 on the second day, the third of Rat 3 on the third day, the first of Rat 4 on the fourth day, etc.

Table 3 shows that the rats touched the cross-wall approximately equally often on the first, second, and third runs.

Not only did the rats touch the cross-wall, but they touched throughout the maze. Figure 4 gives the designations given to

TABLE 3											
CROSS-WALL	TOUCH-RUNS	IN	SUCCESSIVE	RUNS.	CONSTANT	FIRST	PERIOD				

		G_1	rout	A			Group	
							Total	
1st	run	4	8	8	3	8	31	
2nd	run	5	8	6	8	8	35	
3rd	run	6	6	8	6	3	29	
		G	rou	¢Β	}		Group	
	Rats:	6	7	8	9	10	Total	
1st	run	4	10	7	4	8	33	
2nd	run	2	8	6	4	7	27	
3rd	run	4	9	6	2	6	27	
4th	run	3	9	5	4	5	26	
Sth	run	6	10	7	6	1	30	



DESIGNATIONS GIVEN VARIOUS PARTS OF THE MAZE

various parts of the maze throughout this paper; and Table 4, the percentage of the total 400 runs of this Constant Period which involved touches in the various parts. In Table 4 and in all similar tables, the number of runs in which the various parts of the maze were touched is expressed as a percentage of the total runs. The difference between each percentage and 100% will express the percentage of runs in which each part was not touched. These are not given. On account of the manner of construction, no such column totals 100%. The figures of the second column in this and similar tables are the probable errors of the proportions, calculated according to Holzinger (6, pages 248-250).

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TOUCH-RUNS IN EACH PART OF THE MAZE AS A PERCENTAGE OF THE TOTAL RUNS FOR THE CONSTANT FIRST PERIOD

Part of maze	Percen	tage of touch-runs
Left wall		15.2±1.2
Right wall		11.0 ± 1.0
Left corner		41.7 ± 1.7
Right corner		19.2±1.2
Left side		15.2±1.2
Right side		38.0±1.7
Rear		41.4±1.7
	Perfect runs	16.0±1.2

Most of the touch-runs for any part of the maze are composed of one contact with that part, though in a few cases two or even three contacts were made with one part. A consistent use of cutaneous processes is shown. Only 16% of the runs were without touches in some part of the maze. The average total number of touches per run was 2.02 ± 1.83 .

The pathway did not become a highly automatized habit. The runs of the same rat varied nearly as much as those shown in Figure 3. Table 5 shows that two consecutive runs having the same distance occurred only 29 times in this group of 400 runs, that two consecutive runs having the same time and distance occurred only 21 times, etc. In this and similar tables the frequencies for two consecutive identical runs is for two only, and does not include two's occurring within the higher identities.

Even where distances were the same, the relation of the pathways to the maze differed, as shown in Figure 5.

IDENTICAL	CONSECUTIVE RUNS,	CONSTANT	FIRST PERIOD	
Consecutive runs identical in distance	Frequency	ident	tive runs ical in distance	Frequency
2	29	2		21
3	23	3		11
4	5	4		3
5	2	5		1
6	2			
7	0			
8	1			

TABLE 5

	TABLE 6
X7 A T T	CUT-PUNE IN COMPARISO

CROSS-WALL CUT-RUNS IN COMPARISON WITH CROSS-WALL TOUCH-RUNS

Dec. 30 cut-runs	1st run	8	
	2nd run	9	
•	3rd run	10	total 27
Dec. 31 touch-runs			total 19
Jan. 1 cut-runs	1st run	7	
	2nd run	10	
	3rd run	10	total 27
Jan. 2 touch-runs			total 22
Jan. 3 cut-runs	1st run	9	
	2nd run	9	
	3rd run	10	total 28

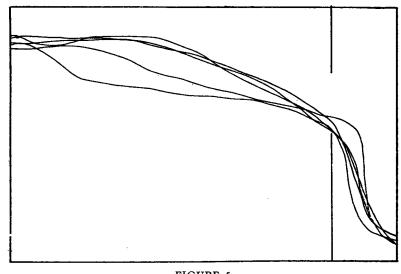


FIGURE 5 Paths of Rat 6, December 21, Five Consecutive Runs with Time and Distance Constant

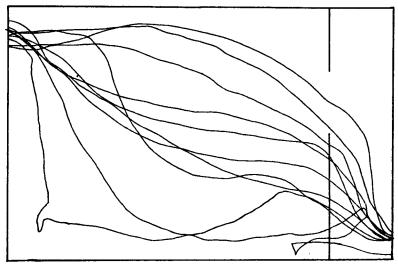


FIGURE 6 TEN TYPICAL TRACINGS ON DECEMBER 30, JANUARY 1 AND 3, WHEN CROSS-WALL WAS LIFTED Selected by taking the first 1un of Rat 1, the second run of Rat 4, the third run of Rat 7, etc.

After the Constant First Period, the cross-wall was lifted and then replaced on alternate days. The cut-runs now exceeded the touch-runs, as is shown by Table 6. This is interpreted to mean that the recording of touches was conservative, and that the touches served to keep the rats in the correct pathway.

The absence of the cross-wall did not cause disorientation nor confusion as a rule, i.e., the rats did not react to the absence of the wall by investigatory movements but ran a comparatively smooth course. The time and distance records were slightly sub-normal. The rats simply passed over the position of the wall at the point where they were usually deflected by its presence. The nature of the pathway followed when the cross-wall was lifted is shown by Figure 6. The path which they had followed from 87 to 100 trials gave way immediately to a shorter one. Of the total records during the three days when the wall was lifted, 64% show some trace of the old habit. In this percentage of cases, that is, the rats went to the right of a straight line between the entrance- and the food-boxes. This deflection varies from being barely noticeable to the full curve of the eight correct runs. Thirty-six per cent of the runs were either on a straight line or to the left of a straight line. There was a general progression of the paths toward a straight line, but the behavior varied from trial to trial and from rat to rat.

Summary of First Period

Blind rats in a very simple maze, but a maze which permitted variability of response, required from 25 to 40 trials to reach the final level of time and distance. Even when learning was complete, touches were made throughout the maze. The cross-wall was touched on 58% of the runs. No significant difference in the number of cross-wall touches on successive runs was found. The same parts of the maze were not touched from run to run. Time, distance, and pathway continued to vary. When the cross-wall was lifted, the rats were not disoriented but frequently cut across the former position of the cross-wall. However, with the cross-wall out, eight trials were correct out of a total of 90 trials. By correct, I mean that, had the cross-wall been in, no contacts would have been made with it.

2) Second Period. During this period only the first cross-wall was present, but the punishment apparatus was introduced to see to what extent the number of touches and touch-runs could be reduced.

The behavior during the Second Period showed distinct effects of the punishment. The rats were more cautious in their running, sometimes running back and forth between the entrance and the cross-wall opening several times before venturing through. Figure 7 gives the typical paths after the Constant Period was reached. In spite of the punishment, however, as Tables 7 and 8 show, the rats were unable to reduce their touch-runs beyond an appreciable percentage, approximately 39% for the cross-wall. The figures italicized are those for days with the wall lifted. The average number of touches per run was $1.32\pm.85$. Dividing the Constant Second TABLE 7

CROSS-WALL	Tou	сн	-R	U	ıs,	C	Co	NS	ТА	NT	S	ECOND	Period
	Rats:	1	2	3	4	5	6	7	8	9	10	Total	
Ja	1. 17	2	0	1	3	1	2	1	0	0	1	11	
- "	18	0	0	2	3	0	0	2	2	0	2	11	
"	19	0	0	0	2	0	2	1	0	1	2	8	
"	20	0	0	1	2	1	0	0	0	2	0	6	
"	21	Ō	1	ō	3	Ō	2	0	1	1	1	9	
"	22	1	Ō	1	2	1	0	0	1	1	2	9	•
"	23	Õ	1	2	2	Õ	Ó	2	2	1	2	12	
**	24	3	$\overline{2}$	õ	3	2	Õ	1	ĩ	ō	ĩ	13	
"	25	1	2	2	2	3	1	ō	2	1	ī	15	
**	26	2	2	2	3	ī	2	ň	2	ō	ō	14	
"	27	2	-	1	3	ō	1	ĭ	2	ŏ	2	13	
"	28	2	1	2	2	ĩ	2	ī	2	ĩ	1	15	
"	29	_	-	ĩ	_	ō	_	ĩ	2	ō	2	13	
"	30	_	_	ō	_	-	_	-	-	2	-	12	
"	31	ĩ	ĩ			ŏ				_	-	14	
	51	1	-	•	5	v	~	•		•	*		
	Total	C	ros	ss-	w	a11	te	ou	ch	- r ı	ıns	175	
	Total	г	un	s								450	
	Perce				of	cı	os	s-	wa	111			
		ou										39	

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TOUCH-RUNS IN EACH PART OF THE MAZE AS A PERCENTAGE OF TOTAL RUNS, CONSTANT SECOND PERIOD IN COMPARISON WITH CONSTANT FIRST PERIOD

Part of maze	Percentage, Constant Second Period	Percentage, Constant First Period
Left wall	9.4± .9	15.2±1.2
Right wall	4.7 ± .7	11.0 ± 1.0
Left corner	18.2 ± 1.3	41.7±1.7
Right corner	8.9±.9	19.2 ± 1.2
Left side	9.8± .9	15.2±1.2
Right side	28.9±1.4	38.0±1.7
Rear	33.8 ± 1.4	41.4±1.7
Percentage of perfect ru		16.0±1.2

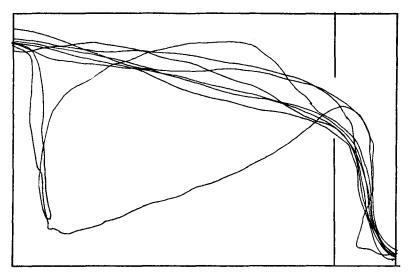


FIGURE 7 TEN TYPICAL TRACINGS, CONSTANT SECOND PERIOD Selected by taking the first run of Rat 1 on the first day, the second of Rat 5 on the next day, etc.

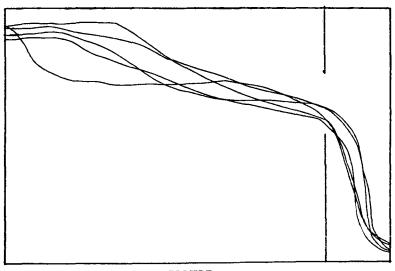


FIGURE 8 PATHS OF RAT 5, JANUARY 26 AND 27, FIVE CONSECUTIVE RUNS WITH TIME AND DISTANCE CONSTANT

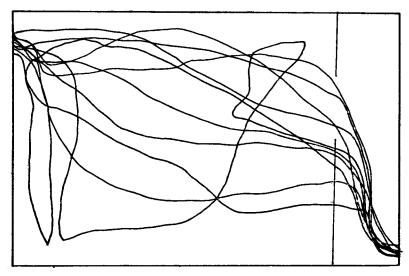


FIGURE 9 First Runs, February 1, Cross-Wall Lifted

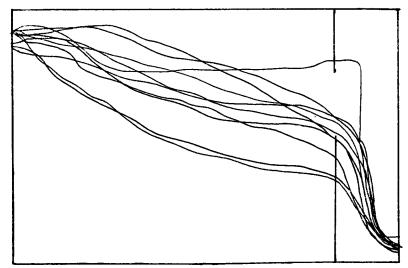


FIGURE 10 Second Runs, February 1, Cross-Wall Lifted

Period into halves, we find that the percentage of perfect runs for the first half is 34.7 while for the second half it is 22.7, showing that in this respect there was a loss of proficiency during the Constant Second Period. Shock-runs were not recorded for the Second Period except for Jan. 31 and Feb. 2, when they were 9 and 7 respectively.

That there was no increase in the Second Period over the First Period in constancy of distance or time and distance is shown by Table 9. The one case of five consecutive runs identical in time and distance is shown in Figure 8. It reveals considerable variability in pathway.

Consecutive runs identical in distance	Frequency	Consecutive runs identical in time and distance	Frequency
2	38	2	18
3	17	3	7
4	6	4	5
5	2	5	1
6	0		
7	1		
8	1		

 TABLE 9

 Identical Consecutive Runs, Constant Second Period

On Feb. 1 and 3 the cross-wall was lifted and the cut-runs were respectively 24 and 21, while on the intervening Feb. 2 the touchruns were 14. This shows that the touch-runs were not being overestimated, that the rats had been kept in the true pathway by their touches on the cross-wall, and that the pathway soon altered when the wall was removed.

Figures 9, 10, and 11 show just what the rats did on runs 1, 2, and 3 when the cross-wall was removed on Feb. 1. Figures for Feb. 3 were drawn and found to be very similar. These figures show that very few investigatory responses were elicited by removal of the wall, that traces of the habit were present in the absence of the wall, but that perfect runs were few.

Summary of Second Period

Punishment was effective in reducing touch-runs and touches, but the second half of the Constant Period showed a loss over the first. The cross-wall was touched in 39% of the runs. There was no improvement in constancy of distance or time and distance over the First Period, and there was variation of pathway when both time

 CROSS-WALL TOUCH-RUNS, CONSTANT THIRD PERIOD
Rats: 1 2 3 4 5 6 7 8 9 10 Total
Feb. 12 3 1 3 0 3 1 2 3 3 3 22
" 13 2 1 2 2 3 3 1 3 3 3 23
" 14 3 2 3 2 3 1 3 23 " 15 2 0 2 2 1 3 23
13 2 2 0 2 3 2 1 3 1 3 19
" 16 2 3 2 3 3 2 1 2 2 3 23 " 17 1 3 1 3 3 1 1 3 2 3 21
" 18 2 3 1 2 3 2 2 3 2 3 23
" 19 3 1 2 3 2 1 3 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 2 1 2 2 1 2 2 2 1 2 2 2 1 2 2 2 1 2 2 2 1 2 2 2 1 2 2 2 1 2 2 2 2 3 1 2 2 2 2 2 3 1 2 2 2 2 3 1 2 2 2 3 1 2 2 3 1 3 2
20 3 2 3 2 3 1 2 3 2 3 24
"21 2 1 2 0 3 2 0 2 3 3 18 "22 3 1 2 3 3 3 1 2 3 3 24
" 23 1 2 3 3 3 1 3 2 1 3 22
" 24 3 2 3 3 3 2 2 2 1 2 24 " 25 3 1 3 3 2 2 2 1 2 24
43 3 1 4 3 3 4 2 3 3 2 24
" 26 3 1 3 1 2 1 3 2 1 3 20 " 27 3 1 2 2 2 2 0 3 3 3 21
" 28 3 3 2 3 3 3 1 3 2 3 26
Mar. 3 3 2 2 2 3 3 3 3 3 1 25
" 4 2 0 1 3 2 3 1 3 20 " 5 3 0 1 3 2 3 2 3 2
" 5 3 0 1 3 3 3 2 3 2 3 23
Total cross-wall touch-runs 445
Total runs 600
Percentage of cross-wall
 touch-runs 74
TABLE 11
 SHOCK-RUNS, CONSTANT THIRD PERIOD
Rats: 1 2 3 4 5 6 7 8 9 10 Total
 Feb. 12 0 0 2 0 2 1 0 1 3 1 10
" 13 0 1 2 2 1 2 0 2 3 2 15
" 14 1 1 3 2 1 3 1 7 " 15 1 0 1 1 1 2 1 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 3 3
" 15 1 0 0 1 1 1 1 3 1 2 11 " 16 1 3 0 3 2 1 1 1 0 1 13
" 17 0 2 0 0 1 1 0 3 1 1 9
" 18 1 2 1 0 2 1 1 2 2 2 14
" 19 0 1 0 1 3 2 1 2 1 0 11
" 20 0 0 1 2 3 0 1 3 2 1 13 " 21 0 1 0 0 2 1 0 0 2 2 9
" 21 0 1 0 0 3 1 0 0 2 2 9 " 22 1 0 1 1 3 2 1 1 1 3 14
" 23 0 1 2 2 3 1 0 1 0 3 13
" 24 1 1 1 2 1 1 1 2 0 0 10
" 25 1 0 0 2 2 1 1 3 2 1 13
" 26 0 0 1 0 1 1 2 2 1 2 10
" 27 0 1 2 1 1 1 1 " 28 0 1 2 0 0 1 10
" 28 0 1 2 3 1 2 0 0 0 1 10
Mar. 3 1 0 0 2 2 2 2 2 1 2 14
Mar. 3 1 0 0 2 2 2 2 2 1 2 14
Mar. 3 1 0 0 2 2 2 2 2 1 2 14 " 4 0 0 0 0 1 3 1 2 0 1 8 " 5 1 0 0 3 2 2 1 1 0 2 12
Mar. 3 1 0 0 2 2 2 2 2 1 2 14 " 4 0 0 0 0 1 3 1 2 0 1 8

TABLE 10 CROSS-WALL TOUCH-RUNS. CONSTANT THIRD PR

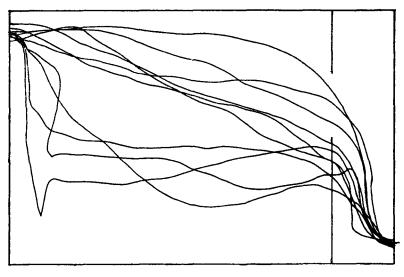


FIGURE 11 Third Runs, February 1, Cross-Wall Lifted

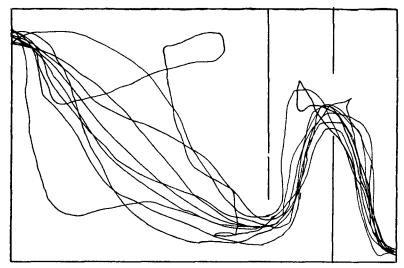


FIGURE 12 TEN TYPICAL TRACINGS, CONSTANT THIRD PERIOD Selected by taking the first run of Rat 1 on the first day, the second of Rat 2 on the third day, the third of Rat 3 on the fifth day, etc.

and distance were identical. Lifting of the cross-wall showed the keeping of the true pathway dependent upon the cross-wall touches. When the wall was lifted, only 15 of 60 trials were perfect.

3) Third Period. During the Third Period two cross-walls were in place, each with a punishment apparatus, and the effect of the increased complexity was studied. The characteristics of the behavior of this period are well shown by Figure 12, and Tables 10, 11, and 12. The rats made definite efforts to avoid shock-carrying regions. They often ran several times from the entrance-box to near the first cross-wall opening before attempting the passage, reacted vigorously when shocked, and gave the appearance of making avoid-ing behavior to contacts.

TABLE 12

TOUCH-RUNS AND SHOCK-RUNS FOR EACH PART OF THE MAZE AS A PERCENTAGE OF TOTAL RUNS FOR THE THIRD CONSTANT PERIOD IN COMPARISON WITH PREVIOUS CONSTANT PERIODS

Pait of maze	Touch-runs 'Third	Shock-runs Third	Touch-runs Second	Touch-runs First
Left wall	12.7±.9	7.0± .7	9.4± .9	15.2±1.2
Right wall	5.5±.2	3.5±.2	4.7±.7	11.0 ± 1.0
Left corner	42.4 ± 1.3	18.4±1.0	18.2 ± 1.3	41.7±1.7
Right corner	7.5±.7	$3.3 \pm .2$	8.9±.9	19.2 ± 1.2
Back	$10.6 \pm .8$	5.8±.2		
Section	8.3±.7	$3.0 \pm .2$		
Second wall	13.0± .9	8.0±.7		
Second corner	32.2 ± 1.3	12.5±.9		
Left side	10.0± .8		9.8±.9	15.2 ± 1.2
Right side	14.8± .9	•	28.9±1.4	38.0±1.7
Rear	31.3 ± 1.3		33.8±1.4	41.4±1.7
Percentage of				
perfect runs	15.6± .9		27.7±1.4	16.0 ± 1.2
Percentage of ru	ins			
free from sho		62.6±1.3		

Dividing the Constant Third Period into halves, the runs free from touches are 16.6 ± 1.4 and 14.3 ± 1.3 , and those free from shocks are 62.8 ± 1.9 and 62.5 ± 1.9 for the first and second halves respectively, indicating that there was no learning during the Constant Period.

The average number of touches per run was 1.82 ± 1.59 , and the average number of shocks per run was $.645 \pm 1.33$.

The two cross-walls of this period increased the number of crosswall touch-runs over those of the Second Period, especially on the left corner. The number of perfect runs was nearly cut in half. The average number of touches per run was increased. The increased complexity of the maze undoubtedly caused an increase in the cutaneous processes involved in sensory control.

The second cross-wall caused a change in the relative distribution of touches in the different parts, the number of touches tending to be greater on those points that most opposed a straight line path from the entrance-box to the food-box.

In regard to the constancy or consistency of response in this Period, Table 13 shows that, considering the fact that the Constant Third Period comprised 600 runs, comparatively few consecutive runs were identical. The one case of five consecutive runs with identical time and distance is shown in Figure 13. Variability of pattern is shown, which, though it appears small in the figure, amounted to several inches' displacement in the 36" by 54" maze.

TABLE	13	
 _	-	

IDENTICAL CONSE	CUTIVE RUNS,	Constant	Third	Period
-----------------	--------------	----------	-------	--------

Consecutive runs identical in distance	Frequency	Consecutive runs identical in time and distance	Frequency
2	67	2	39
3	19	3	4
4	6	4	0
5	2	5	1

The results of cross-wall lifting of March 6 and 10 as shown by Table 14 and Figure 14 gave the same results as before: the cut-runs exceed the touch-runs when the cross-walls are removed. A habit, part of which has been imposed by over 300 runs, practically never remained unchanged when the cutaneous processes were eliminated.

		Rats:	1	2	3	4	5	6	7	8	9	10	Total
			_	-	-			-			-		
March	6	Cut-runs	3	3	3	3	3	3	3	2	3	3	29
-		Shock-runs	1	2	1	2	3	2	1	2	2	0	16
"	7	Touch-runs	-3	1	3	2	3	2	2	3	3	3	25
		Shock-runs	1	0	2	1	1	1	1	2	3	1	13
"	8	Touch-runs	3	1	0	3	3	2	1	3	2	3	22
		Shock-runs	2	0	0	3	3	1	0	1	2	2	14
"	9	Touch-runs	2	2	2	3	2	3	3	3	0	2	22
		Shock-runs	1	2	0	3	2	2	3	3	0	2	18
"	10	Cut-runs	3	3	3	3	3	3	3	2	2	3	28
			-	2	-	-	-	-	-		-		21

TABLE 14 Results of Cross-Wall Lifting. Third Period

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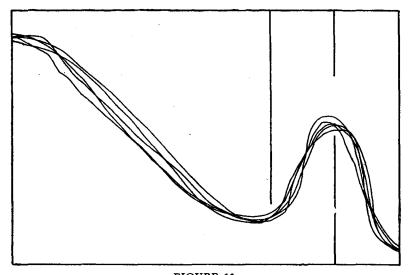


FIGURE 13 Paths of Rat 9, February 16 and 17, Five Consecutive Runs with Time and Distance Constant

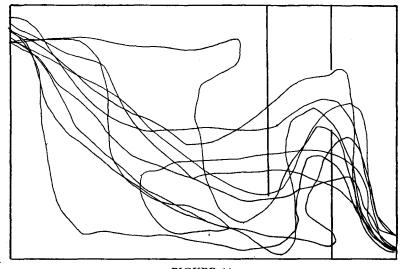


FIGURE 14 TEN TYPICAL TRACINGS, WALLS LIFTED, MARCH 6 AND 10 Selected by taking the first run of Rat 1, the second of Rat 2, etc.

On March 11 the brass of the punishment device, which had been on the floor of the first alley throughout the Second and Third Periods and on the floor of the second alley throughout the Third Period, was removed; the walls were left in place. The animals were disturbed by the cutaneous alteration, their time and distance records being lengthened by hesitation and by investigatory responses. They were run under the same conditions March 12. The crosswall touch-runs for the two days were respectively 27 and 25. On March 13, the last day of Experimental Part A, the cross-walls were removed as well, leaving only the empty maze. There was not a run that was not a cut-run.

Summary of Third Period

Alteration of the maze toward complexity increased the use of cutaneous processes. As in the previous periods, there was no decrease in contacts after the first few days. The contacts were greatest where the pathway varied most from a straight entrancebox-food-box pathway. In a simple maze which allowed variability of response, overlearning of the habit did not bring with it a fixed and invariable response as measured by time, distance, and spatial location. Lifting of the walls showed the habit to be dependent for accuracy upon cutaneous processes, but, as before, the removal did not disorient the animals. Alteration of the cutaneous stimuli on the floor disturbed the animals.

III. EXPERIMENTAL SECTION B

A. Problem and Apparatus

Experimental Section A had required a turn in coming out of the entrance-box and another at the cross-wall opening. Since these turns were not accurately acquired on a purely proprioceptive basis, the problem of Experimental Section B was to find if a single turn could be negotiated proprioceptively.

In order to study this problem, the same apparatus was used as in the Second Period of Experimental Section A (one alley and a punishment device), with the following modifications. The entrancebox was changed so that its $1\frac{1}{2}$ " doorway came in the middle of the left end of the alley. A single turn of slightly more than 90 degrees was now required. In addition, the alley was broadened to 10". The punishment apparatus was built of $\frac{1}{8}$ " polished brass instead of sheet brass. The cracks between the main piece of brass and the strips were carefully filled in with plastic wood, a composition substance which made the surface smooth. There was sheet brass on the cross-wall to the height of 5".

B. Method

Rats. Eight blind vibrissæless white rats, progeny of the 1) earlier group, were used. They were blinded by enucleation of the eyes several days before the beginning of the experiment. The rats were from 40 to 50 days of age when they began training.

2) Procedure. The procedure was the same as that of Experimental Section A except that no tracings were made. The rats were given three trials daily from April 17 until June 1. The punishment device was present throughout and was connected in circuit beginning April 22.

C. Results

As in the earlier experimental section, touches and touch-runs were reduced most during the first few days. The number of cross-wall touch-runs did not decrease after the tenth day.

The circular habit, or the generalization of a touch on the right side of the head, noticed in the First Period of Section A was for some reason much more prominent with this group of rats. If a touch on the right side of the head when the rat made contact with the right side-wall deflected him far enough to the left to hit the rear wall, this second touch on the right side of the head seemed to be the stimulus for a similar reaction, and repetitions of this response conducted the rat about the maze. The rats often ran about the large end of the maze two or even three times before hitting the т

ABLE

	Dates	1	2	,	4	e	(7	0	Total	
	Kats:	1	4	3	*	<u> </u>	0		<u> </u>	10121	
May	7 19	2	2	3	1	2	2	2	2	16	
، ن	20	1	2	3	9	2	1	2	2	13	
**	21	2	1	2	2	1	2	1	1	12	
44	22	3	2	2	1	2	2	3	2	17	
"	23	1	2	3	3	0	2	2	1	14	
"	24	3	3	2	1	0	1	3	2	15	
"	25	1	3	2	2	1	1	1	3	14	
"	26	2	3	2	1	2	1	3	1	15	
										<u></u>	
Tot	al cr	os	8-V	va	11	to	uc	h-			
	runs									116	
Tot	al ru	ns								192	
Per	centa	ge	0	f	cro	oss	-7	7al	1		
	touc									60	

CROSS-WALL	Touch-Runs,	Constant	В	Period
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opening of the food-box. This response appeared in all the rats under the conditions described, and seemed to be eliminated gradually. A contact on the rear wall was followed by shorter and shorter excursions to the left, and finally a contact on the rear wall was followed immediately by a correction of pathway to the right. As training progressed, a touch anywhere in the maze was usually followed by a turn that led to the approximate region of the foodbox.

The eight days immediately preceding the lifting of the wall were chosen as the Constant B Period. However, 15 days previous to this period show equivalent results.

TABLE 17

CROSS-WALL SHOCK-RUNS, CONSTANT B PERIOD

,	Rats	1	2	3	4	5	6	7	8	Total
Ma	y 19	0	1	0	0	2	2	1	2	8
""	20	0	1	2	0	2	0	0	2	7
"	21	0	1	0	2	1	1	1	1	7
"	22	1	2	1	1	1	2	2	1	11
"	23	1	2	1	3	0	1	0	1	9
"	24	0	3	1	0	0	0	3	1	8
"	25	1	3	2	2	0	0	1	2	11
"	26	2	3	1	0	1	0	1	0	8
To	tal sh	ocl	(-r	u	19					69
Tot	Total runs							192		
Per	centa	ge	o	f	she	ocl	(-1	uI	ıs	35

The number of cross-wall touch-runs in this period is reliably greater than in the Constant Second Period. Whether the difference is due to differences in the conditions or in the group of rats cannot be determined.

The touch-runs for all parts of the maze are given in Table 18 in comparison with the Constant Second Period, the most comparable period. The outstanding difference in the distributions is the greater number of touches on the right corner, right wall, and right side in the Constant B Period. This is probably due to the differences in initial orientation of the rats in the two periods, the rats of the B Period being oriented toward the right side and the rats of the earlier period being oriented toward the rear side when they left the entrance-box.

After May 26 the rats were run for five consecutive days with the cross-wall removed. The results are shown in Table 19.

TABLE 18								
TOUCH-RUNS FOR EACH PART OF THE MAZE AS A PERCENTAGE OF THE TOTAL RUNS FOR CONSTANT B PERIOD IN COMPARISON WITH CONSTANT								
SECOND PERIOD								

<u> </u>
47+7
T.//
18.2±1.3
8.9±.9
9.8±.9
28.9±1.4
33.8±1.4
27.7±1.4

TABLE 19

CUT-RUNS, EXPERIMENTAL SECTION B, CROSS-WALL LIFTED

	Rats:	1	2	3	4	5	6	7	8	Total
Ma	ay 27	3	3	2	1	2	3	3	3	20
"										
"	29	3	3	3	3	3	3	2	3	23
"	30	3	3	3	3	3	3	3	3	24
"	31	3	2	3	3	3	3	3	3	23
	Total	cυ	ıt-	ru	ns					112
	Total	rυ	ins	8						120
	Perce	nta	ige		of	с	ut-	٠ru	ins	s 93

This table shows that the cutaneous processes were necessary to maintain the pathway. In the successive days the runs became more and more an approximate straight line toward the food-box, with contacts near the food-box on account of the inaccuracy of the course followed.

Summary of Experimental Section B

After extended training eight vibrissæless blind rats in a modified form of the maze made more touch-runs than the earlier groups. Lifting of the cross-wall showed the pathway to be dependent upon cutaneous processes. Five days with the wall lifted destroyed nearly all traces of the former habit.

IV. EXPERIMENTAL SECTION C

So far in the experiments only blind rats had been used. With these subjects it was found that contacts could not be eliminated, even though the animals were extensively trained and even though a punishment device was installed in order to force the elimination as far as possible. The conclusion indicated by these findings is that proprioceptive impulses, while present and influential in the control of behavior, could not control the accurate spatial adjustments necessary for the running of the maze without contact with the walls.

A further experiment was now made using rats whose vision was unimpaired. Three untrained adult seeing rats were used in the same apparatus and with the same method found in Experimental Section B. Three trials daily were given throughout the brief experimental period-May 20 to June 7. The rats were first run without connecting the punishment device in circuit to see to what extent they would decrease touches normally. On both the sixth and seventh days the cross-wall touch-runs were 33% of the total runs, which was a record equal to the final level of attainment in the Second Period and better than that of the B Period. How much further the touch-runs would have decreased with additional training is not known. On account of the shortness of the remaining experimental time, the shocking apparatus was put in circuit on the eighth day, May 27. The final level of attainment was reached in four days. Tables 21 and 22 show that the rate greatly decreased cross-wall touch-runs and shock-runs.

With only four days (12 runs for each rat) of practice, these vibrissæless seeing rats made a much lower percentage of cross-wall touch-runs and shock-runs than any other group. As far as shock avoiding is concerned, the last four days were perfect. The touches that were made differed from those of the blind rats in kind as well as in number. The seeing rats never ran into the wall. The touches

TA	BLE	21

CROSS-WALL	Touch-Runs,	Constant	С	Period
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R	lats:	1	2	3	Total		
May	31	0	1	0	1		
June	1	0	0	0	0		
"	2	2	0	2	4		
"	3	1	0	1	2		
* 6	4	0	0	0	ō		
41	5	0	1	0	1		
"	6	1	2	1	4		
Total touch-runs	Total touch-runs						
Total runs	Total runs						
Percentage of to	ouch	-ru	ın	8	21		

	R	ats:	1	2	3	Total	
	May	31	0	0	0	0	
	June	1	0	0	0	0	
	"	2	2	0	0	2	
	"	3	0	0	0	0	
	"	4	0	0	0	0	
	"	5	Ó	0	Ó	0	
	"	6	0	0	0	0	
— • • • •							
Total shock	c-runs	3				2	
Total runs						56	
Percentage	of sh	lock-	-ru	ins	t I	3.6	

that were made were made incidentally as the rat ran through the opening, because some part of the head or body extended over the strips or to the wall. These rats, it will be remembered, were older and larger than the blind rats, and had to show a finer discrimination of distance in proportion to their size. Their behavior indicated that normal rats could probably be trained to run a simple maze without touching the walls.

The seeing rats also differed from the blind ones in that the circular responses previously mentioned never occurred with them. They often followed the right wall but the infrequency of touches in other parts of the maze shown by Table 23 points out as a further difference that the seeing rats were more accurate in finding the foodbox. (In this connection the short training period of the normal rats must be considered.)

TABLE 23

TOUCH-RUNS IN EACH PART OF THE MAZE AS A PERCENTAGE OF TOTAL RUNS FOR CONSTANT C PERIOD IN COMPARISON WITH CONSTANT SECOND AND B PERIODS

Part of maze	Touch-runs Constant C	Touch-runs Constant B	Touch-runs Constant Second
Left wall	00.0	16.3±1.9	9.4±.9
Right wall	00.0	16.3 ± 1.9	4.7±.7
Left corner	16.0±3.3	16.3±1.9	18.2 ± 1.3
Right corner	5.4 ± 2.1	27.6±2.3	8.9±.9
Left side	00.0	6.2 ± 1.2	9.8±.9
Right side	34.0 ± 3.2	44.2 ± 2.4	28.9±1.4
Rear	3.6 ± 2.0	38.4±2.3	33.8±1.4
Perfect runs	60.7±3.3	14.6±1.7	27.7±1.4

On June 7 the cross-wall was lifted, and all of the rats cut across the former position of the left wall. Otherwise the runs were normal. Most of the cutting was immediately after emergence from the entrance door, which means that there was very little trace of the old pathway.

Summary of C Period

Three seeing rats with only a short training period made fewer touches than any other group and practically eliminated shocks. All runs made when the wall was lifted were cut-runs.

V. INTERPRETATIVE COMMENT

In Experimental Sections A and B, as far as is known, all sensory processes except the proprioceptive and cutaneous were inoperative. (In the light of other work, olfactory processes can undoubtedly be neglected in the present experimental setting.) The cutaneous processes set up by contact with the various walls of the maze did not approach elimination after 300 trials even when at least half of them in the alley section were accompanied by electrical punishment. In each period a small percentage of the runs was made with only proprioceptive stimuli and cutaneous stimuli from the floor operative, i.e., in these cases the rat ran from entrance to exit without receiving contacts from the walls. Lifting of the cross-walls showed that the cutaneous processes were necessary for the maintenance of the correct pathway in all except a very few runs. In Section C, where seeing rats were used, lifting of the cross-wall showed that visual processes were necessary for the maintenance of the correct pathway. The conclusion, therefore, is that even the simple maze here used can be run only occasionally by means of proprioceptive stimuli and cutaneous stimuli from the floor.

The results of the present experiments indicate that the rat cannot make responses of the degree of accuracy of spatial adjustment required by the maze on the basis of proprioceptive processes. These processes are active, to be sure, as is indicated by the occasional perfect runs and by the curved character of the pathways. However, the blind rat must in the very great majority of cases receive a cutaneous stimulation from the walls in order to find the proper openings. To a large extent and perhaps entirely, the seeing rat can dispense with these cutaneous stimuli and utilize vision to supplement the proprioceptive processes. These statements do not necessarily imply that the cutaneous and visual stimuli must serve as differential cues, i.e., that there shall be one kind of contact at one part of the maze and another kind of contact farther on. The cutaneous and visual stimuli may have a *releasing* function only. In such a case, proprioception might indicate that a turn is to be made but that turn would be made only when contact or vision, or both, indicated the presence of an opening through which to turn.

The question arises as to how far this conclusion applies to all mazes. We believe that it applies to all in which the white rat has been used. Our First, Second, and B Period maze had a single alley more than 9" in width. We know of no mazes that have used alleys more than 6" in width. The rats were given $6\frac{1}{2}$ " in which to make a simple turn after running 18". In one case the 18" run was preceded by a turn, in another it was not. No rats out of 18 reduced touches below an appreciable percentage. The Third Period showed that an increase in complexity increased the difficulty of the problem. Since a maze as simple as those here used cannot be mas tered by proprioception alone, and since complex mazes are more difficult, it seems highly improbable that any of the mazes in which rats have been used can be run with only proprioception operative.

As to the theory that the sensory control in the maze passes over to the proprioceptive processes in the course of learning, we find that the cutaneous processes do decrease during learning but are normally not eliminated, and cannot be eliminated unless vision is present.

Does maze running depend upon the reception of identical stimuli from run to run? The ordinary maze with 4" or 6" alleys permits little variation in the pathway followed other than downright entrance into blind alleys. We find in a maze which permits variability that touches are made in all parts of the maze, and the same parts are not necessarily touched on successive runs; distance is not often identical on successive runs, and time and distance still less often identical; the pathway varies from run to run; the blind rat is not disoriented if a cross-wall which has been touched on 39% or more of the runs is removed. (This latter point would suggest strongly that the contacts with the wall were serving a releasing function The maze habit, then, does not depend upon the reception only.) of identical stimuli from run to run, but may be called a variable habit. The habit is not an automatized invariable pattern. Nor is the variable habit a permanent or persistent one; the removal of the cross-wall was followed by almost immediate modification of the pathway.

VI. CONCLUSIONS

1) A simple maze can but rarely be run by the rat by means of proprioceptive processes alone.

2) Either cutaneous or visual processes in addition to the proprioceptive processes are adequate for the maze habit, but in normal animals probably all three are jointly used.

3) Maze running does not depend upon the reception of identical stimuli from run to run.

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LE CONTRÔLE SENSORIEL DU RAT BLANC DANS L'HABITUDE DU LABYRINTHE

(Résumé)

Dans un labyrinthe d'un couloir comprenant deux tours, on a constaté que dix rats aveugles sans vibrisses ont touché les parois, même avec beaucoup d'entraînement. On a ajouté un appareil à punir les contacts au moyen d'un choc électrique, mais les rats ont su toujours faire les parcours seulement rarement sur une base purement proprioceptive. On a ajouté unc deuxième paroi, et cette nouvelle complication a doublé le nombre des contacts. Dans chacune de ces trois conditions, après que les rats avaient travaillé pendant quelque temps à leur dernier niveau de rendement, on a enlevé la paroi ou les parois. Les rats n'ont pas été désorientés; mais leurs parcours, imposés par contact avec la paroi ou les parois, ont changé tout de suite.

Un deuxième groupe de huit rats aveugles sans vibrisses dans un labyrinthe simplifié à un tour et fourni d'un appareil à punir au moyen des contacts n'a su parcourir le labyrinthe sans contacts que très rarement. L'enlèvement de la paroi a montré que le parcours dépend de ces contacts.

Trois rats voyants sans vibrisses dans le même labyrinthe avec très peu d'entraînement ont éliminé ces contacts qui causent la punition, mais ont gardé les autres. Leur parcours aussi a été changé au moment de l'enlèvement de la paroi.

On a trouvé une variabilité de réponse chez tous les rats; les rats n'ont pas reçu les mêmes stimuli pendant les différents parcours.

L'auteur conclut que le parcours du labyrinthe ne peut pas avoir lieu avec un contrôle purement proprioceptif, et que des processus sensoriels visuels ou tactiles sont un supplément suffisant. Ces stimuli auront une fonction de libération et servent à rendre précises les réponses initiées par des stimuli proprioceptifs.

Dennis

DIE SENSORISCHE KONTROLLE DER WEISSEN RATTE BEI DER LABYRINTHGEWÖHNUNG

(Referat)

Bei Experimenten mit einem Labyrinth, das aus einer Gasse mit zwei Wendungen bestand, fand es sich, dass zehn blinde Ratten, ohne Barthaare selbst nach langer Übung die Wände berührten. Man stellte dann einen Apparat her, der jede Berührung mit einem elektrischen Schock strafte, aber trotzdem waren die Ratten nur selten im stande ihren Lauf ohne Kontakt auf rein propriozeptiver Basis auszuführen. Man fügte dann eine zweite Wand hinzu, und diese erhöhte Schwierigkeit verdoppelte die Zahl der Berührungen. In jedem dieser drei Fälle entfernte man die Wand oder die Wände, nachdem die Ratten eine Zeitlang bei höchster Leistungsfähigkeit gearbeitet hatten. Die Tiere wurden nicht disorientirt; doch ihr Lauf, der bisher durch Kontakt mit der Wand oder den Wänden bedingt wurde, veränderte sich sofort.

Eine zweite Gruppe von acht blinden bartlosen Ratten, in einem "maze" mit nur einer Wendung, und ebenfalls mit der elektrischen Vorrichtung versehen, konnten doch nur selten den Lauf ohne Berührung ausführen. Das Entfernen der Wand bewies, dass der Lauf von diesen Berührungen abhing.

Drei bartlose sehende Ratten, vermieden, nach ganz kurzer Trainirung, nur die Berührungen, welche den elektrischen Schock verursachten; ihr Lauf änderte sich ebenfalls nach Entfernung der Wand.

Bei allen Ratten zeigte sich eine Verschiedenheit der Reaktion; man benutzte nicht bei allen Tieren dieselben Reizmittel von einem Lauf zum andern.

Der Verfasser .schliesst aus diesen Versuchen dass man ein Labyrinth nicht auf rein propriozeptiver Basis kontrollieren kann, und dass entweder Vorgänge des Sehens oder Fühlens die notwendige Ergänzung bieten. Diese Reizmittel haben wahrscheinlich eine auslösende Wirkung, und dienen dazu den Reaktionen, die durch propriozeptive Reizmettel ausgelöst werden, grössere Genauigkeit zu verleihen.

Dennis

контроль чувствительности у белых мышей в обстановке лабиринта.

(Реферат).

Был взят лабирнит с одной дорожкой, делавшей два новорота; оказалось, что слепые и лишенные вибрисс крысы, даже имевшие уже некоторый опыт, прикасались к стенкам. Был устроен анпарат для наказывания крысза прикосновение ударом электрического тока: тем не менее крысы редко были в состоянии выполнять свой пробеги по лабирниту на чисто проприоцентивной основе. Црибавление второй степки, увеличив сложность лабирнита, удвоило и количество контактов. При каждом из этих трех условий, после того как крысы в течение некоторого времени работали у возможного предела своей чувствительности, одна или все степки поднимались. Крысы не быля дивориентированы, но их пути, которые определялись контактом со степками, немедленно изменялись.

Вторая группа из восьми слепых и лишенных вибрисс крыс в лабиринте, упрощенном до одного попорота и снабженном аппаратом для наказывания за контакт, за редкими исключениями не могла пробежать по лабиринту без контактов. Подиятие стенки показало, что путь определяется этими контактами.

Три лишенные вибрасс, по зрячие крысы в том же лабиринте, в течение короткого периода подверглинся обучению, избегали тех контактов, которые сопровождались наказанием, по сохраняли другие. Их путь также изменялся, когда степка поднималась.

сопровождались наказанием, по сохроняти другие. на из со тактикалась. когда степка поднималась. Все крысы обнаруживали разнообразно в реакциях: крысы получали неодинаковые раздражения от одной пробежки до другой. Автор делает заключение, что по лабиринту нельзя пройти с помощью тактидыные

Автор делает заключение, что по лабирниту нельзя пройти с помощью чисто проприоцептивного контроля п что либо зритеальные, либо тактильные ощущения являются одинаково достаточными. Эти раздражения, повидимому, играют освобождающую роль и служат для того, чтобы придавать точность реакциям, вызываемым припроцептивными раздражениями.

Денинс (Dennis).