Thesis

on

The Acquisition of Motor Habits,

submitted in candidature

for

the Degree of M.A. in Philosophy,

by

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The Acquisition of Motor Habits.

The present thesis is based on a study of the acquisition of motor habits by white rats. The behaviour of the white rat has been the subject of considerable study and experiment during the last twenty years. The first investigator in this field was Willard S. Small who began his work in the academic year 1898-9. He was primarily interested in the associative processes, but both in his early study of the development of young white rats, and in his later experimental work with older rats he took care to note the general characteristics of the animal. Small was very much impressed with the necessity of choosing for his experimentation activities and conditions which should be as natural to the rat as possible. He decided that hunger is the most natural motive, and digging one of the most characteristic activities.

His first series of experiments may be described in his own words. "The apparatus used was a cubical box of 6" dimensions. The sides were of ¼" wire mesh; the bottom of wood 7/8" thick, and top of glass. In the front side of the bottom was a hole large enough to admit a rat.

The bottom was raised 1½" from the floor of the cage by strips of wood on the sides of the bottom. In experimentation the food was put inside the box and sawdust was banked around the box to the top of the floor, completely concealing the entrance - - - The experiments were performed in the cages where the rats were usually kept. At the regular time for feeding the box containing the food was placed in the cage and banked with sawdust".[1] Four female rats worked at the box in pairs. The first pair were tried on thirteen successive occasions, and the second pair on nineteen.

Small gives a detailed account of the behaviour of the rats, but for the present purpose it is sufficient to state his results summarily. He found that the time taken to enter the box on successive occasions decreased very rapidly (from 1 hr. 30 mins. to 30 secs. in 13 trials) and that most of the unnecessary preliminary movements were eliminated. Of both pairs of rats there was one which did all the work, while the other showed little or no tendency to imitate him, but merely shared the fruit of his labour.

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1. American Journal of Psychology. Vol. XI, p.135.

In his second group of experiments Small employed apparatus similar to that already described but in place of digging in order to get into the box, the rat had to gnaw through paper which held a little swing door shut. The rats worked in pairs as before. The same general characteristics of the learning process as for the first series are noted. But a comparison of the results brings out in addition a point which is relevant to the subject of the present thesis. This is that useless motor habits acquired in the first series (e.g., digging round box) persisted and were especially noticeable when the rats were particularly hungry or excited. Small remarks that this persistence illustrates the thoroughly automatic character of motor memory.

In the third group of experiments tests with Boxes I. and II, were alternated irregularly with the object of discovering whether the rats could discriminate one box from the other. The results show that the rats vary individually in this respect. One rat discriminated I. from II. perfectly, and always acted appropriately. Another rat always recognised Box I, but did not recognise Box II. Two of the rats out of the four remained idle as in the previous

groups of experiments. Small's next step was to remove the spring from the door of Box II. so that when the rat had gnawed away the label he had still to push the door open for himself. When the first rat found the door did not open on the removal of the label she tried digging desultorily, running to poke the door at intervals. She finally poked the door open far enough to get some bread. In speaking of this behaviour Small says "That the rat <u>feels</u> "why" or "what" is certain, that she <u>thinks</u> "why" or "what" is both doubtful and unnecessary - - Crass images visual, olfactory, motor-organic conditions and instinctive activity are assuredly the main elements. That these elements may bleach out and attenuate into ideas is not impossible." [1]

Small's fifth group of experiments was carried out on four male, eight-week old rats. They were all tested together with Box II. and their behaviour carefully noted with the object of bringing to light individual differences. During the first nine experiments Rat A. did all the work. He was then removed. For the next three experiments B was the only worker and then he was removed. Rat C. did all the work on the next four occasions - no more tests were

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1. American Journal of Psychology. Vol. XI, p.155.

made. These results confirm the view that there are great individual differences, and also that the rat is not very imitative, although Small considers that there was some evidence of imitation. These young, very tame, male rats were much quicker than the older females used in all the previous experiments. It is, however, impossible to say whether this is due to sex, age, or greater tameness.

Another of the rat's activities was now chosen for experimentation -- that of running along intricate paths. Small had a miniature of the Hampton Court Maze made in wire netting. This was separated from the rats' cage by a glass door which could be automatically removed by an observer, without his being seen by the rats. Food was put in the middle of the maze, and the rats were left with access to the maze all night. The subjects were two young males, 3½ months old. In his analysis of the results[1] of this series of experiments Small emphasises several characteristics of the rats' behaviour in mazes. The first is the fortuitousness of the first success, and the indefiniteness of movement during the first two or three attempts. Equally characteristic is the way in which this initial

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1. American Journal of Psychology. Vol. XII, p.220.

vagueness gives place to certainty and rapidity in the course of three or four trials. Once more the rats' behaviour showed little or no sign of imitation, neither did they appear to depend on scent. Small considers that their behaviour with regard to blind alleys - first taking them as a matter of course, then showing "disgust" at the end of them, later running only half-way down, and finally avoiding them altogether - suggests centrally excited sensation (images). All the objective data point for Small to the conclusion that the "central fact in the process seems to be the recognition by the rats of particular parts of the maze", Vol. XIII, p.219. In a note on p.230. Small records the fact that several rats were tested with a maze which had no food in the centre. It was found that they followed out the course of the maze as perseveringly as if the food were there, but in five or six trials they made little progress in learning the direct course. He says that as there was no pleasant association, there was nothing to determine the building up of this definite association train.

Small concludes his study with an attempt to evaluate the role of the different sensations in the learning

process. He considers smell comparatively unimportant because in the absence of air currents the smell of the food can help but little in its location and the rats very often did not follow their own or other rats' trails, and even when on occasion they did, they would often prefer an old trail to a new one. In considering the role of sight he was helped by the fact that some of his rats became blind when they had been in a maze only once or twice. He found that these rats learnt the maze as quickly as the others and had only slightly more difficulty in learning the reversed maze.

To find that tactual-motor sensations furnish the essential data for the recognition and discrimination fundamental to the learning of the mazes was no doubt an unexpected discovery.

The work of this pioneer in rat psychology suffers from faults in technique which will be mentioned in connection with the work of his successors, but in spite of these faults it is extremely valuable, both as suggesting methods and apparatus which have since been fruitfully applied in many other fields, and as giving an insight into rat behaviour which is in itself an acquisition to

comparative psychology.

The next important research upon maze running by white rats was carried out by J. B. Watson in the Chicago Laboratory during 1905-6. [1] He sought to discover the role of kinaesthetic and organic sensations in the reaction of the rat to the maze. He considered that this could be done only negatively, i.e., by eliminating the other senses. He criticises Small's report on the blind rats on the score that it is impossible to ascertain exactly when a rat becomes blind. Watson used a maze differing from Small's in size only, but he made important improvements in technique. His mazes were of wood instead of wire netting, thus shutting off any possibility of the rat seeing from one passage to another. He never put in more than one rat at a time. His greatest improvement on Small's method, however, was taking the rat out when it had had its food instead of leaving it to run the maze all night. This enables Watson to gain a complete picture of the rat's learning, whereas in Small's work a great deal must have taken place at night, when the animal was unobserved. Watson put bread and milk and cheese in the middle of the maze. He timed the animal

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1. Psychological Review (American) Supplement Vol. VIII.

from its entrance to its arrival at the food. When the rat had eaten a little, he took it out, and after a few minutes let it run the maze over again. He let it repeat its performance in this way from four to six times each day. As Small decided that the rats did not rely upon tracking by smell in order to learn the maze, Watson did not attempt to rule out the possibility. All Watson's animals were very tame, and he let them eat their food in the middle of the maze for a week before beginning his tests, to preclude error arising from emotional disturbance.

The experiments were planned to afford a comparison between the performance of rats deprived of different senses and the performance of normal rats. The first series was carried out on four males a year old. It showed the same main characteristics of the learning process as Small had recorded. Carr with whom Watson was working then trained five rats and when they were proficient he tested them in the dark. Four of the five rats made the trips in the dark in an absolutely shorter time, while the remaining rat did approximately as well as he did in the light. Watson points out that this method is open to two objections. In the first place adaptation of the eyes to darkness is not

precluded, and in the second, the most that it can prove is that once the maze is learned, it can be run without visual cues. The next step was therefore to endeavour to make the rat learn the maze in darkness. The records for the rats which had to learn the maze in the dark are actually superior to those for daylight learning. As these results favoured Small's conclusion that tactual kinaesthetic sensations are the most important, Watson and Carr tried to increase the vividness of these by placing obstructions through which the rat had to squeeze, at each turn. The results are not so good, but as Watson points out, the method is open to objection -- the actual scrambling through takes time and very probably frightens the rat.

From the work he had done up to this point, Watson was convinced that his problem could be solved satisfactorily only by eliminating the activity of the various sense organs either by section or anaesthetisation. His first experiments were made upon four male rats whose eyeballs were completely removed. He reports that there were no shock effects and that forty-eight hours after the operation, the animals were "absolutely normal." He succeeded also in removing the olfactory lobes, and in rendering the

rat insensitive to sound by destroying the drum of the ear, and breaking up the chain formed by the bones of the middle ear, the ear being then filled with paraffin wax. The records of these rats for learning mazes are normal. Watson is thus led to the conclusion that none of these senses -- sight, hearing, smell -- affords exclusively the essential clues in the learning process.

Watson's next problem was to discover the part played by the various cutaneous elements in the formation of the maze associations. The constant movement of the vibrissae suggests that they play an important part in orientation. To test their importance Watson cut off the vibrissae of the blind, deaf, anosmic and normal rats. His results show that the loss of the vibrissae has no permanent effect on the rats' ability to run the maze. Further incomplete experiments carried out by Watson suggest that the rat in no way uses his cutaneous sensations as a basis for sensing the correct turns in the maze from the incorrect.

Watson concluded his investigation with a study of the effect of changing the absolute position of the maze. His results are not complete, but as far as they go,

they show that rotation of the maze does ~~not~~ confuse the rats, and that rotation through an angle of 90° has more effect than through 180°. He is inclined to attribute "a sense of orientation" to the rat.

Watson's results all tend to confirm Small's conclusion. That is to say they favour the view that none of the extra-organic clues is essential to the rat in running the maze, and from the negative evidence on this subject Watson passes to the hypothesis that the rat depends on organic and kinaesthetic sensations. In order to test this Watson performed another series of experiments in which, after the rat had learnt a maze, some of the passages were lengthened and others shortened. He reports that this caused precisely such disturbances as would be expected if the kinaesthetic sensations are the fundamental ones. If a passage is made shorter than before, the rat runs against ~~ite~~ the end even though this would appear to be "in plain sight." If a passage is made longer, the rat tries to turn when it has gone the usual distance; it thus runs against the side walls. If a blind passage now opens at a distance corresponding to that of a former correct turn, the rat runs into the blind passage. After many

trials in the altered maze the rat finally learns to run through it as readily and correctly as before. This result is reached after many experiences of running into ends, "nosing" along side walls, trying to turn where there is no passage way and the like. [1]

Watson's problem was worked upon later by Florence Richardson in the Chicago Laboratory. Her aim was to discover how much the guidance from vision and olfaction may assist the functioning of kinaesthetic and organic processes in the learning of a type of problem more complicated than the maze. [2] The experimenter's general technique resembled Watson's and need not, therefore, be further described. The problems she employed were four puzzle boxes. The first was similar to Small's original sawdust puzzle box. The work of three groups of white rats was studied. The first group consisted of four male and four female normal rats; the second of four male and five female blind rats, and the third of five anosmic male rats. Richardson averages these groups

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1. Journal of Comparative Neurology & Psychology, Vol. XVIII.
2. Psychological Review (American), Monograph Supplement, Vol. XII.

regardless of sex differences, and the curves so obtained show the blind rats to be on the whole slower than the anosmic, and these latter slightly slower than the normal. It is possible that the small differences observed depend on the varying proportion of males to females and other irrelevant characteristics of the three groups. As, however, both the anosmic and the blind rats show much less uniformity from day to day than the normal rats it seems very possible that this is due to their abnormality.

The second puzzle box consisted of a wire mesh box 20 x 20 x 15 cm., the door of which was fastened by a latch on the inside. This latch was controlled by a cord which passed up through the roof of the box, over to the further side and was attached to an inclined plane (15^{o}) on the floor 11 cms. from the side of the box. When the rat stopped on the plane the latch was pulled up, and the door opened inwards. Only the blind and the normal rats were tested with this apparatus. All the anosmic had died or were too abnormal. The blind rats took longer than the the normal, but the results are open to the same objection as the former -- the groups compared are not sufficiently alike.

The third puzzle box was fastened by a latch which the rat had to raise with either its teeth, snout or claws. The latch was rubbed with cream cheese at the beginning of the trials in order to attract the rats' attention. The blind rats took much longer over this problem than the normal. This again may be partly due to the greater proportion of females in their number or to a special character of this box -- the door in springing back was liable to hit the rat, if he did not stand well to the left. The blind rats showed much greater emotional excitement when this happened than did the normal.

Richardson discusses the results for these three problems in some detail and concludes that they do not afford unambiguous evidence for the role of smell or vision in the learning process. She emphasises the importance of impulses furnished by the sense of touch. With regard to kinaesthetic sensations she says "The role of kinaesthetic impulses in the early processes of learning probably varies in inverse proportion to the degree in which the movements must be adapted to a definite locality. Later in the process, as the movement becomes more or less automatic the kinaesthetic and allied impulses seem to assume

first importance as the means of control."[1]

Richardson's fourth problem involved jumping from one small platform to another in a horizontal direction. She trained the animals to do this by beginning with a very short distance and coaxing them across with a morsel of food. Then she gradually increased the distance to 22" and even more. In these tests the blind rats showed marked incapacity for the greater distances but learned to jump 11" and even in one case 15". Only two anosmic animals were tested. One of them failed utterly, but the other was in no way inferior to normal rats. The results she obtained by varying the position and distance of the second platform led Richardson to assume that the rat's vision gives it information as to the direction but not as to the distance of a stimulus. As she herself says, however, the tests were not sufficiently numerous or clear cut to warrant a conclusion.

The next point raised by Richardson is entirely new. She found when training two female rats to solve problem I.(sawdust puzzle box) that their time records were lower than normal. Thinking that this lower time might be

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1. Psychological Review (American) Monograph Supplement, Vol. XII, p.69.

the result of their having previously learned the Hampton Court Maze, she compared their results with those of eight untrained rats. The average time records of the trained were below the minimal records of the untrained. This led her to let untrained rats attempt the second and third problem box to afford a comparison with the trained ones which had learnt them previously. The results may best be given in Richardson's own words. "The comparison of the time records and of the learning curves of each group of untrained rats with a trained group corresponding in age, variety, and condition (normal or defective) shows that in every instance - - - the trained animals made uniformly better records than the corresponding groups of untrained rats." [1] Richardson seeks to account for this by supposing that neurological and physiological changes occur both in the motor and in the sensory system; changes in virtue of which the stimulus is more intense and the activity more immediate, and better co-ordinated. [2] She considers also that the greater emotional disturbance in the untrained rat, partly accounts for its inferiority.

In 1911 Bogardus and Henke carried out a series of experiments to determine the function of the tactual sensations

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1. ibid, p.114.
2. ibid, p.115.

of the white rat and "to ascertain the effect of the running of previous mazes upon the learning of subsequent alterations of the original maze by opening and closing definite pathways." Journal of Animal Behaviour, Vol. I, p.125. They designed the maze which is named E in the present work, (see Fig. 3). From the results of opening and shutting different passages after the maze had been learned in its original form, they conclude that previous learning is advantageous or disadvantageous according to circumstances, but that on the whole the disadvantages of the old habits rather overshadow their advantages. The analysis of the results is interesting as showing how alterations in different parts of the course have different effects. An alteration near the beginning is much less upsetting to the rat than one further on, and alterations which involve entry into former blind alleys present greater difficulty than those which involve a short circuit.

During the last ten years there have been several other studies of rat behaviour in the maze, but they have been concerned chiefly with the statistical aspect of the subject and are not therefore very relevant to the present study. The only one which bears upon it directly is that

described in the "Psychological Studies from the Bedford College Laboratory." The object of this research was to study learning and relearning in mice and rats. The results showed incidentally that animals which are practised learn to solve a new problem more quickly than do animals which are unpractised. Another study which has been published more recently than this, appears at first sight to come to a contradictory conclusion. Walter S. Hunter in an article "The Interference of Auditory Habits in the White Rat" [1] concludes that "habit interference occurs in the white rat between a first habit and the formation of a second one." [1] This result, however, is not necessarily in conflict with the others which have been quoted because Professor Hunter's problem was of a very special character. The first habit which his rats had to learn was to go to the right for handclaps, to the left for silence. When they had learnt this, they had to acquire contradictory habits such as turning to the left for tuning fork. It is obvious that problems such as this, which involves attaching a certain meaning to a certain stimulus, then learning to attach the very reverse significance to it.

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1. Journal of Animal Behaviour, Vol. VII.

are not on a level with the ordinary acquisition of motor habits. In fact it seems questionable whether the term "habit" should be employed at all in such a case as this. The term Hunter uses - "Auditory Habit" - certainly calls for explanation. The rat did not form a habit of going any one way, he learnt which way he ought to go when he received a specific stimulus. The problem is one of the acquirement of meaning. The results of Hunter's first group of experiments, which show that the rat did learn to attach meaning to the alternative signs, are extremely interesting.

Statement of Problem.

The results of the studies which have been described in the last section show that the rat's acquisition of motor habits is a complicated process. The work of Small and Watson indicated that the rat is not dependent on any one group of extra-organic clues, and that when he has learned the maze he may be independent of all of them. From this, Watson proceeded to picture the rat's learning as a very mechanical process. He seems to imagine that the right path is gradually acquired by the rat as a result of the hindrance encountered in the blind alleys. For Watson a practised rat runs its maze much as a river runs its course, only that if the bed of a river alters, the river automatically alters also, whereas if the maze is altered the rat is so governed by his past history, that he bumps into the walls. The results of other experimenters do not all confirm this view. Small's does not on the whole, although they show that rats which were learning puzzle-boxes tended to carry over movements from one box to the next, and to persist in them although they were quite useless. Small mentions, however, that they

persisted in this way chiefly when they were very hungry or excited, and he mentions another fact which conflicts with the view of these motor habits as entirely automatic. When he let some of his rats run in a maze which had no food at the end they persevered in following out the course of the maze, but in several trials they made little progress in learning the direct course. Watson inclines to the view that the rats behaviour in the maze is very automatic because when the alleys were altered the rats bumped into the walls or tried to turn where there was no opening. As Watson did not attempt to remove the rats' tracks from the maze it is possible that the bumping, etc., which he reports was due to the rats' trying to follow their own trail.

The work of Bogardus and Henke, showing the effect of altering a maze which the rats have learned, appears to support the view that the acquisition of motor habits is very automatic. Their conclusions, however, are open to question. In the first place, as in the case of Watson's modification of the maze, the rats may have been hindered by old trails. In the second place Bogardus and Henke used no control rats. There is nothing to show whether the rats

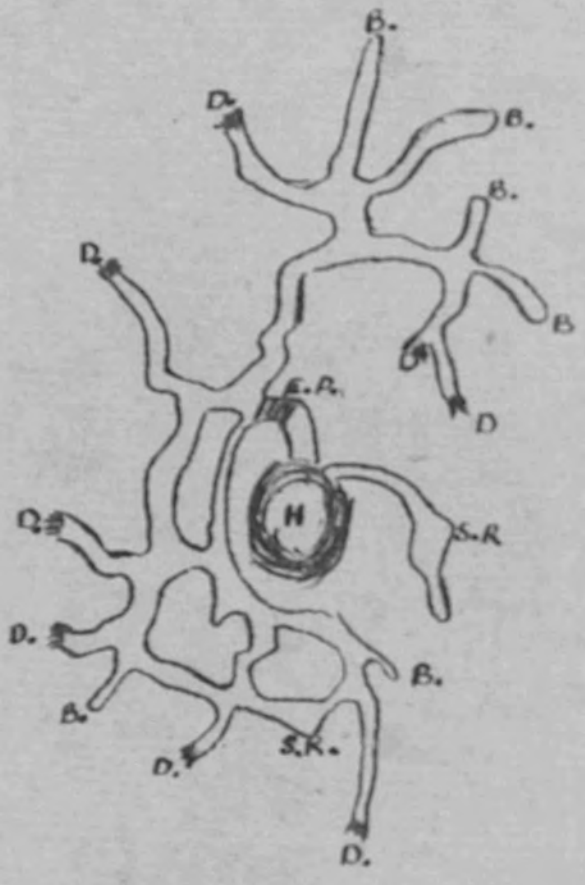
learned the modified maze more slowly than unpractised rats. There is therefore no criterion of whether the old habits interfered with the formation of new ones. In addition to these objections there is the fact that they give the record of only one rat, and that a blind one. On the other hand Richardson's work and the work from the Bedford College Laboratory shows, that instead of the rats being hindered by old habits, they improve in learning from one maze to the next. Incidentally, it may be mentioned that this result agrees with what Yerkes found in the case of his dancing mice.

Those who have written about the work on rats have accepted Watson's view. Thus in her book "Mind in Animals" Smith maintains that the maze habits of rats are automatic in character and that"rats do not learn mazes with any greater facility after having had experience in previous mazes," p.41. In another place she says "The acquirement of modification in the form of a habit appears to render the establishment of subsequent modification of a similar character more difficult," p.46.

In view of this conflict of opinion it seemed desirable to investigate the nature of the acquisition of a

series of motor habits by rats. To this end the experiments which are to be described were planned. Their aim was to test the matter of fact - whether rats learn to solve a problem more easily for having learned to solve a similar one - and to lead if possible to an analysis of the factors involved.

The Kangaroo Rat's Home.



B. Blind Alley.

D. Door.

E.P. Earth Plug.

H. Home.

S.R. Store Room.

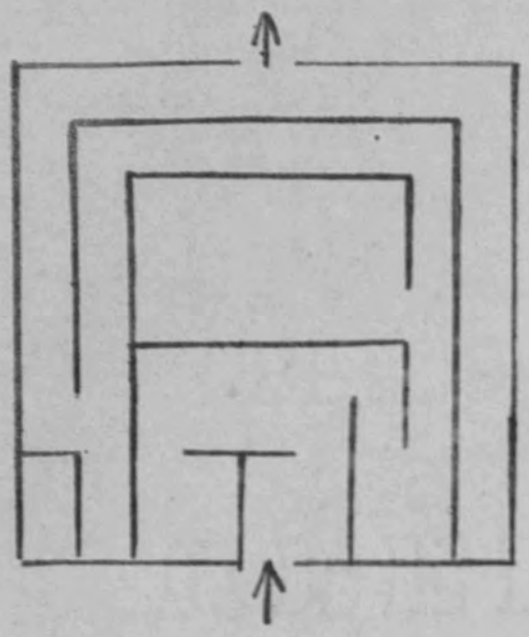
Description of Method.

Mazes were chosen for the present study because the kind of activity which they involve is perfectly natural to the rat. This is illustrated in an article by Ernest Seton Thompson on the "Kangaroo Rat." In it he gives a drawing of the maze, which one of these little creatures had tunnelled for himself. (Fig. 1). The plan might well serve as a suggestion for a simple maze. Mazes, as problems, have the additional advantage that they admit of endless variety without necessarily involving any kind of fresh activity. Whereas it is difficult to make a series of puzzle boxes of even approximately equal difficulty.

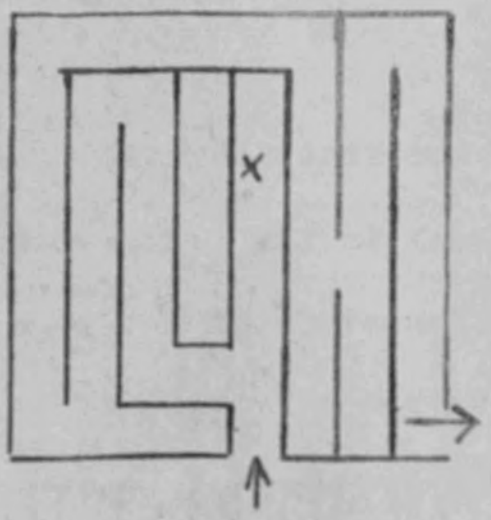
The original plan of experiment was to use pairs of mazes, to let one rat learn one of these and then to test him and an unpractised control rat in the other. While the first rat was learning his maze the control rat was taken out of his cage every day and made to find his food in different places. This was done to ensure that the control rat's learning was not hindered by the novelty of being handled, and of running outside his cage. This plan

Plan of Mazes A, B, C, and D.

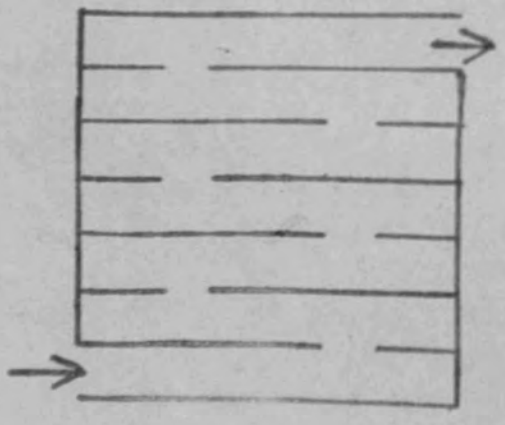
Maze A.



Maze B.



Maze C.



Maze D.

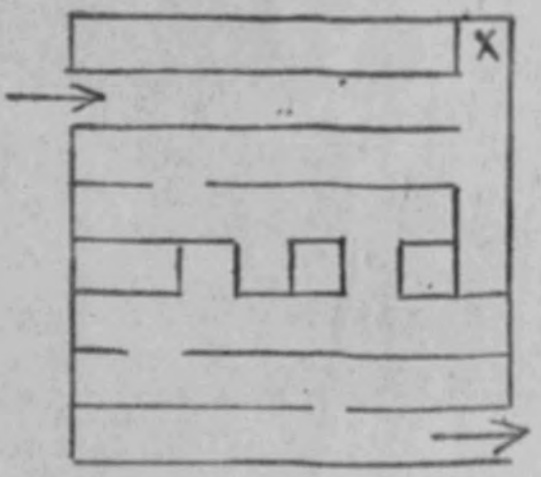


Fig 2.

was abandoned after the first series of experiments; because it meant that for a large part of the time only half the rats were supplying records, and the control rats who were not learning mazes demanded more time and attention than the others. The general plan adopted afterwards was to let a pair of rats each learn a different maze. Then they were changed over and each learnt the maze that had been learnt by the other. This affords a comparison between the learning of each maze by a practised, and by an unpractised rat, and also between the work of the same rat practised and unpractised. In the first instance care was taken to have pairs of mazes with the same number of turns and possibilities of error, but it is not certain that this ensures their being of equal difficulty for the rat.

Fig. 2 shows the first four mazes to be used, mazes A, B, C, & D. A and B, and C and D respectively, were planned as pairs. Experience showed, however, that all four were of approximately equal difficulty. In later work the mazes were complicated by having their passages blocked so that the rat had to leap over, or sometimes to climb in between two obstructions. The last series of

Maze E.

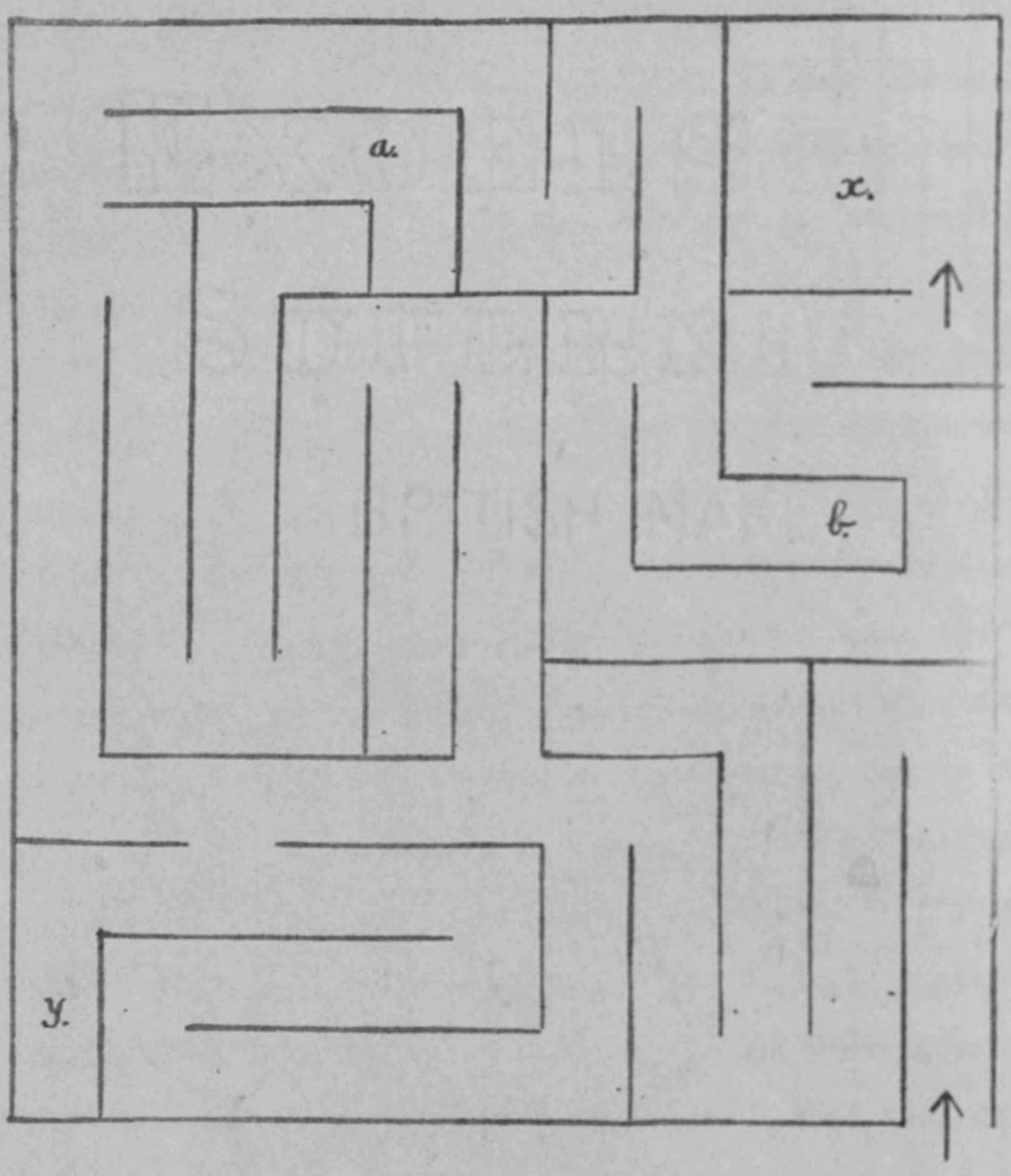


Fig. 3.

experiments was performed with a copy of the maze used by Bogardus and Henke. This maze, E (Fig. 3), is much more difficult than any of the others, making comparison between them and it impossible. It was learned by six practised, and six unpractised rats, and when they had all learnt it to varying extents, the position of the food was altered from x to y, while the rats were still free to run to x. As will be seen in a later section, the results for this maze were more suggestive than those for any other.

All the mazes are made of wood. The walls are six inches high and the alleys uniformly four and a half inches wide. The mazes were scrubbed at frequent intervals with a very strong solution of Jeyes' Fluid, and the floor and walls were covered with clean grease-proof paper every time a rat ran in the maze, except in the case of Maze E, when the paper was omitted and the maze was rubbed over with Jeyes' Fluid after each rat. The paper and Jeyes' Fluid were used to guard against the rat finding his way to the food by following his own, or other rats' tracks. As, however, it seems a matter of controversy whether any method removes the rat's tracks, the argument for his not using this method of finding his way, will be based on his behaviour,

and will be considered in the next section.

The rats were carried in the hand from the cage, and placed in the entrance to the maze. At the end of their journey they found a little food which they were allowed to eat at the exit, and then they received their food for the day immediately afterwards in their cage. The rat's course was traced on a diagram of the maze while he was running and the time from entry to exit was taken with a stop watch. The cages in which the rats lived were large and composed chiefly of wire on which the rats climbed most of their time. This kept them lively and nimble. All the rats used were males, and they were not put into the maze unless they were in good health. Throughout the whole of the experiments there were only four rats which behaved abnormally in the maze. The first of these, M, showed great fear of both the operator and the maze. Experiments were begun with him in the hope that he would lose his fear. At first he behaved very wildly, and tried persistently to climb out. Then he went to sleep on two or three successive occasions. One day when he was probably particularly hungry he ran about and found the food and it looked as if he might learn the maze as the other

rats, but a day or two afterwards he was found dead in his bed box. This was the only rat to die suddenly without showing any sign of illness. It seems probable that he had some form of heart disease, which may have accounted for his greater excitability.

The second rat to behave abnormally was rat J. From the first he took a very long time to run the maze and his learning curve is very irregular. It was noticed that when he found the food he did not eat it. Later, he showed signs of ill health, and was not made to run any more mazes. In the other two cases there was no indication of delicacy to account for the behaviour, but in each case the rat showed little or no tendency to run about in the maze. The first of these Rat I found the food once, but on the succeeding days he settled down to sleep directly he was put into the maze. As he showed no sign of illness the experiments were continued. It had been noticed that the rats have a tendency to follow a slowly moving object, and it seemed that this might afford a possible way of leading him to the food. The operator's hand was therefore drawn slowly away from him, and he was thus led gradually

through the maze. After this, he behaved quite normally and his learning curves are comparable with those of the other rats. The fourth case was similar to this, only that on four successive occasions the rat did not find the food in half an hour. On the fifth occasion he was led through by hand with the same result as with the previous rat. The learning curves of these two rats will be given in detail in a later section.

The rats whose records form the bulk of the results showed no disturbance at being put into the maze, and after a very few experiments they strained to get into it when they were brought near. If on any particular day a rat showed signs of being frightened, he was removed and tested later, or the experiment was omitted for that day. At first, the only signs of fear which were regarded were starting or running wildly, but later experience suggested that the "position habits" mentioned by different experimenters are a sign of fear or some other abnormal condition. The rat for instance persists in trying to jump up on to the partition, however many times he is checked. If he is left in the maze he is likely to acquire a permanent habit of doing this, but if he is lifted out and given a little

food or merely stroked, he usually behaves quite normally on his return. After this was discovered a rat was removed from the maze at the very first sign of a position habit. The position habit would be an interesting subject for investigation. It seems to be a form of circular reaction, and if it is allowed to go on for long, the rat's eyes become glazed and he has much the same look as a person who has been mesmerised.

Statement of Results.

I. Preliminary Considerations.

A number of articles have been written recently about the relative merits of the different ways of recording the rat's learning in the maze. It can be recorded in time taken, in errors made, or a coefficient of the two. Furthermore it is possible to rate errors in a variety of ways. It seems that the way in which the results are expressed should depend on the object in view. If all that is needed is an indication of rate and degree of improvement, the time record is adequate, and the curve which it gives will correspond very closely with the error curve. The time curve has the advantage over the error curve that it does not involve any arbitrary judgment on the part of the experimenter. In counting errors, on the other hand, he must decide to count all mistakes as equal or to make distinctions between them. Whichever he does may more or less distort the results.

The present results are designed to show mainly two things -- whether practised rats learn a new maze more quickly than unpractised rats; whether there are any characteristic differences between the behaviour of practised

and of unpractised rats in a new maze. For the first of these purposes the time records are adequate. For the second, consideration of the different kinds of errors made is necessary. Errors will be considered in two groups, those which consisted in entries into blind alleys and those which consisted in returns on the path. Within each of these groups no distinctions will be made, because, while it is certain that entry into one blind alley is not always on a level with entry into another, it is not possible for the onlooker to rate the difference. In the same way it is impossible to say whether one return on the path should be considered as equal to another. The most that can be done in such cases as these is to gather data which are approximately representative of the process. In maze E a third kind of error was possible, viz., running a longer route to the food than was necessary. The instances of this will be shown in the curves for Maze E (Table I).

As the object of the present study was the acquisition of motor habits, the records for the first few occasions on which a rat succeeded in running a maze will be all that it is necessary to consider. In most cases the rats continued to run in a maze until they had done so on

at least three successive days without error. The records show that after this point the rat makes only occasional mistakes if any, and the time taken decreases to a minimum at which it remains. The fact that some rats find the food on the first day on which they are put into the maze, while others do not find it for two or three days introduces a difficulty. If the learning is counted from the first day, the rats who do not find the food are put at a disadvantage because until they have found it, there is no reason for their beginning to learn to run the maze. On the other hand, if the learning be counted from the first time each rat finds the food, the rats who do not find it for the first two or three days are at an advantage because during these days, which do not count in their record, they are running about and becoming familiar with the maze and its intricacies. In the results that are to follow the second alternative will be accepted -- the learning process will in every case be supposed to start with the first day on which food is to be found. This will be done because it throws the advantage on to the side of the unpractised rats, who were the ones, if any, not to find the food on the first occasion. This will make any superiority shown

by the practised rats more significant.

In carrying out the experiments great care was taken to ensure that the rats, whose results were to be compared, should be as far as possible on the same footing. For this reason only males were used. The experiments were performed at the same time each day. The rats compared were usually of the same age, from the same family, and working at the same time of year. None of the results is from a rat under three months or over twelve months old.

It is obvious that the records would be of very little use as showing learning if it were possible that the rats found their way to the food once by chance, and then on later occasions followed their own tracks. This is why it is an important preliminary to any study of learning such as the present to establish that tracking by scent is out of the question. To ensure this the mazes were lined with paper and scrubbed with a solution of Jeyes' Fluid, as has been described in an earlier section. Some experimenters, however, speak as if no method would remove the rat's trail from the maze. It is, therefore, necessary to show from the actual results that tracking is not the explanation of the rat's learning. For this there seems to be abundant

evidence. One of the best records for learning a series of mazes was given by Rat T who was the first to enter them after they came from the carpenter. This rat's first run in each successive maze showed at least as much improvement on the first run in the preceding maze as was shown by the rats who followed him. This will be evident from a consideration of Tables 5 and 6 where the individual records may be compared. The tables show also that the learning curves for different rats at the same stage of practice are extraordinarily similar, which would not be the case if an unpractised rat tracked a practised, or any one rat tracked his own previous course. In the latter case modification would be unexplained. In the former, much greater irregularity would result. Apart from these particular considerations it is to be noted that the problem of the present work is the one which would be affected least by tracking. The latter might account for the appearance of habituation, it could not account for the transference of improvement in learning from one problem to another. Indeed this transference might, if established, be taken as in itself confirmatory of Small's and Watson's conclusion that the rat does not depend upon olfactory clues in running the maze.

On the other clues which the rats may use it is not necessary, for the purpose of the present study, to dwell. The rats may have discriminated the passages by visual, tactual, kinaesthetic, or distance clues, although it is difficult to see how they could use visual or tactual clues when the mazes were lined with paper, the surface of which would be different every day. The important question for the present enquiry is not which clues the rats used, but whether they learned to use them more efficiently with practice.

Table 1.

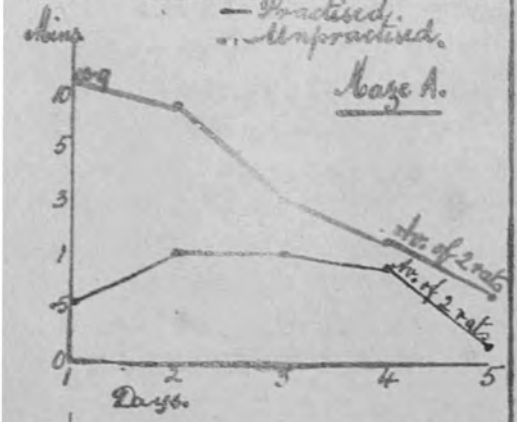
Learning of Mazes by Practised and Unpractised Rats.

I. Time Records.

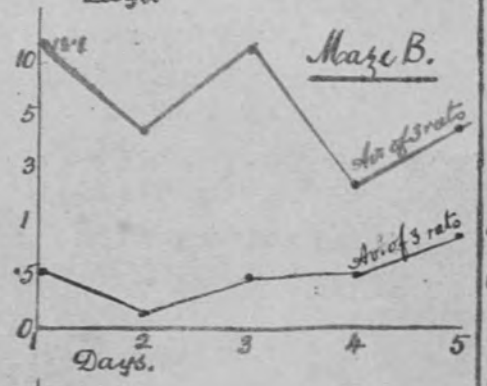
— Practised.
.. Unpractised.

Mins.

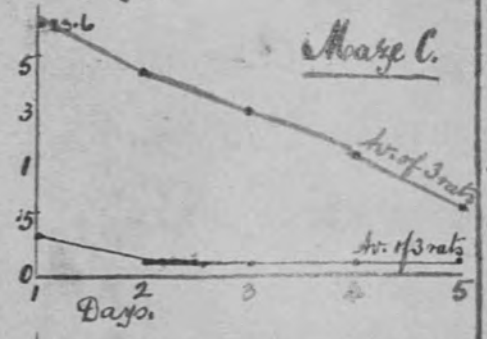
Maze A.



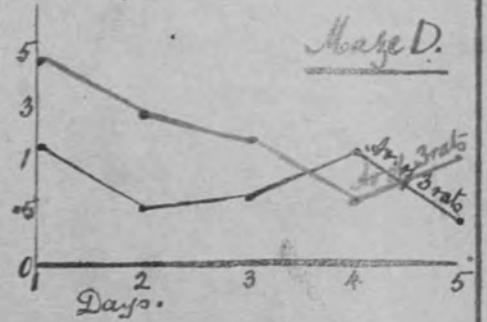
Maze B.



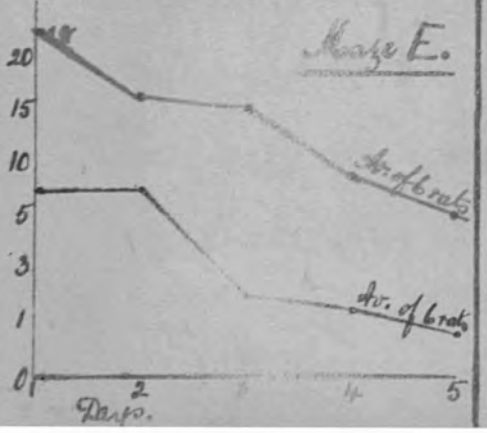
Maze C.



Maze D.



Maze E.

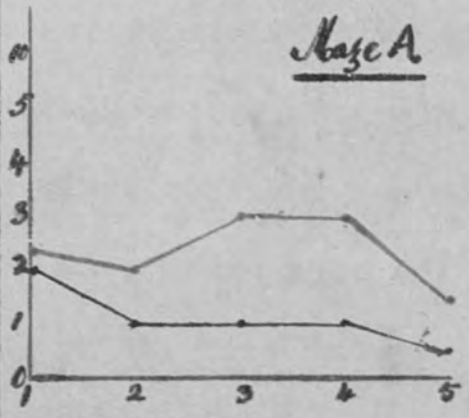


II. Error Records.

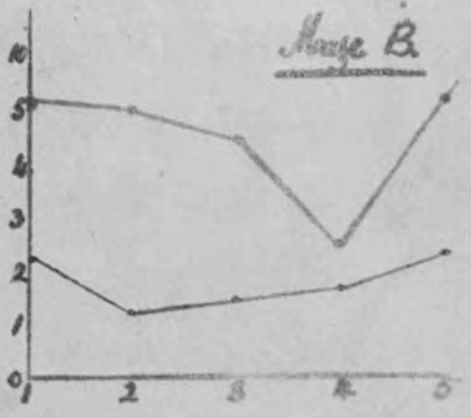
— Practised.
— Unpractised.

Entries into Blind Alleys.

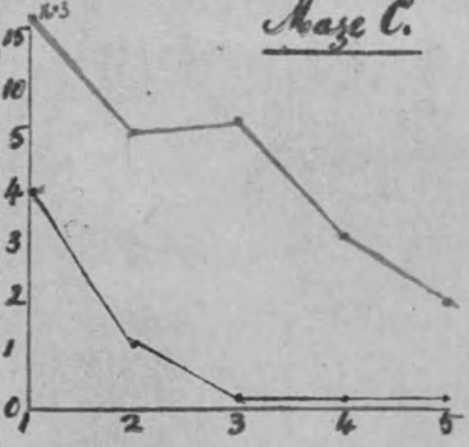
Maze A



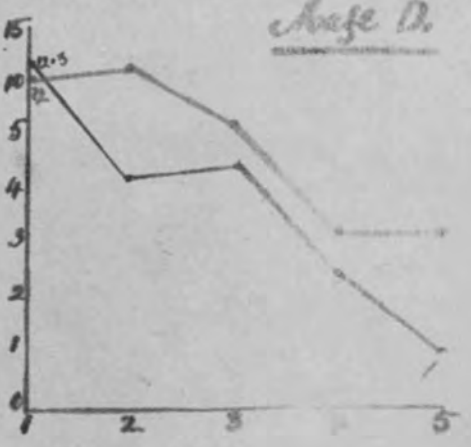
Maze B.



Maze C.

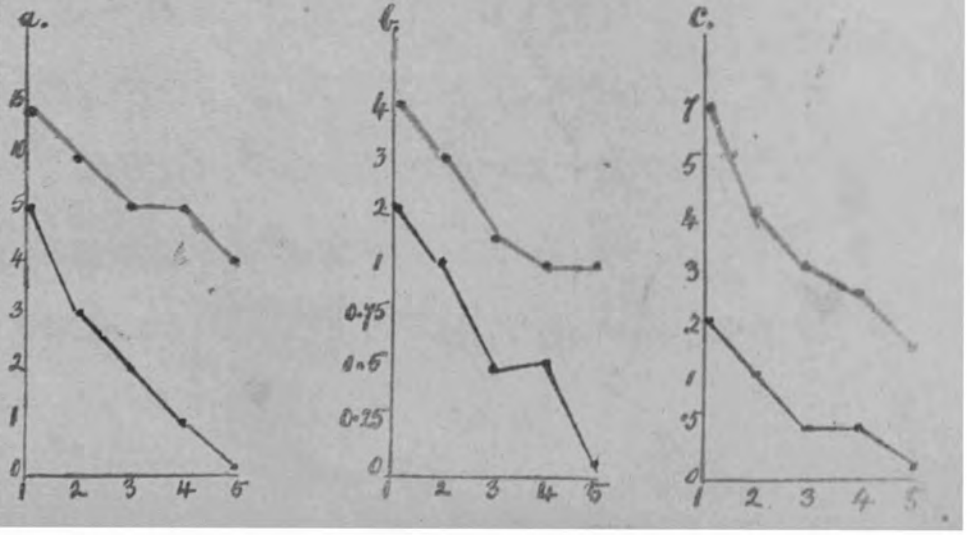


Maze D.



Maze E.

a. Blind Alley entered. b. Longer Route chosen. c. Path retravelled.



II. Statistical Summary of Results.

1. Records of Practised and Unpractised Rats for the same maze.

The graphs in Table 1 represent the learning curves of groups of rats practised and unpractised. There were three rats in each group except in the groups for Maze A in each of which there were only two; and for Maze E in each of which there were six. The records are founded on the work of twenty-two rats most of which figure as unpractised for one maze and practised for another, a fact which makes it improbable that any difference between the two should depend on individual differences in the animals. The practised rats had sometimes run one maze previously, and sometimes more than one. The curves show a constant and considerable difference between the work of the practised and the unpractised. The difference between the time taken by practised and by unpractised rats is much greater than the difference in time for different mazes, in spite of the fact that the path to be travelled in them varied from 11 ft. to 31 ft. It is evident that the improvement in learning may be due to the practised rats' running more quickly; to their making fewer errors; or to a combination of these two factors. That they run more quickly is certain; any one who has experimented with rats, can tell whether a given rat is practised in maze running by

the rate at which he runs.

The error curves in Table I indicate that the practised rat enters blind alleys less often than the unpractised. Not only so, but the more mazes he has learned the more this is the case. Thus the greatest difference between practised and unpractised occurs in the case of Mazes D and E. The practised rats for both these mazes had learnt more mazes previously than the practised rats for any other maze. The three practised rats for Maze D had learnt three other mazes; the six for Maze E had learnt from four to seven previously. The difference in the number of blind alleys entered by practiced and unpractised rats is not confined to any one part of the learning process. If it were characteristic of only the first day or two it might be that the greater emotional disturbance of the unpractised rats causes them to run about more blindly even though they do not show signs of fear. The curves show however, that the difference is at least as great on the fifth as on the first day.

In Maze E the rats had to choose between a shorter and a longer path in two cases. Curve b shows the average number of times each group ran over the longer course.

The practised rats learnt to choose the shorter path much more quickly than did the unpractised. The rats returned on their paths more often in Maze E than in the others, but here again the practised rats wasted much less time than the unpractised, as is shown by the curves in c. for Maze E. Table I.

The effect of particular motor habits may be studied from three crucial instances which the mazes afforded. Rats which learned B after A might be expected to show a particular tendency to overlook the first turn to the left and to run along alley x ; rats which learned A after B might show a tendency to turn round to the left at the first opportunity; rats which learned D after C might turn to the left into X (Fig. 2). The following tables show that, on the whole, the practised rats who might be expected to show these survivals of old motor habits do not enter the blind alleys in question nearly as often as the unpractised.

I. Entries into x in Maze B.

a. By rats who immediately before have learned Maze A.

Rat	Days. 1st	2nd	3rd	4th	5th	Total.
D	4	1	1	1	0	7
S	1	0	1	1	3	6
P	1	1	1	1	1	5
A	3	1	0	0	0	4
B	3	2	1	0	0	6
C	2	0	0	1	0	3
D	4	1	0	0	0	5
Total	18	6	4	4	4	36

b. By unpractised rats.

Rat	Days. 1st	2nd	3rd	4th	5th	Total.
J3	6	2	1	1	2	12
S1	1	1	6	1	5	14
J2	9	0	2	1	3	15
I	2	5	3	1	0	11
II	6	0	0	1	4	11
III	0	6	0	1	1	8
IV	3	2	0	4	2	11
Total	27	16	12	10	17	82

II. Entries into x in Maze A.

a. By rats who immediately before have learned Maze B.

	Days.					
II	3	1	1	0	0	5
III	0	0	0	0	0	0
IV	4	2	0	0	0	6
Total	7	3	1	0	0	11

b. By unpractised rats.

	Days.					
A	6	0	0	0	0	6
B	1	5	0	3	0	9
C	0	1	0	0	3	4
Total	7	6	0	3	3	19

III. Entries into x in D.

a. By rats who immediately before have learnt Maze C.

	Days.					
T1	3	0	0	1	0	4
T	3	1	0	0	0	4
J3	1	0	1	1	0	3
A	0	1	0	1	0	2
B	0	1	1	0	0	2
C	1	0	3	0	0	4
Total	8	3	5	3	0	19

b. By unpractised rats.

	Days.					
J	3	0	0	0	0	3
J1	2	2	1	0	0	5
P	2	3	1	1	1	8
x I	2	1	0	0	0	3
x II	0	0	0	0	0	0
xIII	0	1	0	0	0	1
Total	9	7	2	1	1	20

xThese rats were not unpractis but had learnt a maze which would favour turning in the right direction.

Table 2.

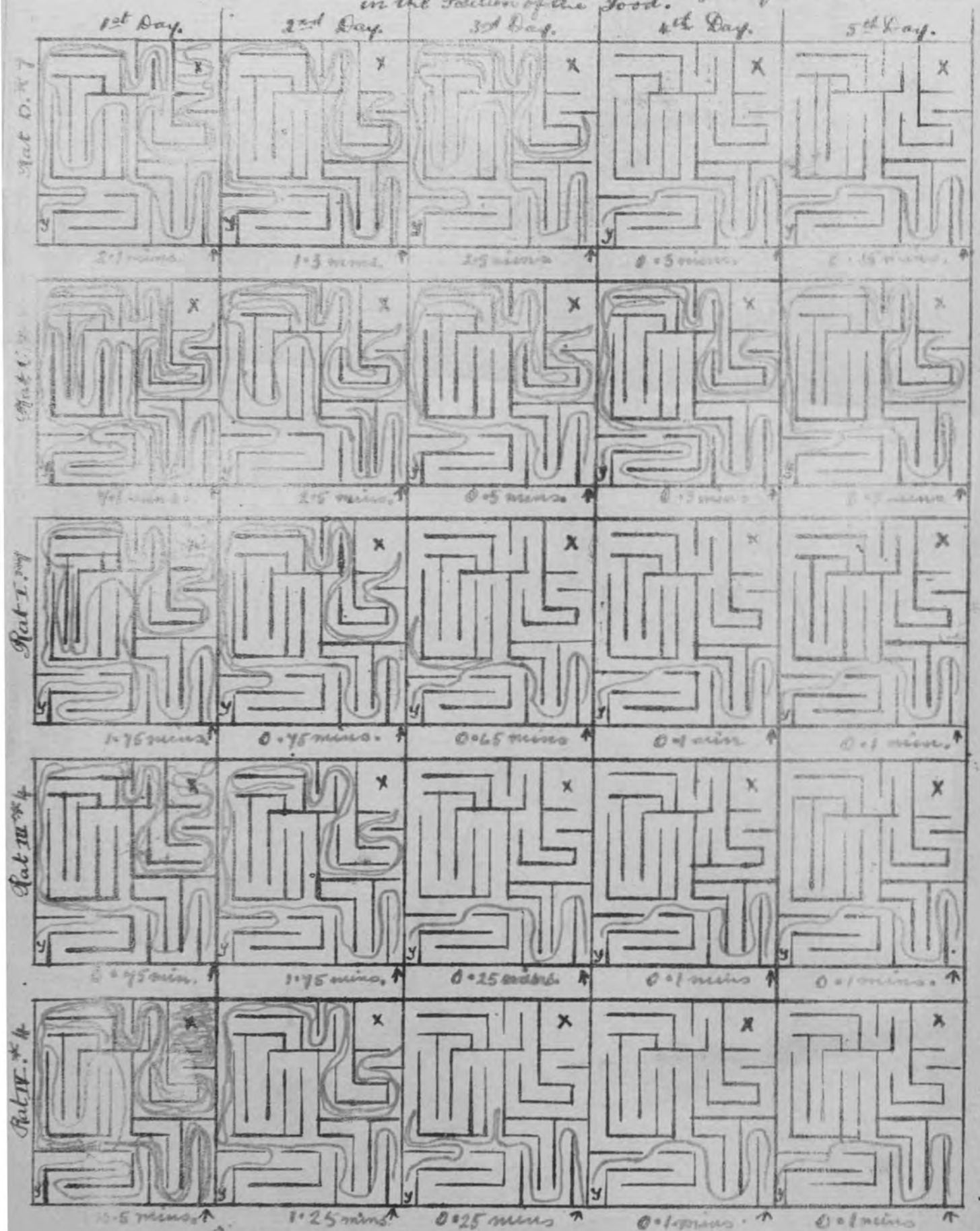
As will be seen in the description of the work of individual rats, four of them (Rats A, B, I & II) learnt mazes A and B with all the openings blocked so that they were obliged to climb over the partitions. When these four came to learn other mazes, in which climbing over was not allowed, the results were similar to the above; the rats very soon lost any tendency to climb over, and the curves show that they were not hindered by their previous habit. (Table 6).

2. Records showing the Effect of altering the Position of the Food in Maze E.

When the rats who learned Maze E had mastered it to varying degrees, the position of the food was altered from x to y (Fig. 3). The results show that the rats which had the more perfect habit for running the maze in its original form were as a group the quickest to adapt themselves to the altered position of the food. The following table shows this in the total time taken by the rats for all the five occasions on which they ran the altered maze.

Table 4.

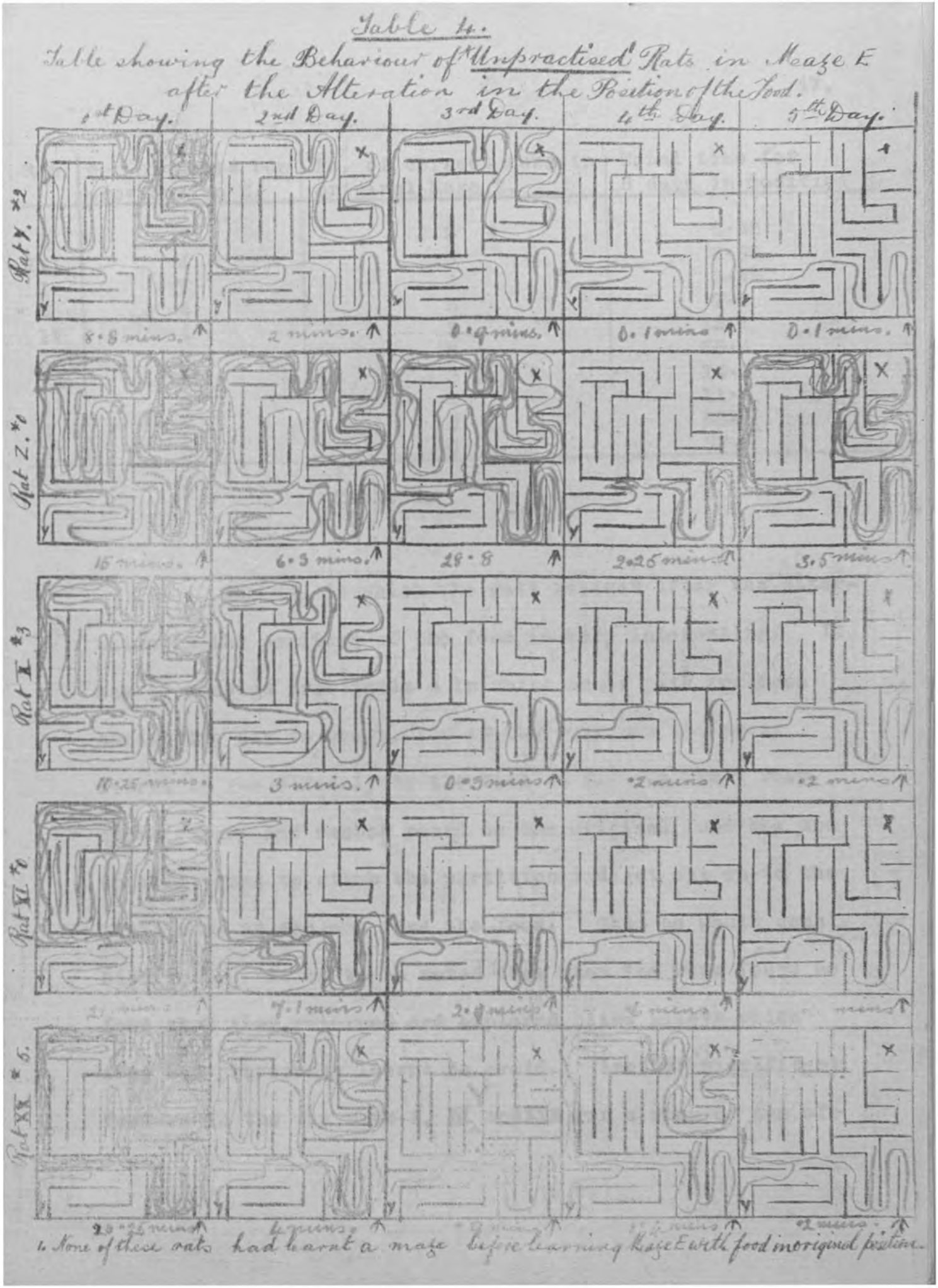
Table showing the Behaviour of Rats tried Pots in Maze E after the Alteration in the Position of the Food.



* Number of times which the rat had found food in its original position without error.

Table 4.

Table showing the Behaviour of Unpractised Rats in Maze E after the Alteration in the Position of the food.



1. None of these rats had learnt a maze before learning Maze E with food in original position.

Rat.	No. of Mazes run previous to E.	No. of correct runs in original Maze E.	Total time for 5 days in modified E.
B	7	8	6·45
III	4	5	2·85
I	7	4	3·43
C	4	3	7·2
IV	4	3	12·1
X	0	5	25·4
~~XX~~	0	3	14·6
Y	0	2	11·9
Z	0	0	55·8
XI	0	0	32·0

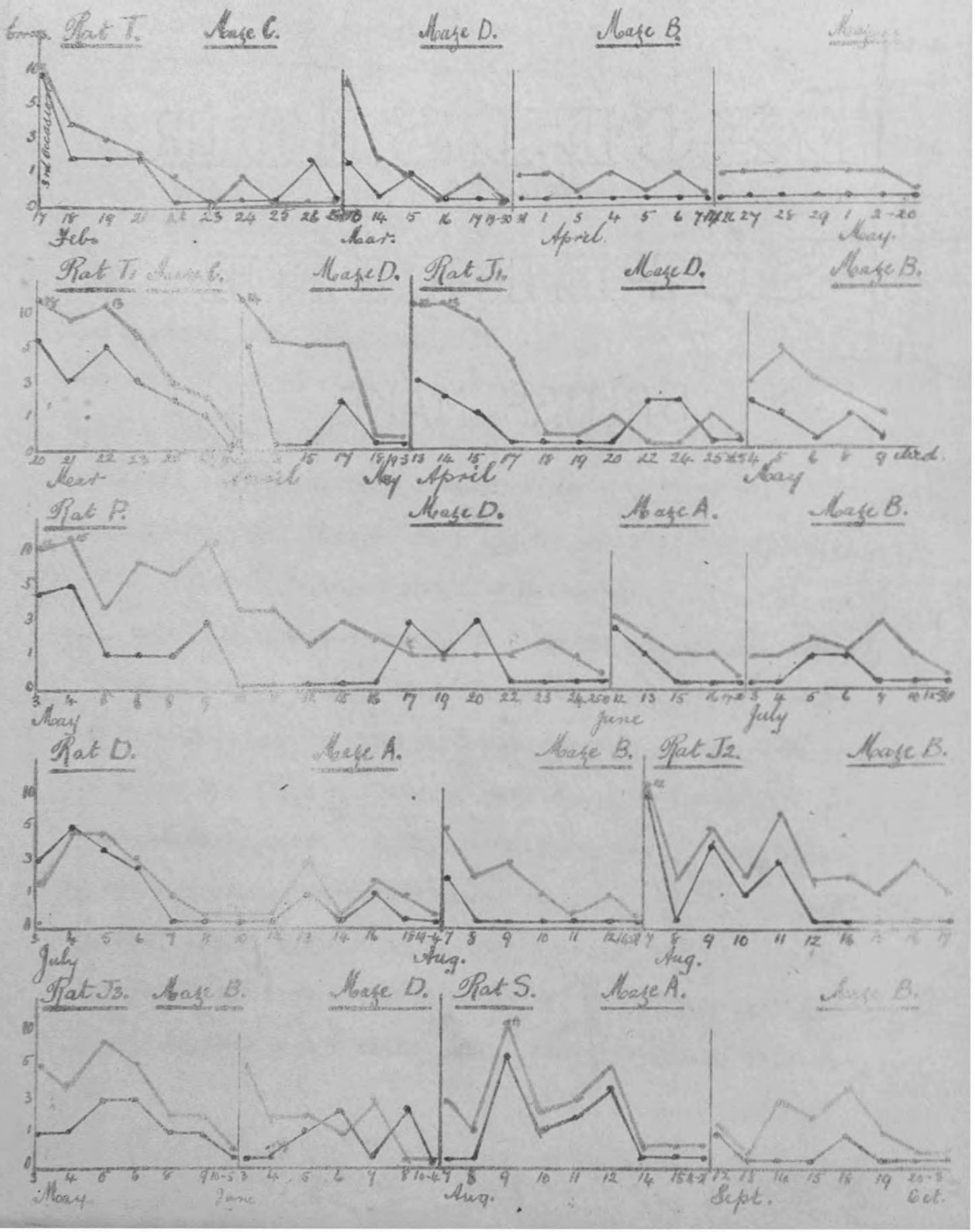
Table 3.

The way in which the rats behaved after the alteration in the position of the food is very interesting. It may be studied from Table 4 in which their path for each successive day is shown. C is the only one who never learnt to run directly to the food at Y. He was a very quick runner and dashed round to the original food box and usually tried to climb the partition and get out on to the table when he did not find the food. Then he would dash back to Y. It is to be noted that when the rats found no food at X they returned and explored blind alleys which they had previously learnt to avoid. Another significant feature is the way rats I, IV, and ~~XI~~ ran a step or two of

Table 5.

Records of Errors made by Rats in Learning a Series of Mazes.

—Entries into blind alleys.
—Returns on path



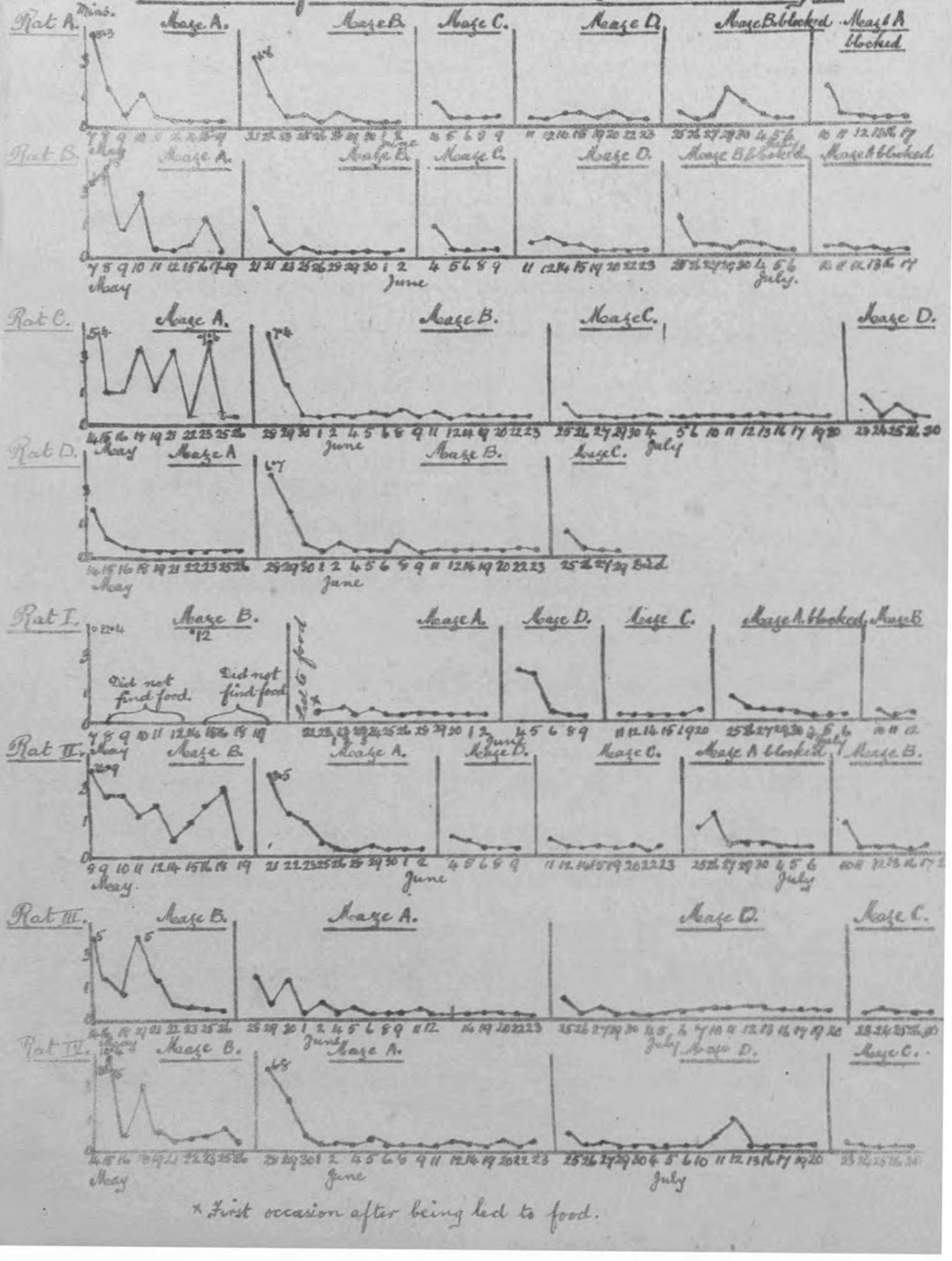
~~of~~ their old route and then back to where they had more recently found the food.

3. Records showing the Work of each Rat in the order of performance.

These records may be divided into two groups. The first is composed of a small number of rats which worked in 1916. (see Table 5). There were only a few working at a time and none of them learnt more than four mazes. Rats T & P have the longest records, and a glance at the curves of their learning shows how few errors they made in the later mazes. Rat J2 learnt only one maze, but his record is given for comparison with other unpractised curves. Table 6 shows the time curves of the other group. It was composed of eight rats working under particularly uniform conditions. Their records are given in time because it is not possible to count errors in the blocked mazes which formed part of their series. It will be seen that Rats A, B, I, and II learnt the same number of mazes, but A, B, and I, II, respectively learnt each pair in reverse order. This was to determine whether differences in the learning were due to differences in the mazes. Rats C, D, III, IV

Table 6.

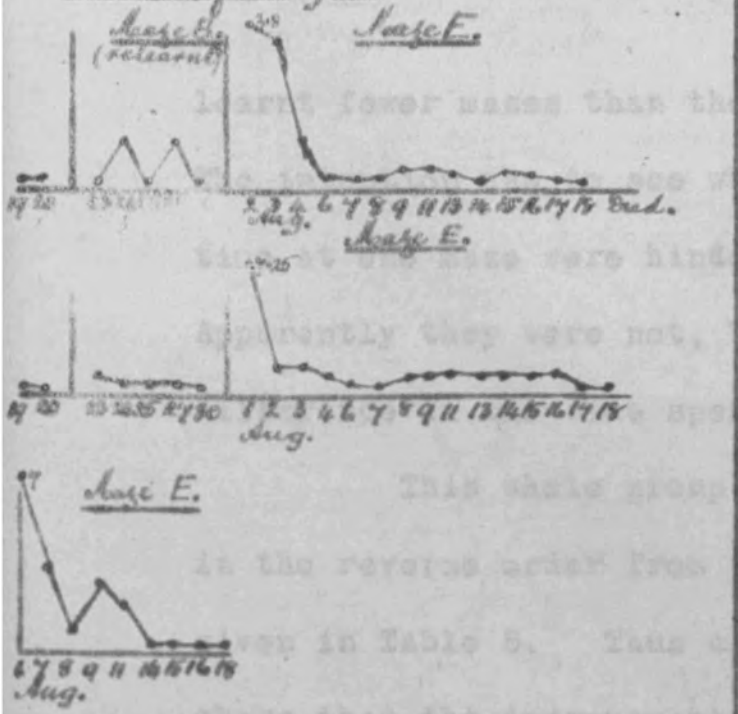
Records of Individual Rats Learning a



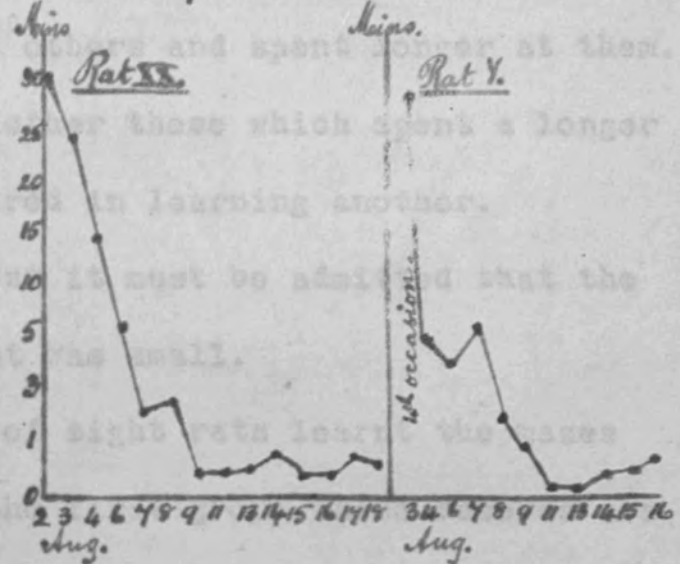
× First occasion after being led to food.

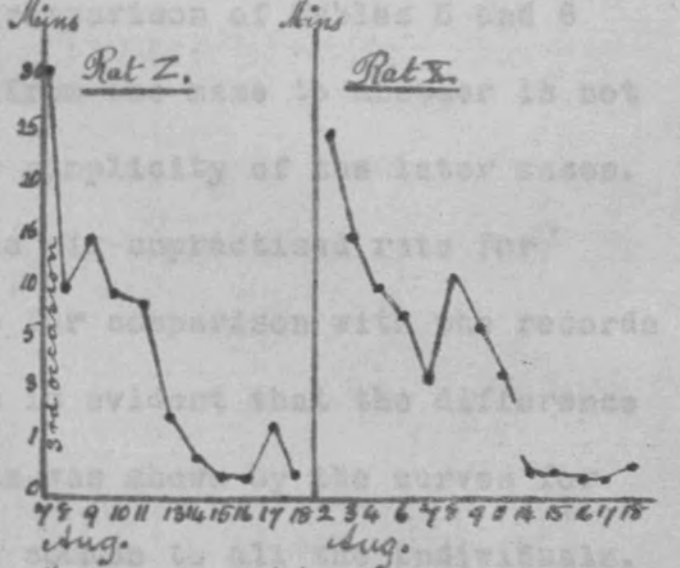
Table 6.

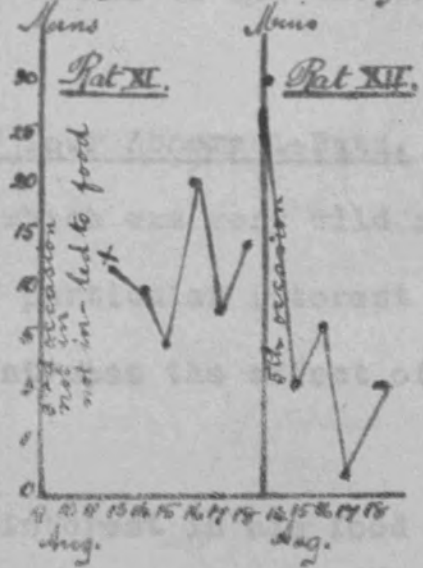
Series of Mazes.



Learning of Maze E by Six Unpractised Rats.







*First occasion after being led to food.

learnt fewer mazes than the others and spent longer at them. The intention was to see whether those which spent a longer time at one maze were hindered in learning another. Apparently they were not, but it must be admitted that the difference in the time spent was small.

This whole group of eight rats learnt the mazes in the reverse order from the first group whose records are given in Table 5. Thus a comparison of Tables 5 and 6 shows that the improvement from one maze to another is not attributable to the greater simplicity of the later mazes.

The records of the six unpractised rats for Maze E are given in Table 6 for comparison with the records of the practised rats. It is evident that the difference is not only considerable, as was shown by the curves for the averages (Table 1), but common to all the individuals.

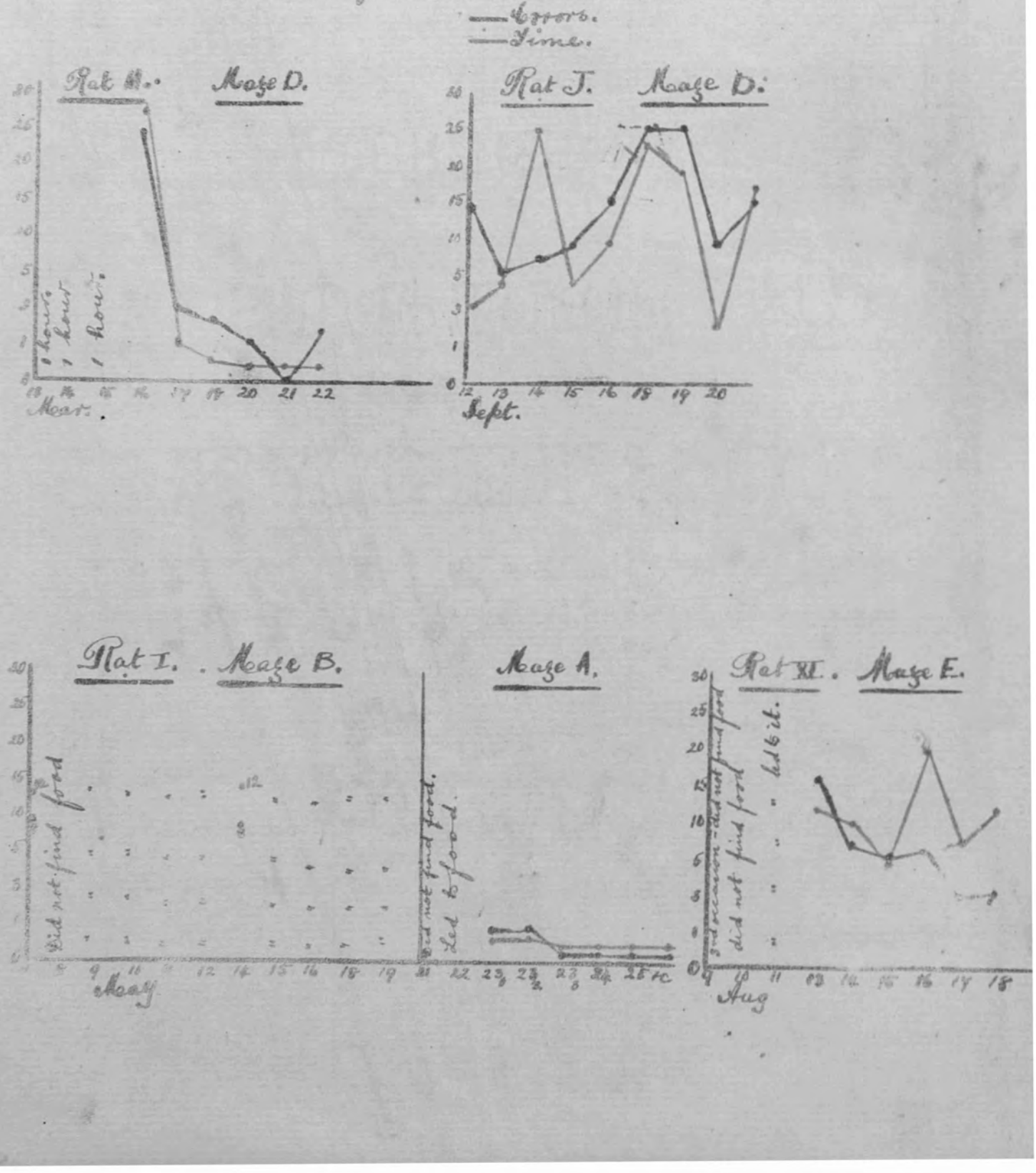
4. Learning Curves of Four Abnormal Rats.

Rat M is the rat which was very wild at the beginning. There is nothing of particular interest in his learning curve, but it illustrates the effect of wildness, (Table 7).

Rat J, never showed any interest in his food and before

Table 7.

Records of Four Abnormal Rats.



the end of the experiment fell ill. His learning curve shows exactly what Small found with the rats which were made to run a maze with no food at the end -- he threaded the maze, but he made little progress in omitting blind alleys.

Rats I and XI were both led through the maze because they showed no inclination to run through. As the curves show, they found the food for themselves on the succeeding days.

III. General Characteristics of the Rats' Learning.

The records that have been under consideration show that rats improve in their ability to acquire motor habits, and that any hindrance to learning which may be offered by the survival of old habits are more than counterbalanced by the mastery which the rat gains over the situation. Analysis of the records has shown that this improvement is due to several factors. The practised rat runs more quickly; he enters blind alleys less often; he very seldom returns on his path; if there is a choice of paths he learns to choose the shorter one more quickly than the unpractised rat learns. There is another characteristic of the practised rat's behaviour which it is not easy to establish statistically, but which becomes apparent in a series of experiments. The practised rat appears much more indifferent to his exact path, and is less upset by making a mistake than is the unpractised rat. This is probably one reason why he seldom returns on his path. His indifference to the exact path showed itself very well in his running of Maze E. Here after the six practised rats had learnt the correct path they would sometimes run

into blind alley a or b. Without a moment's delay they leapt the partition and continued on their path. If the unpractised rats made the same mistake they always ran out of the alley and often wasted time running back and forth, or right back to the beginning. This difference suggests the analogy of the beginner and the accomplished pianist. When the former has learnt a piece of music by heart, one mistake may oblige him to go over the whole piece again, whereas the latter glosses over his mistake and finishes with very little disturbance.

In spite of this apparent indifference to the exact path he takes, there are signs that the practised rat is affected by unusual features in his path. He would sometimes start if the paper bulged or if ends of it stuck out; he showed disturbance when the cover was left off the maze. When the practised rats were learning Maze E which had a much longer course than any of the other mazes, they crouched and ran very slowly when they had gone further than the distance at which they were accustomed to finding the food.

The most marked instance of a rat showing disturbance at an unusual feature in his path occurred in the

running of Maze E by Rat A. The shadow of someone between the window and the maze, fell on his path. He was running quickly, but he stopped, turned, and ran round the longer alternative path, so avoiding the shadow. (Fig. 4).

In describing the work of the two abnormal rats I and XI it was mentioned that being led through the maze seemed to help them in learning it. Two instances such as these are not sufficient to establish that rats can learn in this way, but they are suggestive. It would be interesting to train a number of rats by leading them, and to compare their later records with those of rats which had learnt by the trial and error method. Whatever the results, it would be difficult to evaluate them, because the factors involved in the following are not known. It is the same difficulty as attends all experiments on imitation which involve putting animals through performances. If, however, the rats who had been led compared well with those who had learnt for themselves, it would certainly suggest a very elementary form of inferential imitation.

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Course followed by Rat A when disturbed by Shadow.

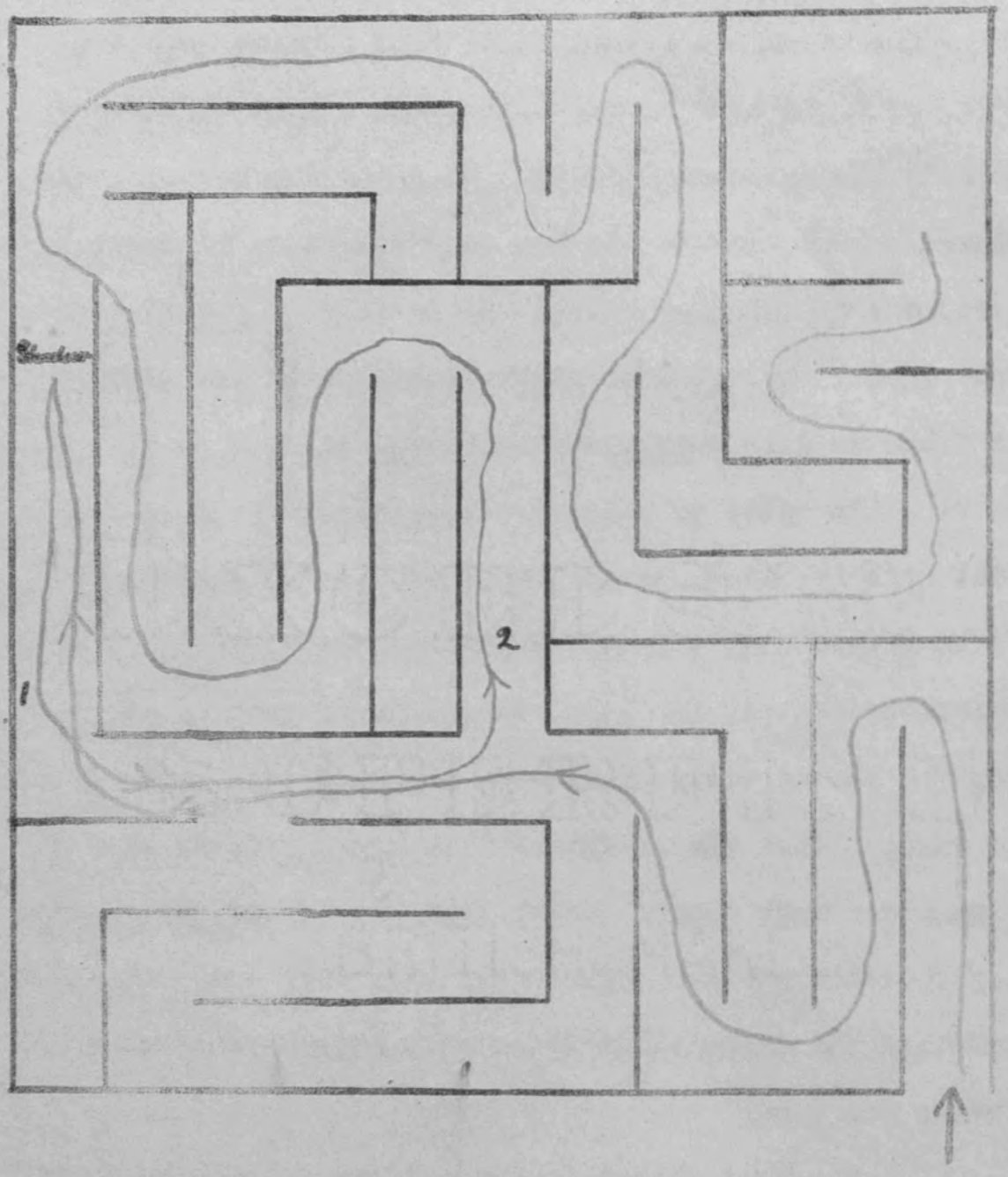

Fig. 4.

Theoretical Implication of Results.

The implication of these experimental results is open to controversy. The fundamental question is whether the rat's acquisition of motor habits can be satisfactorily explained as due to an impulse expressed in the method of trial and error, together with a retentiveness which does not involve ideational factors. If this be allowed it is very easy to take the further step, and to say that the whole process can be explained adequately on the physiological level. In his earlier writings Thorndike, who was the first to experiment systematically in animal psychology, proposes the former of these two theories; in his later writings he looks to the physiological theory as a sufficient explanation.

There is no one passage in which he states his earlier view, but it may be gathered from the following extracts. In "Animal Intelligence" first published in "Science", Vol. VIII, he says, "Animal intellection is made up of a lot of specific connections whose elements are restricted to them, and which subserve practical ends directly, and is homologous with the intellection involved in

such human associations as regulate the conduct of a man playing tennis. Conception, inference, judgment, memory, self-consciousness - - - - association and perception in the common acceptation of the terms are all absent from the animal mind." [1] Again in speaking of a man swimming or playing tennis -- the human experience which he considers most nearly approaches that of an animal -- he says "One feels sense impressions, has impulses, feels the movements he makes, that is all." [2] In passing, it may be noted that this description is true - if at all - only when the habit is perfectly formed. At the learning stage the mechanism of the delicate adjustments is not present to consciousness, but if consciousness were not continually checking and varying movements relative to their success, the adjustments never would be made.

In another place Thorndike defines "impulse": "Above all it must be borne in mind - that by impulse I never mean the motive to the act. In popular speech you may say that hunger is the impulse which makes the cat claw. - - - - Impulse means the consciousness accompanying a muscular innervation apart from that feeling of the act

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1. "Science" Vol VIII, p.823.
2. Animal Intelligence 1911 edition, p.133.

which comes from seeing oneself move. It is the direct feeling of the doing as distinguished from the idea of the act done gained through eye, etc." [1] In his chapter on "Laws and Hypotheses for Behaviour" Thorndike describes what he considers to be the explanation of the learning process more in detail. He formulates two laws. The Law of Effect is that: "Of several responses made to the same situation, those which are accompanied or closely followed by satisfaction to the animal will, other things being equal, be more firmly connected with the situation; so that, when it recurs, they will be more likely to recur; those which are accompanied or closely followed by discomfort to the animal will, other things being equal, have their connections with that situation weakened so that, when it recurs they will be less likely to occur. The greater the satisfaction or discomfort, the greater the strengthening or weakening of the bond."

The Law of Exercise is that "Any response to a situation will, other things being equal, be more strongly connected with the situation in proportion to the number of times it has been connected with that situation and to the

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1. Animal Intelligence, Psychological Review, Monograph Supplement, Vol. II.

average vigour and duration of the connection." [1]

Presumably the rat's behaviour might be expressed in the terms of Thorndike's theory by saying that the animal is driven by the discomfort of his situation to act. This action is accompanied by feeling of activity which Thorndike calls "impulse" and the action is continued until satisfaction is reached. On later occasions satisfaction is attained more quickly because the rat "feels like doing certain things and not doing certain others." He expresses this supposition in his review of Small's work. — "An animal may feel like going down a certain path, or feel like hesitating, or feel like doing one thing where he could do either of two or more and still have no images or ideational consciousness whatever."[2] To use the "open sesame" of this theory, the right reaction becomes "stamped in". It is not of great importance to ask why Thorndike in his earlier writings so carefully insisted on the psychic character of impulse when it is merely a feeling which accompanies innervation and is not even Man Friday to the mental Robinson Crusoe of satisfaction and dissatisfaction. The

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1. Animal Intelligence, p.244.
2. Psychological Review, Vol. VIII, p.644.

question which begs for an answer is how we can conceive of this "feeling like taking certain paths, etc." as the resultant of purely physiological changes. In his contribution to the "Essays Philosophical and Psychological" in honour of William James, Thorndike proposes a theory to account for the facts of learning. "The formation of a habit "means the survival of one (neurone) connection, the elimination of a futile response to a given situation, means the death of another." "A modifiable "neurone" he says "behaves in its movements essentially as do the "unicellular organisms. When its life activities, other than movements, are going on well, it continues whatever movement activity it is engaged in; when its life processes are interfered with, it makes one or more of the responses to such interference provided in its repertoire. The action system of a neurone is probably as narrow as an "amoeba's," (p.593)."[1] "The physiological parallel of the satisfying" (Thorndike distinguishes this from pleasure)"is normal stimulation to conduction in the neurones" (p.595).[2] "Over stimulation of any neurone group decreases, and normal stimulation, increases the temporary supply of food to the nervous system as a whole" (p.596).[3]

1, 2 & 3. ~~Psychological Review, Vol. VIII~~, pp.592-5-6.
"Essays Philosophical and Psychological"

In "Animal Intelligence", he says, "The learning of an animal is an instinct of its neurones" (p.249).[1]

In these later writings, Thorndike omits any mention of the psychic element in impulse, or of pleasure and pain as conscious factors, and it is evident from the way in which he sketches his physiological theory, that even if he considers that the psychical elements are present, it is only as epiphenomena. From this, and from his repeated denial of the ability of ideas to lead to action, it appears that he means his physiological theory to account for the whole of behaviour. This was made very clear in the paper on "Ideo-Motor Action" which he read before the American Psychological Association in 1912. In it he absolutely denies that an idea can in any way assist in, or bring about a movement -- the physiological correlates are the only agents. It is significant that in maintaining his thesis, Thorndike considers ideas as models of action only, and puts on one side ideas as having meaning. He distinguishes the two functions thus, "The first is that the idea in question is like the movement -- is to some extent a copy or correspondent of it, in much the same way that the mental image of a square inch of red is like a square inch of red. The second is that the idea means the

1. ~~Psychological Review, Vol. VIII~~ "Animal Intelligence", p.249.

movement in much the same way that the thought of the words 'square inch of red' means such a square". He says that if he establishes the thesis that the former have no power to bring about action, it will be easy to apply his arguments to the latter. As a matter of fact, however, none of his arguments has the slightest relevance to ideas as meaning. ("Ideo-Motor Action" in the American Psychological Review for 1913). This article confirms the suspicion which Harvey Carr says is engendered by reading "Animal Intelligence"; the suspicion namely that "- - ideas are" (for the author) "mere by-products of sensory-motor connections, and the author could give a smooth account of all the processes involved, and of the development of intelligent behaviour in both man and beast without the least reference to ideas." [1]

The particular form of Thorndike's materialist theory does not call for serious consideration; apart from all other objections the amoeboid changes in the neurones are too slow to account for association. This has been pointed out by Loeb in his Comparative Physiology (p.257). Such an objection as this, however, would not disconcert

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1. Journal of Animal Behaviour, Vol. II, p.446.

Thorndike. He would merely say that, although he did not know enough physiology to choose a possible hypothetical apparatus, such a one can and must be found. We have then to inquire whether any other writers have suggested an actual or hypothetical mechanism which would answer the purpose. The "mnemic" theories of Samuel Butler, Hering, Francis Darwin and Semon, and Jennings' theory of the resolution of physiological states, comprise the possible alternatives. The theories of Butler and Hering were not offered to explain learning to the exclusion of consciousness and ideas. On the contrary both these writers assign an important role to consciousness in the acquisition of habits. It is only when the performance has been often repeated and does not meet with any opposition, that they would consider the behaviour fully accounted for by their theory. Thus Hering says "How could all this (perfection by practice) be if every part of the central nervous system were not able to reproduce whole series of vibrations which at an earlier date required the constant and continuous participation of consciousness, but which are now set in motion automatically on a mere touch, as it were, from consciousness." 1

Semon - and Francis Darwon appears to agree with

1. Translation of Hering's lecture given in Butler's "Unconscious Memory", p.73.

with him in essentials - has developed a physiological theory more fully than the other writers and considers that it is sufficient to explain behaviour without reference to consciousness. We must therefore ask whether it will fulfil Thorndike's purpose. To test it is not an easy matter because on the one hand Semon's terminology is very original in some respects, and on the other hand he uses some psychological terms without pointing out that they do not harmonise with his strictly materialist theory. An instance of this is the term "Aufmerksamkeit" which does not appear to be anywhere more fully defined than on p.386 of "Mnemische Empfindungen" where it is made synonymous with the disposal of Vividität although in an earlier passage "Aufmerksamkeit" is made casual to "Vividität", - - - denn diese Spannung die die Aufmerksamkeit auf das betreffende Gebiet konzentriert, bedingt bei eventuell eintretender Ekphorie eine bedeutend lebhaftere Färbung (Vividität) der entsprechenden mnemischen Empfindungen, als sie unter gewöhnlichen Umständen aufzutreten pflegt", p.388. In yet another place (Mnemische Empfindungen, p.300) he says that while Homophonie increases Vividität, it makes the mnemic factors follow each other so much more easily that attention can be taken from

them. It does not seem possible to gather any clear conception of what Aufmerksamkeit is for Semon in view of these three conflicting statements. A further difficulty lies in the fact that he is chiefly concerned with the lower forms of animal life, where the facts are easier to explain by mechanical principles.

Semon's theory is that every excitation brings about a change in what he calls the "energetic situation" of the organism. This change has in some way a lasting effect, the trace of which is called an "engram" - the exciting stimulus is said to act "engraphically." Engrams are physical in nature, but they are not localised in the way in which we ordinarily conceive of localisation. In varying degrees of intensity, every engram is impressed on every part of the excitable substance of the organism. In higher animals, however, the cerebrum acts as a "Multiplikator" and the engrams which affect behaviour are stored in it. The engram of any one experience has the maximum intensity in that region of the cerebrum which is concerned in the reception of the stimulus of which it is the effect. The engrams of all the different excitations received during any one "energetic situation" of the organism, tend to be associated in such a way that the partial

return of the "situation" may excite any or all of them. This action Semon calls "Ekphoric."

When a stimulus is repeated it does not merely excite an already existent engram; it creates a second one "also immer wie $f(a_1) + f(a_2)$, und nicht wie $f(2a)$." [1]

Thus at the same time, the original engram is excited ekphorically, the later one engraphically. This Semon calls "Homophonie" - the two engrams are, as it were vibrating together. If the two are very much alike the homophonie is "kongruent," if they have important differences it is "inkongruent." To this relation of kongruenz or inkongruenz the organism may react in a specific manner.

In his discussion of Homophonie, Semon takes an example of animal behaviour which may be compared with the rats' behaviour in the maze. A fox terrier has been running after stones thrown for him. On each occasion he watches for the appropriate arm movement and then turning round runs after the stone. Once, however, he is deceived. His master swings his arm, but does not throw the stone. The dog runs and discovers that there is no stone for him. Semon says " - - verdoppelt or, nachdem er einige Male

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1. Die Mneme, Third Edition, p.308.

getäuscht worden ist, seine Aufmerksamkeit. Er fixiert noch genauer als vorher, und dadurch wird das Detail des originalen Erregungs Komplexes vervollständigt. Die Reaktion des Sichumdrehens und in der Wurfrichtung Fortstürzens erfolgt nur noch, wenn er das Steinchen wirklich fortfliegen gesehen hat, also nur bei vollkommener Kongruenz der Homophonie von mnemischem und neuem originalem Erregungskomplex. Bei Inkongruenz: Schleuderbewegung ohne Wurf, reagiert er anders. Er bleibt entweder ruhig stehen oder antwortet in seiner Aufregung mit einem kurzen Zusammenfahrung das aber gleich wieder der früheren gespannten Ruhe Platz macht. Dies verschiedene Verhalten des Tieres in den beiden Fällen können wir geradezu als Reaktionen darauf bezeichnen ob Kongruenz oder Inkongruenz bei der Homophonie der mnemischen und der neuen Originalerregung vorhanden gewesen ist." [1] The dog's learning to avoid reactions to the non-productive movements of his master is very closely analogous to the rat's learning to avoid non-productive paths in the maze, and if Semon's theory satisfactorily explains the one, it must be acknowledged to explain the other. The explanation is that the

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1. Die Mneme, 3rd Edition, p.213.

first experience is recorded by physical means on a material medium, as is also the deceptive experience. After the deceptive experience the dog redoubles his attention and on account of this the turning round and running occur only when the later physical writing is exactly the same as the first, "pre-deception" writing. In this instance it is imperative that one should know what Aufmerksamkeit is, before one can allow that Semon has succeeded in expressing the matter in physical terms, much less in explaining it by those terms. Putting this question aside there is the further difficulty of how one physical writing can affect another and by its agreement or difference bring about a specific reaction. One knows that excitations are, on Semon's theory, writing themselves on the organism at every moment and yet it is only in selected cases that their Kongruenz or Inkongruenz brings about action. The vital problem for the psychologist is just this selection. That engrams are a myth and ekphoric action a mere supposition, would not be a vital objection to Semon's theory, which is frankly hypothetical, if he offered any solution of this problem of selection.

Semon states this objection as coming from his

opponents and gives his answer. "Aber, so wird unser Gegner nun einwenden, wenn in unseren Ausfuhrungen die Regulationen und verwandte Erscheinungen als Reaktionen zur Beseitigung der Inkongruens einer Homophonie bezeichnet worden sind, so ist jedenfulls dieses Problem dadurch nicht erklärt, sondern in eklatanter Weise nur umschrieben worden. Die Art und Weise, wie die Beseitigung dieser Inkongruenz stattfindet ist ja gerade das wesentliche, was erklärt worden sollte, und mit der Aussage: es tritt eine Reaktion ein, die die Inkongruenz beseitigt, beschreiben wir den schönsten Zirkelschluss der Welt.

Dem gegenüber habe ich zu betonen, dass ich mir durchaus bewusst bin, die Regulations vorgänge keineswegs in allen ihren wesentlichen Zusammen - hängen aufgeklärt zu haben. Wohl aber scheint mir ihre Erklärung durch ein neues Erkenntnis moment auf eine völlig neue Stufe gerückt; dieses Moment beruht auf der Einführung des Begriffs der Homophonie.

Die in diesem Begriffe enthaltene Erkenntnis lehrt uns das Vorhandensein zweier real vorhandener Erregungen in dem regulierenden Organis mus: einer Originalerregung als Reiz produkt des gegenwärtigen (anormalen)

Zustandes und einer mnemischen Erregung die dem zugehörigen normalen Zustande des Organismus bzw. seiner Aszendenten entspricht. Wie sich unter der gemeinschaftlichen Wirkung dieser beiden Erregungen die regulierenden Reaktionen einstellen, und wird es wohl auch so lange nicht werden, bis nicht der Zusammenhang zwischen Erregung und Reaktion im allgemeiner viel genauer studiert und besser durchschaut sein wird, als dies beim jetzigen Stande unsener physiologischen Kenntnisse möglich ist." [1]

This climax to Semon's elaborate structure recalls irresistibly the story of the "Emperor's Clothes." The Emperor is surely naked. If behaviour were not selective, and apparently adapted to certain ends the psychologist might well agree with Semon that it can be explained satisfactorily by a physical theory. Semon claims that his theory makes it unnecessary to resort to any notion of an immaterial factor, and then at the crucial point, the modifiability, he admits that he cannot throw light on the problem. In other words belief in Homophonie is an article of faith just as much as belief in purpose, or modifiability by the end in view. All that Semon says is in essence

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1. "Die Mneme", p.382.

little more helpful than what was said by Charles Bonnet in 1766. [1] Its greater plausibility accrues from its difficult terminology and quotation of modern scientific experiments.

The application of Semon's theory would be even more difficult in the case of the rat than in that of the terrier, because the Inkongruenz is initiated by his own action and exists between only a part of the original, and the second engram. If for instance a rat has run into blind alley x one or more times we may say in Semon's terminology that the various stimuli which the rat receives from the maze have affected him engraphically. The next time perhaps, he avoids the blind alley. On this occasion the stimuli act ekphorically on the previous engram and the rat's behaviour follows accordingly, but at the critical point a new reaction appears. There is nothing of kongruenz or inkongruenz in the engrams concerned to bring about the change, except in relation to an often far distant object, i.e., the food.

Jennings expresses his theory much more concisely than Semon expresses his. Its essentials are contained in

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1. "Contemplation of Nature" Pt. V, Ch. VI.

the following quotation, "Habit and memory objectively considered are based on the law of the resolution of physiological states which may be set forth in application to the present subject as follows. If a given physiological state induced by a stimulus, is repeatedly resolved into a succeeding state, this resolution becomes easier and may take place spontaneously so that the reaction induced is that due primarily to the second physiological state reached. Wherever we find this law in operation we have the ultimate basis from which habit and memory (objectively considered) are developed." [1] He considers that there is no difference in kind between memory in the general sense and associative memory, which is distinguished from the former "by the fact that the response at first given to one stimulus comes after a time to be given to another one." He says, "The existence of associative memory has often been considered a criterion of the existence of consciousness, but it is clear that the process underlying it is as readily conceivable in terms of matter and energy as are other physiological processes." [2]

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1 & 2. "Behaviour of Lower Organisms", p.333 and p.~~333~~ 334.

The physiological state is to be looked upon as a "dynamic condition, not a static one. It is a certain way in which bodily processes are taking place and tends directly to the production of some change".[1]

With Jennings, as with Semon, there is the difficulty that his theory was formulated in connection with the study of very simple organisms, and while he says that it applies to the higher forms of behaviour, he does not give illustrations. There is nothing to show what the physiological states which function in such behaviour as the rat's can be.

Has he a specific physiological state corresponding to each part of the maze? It seems impossible to affirm or deny. The states are hypothetical in exactly the same way as engrams and homophonic. Their postulation must be justified by their ability to explain the facts. As an explanation of the rat's behaviour, the resolution of physiological states, qua physical process, is open to the objections to any purely physiological explanation which will be considered in the next paragraph. Jennings' theory has the further difficulty that supposing the rat

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1. "Behaviour of Lower Organisms", p.289.

has a physiological state corresponding to each section of the maze, his learning does not involve merely the readier resolution of one of these states into the other, but (as Driesch has pointed out in another connection) the actual omission of some of them. That "natura non facit saltum" seems indisputable when "natura" is physical process.

Physiologists such as Semon and Jennings, who attack psychologists for clinging to an immaterial factor as essential to the explanation of such behaviour as the rat's, do not appear to realise the fact on which the psychologist bases his a priori claim that no physical explanation is adequate. It is the fact that what the animal is not, and does not possess, can influence what he is. This distinction between being something and having the something as an object is possible only in cognition. Wherever the distinction can be made, and it can be made in the simplest cases of impulse, there purely physical explanations are out of court. Hobhouse, whose arguments will be considered in a later section, has well maintained this in "Mind in Evolution." It must be noted that this opinion is not held by a certain school of psychologists alone. Driesch and J. A. Thomson, both eminent biologists,

have maintained the same argument from the biological point of view.[1]

The Behaviourist School is no doubt ready with the reply that it is not necessary to suppose that, when the rat ceases to run into the useless passage it is because of any knowledge of food ahead. The Behaviourist says that the rat has immediate dissatisfaction in a cul de sac. This reply, however, only pushes the difficulty a stage further back; it does not solve it. Before the rat has discovered food at the end of a maze, blind alleys do not dissatisfy him. He appears to be satisfied with them, perhaps as less draughty than the other parts, and he always selects them for his naps. Once the food has been discovered, blind alleys which do not lead to it may well be dissatisfying but this is because in some form, however crude, there is present to the rat something which is not present in immediate perception. It may be noted here that Thorndike's theory of satisfaction, etc., would be extremely difficult to apply in the case of a maze such as Maze E, where running into 1 or 2 does not give the specific experience of being

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1. Driesch, "Science and Philosophy of the Organism", Thomson "The Wonder of Life," p.623 and section on "Mnemic Theories."

pulled up short and made to turn round, but merely causes his total path to be longer. (Fig. 3). If the rat once found the food after the longer course, and he often did, there seems no reason why on Thorndike's "stamping in" theory he should not always take that way to find it. The fact that he invariably finds and follows the shorter path, seems to confirm the view that while the rat is learning to run the maze, his movements are affected by an element over and above the elements which Thorndike allows. Claparède has criticised this tendency to ignore some of the features of animal behaviour in his article on the "Consciousness of Animals." [1] He says, "Wishing at all hazards to give an account of their experiments in comparative biology in physiological language, the savants of the new school find themselves obliged in order to satisfy the stipulation of their contract to adhere to their so-called objective nomenclature, to bring the facts down to the level of their vocabulary, just as a tailor for children, if he had to fit an adult in one of their costumes might cut off the arms and legs of his unfortunate customer." [2]

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1. Translation in the International Quarterly, Vol. VIII, Part II.
2. Ibid, p.312.

The Behaviourist School appears to base its refusal to allow any role to cognition in animal behaviour on the ground that it would involve "spiritism" and the break down of the scientific attitude. This fear does not seem to be justified. It is possible for the most rigorous scientist to admit that a specific form of action (striving towards an end by varying means) is not found in any purely physical process, and to maintain that it can take place only where there is conscious reference, i.e., where the actual and the possible can be held together and yet distinct. This does not necessarily invalidate the principle of the Conservation of Energy, which is relevant only to the physical. The most that scientists are justified in maintaining is that within the physical world any form of energy is always converted into an equivalent amount of any other form of energy. This does not preclude the possibility of the psychical which falls outside the phenomena of which the principle holds, having an effect, particularly a regulative effect upon the physical. As Ward says, [1] "- energy is essentially a metrical notion, and its conservation in finite and isolated material systems,

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1. Art. Ency. Brit. p.602, 11th Edition.

has been ascertained by careful quantitative experiments. To say that the energy of the material universe is constant is only a way of expressing the generalisation of this result - is tantamount in other words to saying that it holds of all finite isolated systems. The whole universe may perhaps be called isolated, but we do not know that it is finite. We cannot therefore apply metrical concepts to it; and consequently we cannot interpret the conservation of energy as meaning that the physical part of it is a closed system. But, if not a closed system, then the energy of a given group of bodies may be increased or decreased without interaction between that group and other bodies -- may be increased or decreased by psycho-physical interaction, that is to say. And moreover, such psycho-physical interaction would not invalidate the conservation of energy rightly understood; for that merely means that the energy of a group of bodies can be altered only from without, and this might happen whenever such intervention occurred."

That the conscious process is in some way dependent upon, or accompanied by a physical process does not mean that the physical process performs the conscious function

any more than the fact that a work of art may be created out of the poorest clay, puts it on a level with the clay which has not been moulded. We have no knowledge of whether the physical changes accompanying the conscious process are different from other physical changes or not. But we can assert that even if they are unique, they cannot qua local and extended, explain striving after ends, and the kind of learning by experience of which even a rat is capable. Further proof of this will appear in the consideration of the way in which rats improve in learning a series of mazes.

It is probably futile to press an a priori argument against the Behaviourist School because its very name is sufficient to discredit it in their opinion. Professor Angell has more wisely expressed the difficulty from the empirical side. In speaking of Loeb's attempt to reduce consciousness to an "associative memory mechanism" he says "To make consciousness synonymous with associative memory is thoroughly justifiable if the one really includes all that is in the other. But if, as is all too easy, one has attention fixed largely or solely upon the purely memorial part of the process much will be overlooked which

is not memory at all in any proper sense, and much which requires explanation and interpretation in a peculiarly urgent manner."[1] And as Ward has maintained in "Heredity and Memory," memory itself is travestied by the mechanical theories - although Loeb's theory might possibly not come under his strictures.

Up to this point we have been concerned with arguments which would apply to the rats' behaviour in learning only one maze. The results given in the present paper, showing how they improve in learning a series of mazes, seem to confirm the view that their learning is not a purely mechanical process. The fact that they are not hindered by a previous habit is in itself suggestive of this, but their actual manner of dealing with the later mazes is even more significant than the numerical results.

That the practised rat confronted with a new maze spends comparatively little time in running into blind alleys suggests that they have acquired meaning for him with reference to the maze as a whole. This acquirement of meaning is another feature characterising animal behaviour,

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1. Journal of Animal Behaviour, Vol. III, p.467.

which cannot from its very nature be expressed in physical terms. In his "Science and Philosophy of the Organism" Driesch has insisted on this impossibility. He calls the characteristic in question "Individuality of Correspondence" - "- - action (animal or human) always is a reaction corresponding to an individualised stimulus. I need only remind you that the sight of a specific person or a specific house may influence your behaviour in a specific manner - - - And then the individualised stimulus has an effect that is individualised also." After exemplifying this in two or three ways Driesch continues "There can hardly be a clearer expression of the fact that it is the totality in its specificity both of the stimulus and of the effect, that comes into account in acting, and nothing else. But what is the meaning of this totality? Here we have used the word that embraces our problem almost unwillingly, we may say that it came upon us unawares: the word'meaning'. The totalities of stimulus and effect have a "meaning", and & their meanings do not at all depend on one another piece by piece." [1] Driesch regards this as one of the most cogent

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1. Driesch's "Science of the Philosophy of the Organism", p. 71.

reasons for denying that action can be explained on the basis of "physico - chemical tectonics" of any sort.

If the practised rat forms an automatic association between being put into a maze and running on until food is found there is no reason why he should abandon the course of running into blind alleys any more quickly than the unpractised. If he avoided them in the second maze without running into them the Behaviourist might say that his action was a remainder of the automatic habit of the preceding maze. Hunter apparently has some such argument as this in mind when he says "Not only must the stimulus be known in the case of the first habit, but the second stimulus must be known physically and also physiologically in terms of the first one. Thus one can know whether or not the stimulus is for the subject in that situation the same as the first stimulus. Where the type of habit set up is kinaesthetic as opposed to auditory or visual, the control of the stimulus is very difficult because the stimulus lies in the animal's own movements." [1] It does not seem possible that the blind alleys offered any constant stimulus of the kind suggested because they were of

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1. Animal Behaviour, Vol. VII, No. 1, p.61.

varying length and in different positions relative to the other passages. Further than this, the results show that the practised rat has no patent method of avoiding blind alleys - he has to discover which they are by running into them.

It has been urged as an argument for the automatic character of the rat's behaviour that when he goes astray on the path he will often run right back to the beginning and start afresh.[1] It is true that in the earlier stages the rats often do this, but the records show that as they become more practised this behaviour ceases and if they make a mistake they recover themselves and run on without retracing more than the wrong steps. (See Table I, Curve b for Maze E). Further than this the more practised a rat is the less he seems tied to any one particular route. If he happens to take a wrong turning he leaps over a partition and continues on his accustomed route. The instances quoted on p.48 show that even when the rats have a perfectly formed maze habit they notice novel features in their path.

Probably the strongest argument for conscious guidance is that afforded by a consideration of the behaviour

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1. Washburn, The Animal Mind, p.231.

of the rats in Maze E. Here when the food was put at y, while the rats were still free to run to x, the accustomed place for the food, those who had a perfectly formed habit were quicker at finding the food in the new place than those who had run the maze only a few times. Several of the rats learned to go straight to y by the third trial although they had never gone to it before except via x. This is an instance where it would be extremely difficult to apply Thorndike's theory. The "feeling like" turning into y is inexplicable in terms of the rat's earlier experience if it be interpreted mechanically as Thorndike proposes. But here again, it is not the bald fact that the rats come to a certain modification of their path in a certain time that teaches us most about their learning; it is the way each individual rat behaves. If we consider this, we see that there is great variety. Some rats omit the whole of the useless x run on one occasion, some run the first two or three steps on it, and then turn back to y, others again run to the outside of the x food box, and without entering run back. All these characteristics of the rat's behaviour in the maze make it seem impossible that any physiological theory can completely account for

his behaviour; they seem necessarily to involve ideational factors.

The Psychological Factors involved in the Rat's Acquisition of Motor Habits.

In the preceding sections terms such as "ideational factors" and "conscious reference" were used without comment or definition. This was because any attempt at precision would have involved a lengthy digression which would have served merely to obscure the issue. The aim of the argument was to prove that the rat's acquisition of motor habits has characteristics which would not be possible if the animal were not conscious of an end to be attained. Supposing this to be proved, there is the further question of the nature of the psychological factors involved. This latter problem is both interesting and important, but it is in no way fundamental to the former. One may be able to assert that some kind of conscious process is involved in the rat's behaviour, without being at all confident as to exactly what kind of conscious process is involved. It must be conscious because it shows the influence of a vis a fronte, but its exact character may be indeterminable for the very reason that wherever there is conscious reference

there is the possibility of vis a fronte action developing.

Having fortified ourselves in case of disaster we may the more cheerfully embark on an attempt to discover what are the possible psychological factors in the rat's behaviour. The writer who has devoted most attention to this question is Small. His views may be given in his own words. Speaking of the rat's learning he says, "How explain this improvement? -- Doubtless one factor in "the process is the memory of the pleasant experience at "the end. In addition to the undirected and undifferen-"tiated motive of hunger and the motor trait of the first "trial, there is, in the second, a dimly ideated end which "probably becomes progressively clearer in the subsequent "experience. But the essential point is certainly the "recognition of the critical points along the way and the "discrimination of the divergent paths at these points lea-"ding to purposive selection of the right path. The mem-"ory of the pleasant experience at the end would be of "slight avail, if the rats did not recognise the critical "points and discriminate and select their paths. The "animal begins by going right and wrong wholly by chance. "After a few trials he comes to recognise the doubtful

"places, and hesitates when he comes to them undecided "which way to take. The external signs of indecision "vary between standing still as if trying to think which "way to go, and abortive starts each way."[1] Again in "speaking of the rat choosing the shorter path he says "In such cases profiting by experience manifestly invol- "ves the process of recognition, discrimination and choice. "If the problem set were merely the selection of one effec- "tive movement out of several haphazard movements, as was "the case with the puzzle box experiments --- then the "profiting by experience could be accounted for by the fading "away of the useless movements---- In the present case, how- "ever, two distinct associations are formed and discrimina- "ted between and the advantageous one selected. Recog- "nition of the critical places is equivalent to doubt as "to the right path --- The positively useless or less ad- "vantageous association does not fall away mechanically, "but only in virtue of discrimination between the two con- "structs, and finally the conscious selection of the right "one. In such a case as that of choice at x if the ani- "mal did not consciously select, there could never be any

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[1] American J. of Psy. Vol. XII p. 230

"fixed association consequently never any habitual action --
"But the short road is soon habitually selected just as is
"the right path at other critical points. There is involved an elementary form of comparison and judgment; for
"comparison, judgment and reflection even are present in embryo. They all take their rise in the struggle of ideas
"and images, and lower down of "constructs" which gives in
"animal as in man the illusion of choice and free intelligence."[1] It is evident that for Small the rat differs from man not so much in having fewer conscious elements as in having them in a more elementary form.

Watson, who was the first to take up the problem formulated by Small, refuses to consider anything but the objective elements in the rat's behaviour, and, therefore gives no analysis of the psychological factors, although he assumes that organic sensations function in guiding the rat through the maze. As Jennings says in his review of Watson's work, it is very unsystematically formulated and there is so little analysis that criticism is almost impossible.[2]

Dr. F. Richardson who was the first to report

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1. American J. of Psy. Vol. XII p. 231.
2. The American Naturalist Vol. for 1908.

the rat's improvement in learning to solve a series of problems, appears to regard the process as merely the acquisition of associations. The fact that later mazes are learned more quickly she attributes to the fact that the associations are formed more rapidly owing to the stimilus releasing a greater amount of innervation, and also to its releasing movements which had become habitual in the earlier experience and which would be of use in the new problem. She does not consider the question of why some of the possible assocciations become fixed and others do not, and her physiological hypothesis does not give any clue to why the practised rat eliminates running into blind alleys with fewer experiences than the unpractised. As she was using puzzle boxes there may not have been any feature corresponding to this ~~on~~ in the rat's behaviour.

The other study of rat behaviour which reports improvement in learning to solve a series of problems concludes that "the successful response is developed in con-"nection with the general meaning of the situation" and that "the learning does not fall entirely under the law of habit"[1].

Those who have written about the experiments of

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1. Bedford College Psychological Studies, p. 10.

Small and others incline to the view that the rat's behaviour is automatic i.e. explainable in some such terms as Thorndike proposes in his review of Small's work. Miss Washburn may be taken as representative of this attitude. The following is her discussion of the subject.

"What is the mental aspect of the process of "learning a labyrinth? Does it involve that form of mem- "ory which consists in the revival of images of past ex- "perience? Or is it simply the gradual formation of a "habit of movement, at no stage of which a memory image "functions? In the first place we may note that no meth- "od less calculated to involve images could well be de- "vised. A human being in such a labyrinth as that at "Hampton Court, with all his wealth of image forming and "controlling power is at a loss to make use of it for his "guidance. Secondly there are various phenomena which "tell against the image theory. For one thing the slow- "ness of the learning process in the simple labyrinths in- "dicates that memory in this sense is not concerned. "Again the nature of the errors made in some cases suggests "that memory images are not present. For instance when

"Small's two rats had learned the complicated labyrinth "almost perfectly, the one error in which they both per- "sisted lay in taking the wrong turn at the entrance. "Now this it is safe to say, would be the very first err- "or that a being which guided itself by images would elim- "inate. Furthermore it is very difficult to interpret the "learning process here as a case of association of ideas. "In Small's labyrinth two kinds of errors could be made "the one would land the animal in a cul de sac, the other simply meant taking a longer passage when a shorter one "would suffice. If the former came to be avoided as the "result of the calling up of a memory idea, this idea might "be that of being brought up short and compelled to retrace "one's steps, but how are we to imagine the idea of a short- "er path as balanced against that of a longer path? Small "says they must be "distance or temporal ideas in tactual "motor terms", and urges that our own lack of experience of "such ideas should not make us doubt their existence in the "rat mind, but Thorndike's position, that no ideas are in- "volved at all, that the rat merely comes gradually to "feel "like"taking one turn rather than the other, seems more prob- "able. In other words, we have the formation of a habit

"of movement rather than an association of ideas".[1] In as far as Miss Washburn endorses Thorndike's explanation of the rat "feeling like doing this and not doing that etc." her view has been criticised in an earlier section. Her reasons for thinking that ideas or images in any form are unnecessary are that the elimination of useless movements is slow; that the method is not such as to involve images; that some of the mistakes made by the rats are the ones that would be least likely if the animals depended on any kind of image. These objections will be considered in order.

The view that the possession of ideas should lead to the immediate elimination of useless movements, once a problem has been solved, is frequently put forward. But this is not true even of human beings. The idea of how a problem was solved the first time may be very vague, and help merely in selecting likely actions and eliminating some of the errors on the next occasion. Lindley confirms this in his "Study of Puzzles"[2]. Or again even though the idea has been clear in the first solution, in

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1. "The Animal Mind" p. 325 ff.
2. American "Psychological Review" Vol. VIII.

the second performance attention may stray for a time, or the idea of the correct solution may be difficult to recall. It seems then wholly illegitimate to argue that because the rats, after having solved the problem once, do not necessarily do it without mistakes the next time, they have nothing corresponding to ideas. Miss Washburn has brought as an argument against the view that rats depend on images, the fact that it is very difficult to conceive of an image of the desired kind which would be sufficiently definite to help. The conceivability of these images appears to be largely a matter of personal experience. It is a subject on which definite experimental results would be both interesting and valuable. A human problem which comes very near to the rat's in threading the maze is finding one's way about in underground railway labyrinths. Some individuals find this very difficult and rely to the end on the written signs, but others appear to have kinaesthetic images and images of orientation which guide them in familiar places and mislead them in strange ones. It is possible that for rats who spend their lives in subterranean windings, it is just these

kinaesthetic images and images of orientation which are clear, while their visual images have the blurred, undiscriminated character which we associate with images of organic sensations.

It is difficult to discuss Miss Washburn's third argument based on the alleged fact that rats continue to make mistakes which would be the very first to be eliminated if they had images. It is difficult because she quotes only one instance, the case of Small's rats which persisted in taking the wrong turn at the beginning. Small suggests that this was just because it did come at the beginning before the rats had settled down to work, as it were. This suggestion seems plausible. Although the first choice might be expected to make a strong impression as being the first, greater emotional disturbance and the lack of incitement at the beginning may be counteracting influences. For the rest the results do not show the inexplicable survivals of useless movements of which Miss Washburn speaks.

It is evident that Small's is the only analysis of the psychological elements concerned in the rat's acquisition of motor habits. It has the merit of taking

into account the different aspects of the rat's behaviour and of suggesting the terms which would be applied to such aspects in human psychology. It is necessary to raise two questions with regard to his conclusions. Are all the terms he suggests necessary to explain the rat's behaviour? Can the terms which are essential be defined or modified in such a way as to give a more exact description of the psychological processes concerned? Instead of attempting to answer either of these questions directly it seems desirable to consider the analysis of the different levels of behaviour which Hobhouse has made in "Mind in Evolution" and to decide to which of these levels the rats behaviour belongs. This course seems desirable because Hobhouse's analysis is very thorough and is consistent with the work of other eminent psychologists such as Ward and Stout.

Hobhouse describes four chief stages in the adjustment of actions to needs by the animals below man. In the higher animals, of course, all four stages may be present, and any one of the forms of behaviour may function in different adjustments, but it may be necessary to assume

that the lower animals are not capable of behaviour beyond that of the first, second, or third stage. The first stage is Primary Retentiveness. In this, past experience influences the present, although no memory or inference is present. Hobhouse gives as an example of this "the snail which after it has eaten and is well filled returns along its trail to rest in the corner that it has already found secure".[1] The most that Primary Retentiveness can account for in behaviour is repetition without modification, and it does not necessarily imply experience of results at all. The second stage is Assimilation. This term is used to describe the cases in which impulsive, reflex, or random actions are modified by the pleasure or pain immediately resulting. These cases may be regarded as affording examples of a specific and very primitive type of learning by experience. "But what seems essential is that "the result should follow immediately upon the first reaction, "and by "immediately" we mean closely enough to impinge upon " and so confirm or inhibit the conational impulse by which "that reaction is initiated and sustained". Hobhouse distinguishes various forms of assimilation one of which is

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1. Hobhouse "Mind in Evolution".

retrogressive. This differs from the others in that a reaction is acquired to which there was no initial tendency. An example of this is afforded by the animal which learns to know its keeper and its feeding time - "In these cases of assimilative recognition, the "crude" " sensation has assimilated certain characters which, if "disentangled, form the contents of ideas, but which are "not disentangled as long as they are assimilated."[1]

In assimilative modification two terms are concerned but they are not held apart. The one takes on the character of the other which was related to it in past experience so that for the animal acting there is not, for instance, a caterpillar which tasted nasty but a caterpillar - with - a - disagreeable - flavour. Ideas are not involved in this modification; it is on the sensory level. The next stage suggested by Hobhouse involves the Association of Ideas. "Here the perception does call up an idea or "one idea calls up another, but, as the association pro- "cess is generally conceived the ideas merely succeed one "another".[2] In order to distinguish this stage clearly

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1. Hobhouse "Mind in Evolution" p. 131 - 2.
2. Ibid. p. 146.

from the stage of judgment, Hobhouse limits the term Association of Ideas to cases where the relation between the associated elements is not apprehended. When he is distinguishing Association of Ideas from Assimilation he considers the question of "how we can distinguish the two when we are judging not by our own consciousness but by in-"ference from behaviour. A relation is explicit in con-"sciousness if its terms are united and yet distinct. It "is implicit if it merely influences consciousness, so as, for example, to affect the way in which one of its terms is "apprehended. Generalising this we may say that in con-"sciousness the explicit is present on its own account while "the implicit is that which is present merely as qualifying "or influencing something else. Extending the distinction "to cases where we can judge only by behaviour, we may say "that an element of experience is explicitly grasped by the "mind if a distinct function in the guidance of behaviour "can be assigned to it. It acts implicitly if, without "having any distinctive effect of its own, it is yet a neces-"ary part of some experience which has a function as a "whole".[1]

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1. Hobhouse "Mind in Evolution" p. 144.

The Association of Ideas is distinguished from the Practical Judgment by the fact that in the latter the elements are "held together in some distinctive relation "making of them a whole with a character of its own".[1] "Such a synthesis will deal with the particular objects "and events of experience and its purpose will be to guide "action in relation thereto".[2]

Hobhouse proceeds to describe more particularly what he means by the Practical Judgment. "What is per- "ceived" (in any ordinary perception) "is a complex of "distinct but related parts. Such a complex is what we "call articulate, and the terms - in - relation which it "comprises may be called a perceptual relation as against "the conceptual relation which is held apart from its "terms". He gives as an instance of such perception of terms - in - relation the perception of one side of a house which calls up the idea of the unseen door on the other side. "It is more than Assimilation, because what is re- "vived is an idea, a definite reference to something un- "perceived. It is more than Association, because the re-

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1. Hobhouse "Mind in Evolution", p. 146.
2. Ibid, p. 147.

"relation between the revived idea and the given percep-
"tion is an essential part of it, and it is less than an-
"alytic thought because the relations involved are not dis-
"sected out as distinct elements in consciousness".[1]
"The formation of such a judgment depends on the power of
holding distinct experiences in a single state of conscious-
"ness without prejudice to their distinctness, and involves
"that distinct reference of a state to something beyond it-
"self which we call an idea,"[2] "----"revival" in this stage
"is no longer necessarily dominated by association but is
"free to supply means to ends as circumstances require"[3].
In speaking of the idea which he has made fundamental to
judgment Hobhouse says "Generically an idea is distin-
"guished from all the modes of consciousness which we have
"considered hitherto, by the fact that in the scope of
"its reference it goes beyond what is directly present to
"our senses"4. He considers that the original function
of ideas is probably to direct effort and "they may be
supposed to arise in the process by which effort acquires
definiteness of direction towards something unseen, un-
presented to the senses".

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1. Hobhouse "Mind in Evolution" pp. 148-9.
2. Ibid, p. 150.
3. Ibid, p. 151.
4. Ibid, p. 152.

As with the presence of ideas anticipation is possible so also is purpose, and it is here that Hobhouse's analysis promises to be most helpful in the consideration of the rat's behaviour. He says, "Where --- we have ac- "tion not based on habit, but on the relation between the "thing done and the result of doing it, there we have pur- "pose. In acquired adaptation, though the response pro- "duces a result suited to the organism, it is performed, "not because the result will follow in this particular case, "but in the last analysis, because similar results have followed in previous cases, and they have fixed the habit. "In purposive action, so far as it is purposive there is no "habit fixed, but the response to the surroundings is de- "termined by the effect which it will have in the particular "case; that is to say by the relation between act and con- "sequence"[1]. "As judged from outward action, then, the "certain signs of purposive action appear so far to be "these two. The relation upon which it is based may be ex- "perienced without leading to the formation of a habit; "and again, may be applied in circumstances differing from "those in which it was originally perceived. Action may

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1. Hobhouse "Mind in Evolution", p. 162.

"often be purposive without possessing these marks, but "where we find these marks we may be sure that it is pur- "posive".[1]

"The formulation of the end constitutes an idea "and the impulse so qualified becomes a desire. In the "animal world, though we know nothing of what passes in an "animal's consciousness, we must yet, if we find action "similarly determined, impute to the animal something which "if not an idea, is capable of performing an identical fun- "ction. If ideas arise in this way as a definition of im- "pulse, it is easy to understand that they carry a motor "impulse with them. Action would seem to be the primitive "and natural accompaniment of an idea, and it is only in "the course of further evolution that ideas arise which do "not prompt to action".[2]

It does not seem necessary to apologise for this lengthy quotation of "Mind in Evolution" because it is all relevant to the present problem and does not admit of any condensation. His plan affords a survey of the psycho- logical field in view, and helps in the consideration of what is involved in the rat's behaviour. Can the be-

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1. Hobhouse "Mind in Evolution" p. 165.
2. Ibid, p. 166.

haviour be explained wholly by Retentiveness, Assimilation, Association of Ideas? Or while each of these may be present, in varying degrees, are there elements which are left unexplained by them? Primary of Retentiveness may be dismissed as a complete account of the rat's acquisition of motor habits, because the rat does not tend merely to go over a path which it has once been over - it modifies its course. At the same time, however, retentiveness is essential as a conservative factor.

Assimilation would probably be considered sufficient by several of the writers who have been quoted. Apparently it is Thorndike's explanation when he allows a psychological side to the process, and it appears to be implied in Dr. Richardson's explanation. To accepting it as a full account of the rat's behaviour, there are several objections. In the first place it is impossible to see how, for an animal which did not discriminate parts, blind alleys, and even more particularly detours from which he had not the specific experience of turning back on his path, should become complicated with rejection, owing to their not leading to food. If the rat were capable of Assimilation

merely, any one yard of the maze except the last which leads directly to the food, ought to be complicated with dissatisfaction, and rejected on that account. Again, this explanation does not appear sufficient to account for several facts of behaviour which have been noted, such as the rat's being disturbed by an unaccustomed shadow; the cases where the rat runs a few steps into a blind alley and then out again; the fact that practised rats in learning a new maze enter blind alleys less often than unpractised rats, and, indeed, the whole fact of improvement in learning from one maze to the next. But the chief reason is that it is impossible to describe the rat's learning without using terms irrelevant to Assimilation. To say that the blind alley is rejected because it does not bring food implies that food is wanted, and not found - this means that an ideal element is present. Blind alleys apart from a search for food, are neither satisfying nor the contrary.

Association of Ideas does not furnish a much better explanation than Assimilation. It does not show why, once a maze has been run in one way it should ever be run in any other. It does not show how a series of movements

is selected in accordance with the success which they attain as a series. Retentiveness, Assimilation, and Association of Ideas, while each is undoubtedly involved in the rat's behaviour, do not supply the key to its most important characteristic. They do not explain his persistence with varied effort, nor his subsequent choice of the method which not merely brought satisfaction, but brought it most quickly.

We are left then with Practical Judgment as a possible explanation. Three of the studies of rat behaviour bear out the statement that this animal's learning "does not fall entirely under the law of habit." This in itself is sufficient to justify the expectation that the Practical Judgment is involved, because Hobhouse shows that this is the first stage beyond mere habituation. The fact that the rat learns the second maze more quickly than the first provides one of Hobhouse's objective criteria of purposive action - the relation upon which the action is based is applied in circumstances differing from those in which it was originally perceived. When the rat's behaviour is considered in detail there seems to be further evidence for at least an elementary form of Prac-

tical Judgment. The way in which blind alleys acquire meaning suggests that the maze is perceived as a whole of parts in relation. As Hobhouse has pointed out this does not mean that the relations are apprehended as such or that any conceptual factors are involved. It probably implies a much less definite understanding than that of the man who from seeing one side of the house, walks to the door on the other side. But that there is this kind of perception seems certain from the way in which the rats behaved when the position of the food was altered in the Maze, and from the way in which the more practised rats would try, if they ran into a blind alley by mistake, to leap over the end and continue on the right path.

What Hobhouse says about the necessity of allowing ideal factors in order to account for the reference to things unperceived has been maintained already in the consideration of physiological explanations and does not call for further discussion except in so far as it helps to point to the signs of ideational factors in lower forms of conscious life. The important point is that the idea should stand for something not actually present to sensa-

tion in such a way as to affect action. Any conscious element which does this, however crudely, may be called an ideational factor.

If now we try to picture the rats experience in the maze it seems that it must be something like this: On the first occasion he runs about either from his impulse to explore or from his want of food. Sometimes he sits still for a long time taking no interest in his surroundings. Sooner or later food is found. Usually one experience of finding food is sufficient to form an association between being put into the maze and food. That the association is soon firmly fixed is shown by the way the rats struggle to get to the maze when they are held near it. Once the association has been formed the idea of food which is aroused by the perception of the maze, acts as a regulative factor

Hobhouse speaks of "desire" in this connection. The impulse qualified by the idea of an end becomes a desire. In as far as this process implies trains of ideas and some dim consciousness of self it seems probable that rats do not desire. They are restricted to the elementary stage of the practical judgment at which thought does not

pass from one ideal element to another but immediate perceptions may guide action with reference to an ideal element.

Food is to be had in the maze but not by sitting still; not by running backwards and forwards; not by running into this, that, or the other alley; not by trying to jump over partitions. It is impossible to say what form the idea of food takes. The rat may have a visual image of his food basin with an "at-the-end-of-the-run" reference attached to it or he may have merely a vague idea of pleasure in store. We know that in a human consciousness the idea might take any of several forms of which these are two. The form is immaterial as long as it is sufficiently definite to act as an incentive, a reference to a beyond. If it does contain an image it is much more likely to be of the organic sensations aroused by eating than a visual one of the basin, because sight does not appear to be highly developed in the rat, and also because on general principles we should expect to find the vaguer but more intense sensations playing the chief role in the consciousness of lower animals.

When the rat comes to a critical point, let us say on the first occasion of omitting a specific useless

run, it does not seem possible to say what are the factors which determine his choice. In a fully developed consciousness there might be the recognition of the passage as that first turning on the right, or that passage with the dirty finger mark on the right hand side. But it would be violating the Law of Parsimony to credit the rat with such discrimination. He is more likely to judge "this-turn-coming-within-the-distance-I-have-just-run" does not mean food. This colouring of his perception by a revival of past experience is a case of Association of Ideas. The perception reproduces by association an acquired meaning. In some cases it seems as if the rat must discriminate by extra organic clues, and it is of course, possible that he always does so. An instance, in which it seems necessary to suppose that he thus discriminated is that of choosing the direct route to the food in its altered position in the ~~Long Maze.~~ Maze E. In that case he had no organic clue to determine him to enter without running round to y. Some aspect in the perception of the entrance must have become associated with the idea of the food so strongly as to inhibit the habitual course.

Hunter's results, which have been quoted in an earlier section are conclusive in this matter. We cannot suppose any organic state of the rat to correspond to a "tuning fork" or "silence", and Hunter's rats even showed discrimination between different auditory stimuli. Signs of a similar kind of discrimination are reported in Bedford College Psychological Studies. A rat which had learnt the Sawdust Puzzle Box and the Spring Door Puzzle Box appeared to discriminate between them by stretching up as if testing the height of the box. "The behaviour was interesting as although it might be insignificant, just one of the many trial movements, it suggested the rudiments of a practical comparison x and not-x. Xness being in terms of muscular experience and sufficiently distinct in the complex of experience to influence behaviour."[1]

If the terms in which the rat's behaviour has been described are compared with Small's it will be seen that there is not a great deal of difference. The differences there are all depend on the same fact viz. that Small uses terms (doubt, hesitation, ~~which~~ and comparison, and reflection, which imply conceptual factors. In so far as comparison is fundamental to the other three, the difference in the use of terms may be resolved into the question "Does

1. Bedford College Psychological Studies, p.8.

the rat's behaviour necessarily involve comparison; when he chooses between two paths does he weigh one against the other or does he recognise the right one and run down it?" If we allow that the rat compares, it means that "the common elements stand out in contrast to the differences, where-"as in mere recognition no such contrast exists".[1] It seems that all that is necessary to explain the rat's behaviour, is his recognition of the wrong path, whether it be a blind alley or merely the longer of two possible paths, as the one which does not mean food, and the right path as the one which does mean food. It is not necessary that he compare them as paths or even that he has them copresent in consciousness. "Comparison is absent inasmuch as the suc-"cessive moments of an apperceptive process, though unified "by their relation to a common end, fail to enter into apper-ceptive relations with each other".[2] If the rat is not capable of comparison he cannot be capable of "hesitation" and "doubt" inasmuch as some form of comparison is fundamental to both of these.

It is not clear what Small means by "reflection". If he means that the rat thinks over his maze experiences,

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1. Stout "Analytic Psychology," Vol. II, p. 175.
2. Ibid, p. 175.

this seems an unnecessary supposition - it would certainly fall beyond the perceptual level of the Practical Judgment. However it is not necessary to consider the point seriously as Small merely suggests that "reflection" may be present, and, of course, it may. No one can deny that in the quietude of his cage, the rat may think over the different aspects of maze running, and plan his campaign for the next day!

Just as one cannot improve much on the terms used by Small, so one cannot define them much more exactly. It does, however, seem desirable to dwell, as Hobhouse does, on the necessity for ideas as references to what is not in perception. Small implies this, but he does not insist as he might on the point that it is only in so far as images have meaning i.e. point beyond themselves and so take on the character of ideas, that they are explanatory of the purposive character of the rat's behaviour. Indeed, it is only in so far as the rat's behaviour shows signs of elementary purposiveness that there is any need to invoke ideas in order to explain it. While from the other side, the fact that he does not learn more quickly, and the limited character of the problems he can solve

make it appear that his ideas are crude; that they serve merely to enable him to accept or reject what is present in perception, but do not enable him to plan ahead. This distinction has been clearly drawn in "An Introduction to Psychology" by Loveday and Green. In distinguishing "purposive" from "purposeful" action the authors say, "So, when "we say that to pursue ends, to choose means, and to learn "by experience are general characteristics of mental beha-"viour as we know it, we must remember that these character-"istics may be rudimentary; they develop and have not al-"ways the same form. This is most easily to be seen in "purposiveness. We call the behaviour of infants purposive, "because it does make towards ends, the attainment of which "brings satisfaction; but these ends are not forethought "or foreseen in the imagination, as are the ends at which "adults aim".[1]

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1. Loveday and Green, "An Introduction to Psychology", p.24.

Conclusion.

The experimental results which have been described in this paper seem to show conclusively that in his acquisition of motor habits the rat is not a mere machine. If the analysis based on these results is correct, it does not seem possible that the rat's acquisition of one motor habit should ever seriously interfere with his acquisition of another. Habituation will, of course, count for something. The rat will be likely to try to run his accustomed path in the new maze, but a very few experiences will suffice to cure him of this. If it be objected that in the experiments which have been described the rat was not given sufficiently long at any one maze for the running to become automatic it may readily be admitted in reply that it is desirable that more work be done on this subject. If a rat run in one maze every day for a year, does he then take longer to learn a new maze? A consideration of the results so far obtained would, I think, make it appear improbable that he would take longer than an unpractised rat, but it is very likely that he would take longer than a rat which had learnt several mazes in that time. But, whatever the result of this further experiment, it would not prove that

the rat is any more of a machine than a man. A year to a rat's organism is probably as twenty years to a human being. A man who had gone to the station by a certain route every day for twenty years would find it difficult to learn a new route.

As is always the case with experimental work in psychology the present study has suggested a great many more questions than it has even attempted to answer. The work was planned to discover whether improvement in learning is a general characteristic of rat behaviour in the maze, and for this reason as many rats as possible were used, and the conditions and problems were kept uniform. The experience gained, however, points to the fact that while numbers and uniformity are essential bases for statistics, there is important pioneer work which can be done only by varying the conditions and by planning situations to test individuals which show special tendencies. Several problems which might be attacked in this way suggest themselves. For instance, how does a practised rat behave when all the walls of his maze are removed (as Jennings suggested long ago), and he may if he like run straight to the food? When he does not find any food in

his maze on several successive occasions? When the aspect of the maze he has learnt, is very much altered by paint on the walls or obstacles in the path? When the removal of a door makes it possible for him to reach his goal by a much shorter path than he has learned? Again there is the question of whether rats can be taught to run a maze by being led through it as was described in an earlier section.

The answers to all these questions will show to what extent Practical Judgment is involved in the rat's acquisition of motor habits, and they will inevitably lead to the formulation of other problems. The present work has merely proved that so far from the acquisition of one habit hindering the acquisition of another, as is generally maintained, it favours it, thus supporting the conclusion that "the learning does not fall entirely under the law of habit."

The fact that this should be true of an animal as low in the scale as the rat suggests that conclusions as to the automatic character of behaviour, wherever it occurs, should not be drawn hastily. This is, indeed, the lesson taught by all the most recent work in animal psychology. Loeb discovered that certain parts of lower organisms have

specific irritability for certain forms of mechanical stimulation which make the orientation of the body with reference to such stimulation possible. He concluded that the action systems of these organisms are an aggregate of these mechanical effects. Since Loeb propounded his theory Jennings, Holmes, and others have studied the forms of animal life in question, and have found that their behaviour is much more complicated and regulatory than would be at all possible on Loeb's theory.

Bethe - after six experiments with two crabs in which the poor creatures on being faced with the alternatives of dashing into the dark where dwelt a devil-fish or remaining in the light an easy prey to the experimenter chose the former - concluded that crabs are reflex machines. Yerkes and Spaulding in a series of long and tedious experiments proved that the crab can learn even when the requisite behaviour demands that he should inhibit such an inborn tendency as his preference for the dark. There is the same contrast between Thorndike's summary treatment of the learning capacity of cats, dogs, and monkeys, after comparatively few experiments under unfavourable conditions, and the contradictory results founded on long and careful experiment by

such workers as Cole and Hobhouse. Such instances as these make it at least possible that further study of the acquisition of motor habits by animals, human or otherwise, may bring to light another example of the inadequacy of mechanical explanation. It may show that the animal on which mechanical forces "stamp in" their lesson by mere repetition is as mythical as the new born's tabula rasa, or any of the other creations of an over-simplified psychology.

In as far as any animal profits by experience in its acquisition of a motor habit it seems that intelligence must be involved. The mere repetition of the experience cannot account for the improvement. As Stout says in speaking of instinctive action "- it is not on the subsequent occasion that the animal first learns the lesson. It is only then that it begins to profit by what it has learned. The state of having already learned, as shown by change of behaviour in subsequent situations, otherwise similar, presupposes the learning itself at the time when the original performance was taking place. -- All that we know seems to show that learning by experience is conditioned by attention and continuity of interest leading to

the formation of appropriate dispositions and associations and so to acquirement of meaning, etc." [1]

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1. Stout "Manual of Psychology", 3rd Edition, p.350.