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PRELIMINARY EXPERIMENTS ON THE CAUSAL FACTORS IN ANIMAL LEARNING

J. A. GENGERELLI

A THESIS

IN PSYCHOLOGY

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

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PRELIMINARY EXPERIMENTS ON THE CAUSAL FACTORS IN ANIMAL LEARNING[1]

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That the problem of learning should occupy the focus of attention in present-day psychology is obvious. It could not be of such overwhelming importance in a purely structural system; but in a functional or behavioristic psychology saturated with biological concepts, it brings us up short at every step. Titchener once said, I believe, that a man's view on attention furnished the key to his whole psychological system; it is probably not unjustified to submit the observation that the statement is still true to-day if only we substitute the word *learning* for attention.

Of the many theories of learning which have been proposed, the theory of trial and error in its purest form is probably the most amenable to experimental treatment. This, of course, is a great virtue in any theory, and in this paper, which makes no pretense of considering the various theories of learning, it has been used as a point of departure in experimentation and discussion.

EXPERIMENTAL

There is no doubting the fact that the trial and error theory of learning as Watson first accepted it cannot be defended. In fact, it can be said to have been disproved three years before Watson's "Behavior" appeared.[2] But Thorndike's criticism aside, the mathematical considerations of Peterson,[3] together with

[1] The experiments herein reported were all planned and carried out at the University of Wisconsin.

[2] Thorndike's Animal Intelligence was published in 1911.

[3] Peterson, J. Frequency and Recency Factors in Maze Learning, Journal of Animal Behavior, 1917.

of probability is eliminated at a single stroke,[9] and the factors of frequency and recency controlled in such a way that we can tell at once by merely observing the behavior of the animals whether they are the causal factors in the situation. For if a rat were to

TABLE 1A
Control group

RAT'S NUMBER	1	2	3	4	5	TOTAL RUNS
19	5	0	0			5
11	3	3	0	0		6
9	2	3	1	0	0	6
7	1	2	1	0	0	4
1	3	0	1	0	0	4

TABLE 1B
Test group

RAT'S NUMBER	1	2	3	4	5	TOTAL RUNS
13	4	0	0			4
3	1	3	1	0	0	5
5	2	0	0			2
12	2	0	0			2
15	0	0	0			0

TABLE 1C
Test group I

RAT'S NUMBER	1	2	3	4	TOTAL RUNS
66	1	0	0		1
70	0	0			0
62	1	1	0	0	2
64	0	0			0
53	0	0			0

enter the blind-box by chance on the first run, he should as a consequence of the experiment, and if the laws of frequency and recency are at all significant, enter it again the second time, the

[9] We are assuming that the reader is acquainted with Watson's argument based on probability. See his Behavior.

third, and so on: so that he would never learn to go into the food-box.

The rats in the Test Group I were treated much as those in the Test Group: the animal was locked in the blind-box for thirty seconds, then taken out by the experimenter, and put back in the starting box. Here the same reasoning applied as in the Test Group—more rigidly in fact.

The scores for the three groups of rats in tables 1a, 1b, 1c are given in terms of the number of times the rats entered the blind-box each day.

The tables clearly show what others have anticipated from general considerations. If probability, frequency, and recency were the only factors in animal learning, *the rat would never learn.* The results from Test Group I are disappointing. As table 1c shows, the rats in this group made hardly any initial errors; so that these rats contributed nothing to the results of the experiment.

This is due, in our opinion, to an oversight in technique. The three groups of rats were run simultaneously (i.e., all on the same night), with the exception of the first day, when only the Control Group and the Test Group were run. The Test Group I was not started until the second day. Furthermore, the three groups of rats were run in the following order: the Control Group first; Test Group second; and the Test Group I third. In consequence of this fact, and the fact that the Test Group I was not started until the second day, the maze had acquired for the latter group certain olfactory "local signs." That is, when the rats in Test Group I were introduced into the maze for the first time, there had already been 60 runs into the food-alley as against 34 into the blind-alley.

This fact that rats can and do use olfactory trails during the earlier trails of the learning series has been amply demonstrated by the researches of Vincent.[10] We have had occasion to observe the same thing in connection with another piece of work,[11]

[10] Vincent, S. B. The White Rat and the Maze Problem, III, J. Animal Behavior, 1915.

[11] Gengerelli, J. A. Effect of Rotating the Maze on the Performance of the Hooded Rat, J. Comp. Psychol., 1928.

although we neglected to mention it there. It was observed that in learning a maze which had not been used heretofore, the rats in the group which were the first to run made many more errors and took much more time than those following them. It is difficult to see what could have been responsible for this if not some sort of olfactory orientation.

Many of the rats during the course of the experiment exhibited behavior which, when closely considered in the light of the current physiological concepts, is of the greatest significance. It was observed quite often, after the habit of going directly to the food-box had been fairly well established, that whenever the door to the food-box was held shut by the experimenter, the rats would lose no time in trying to pry it open with nose and feet. Their frantic efforts were most amusing to watch.

This is the sort of thing which the conventional Watsonian had been accustomed to dismiss with a shrug of the shoulders. The animal has been conditioned positively to the food-box; why shouldn't he attempt to get in, he asks. But consider that on all previous runs the door was wide open and therefore presented a radically different stimulating environment. In all strictness, the animals were conditioned to this stimulating environment, not to the one which presented itself when the door was closed. Yet the animals lose no time in prying it open as soon as they got there. This should not happen if conditioning were the sole explanatory factor. The concept in question admits of only a hesitating, undirected, confused behavior under such conditions.

This nonchalantly slipping over certain apparently trivial aspects of behavior which, at bottom, cannot be subsumed under the explanatory concepts is what gives the orthodox behavioristic arguments so much plausibility. Prying at a door with nose and feet is a highly complex activity which was not present in the learning process. Why should it suddenly appear, out of nowhere, under the conditions present? It is forgotten quite often that the notion of conditioned response as we are justified in understanding it does not admit of anything happening which had not already happened, which is not a *link in the chain of activity* acquired.

Another significant piece of behavior, which everyone who has worked with rats has observed, is that after the rat has made the first run, his behavior on the starting box before he sets out for the second is entirely different. This happens even when the rat has been fed in the maze for some time as Warden suggests,[12] and has become thoroughly accustomed to the new surroundings. When he is put in the starting box for the first time, the rat leisurely looks all around and walks out slowly through the door leading to the alley. This does not happen in the second or third run. Even before the starting-box has been opened, our rats have been observed to scratch at the entrance and try to get out; and when they emerge from the box, they start out as if—merely to use a vivid phrase—"they were going some place." Yet, when they left the box for the first time, many minutes elapsed before they reached the goal and food. Surely, the meaning of the concept conditioned response must be broadened a bit to include this characteristic way of behaving.

Experiment II. The same three groups of rats were used in this experiment as in the preceding; also the same maze pattern. In fact, the two experiments are identical in every respect, with the exception that what in experiment I was the blind-box was now made the food-box, and what had been the food-box was now the blind-box. Accordingly, in the case of the Test Group, door *a* was closed after the animal has been imprisoned in the blind-box for the required period of time. The three groups were run on the same night, and in the same order as in experiment I. The experiment was begun one day after the completion of the preceding one. Before it was begun, however, the rats were given five runs each in the maze with the food in its original place. This was done in order to equalize any disparity in learning stage among the rats due to unequal periods of inactivity prior to the experiment.

The results are given in tables 2a, 2b, and 2c.

These results, of course, furnish even more striking proof of of the impotence of the laws of frequency and recency. For,

[12] Warden, C. J. The Value of the Preliminary Period of Feeding in the Problem Box. J. Comp. Psychol., 1925.

were they the only factors at work in the learning process, the rats in the Test Group and Test Group I would never have ceased to go into the original food-box, since that box had the advantage of at least eleven runs over the other. It is interesting to note

TABLE 2A

Control group

RAT'S NUMBER	1	2	3	4	5	TOTAL
19	2	1	0	0		3
11	3	0	0			3
7	2	1	0	0		3
1	2	1	1	0		4
9	3	3	2	0	0	8

TABLE 2B

Test group

RAT'S NUMBER	1	2	3	4	5	TOTAL
3	2	0	1	0		3
13	2	2	0	0		4
15	7	0	0			7
5	2	1	1	0	0	4
12	1	0	0			1

TABLE 2C

Test group I

RAT'S NUMBER	1	2	3	4	5	TOTAL
66	3	0	0			3
70	4	1	1	0	0	6
62	3	0	0			3
64	4	0	0			4
53	6	1	0	0		7

that the number of errors on the first day for the Test Group I is perceptibly greater than for the other two groups. It is highly improbable that this is due to the influence of smell; for the number of entrances into the blind-box is almost equal to the number into the food-box (26 and 30, respectively). Moreover, all previous research touching on the subject shows that at an

advanced stage of learning the kinaesthetic receptors are the chief sources of guidance.[13]

It is perhaps pertinent to add at this point that our rats did not show the behavior which Peterson reports.[14] He found, it will be remembered, that rats in learning a maze entered the blind-alleys to progressively shorter and shorter distances. As a rule, our rats went all the way into the blind-box or did not enter the blind-alley at all. The 15 rats taken together, and considering the runs made on the five successive nights during which the experiment lasted, there were only eight runs in which a rat did not go all the way into the blind-box. (These are not included in the tables as errors.)

This, it should be added at once, means absolutely nothing, since the conditions here were so different from those in Peterson's work that it would be absurd to expect similar results. Peterson used a very complicated maze with many blind alleys, whereas in the present experiment we have the simplest possible pattern. In an investigation which has no immediate bearing on the present work this writer reports some facts which it is interesting to consider in this connection.[15] He found that even though a subject had formed an association between two facts, in the stress of a situation in which he tried to recall or associate many other facts, he frequently forgot the existence of the earlier connection. So that in trying to give the number which was to be associated with a certain letter, he commenced by giving a number which he knew to be associated with another letter,—only to stop himself with a "No! that number belongs to letter X!"

It may not be amiss to suggest that the situation in which Peterson's subjects found themselves in such cases is somewhat analogous to that of his rats, which had to enter the blind-alley to a certain extent before they backed out. The same considera-

[13] Cf. Watson, Kinaesthetic and Organic Sensations, etc., Psychol. Monog. No. 33. Vincent, Loc. cit. Carr, Maze Studies with the White Rat, J. Animal Behavior, 1917.

[14] Peterson, J. Effect of Length of Blind-alley on Maze Learning, Beh. Monog., 1917.

[15] Peterson, J. Experiments in Rational Learning, Psychol. Rev., 1918.

tion would also help us to understand why the rats in our experiment, where the conditions were so simple, for the most part either entered as far as the blind-box or did not enter at all.

Experiment III. For this experiment, the maze pattern shown in figure 2 was used. With the alleys to both y and x left open during the training series, the rats were given 25 runs spaced

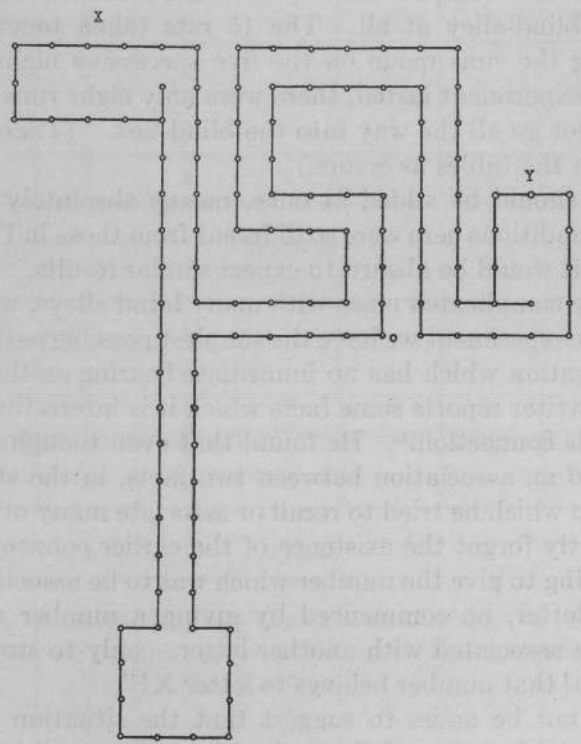

FIG. 2

equally over a period of 5 days to the food-box at y. This was sufficient to strongly mechanize the habit. Three rats were used (58, 55, 42). On the sixth day, the food was placed at X, and when the animals entered what had previously been the food-box, they were imprisoned for a period of 20 seconds. They were then taken out by the experimenter and placed in the starting-box.

During the test series the rats were allowed three runs each night. The criterion of error adopted was turning the curve at *O*.

First day

Rat 58. Two errors, on first and second runs. On third run, went straight down into the food-box.

Rat 55. Two errors, on first and third runs. On second run, went straight down into the food-box.

Rat 42. Two errors, on first and second runs. Paused and hesitated at the bifurcation on the second and third runs.

Second day

Rat 58. No errors. No pause or hesitation at the "cross-roads."

Rat. 55. One error, on the second. On the third run, he dashed into the blind-alley with great speed, advanced about 4 inches, stopped, turned around, and went out.

Rat 42. No errors. No pause at "cross-roads."

Third day

Rat 58. No errors. No pause at "cross-roads."

Rat 42. No errors. Paused for an instant at the "cross-roads" on the first run.

Rat 55. No errors. On first run, halted at "cross-roads" and looked alternately into the blind-alley and food-alley. On the third run, slowed up at "cross-roads."

This experiment is, of course, in all respects similar to experiment II with the Test Group I, with the exception that here the path to the food-box was greatly lengthened. As in experiment II, the animals in this case also entered either as far as the blind-box or did not enter the blind-alley at all. Rat 55 (second day) forms the only exception.

The results have interesting theoretical implications. They show very clearly that the animals avoid an "undesirable" situation *from a distance* under conditions which do not permit the functioning of "distance receptors." Here the proponent of the conditioned-reflex theory would be forced to employ the concept of "distant conditioning" in attempting to cover the facts. Re-

sults similar to the present ones have been reported by several observers.[16]

Circumstances did not permit a similar experiment with blinded rats; although in our opinion similar results might well be expected.

Experiment IV. The maze pattern was here the same as in experiment I and II (figure 1). Food was placed in one of the arms. The rat was put in the starting-box, and by means of the door (either *a* or *b*, depending on whether the food was placed at *y* or at *x*) the rat was made to go into the blind-box, then to turn around and, coming back, to go into the food-alley.

Two new groups of rats were used, *A* and *B*. Group *A*, consisting of 6 rats, had *y* as food-box; Group *B*, consisting of 8 rats, had *x* as food-box. The rats were given 45 runs each, distributed over a period of nine days (i.e., 5 runs a day). When the training series had ended, both doors *a* and *b* were left open for both groups of rats; the purpose being to determine whether, under these conditions, the rats would continue to take the roundabout route or would go straight to the food-box.

But, much to our surprise, the rats showed an unexpected and significant way of behaving during the training series itself.

After a rat had made the first run and entered the food-box, on the succeeding run he would not run down the blind-alley and into the blind-box as he had done before, but would halt before the closed door of the food-alley, pace back and forth and scratch and pry at the door. This was observed for every rat used in the experiment, although to a greater extent in some than in others; and this behavior continued in a gradually lessening degree for three or four nights in succession. Finally it disappeared, and the rats would dash down the blind-alley, stick the head and shoulders into the blind-box, turn around, and coming back, enter the food-alley, the door to which had been

[16] a. Yarborough, J. V. The Influence of Time-Interval upon the Rate of Learning in the White Rat, Psychol. Monog., 1921, 30.

b. Car, H. A. Time Relationships in the Formation of Association, Psychol. Rev., 1919.

c. Anrep, G. V. The Irradiation of Conditioned Reflexes, Proceedings of the Royal Society, Series B, 94, 1923.

noiselessly opened in the meantime. There was also a marked tendency upon the part of all rats to go a less and less distance into the blind-box, and quite often they would turn around before they had reached the entrance.

At the end of the training series the rats were given three runs a night under the conditions which have been mentioned. It should be added that on the first night of the test series the rats

TABLE 3A

Group A

RAT'S NUMBER	1	2	3	4	5	6	7	8	9	10
66	3	1	0	0						
23	1	0	0							
64	2	0	0							
12	3	3	2	3	3	3	1	0	0	
62	3	3	0	1	1	1	1	1	1	1
15	3	3	0	0						

TABLE 3B

Group B

RAT'S NUMBER	1	2	3	4	5	6	7
5	3	3	3	3	0	0	0
13	2	0	0				
1	3	3	3	3	3	3	20
9	0	0					
3	0	0					
19	3	2	2	0	0		
7	1	0	0	0			
11	0	0					

were given each one run under the conditions of the training series; then followed the three runs under test conditions. The contents of tables 3a and 3b are in terms of the number of times the rats entered the blind-box each day.

The tables show several things which are of theoretical significance, but we will take occasion to mention one rather curious thing which happened in the case of rat 62 (see table 3a). It will be noted that this rat persisted in going to the blind-box once

before he went on to the blind-box. He even tried to climb the wall adjacent to the entrance of the food-alley (i.e., the wall on the side of the food-alley).

Rat 30. Showed the same behavior on the third run. But was not quite as violent.

Rat 14. Behaved similarly on both the second and third run. On the second run he paced back and forth in the general vicinity of the food-alley for fully three minutes before going to the food-box.

Second day

All the rats showed the same behavior in a much feebler form; they would simply slow up, sniff, etc.

These results show clearly enough that no frequency-recency theory can ever hope to adequately cover the facts of learning. In this experiment there were no visual clues: the alley presented, *objectively*, a uniform appearance throughout. The rats were required to go all the way down the alley, enter the blind-box, come back and enter an opening to their left which had suddenly appeared. Yet, on the 4th and 5th runs, the rats, before reaching the blind-box, invariably paused in the middle of this uniform alley and ran back and forth in the vicinity of the hidden entrance sniffing from side to side. The theoretical significance of this behavior can only be appreciated when closely scrutinized; the kinaesthetic and visual patterns in the previous three or four runs were incapable of producing the original behavior. The previous circuitous path was *wholly ignored* under conditions in which one would never expect it to occur. It is difficult to square such behavior with the chain-reflex notion; in fact, in the chain-reflex theory *circuitous* and *short-cut* have no meaning. The animal simply takes the path he has taken in the past.

Another interesting thing, though not constant enough to permit generalization, is the fact that one of the rats, (14), as he left the starting-box and approached the vicinity of the food-alley, sniffed and raised himself against not the right wall, on which side the food-alley really is, but the *left.* Rats 24 and 30 usually did the opposite. When they were moving from the starting-box toward the blind-box, they sniffed at the wall to the *right,* i.e., the wall where the entrance to the food-alley really is.

It is hardly necessary to comment on the significance of the behavior occurring in this and the preceding experiment.

Experiment VI. The maze-pattern shown in figure 2 was used in this experiment. It will be seen that the pattern is in all essential respects the same as that used in the preceding experiments, except that the food-alley has been lengthened considerably. The sliding door was here used as in experiment V, and the technique was the same in all respects. A new group of three rats (48, 20, 5) was used. The purpose of the experiment was to determine whether the distance between the entrance to the food-alley and the food-box had any effect upon the behavior under consideration.

First day

No pausing in the vicinity of the food-alley entrance on the part of any rat.

Second day

Rat 5. On the third run, looked continually *to the left* as he went toward the blind-box, pausing and hesitating from time to time. At the end of the blind-alley, he turned *suddenly* and came back.

Rat 48. On the second and third runs, he paced back and forth in the vicinity of the entrance, often pausing at the very entrance section.

Rat 20. Behaved much like 48 on the second and third runs.

Third day

Rat 48. Paused and sniffed to the *right* in the vicinity of the alley entrance on all three runs while going toward the blind-box.

Rat 5 Paused and sniffed to the *left* on second and third runs while going toward blind-box.

Rat 20 Paced back and forth in the vicinity of the entrance, sniffing both to right and left.

The intensity of the behavior was greatly diminished on the third day for all of the rats.

Experiment VIIa. For this experiment the maze pattern shown in figure 3 was constructed. Two groups of "hooded" rats (animals having pigmented eyes, and the forepart of the body entirely black) were used. Group I (constituted of rats A and

C) was made to go in box a (to the left) for food. Group II (constituted of rats F and E) was made to go to box a' (to the right.

During the training series, all alleys were closed except that leading to the food-box. Thus for Group I, the alley had the form ⅂ and led to a; for Group II, it had the form ⌜ and led

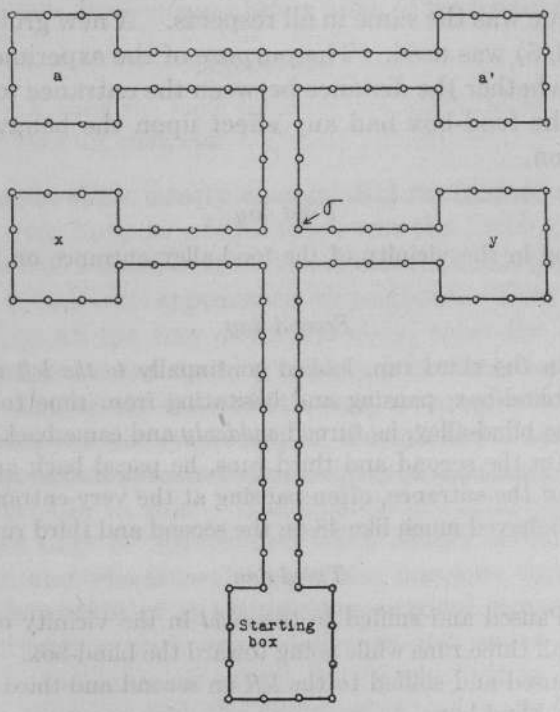

FIG. 3

to a'. Both groups were given three runs daily for 16 days, and the habit was thus greatly mechanized. At the end of the training series, the alley was closed at σ, and the alleys leading to x and y were opened. The rats (on the next day) were put in the starting-box, and their behavior was observed. (During the test series, food was placed at both x and y to equalize the olfactory values of the two boxes, but was accessible to the rats in only one box,—

the box on the side to which they were trained. In all cases, the food was out of sight of the animal until he entered the box.)

Group II (trained to the right)

Rat F. First run—paused for five or six seconds at the end of the straight alley; then entered *left* alley for a distance of three or four inches, turned around and went into right alley. Second run—went straight into right alley. Third run—same.

Rat E. First run—paused at the end of the straight alley for a few seconds, then turned into the *left* alley and entered blind-box. Second run—same. Third run—went to the right.

Group I (trained to the left)

Rat C. First run—entered the *right* alley without any hesitation. Second run—entered left. Third run—same.

Rat A. First run—paused for five or six seconds, looking alternately to right and left. Then entered *left* alley. Second run—the same. Third run—the same.

Experiment VIIb. The following night the rats in both groups were given 5 runs each under the same conditions as in the training series. The maze was then shortened as before and the behavior again observed.

Group II (trained to the right)

Rat F. First run—ran to the end of straight alley, stuck his head in left alley, turned, stuck his head in right alley, turned and entered *left* alley. Second run—entered left alley. Third run—entered right alley.

Rat E. First run—entered *left* alley. Second run—stuck his head in left, then went to the right. Third run—entered right.

Group I (trained to the left)

Rat A. First run—paused for some six seconds at end of straight alley, then entered *right* alley. Second run—entered right alley. Third run—entered right alley.

Rat C. First run—entered *right* alley after pausing. Second run—entered left alley. Third run—same.

Experiment VIIc. The maze was so arranged that now the rats in Group II could go only into y (the right) where they got

food; and for the rats in Group I, so that they could go only into x (the left). The rats in both groups were each given 6 runs in succession under these conditions, then (immediately afterwards) all the alleys were closed except those leading to a and a'.

Group II (trained to the right)

Rat F. First run—stuck his head in *left* alley for an instant, then turned and went to right. Second—run to the right. Third run—same.

Rat E. First run—stuck his head in *left* alley, turned, stuck his head in right alley, turned, and entered *left* alley. Second run—entered right alley. Third run—same.

Group I (trained to the left)

Rat A. First run—entered *right* alley. Second run—entered left. Third run—same.

Rat C. First run—entered *right* alley 2 or 3 inches, then turned and went to the left. Second run—went to the left. Third run—same.

The results in this experiment were unexpected. One would think that the rats would either go to the side they had been accustomed to going in the training series, or else be confused and enter either side at random. Yet the experiment shows clearly enough, even with such few animals, that the rats went to the side *opposite* that to which they were trained. This is particularly clear in experiment *VIIb*. And in experiment VIIc, where one would think that the animals surely would go to the alley they had learned in the training series, they went into the opposite one, which they had never entered.

The writer regrets not having performed a control experiment at the time, to determine whether the behavior was due to shortening of the alley or to the fact that the animals in the test experiment found themselves in a different stimulating environment in the form of two openings rather than one. This could have been easily done. However, a partial answer to the question is given in the following experiment.

Experiment VIIIa. In this experiment the maze pattern was the same as in the preceding. The same technique was used in the training series, with the exception that the alleys to both a

and a' were here left open. Likewise, two groups of animals (hooded) were used, A and B. Group A (consisting of rats Y and Z) was trained to go into a' (the right) and obtain food; Group B (consisting of rats W and X) was trained to go into a (the left). The two groups of rats were given 5 runs a day for 10 days.[18] The test experiment was the same in all respects as in experiment VII.

Group A (trained to the right)

Rat Z. First run—paused at end of straight alley then went to the *right.* Second run—same. Third run—same.

Rat Y. First run—went to the *right* without hesitation. Second run—same. Third run—same.

Group B (trained to the left)

Rat X. First run—paused at end of straight alley, then went to the *right.* Second run—entered right 2 or 3 inches, then turned around. Third run—entered the left.

Rat W. First run—went to the *left* after a pause. Second run—same. Third run—same.

Experiment VIIIb. This is a parallel to experiment VIIb in every respect, except, of course, that it was performed under the maze conditions of experiment VIII.

Group A (trained to the right)

Rat Z. First run—went to the *right.* Second run—same. Third run—same.

Rat Y. First run—looked to the left, then entered *right.* Second run—right. Third run—same.

Group B (trained to the left)

Rat X. First run—paused, then went to the *left.* Second run—same. Third run—same.

Rat. W. First run—looked to left, looked to right, then entered *left.* Second run—left. Third run—same.

[18] The conditions of experiment VII as regards length of training series and number of runs per day could not be met because of lack of time.

While bearing in mind that the small number of animals used justifies only a tentative conclusion, we may say that the results of experiment VIII would tend to show that mere change in the kinaesthetic value of a path (at least a *diminution* of it) does not alter the final response. If it be objected that the results of VIIIb supporting this tentative generalization are of no value because the two groups of animals had already entered their respective food-alleys, it may be pointed out that this apparently did not affect the behavior of the rats in the strictly parallel experiment VIIb.

If it be true, this apparently commonplace fact, when closely considered, becomes of some theoretical significance. It argues against the chain-reflex notion which, strictly taken, demands that every element of the stimulating pattern be present before the goal can be reached.

As for the curious results of experiment VII, we feel that, in the absence of further experiments there is little to be said.

CONCLUDING REMARKS

What value the above experiments may have is chiefly negative. We feel that they show how inadequate the current concepts are to cope with the subtleties and details of the learning process. We hope, however, in the near future, to report results which are more positive in nature.

There has been prevalent for some time an ever-increasing discontent with the concepts at hand designed to explain objectively the behavior of infrahuman organisms. And it may very well be that we shall be forced in the future to adopt new modes of departure in our experimentation and thinking. The words of Professor Tolman are to the point.[19] In adopting, he says, new "categories as a substitute for the stock physiological ones of synoptic resistance and conditioned reflex, we are not denying that the physiological concepts will ultimately prove the more comprehensive and accurate. Eventually, we will undoubtedly

[19] Tolman, E. C. Purpose and Cognition: the Determiners of Animal Learning, Psychol. Rev., 1925.

have to reduce and explain [them] . . . . in terms of physiological categories. *But the date at which this last will be possible is far distant. And, practically, it seems that the current tendency to talk and think primarily in terms of such inadequate and premature physiological concepts as are now at hand is in part responsible for some of the barrenness of our present animal research.*"[20]

[20] Italics ours.

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PRELIMINARY EXPERIMENTS ON THE CAUSAL FACTORS IN ANIMAL LEARNING. II[1]

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In the preceding paper[2] experiments were reported which tended to negate the frequency-recency notion of learning, together with prevailing belief that the white rat, to use the phrase of a recent investigator, is a "kinesthetic machine."[3] The present report concerns itself more with the positive aspect of the learning problem.

It is becoming of increasing importance that we find a satisfactory solution to the problem of learning in the infra-human animals. Whatever other effects the recent discussions arising as a consequence of the behavioristic movement may have had, they have certainly fostered in many minds the ideal of a psychology which is purely objective. What, in detail, the nature of this objectivity should be, is, as has been ably pointed out by some of the members of the Gestalt school, not immediately obvious. That it cannot be in the nature of muscle contractions occurring in temporal series is becoming increasingly clear. What concepts, then, shall we devise to cover adequately the facts of animal learning?

The subtleties and vagaries of introspective report are ruled out in this branch of research. There can be nothing but objective observation of "natural events." Hence, if we succeed in adequately understanding the animal, we will have corrobo-

[1] The writer wishes to express his thanks to Professor Moore and Dr. Parmenter of the Zoology Department for the privilege of making use of the manifold facilities offered by the University Vivarium, and for their kindly interest throughout the course of the work.

[2] Gengerelli, J. A. Journal of Comparative Psychology, vol. viii.

[3] Fields, Paul E. Form discrimination in the white rat. Journal of Comparative Psychology, vol. viii.

rated experimentally what the behaviorists have contended for so warmly from historical and *a priori* considerations. The influence which such achievement would have on our notions in human psychology are hardly to be overestimated.

Ma la via è lunga e dura, as the Italians so well put it. One of the most disturbing things it seems to us, which one encounters in psychology at the present time is the lack of a "philosophy of explanation." There is no agreement as to what constitutes an explanation. The "rigid connection" type of explanation, depending as it does upon synaptic resistances, concatenation of reflexes, and so forth, seems to be failing. And this is the one type of explanation which has the capacity of striking the vast majority of minds as "reasonable." That is to say, an explanation of that type, were it adequate to the facts, would be a continuation and expansion of the familiar experiences which are encountered in the study of mechanics. It is often said by investigators in animal research: "If I could only be rat for a minute, I would know more about animal psychology than all the other 'objective' investigators put together." Yes and no. One is tempted to say that even then the business would not be cleared up. No more so than saying that the reason why one name is remembered and another forgotten is because the owner of the one had a pretty face and the other did not.

It seems that it is along this line that the future battles of psychology are to be fought. What is an explanation? Is an *equation* an adequate explanation? The history of physics should be very instructive upon this point.

EXPERIMENTAL SERIES I.

It is not pretended that the following experiments have any finality or quantitative precision. They will probably strike the reader as crude and grossly qualitative. Such they are intended to be. As the title of this paper indicates, they are mere preliminaries. Before it is possible to write equations, one must find *tendencies*. This is true, even in physics and chemistry.

In the experiments which follow, the Shepherd adjustable maze was used. The platform of this maze was five feet square. In

other details, it was the same as that described in the preceding report. Since a camera lucida attachment was not available, the E stood behind a cheesecloth screen which was 5 feet high and 5 feet wide. In the present series, the maze was not enclosed on all sides, but only on the side which was always the starting point. The E could see the animals through the cheese cloth, remaining himself unseen. The experiments were carried on at night in a room painted uniformly black. Illumination was provided by Mazda bulbs so arranged as not to be used as points of orientation by the animals. The rats' ages ranged from two to five months.

A small cube of cold boiled potato was given as a reward to the animals throughout the course of experimentation. Potato was chosen instead of bread and milk because it was more odorless and eliminates to some extent the factors of olfactory orientation which are introduced when a more elaborate foodstuff is given. It is a familiar fact to all who have worked with rats that they will take a piece of milk-soaked bread out of the dish and "cart" it all over the foodbox before eating it. This, obviously, makes for a greater area of evaporation and heightens the possibility of olfactory orientation.

In order to avoid frequent repetition, it will be stated here that the greatest attention was given to the possibility of "tracking" and olfactory preponderance in the present series of experiments. With respect to the latter, whenever there were two alleys, one leading right and the other left, and the conditions of the experiment required that the animal make a choice, food was placed in both alleys at equal distances from the starting point, but available in one of them only. Any possibility of using vision to determine which alley contained the available food was, of course eliminated.

Furthermore, the platform was thoroughly washed after each experiment as well as after the training period. The one occasion, of course, when "tracking" proves to be an insidious factor is during the test itself. This, in our opinion, is reduced to a minimum in the present experiments by the fact that the test required only three runs, at most, from each rat; and by the fact

that the experimental animals were divided into two groups trained to opposite sides.

Experiment I

The maze-pattern shown in figure 1 was used in this experiment. Eight rats were used. During the training series, the passage was closed at X and the rats were forced to go either to the right or left to obtain food. If they went to the wrong box, they were enclosed for some thirty seconds before they were released. This was done by means of little doors described in the

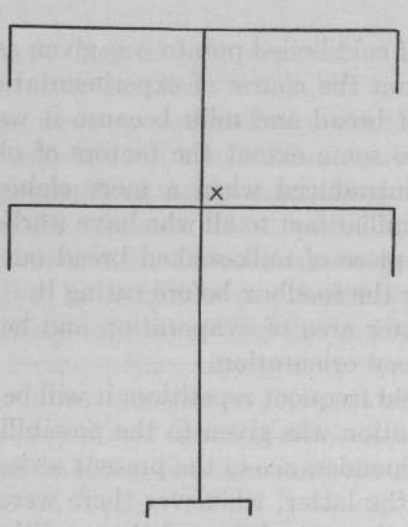


FIG. 1

preceding paper. Rats 30, 10, 21 and 13 learned to go to the right; rats 1, 20, 22 and 12, to the left.

The animals were given ten runs a day for four days. On the fifth day, the entrances to the two alleys were closed, and the plate at X was removed. The problem was to determine whether the rats that had learned to go to the right would continue to turn to the right when the path was thus lengthened; and whether those trained to the left would go to the left.

To avoid olfactory trailing as much as possible, the following technique was observed during the test experiment. (This con-

sisted of three runs for each rat.) A rat was taken who had learned, for example, to go to the right. He was given one run. Then a rat was taken who had learned to go to the left, and he was given one run. Then the first rat was taken again and given another run; then the second, and alternating thus, until each of the pair had run three times.[4] This procedure was followed for the four pairs of rats. Results are given in table 1.

It should be added that rats 13 and 22, the only two that did not enter the same side, were what might be called "misfits." Rat 13 had always been sickly, puny and vacillating. As for 22, his tail had once been caught in one of the doors in the maze, and as a result he had been "jumpy" ever since.

All of the rats hesitated at the "cross-roads," looking from one side to the other, before turning.

TABLE 1

GROUP A (RIGHT)		GROUP B (LEFT)	
30	1st, right; 2nd, same; 3rd, same	1	1st, left; 2nd, same; 3rd, same
10	1st, right; 2nd, same; 3rd, same	20	1st, left; 2nd, same; 3rd, same
21	1st, right; 2nd, same; 3rd, same	12	1st, left; 2nd, same; 3rd, same
13	1st, left; 2nd, right; 3rd, same	22	1st, right; 2nd, left; 3rd, right

It will be observed that the present experiment is a supplement to experiment VIIIa in the preceding paper. In that experiment the path had been shortened; in the present one, the path was lengthened. This, it seems to us, is a significant difference. The results of the first mentioned experiment might possibly be interpreted as the result of "redintegration." That is, a part of the stimilus pattern (kinesthetic), in terms of that hypothesis, would have been sufficient to produce the differential response. It would seem, however, that this explanation cannot readily apply to the present case. This becomes increasingly probable when it is considered that the rats, when they have passed the point where the barrier X had been, advanced in a most slow and

[4] As a rule, however, in the experiments which follow, a rat from one group is given his three runs in immediate succession; then a rat from the opposite group is permitted to run three times.

cautious manner, stretching out their bodies forward as far as possible before taking the subsequent step; in such wise that the whole kinesthetic set must have been appreciably changed.

There is, of course, the possibility of tracking even despite the precautions which have been described; and this, it must be confessed, is the *bete noire* of this type of experimentation; and deplorably so in view of the fact that such varied and conflicting observations have been reported.[5] The possibility in this case, however, is very slight indeed.

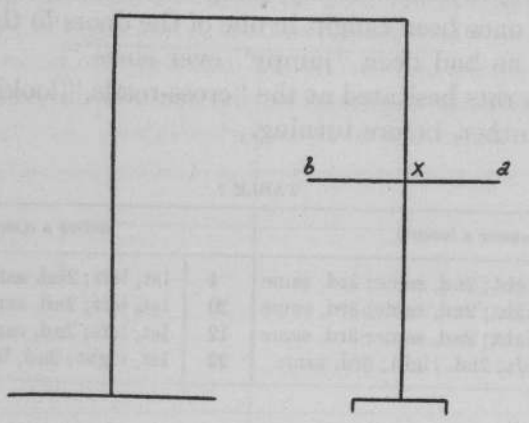


FIG. 2

Experiment II

This is a variation of the preceding experiment; the maze was "doubled on itself," as shown in figure 2.

The animals were given further training on the compartments near the starting point; then the barrier at X was removed, the paths to *a* and *b* closed, and the animals were forced to follow the long path and choose between the two alleys at the end. This additional distance was a good 5 feet.

Two groups of rats were again used. Group A (rats 30, 10, 21, 3) trained to the right; and group B (rats 4, 2, 22, 12, 6)

[5] Liggett, John Riley. An experimental study of the olfactory sensitivity of the white rat. Genetic Psychology Monographs, vol. iii, no. 1.

trained to the left. These rats were given ten runs a day for twelve days; then, on the thirteenth day, they were each given two more. The barrier was then removed, and the test experiment began. The olfactory variable was equalized as much as possible, in accordance with the above scheme. The rats were given only two runs on the test series. Results are shown in table 2.

The results are most curious. In 7 cases out of 9, the first run was to the side opposite that to which the rats had been trained so extensively. It may appear obvious at first glance that those are the results which should naturally be expected in view of the fact that the path had turned 180 degrees; yet one would hesitate to accept such an explanation, particularly in view of certain experiments which are to be reported later.

TABLE 2

GROUP A (RIGHT)		GROUP B (LEFT)	
30	1st, left; 2nd, right	4	1st, right; 2nd, left
10	1st, left; 2nd, right	2	1st, left; 2nd, left
21	1st, left; 2nd, right	22	1st, right; 2nd, left
3	1st, left; 2nd, right	12	1st, left; 2nd, left
		6	1st, right; 2nd, right

The fact that there was a screen on only one side of the maze probably entered into the matter. In the training series, the rats faced a homogeneous black wall as they turned to the right or left; in the test experiment, they faced a white uniform wall nearer to them. Yet it is not easy to see why they should so consistently take the opposite path on this account.

Experiment III

In view of the inconclusiveness of the previous experiment, the following one was performed with the same group of rats. In this experiment, the animals were trained with the maze in its lengthened form (as shown in figure 2); the maze was then shortened to the same form as in the training series of experiment II. The thought being that if the rats now went to the side opposite

It should be added however that when the animals reached the "cross-road," they did not make the choice in a smooth mechanical way, but stopped and looked from one side to the other. This was always found to be the case throughout the present investigation.

Experiment V

Using the same group of rats without giving them any further training, the maze pattern was changed to the following form on the succeeding day (fig. 4). As will be seen, the absolute and

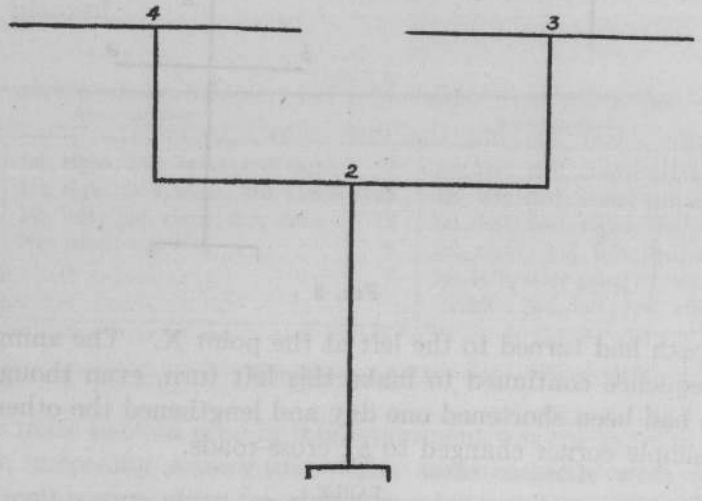


FIG. 4

relative values of the various paths were changed, including the distance to the first "cross-roads."

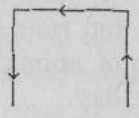
The E took all possible precautions to avoid olfactory clues and "tracking."

The results are shown in table 5. The words "no errors" mean that the rat took the correct path (i.e., went on the same side as the training series) whenever two alternatives presented themselves. The digits indicate the point where the animal took the "wrong" path. This can be found by consulting figure 4.

The results are most interesting, considered, as they should be, in the light of the preceding experiments. It will be observed

that the animals in group B made no errors whatsoever; they ran through very smoothly, although they had never been placed in that situation before.

The significance of the results for group A is conspicuous. As will be seen, only one rat made an error on the first choice; but in three cases out of four, the wrong path was taken on the second choice. Now, in experiment III, these animals, together with group B, had been trained for ten days on the following path.



There was a *left* turn which had been ingrained deeply in their system. After making the first choice correctly, the rats in

TABLE 5

GROUP A (RIGHT)		GROUP B (LEFT)	
21	1st, 3; 2nd, 3	22	1st, no errors; 2nd, same
10	1st, 2, 4; 2nd, no errors	4	1st, no errors; 2nd, same
3	1st, 3; 2nd, 2, 4	2	1st, no errors; 2nd, same
30	1st, 3; 2nd, 3	12	1st, no errors; 2nd, same
		6	1st, no errors; 2nd, same

group A (with the exception of no. 10) went to the *left* at 3. In fact, every one of the three rats bumped his nose into the end of the blind alley with considerable violence.

The animals had learned to make a left turn in the course of their run, and although now the path had been greatly distorted and consequently the stimulus pattern radically changed, they still persisted in "putting in" that left turn.

It should be mentioned that during the course of the training in experiment III, the animals gave the E the decided impression that they were taking the prolonged path "as a whole." More specifically, they seemed to be ready to "take" the left turn before they came to it. The reader who has worked with the white rat will understand this characteristic way of behaving. This is mentioned in connection with the fact that in the test

both groups of animals took their course, whether correct or not, with a smoothness which surprised the E. In short, there could hardly have been any possibility of orientation with respect to the screen.

It might also be added that the behavior of rat 3 on the second run is explained by the fact that he became frightened when the E tried to get him out of the food box after the first run.

Experiment VI

After having been given ten runs in the maze pattern shown in figure 5, the same group of animals were run in the pattern shown in figure 6 the next day.

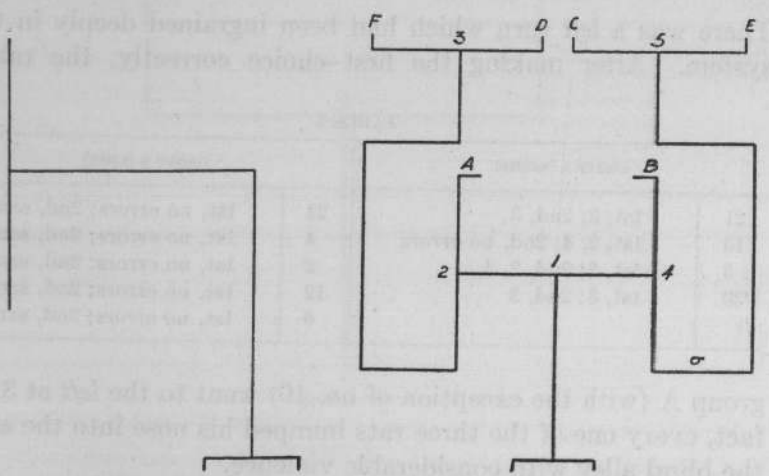


FIG. 5 FIG. 6

The results are shown in table 6. The digits, again indicate points where the animal took the "wrong" choice; the letters indicate specific points in the maze.

The above results are of some interest; particularly the second runs in group A. Three of the four rats made the errors 1, A and D. With the exception of 1, these errors might be termed, following Köhler, "good errors." The animals went to the *right*. With respect to error 1, the E is of the opinion that it was caused by the runs given in the pattern shown in figure 5, and also by

the intensive training in experiment III, where a left turn was made before the path was reversed.

Before considering group B, mention should be made of the peculiar "lability" of which the white rat is capable; exemplified, for example, by group A on the second run. The path is "radically" changed at one point or another. (In the present instance at 1.) We have encountered this sort of thing again and again during the course of the present work. This, we think, is not to be attributed to "chance;" animal investigators have, in fact, been too prone to invoke this element in the past.

On the contrary, the E has had occasion to observe many times that these "radical" swervings from a path which has been

TABLE 6

GROUP A (RIGHT)			GROUP B (LEFT)		
	First run	Second run		First run	Second run
10	No errors	1, A, D	22	No errors	2
30	No errors	No errors	12	No errors	2
3	No errors as far as σ; 2, D	1, A, D	4	2	1, turned, then went on without errors
21	4	1, A, D	6	2, turned, 4, C	No errors
			2	2, 3	2

chosen consistently many times previously is caused by some inconvenience occurring at the end of the run. A too meagre portion of food in the food box, or a slight fright from a sudden sound or movement are examples.

In the present instance, the E is of the opinion that the extreme length of the pathway was responsible for the change. The animals moved forward slowly and hesitatingly, much as a human might, who was marvelling that "the end was not yet."

The persistent error (2) shown by group B is not so clear. That these were not chance errors is proved by the fact that the rats on the occasions of the errors moved through with considerable speed and ran into the end of the alley. The E can only conjecture that the maze pattern used in the test in the preceding

experiment may have been responsible for this curious behavior, although it is difficult to conceive how this should take place in view of the extremely small number of runs which were permitted in this pattern. (The animals were given but seven runs in this pattern, including the two which have been recorded in table 5.)

EXPERIMENTAL SERIES II

In the experiments which follow, the platform was surrounded on all sides by a strip of cheesecloth about four feet high. This made the external environment of the maze homogeneous, and

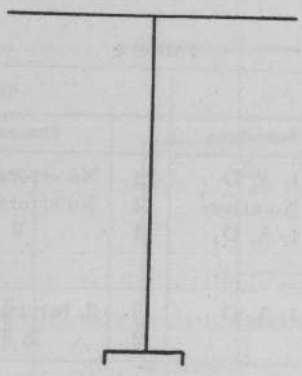


FIG. 7

eliminated the possibility of orientation which was present in the preceding series. The E crouched behind this wall and watched the animals' movements through the cloth.

A new group of animals, consisting of six rats, was used. The group was here again subdivided into lots of three each. They will be referred to as group A and group B.

Experiment I

These animals were given five runs a day for fifteen days in the following maze pattern (fig. 7). After the training series, the maze was changed to the form shown in figure 8.

The results are shown in table 7. The numerals, as before,

refer to points where the animal chose the "wrong" path. Group A had been trained to go to the right, group B to the left.

These results show that the animals were entirely at sea. The behavior of the animals during the test showed this most clearly;

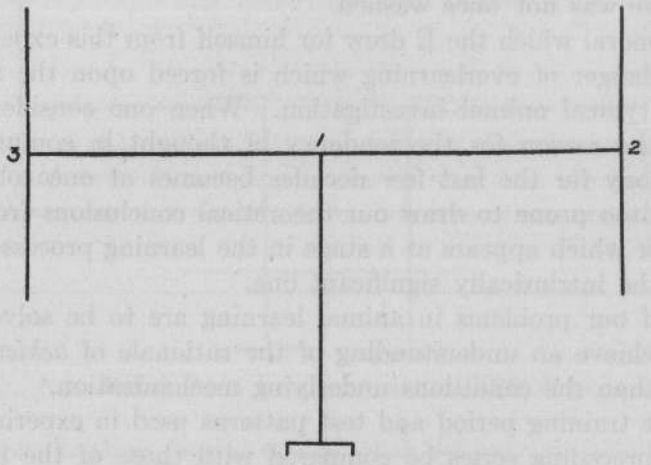


FIG. 8

the rats in both groups vacillated in the most pronounced manner, and never took more than a few steps at the time.

In the opinion of the E, the present results show very clearly what should happen when an animal behaves like a "kinesthetic

TABLE 7

GROUP A (RIGHT)				GROUP B (LEFT)			
	First run	Second run	Third run		First run	Second run	Third run
20a	1, 3	1	No errors	10a	No errors	Same	Same
2a	No errors	No errors	2	30a	3	3	No errors
1a	1, 3	No errors	No errors	3a	1	3	1, 2

machine." It will be observed, in the first place, that the absolute and relative dimensions of the training pattern and the test pattern are markedly different. More important still, however, is the fact that these young animals, never having been placed in a maze before, were trained for fifteen days upon this very

simple pattern, with the result that the habit attained a maximum mechanization. Not only this, but it may very well be supposed that the maze presented a certain olfactory orientation for the rats, as a result of this long training series, during which the maze was not once washed.

The moral which the E drew for himself from this experiment is the danger of overlearning which is forced upon the animal in the typical animal investigation. When one considers this point, the reason for the tendency of thought in comparative psychology for the last few decades becomes at once obvious. We are too prone to draw our theoretical conclusions from the behavior which appears at a stage in the learning process which is not the intrinsically significant one.

For if our problems in animal learning are to be solved, we must achieve an understanding of the rationale of *achievement*, rather than the conditions underlying mechanization.[6]

If the training period and test patterns used in experiment I in the preceding series be compared with those of the present experiment, it will be observed not only that there was less chance for mechanization in the former, but also that the "break" between the training pattern and test pattern was not such a radical one.

Experiment II

The animals were given in this experiment eighteen runs in the pattern used as the test in the preceding one (fig. 8), spread out over a period of three days. On the fourth day, the rats were run in the pattern shown in figure 9. Results are given in table 8.

The results in this table have significance only for group A, since for group B the path had the same value as in the training series, with the exception that the first "cross-roads" was removed. The reason for running the animals in group B at all was to furnish olfactory control.

The same night, some twenty minutes later, the animals were

[6] See Koffka, The Growth of the Mind.

run through the pattern shown in figure 10. Correspondingly, the results in table 9 have significance only for group B; since in this case it was the path for group A that remained the same.

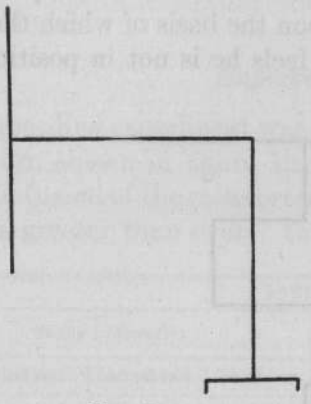


FIG. 9

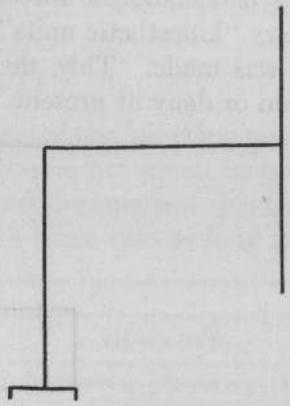


FIG. 10

The results show clearly enough that the animals continued to make a correct choice when they were placed in a situation which they had never faced before. Not only was the path turned

TABLE 8

GROUP A (RIGHT)				GROUP B (LEFT)			
	First run	Second run	Third run		First run	Second run	Third run
2a	Right	Same	Same	10a	Left	Same	Same
20a	Right	Same	Same	30a	Left	Same	Same
1a	Right	Same	Same	3a	Left	Same	Same

TABLE 9

GROUP A (RIGHT)				GROUP B (LEFT)			
	First run	Second run	Third run		First run	Second run	Third run
2a	Right	Same	Same	30a	Left	Same	Same
20a	Right	Same	Same	3a	Left	Same	Same
1a	Right	Same	Same	10a	Right	Left	Same

180 degrees; but the animals which during the training series made a first left turn were now forced to make a first *right* turn, and vice versa.

The animals ran through with considerable smoothness.

The obvious objection to the above statements is that the situation was *not new*,—that the length of the path after the animals had made the forced turn was sufficient to provide the necessary "kinesthetic units" upon the basis of which the correct choice was made. This, the E feels he is not in position either to affirm or deny at present.

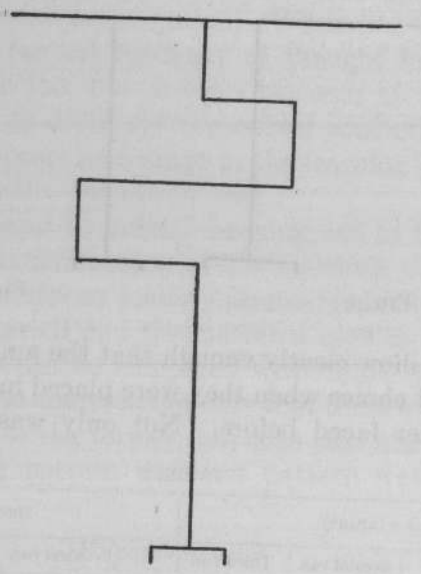


FIG. 11

Experiment III

The following night the rats were placed in maze-pattern shown in figure 11. Results are shown in table 10.

The animals were very much disturbed by this long, tortuous path; they would often run back and forth along the alley and back to the starting box, to start all over again. Notwithstanding this obvious confusion, the majority of the rats continued to make the correct choice.

In answer to the objection, again, that the last segment of the path immediately preceding the "cross-roads" was sufficient to afford the requisite number of kinesthetic units making possible

the correct choice, it should be mentioned that the animals advanced over the distance (some eight inches) very hesitatingly and slowly, straining the body forward in the characteristic way, —which surely would make for a disturbance in the kinesthetic values.

Experiment IV

The preceding experiment was repeated the following night with the pattern shown in figure 12. Results are given in table 11.

The confusion of the rats throughout the length of this tortuous path was greater than ever. It took some rats as long as three

TABLE 10

GROUP A (RIGHT)				GROUP B (LEFT)			
	First run	Second run	Third run		First run	Second run	Third run
2a	Left	Right	Same	30a	Left	Same	Same
20a	Right	Same	Same	10a	Left	Same	Same
1a	Right	Same	Same	3a	Right	Left	Same

TABLE 11

GROUP A (RIGHT)				GROUP B (LEFT)			
	First run	Second run	Third run		First run	Second run	Third run
20a	Right	Same	Same	10a	Left	Same	Same
2a	Left	Right	Left	30a	Left	Same	Same
1a	Right	Same	Same	3a	Left	Right	Left

minutes to reach the food box. As before, the animals dashed back and forth in labyrinth, returning often to the starting box.

This dislike of the rats to run through long alleys having many twistings and windings, even though there is no possibility of running into any blind alley, is somewhat suggestive, particularly in light of the fact that the animals had heretofore been accustomed to simple pathways. That is to say, after an animal has had training in simple straightforward patterns, he does not "follow his nose" if placed in a long path, even when there is no place to go but straight ahead.

EXPERIMENTAL SERIES III

In this series it was intended to attack the problem of the capacity for "generalized behavior" in the white rat in a slightly different manner. The method of interference was used, to see what light it might throw on the problem.

Experiment I

The animals used in this experiment had already been used in Series II. It will be remembered that in that series group A

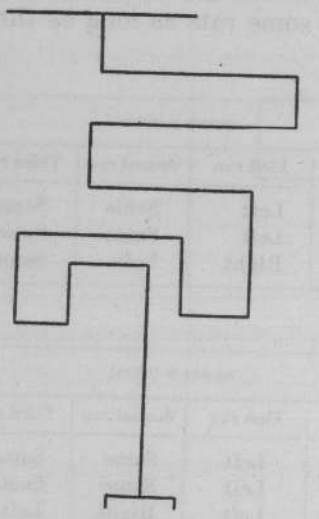


FIG. 12

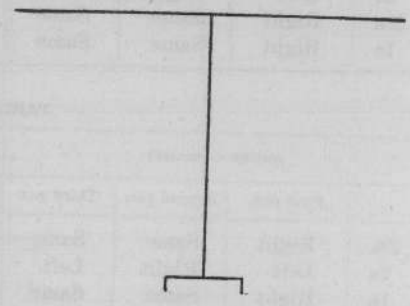


FIG. 13

had been trained to the right, and group B to the left. This habit was broken down in the present experiment. That is to say, the rats in group A were made to go to the left, and those in group B to the right. In addition, to the rats used in the preceding series, two other rats from Series I were also used. In that series, rat 2 had been trained to the left; rat 30 to the right.

The training pattern for this experiment is shown in figure 13. No food boxes were added, and no food placed in the maze. The rat was taught to go to the end of the alley and wait. He was then picked up by the experimenter and fed outside the maze.

The animals were given fifteen runs a day for seven days. To facilitate the breaking down of the old habit, grills carrying 110 volts were used. This appeared to give the animals a very severe shock, but no ill effects were noted. The rats never stepped on the grill more than once, and when it became clear that they had been "negatively conditioned" to the side to which they had been previously trained, the grills were removed and the remainder of the training went on without them.

The test pattern is shown in figure 14. The question which directed the experiment was this: Whether the reversal of the

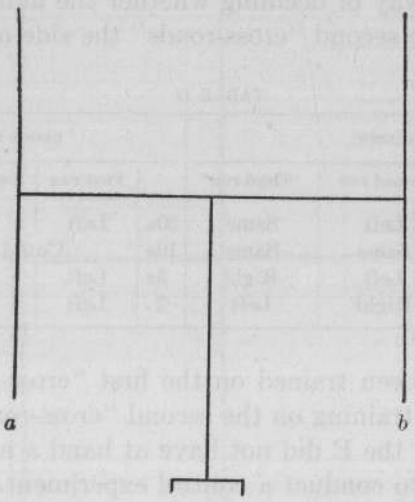


FIG. 14

habit at the first "cross-roads" would bring with it the consequence of likewise reversing the choice on the second "cross-roads." The reader will observe in this connection that the rats had been trained for three days in the pattern shown in figure 8 in connection with experiment II, and later on were run in the patterns shown in figures 9 and 10. In short, the animals had been taught to take to the right or left, as the case might be, whenever they were confronted with a "cross-road." However, a period of ten days had elapsed since the performance of experiment II in the preceding series.

Table 12 indicates the side taken by the animal at the second bifurcation. Food was available only in the food-boxes nearest the starting point: that is, at *b* for group B, and at *a* for group A.

These results show, clearly enough, that the animals continued to go to the same side when they came to the second "cross-roads" as they had in the preceding series. In other words, the reversal of the habit at the first "cross-roads" had no effect on the old habit governing the choice on the second.

The results, however, are not unambiguous. For it is clear that there is no way of deciding whether the animals would not have taken at the second "cross-roads" the side opposite that to

TABLE 12

GROUP A (LEFT)				GROUP B (RIGHT)			
	First run	Second run	Third run		First run	Second run	Third run
20a	Right	Left	Same	30a	Left	Right	Same
1a	Right	Same	Same	10a	Could not be used		
2a	Right	Left	Right	3a	Left	Right	Same
30	Left	Right	Left	2	Left	Right	Same

which they had been trained on the first "cross-roads," even if they had had no training on the second "cross-roads" at all.

Unfortunately, the E did not have at hand a number of naïve rats with which to conduct a control experiment. The supposition mentioned above, however, seems hardly probable; although it is surprising that rat 2 should have also behaved in the same way as animals that had been used in the much more recent Series II.[7]

Experiment II

Here animals (chosen from both Series I and II) were given ten runs a day for three days in the pattern shown in figure 15.

[7] We take advantage of the proofs to indicate that variations of the above experiment have since been performed with over 20 naïve animals, with the same results. A complete account of the experiments will be given in a later paper.

The rats were introduced at *a* (the entrance to *b* being closed). Group A was taught to always take the alley to the right; group B, that to the left; such that the actual paths of the two groups of animals was a rectangular one, the end of which was in the vicinity of the starting point. As in the preceding experiment, the rats were fed outside the maze.

The maze was perfectly symmetrical on all sides.

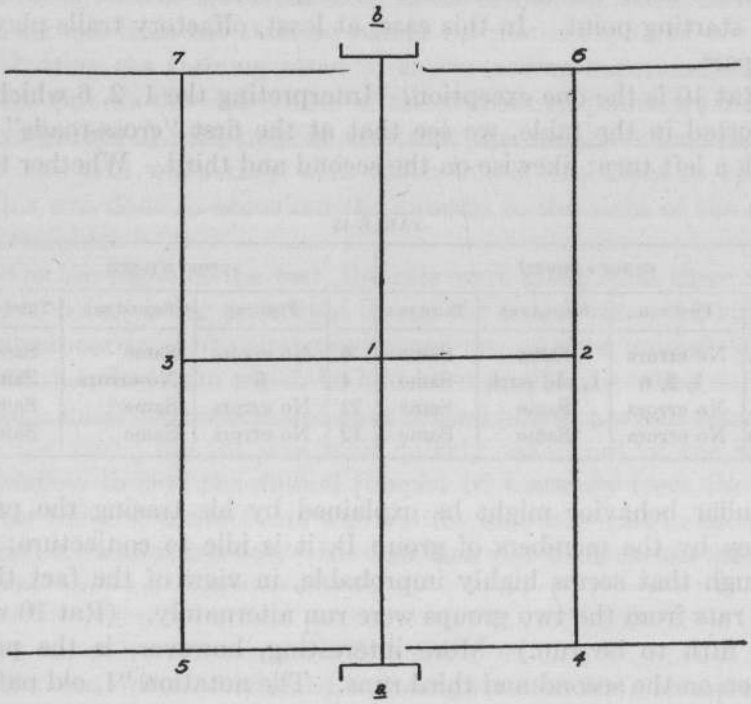


FIG. 15

For the test, the animals were introduced at *b*, and the entrance to *a* was closed. The platform itself, of course, was not rotated; the rats were simply introduced on the opposite side, and the entire field thus reversed.

On the night of the test, however, the animals were given each three runs with *a* as the starting point. The test itself was done immediately afterward. Results are shown in table 13. The

numerals in the table, as always, indicate the point where the animal chose the "wrong" path.

To the E, it would have been surprising had the results been other than those shown in this table. The rats ran through with the greatest smoothness, there being very few pauses at the cross-roads, and these only momentary. The reversal of the field caused no confusion, even though this was done within a few minutes after the animals had been given three runs with *a* as the starting point. In this case, at least, olfactory trails played no part.

Rat 10 is the one exception. Interpreting the 1, 2, 6 which is reported in the table, we see that at the first "cross-roads" he took a left turn; likewise on the second and third. Whether this

TABLE 13

GROUP A (RIGHT)				GROUP B (LEFT)			
	First run	Second run	Third run		First run	Second run	Third run
21	No errors	Same	Same	6	No errors	Same	Same
10	1, 2, 6	1, old path	Same	4	6	No errors	Same
3	No errors	Same	Same	22	No errors	Same	Same
1a	No errors	Same	Same	12	No errors	Same	Same

peculiar behavior might be explained by his tracing the path taken by the members of group B, it is idle to conjecture; although that seems highly improbable, in view of the fact that the rats from the two groups were run alternately. (Rat 10 was the fifth to be run.) More interesting, however, is the path taken on the second and third runs. The notation "1, old path" in the table simply means that he went left on the first "cross-roads" and to the right on the second and third. This, however, is exactly the path taken by the rats in group A during the training series (with *a* as starting point). This, it may be conjectured, is a clear-cut case of "tracking."

Experiment III

In this experiment, the same pattern was employed as in the preceding, with *a* as the starting point, and the entrance to *b*

closed. No further training was necessary for the purpose of this experiment, since the same group of animals was used.

The guiding thought here was to determine what change in behavior the animals would show when they were severely punished at the end of a fairly complicated path where they had been trained to expect food. Having gone to that point and received an electric shock, would a rat belonging, say, to group A, turn to the *left* at the first cross-road, at the second; or would he refuse to set out from the starting point?

During the training series of the preceding experiment, grills were put at the end-points of the respective pathways for the two groups of rats, in such wise that the animals were standing on the grill when they were taken out of the maze to be fed. This was done to accustom the animals to the sight of the grills themselves.

On the night of the test, the rats were given each three runs; then, before being permitted to run the fourth time, the current (which carried 110 volts) was turned on. As the animal dashed into the alley from which he had been previously taken out and fed, a small door was pulled shut behind him to prevent retracing of the path; the rat was then quickly taken out of the maze. Needless to say, the animal jumped off instantly from the grill after the first contact and was waiting at a safe spot in the alley when he was taken out. He was then put back at the starting point, and his behavior observed.

Group A (right)

Rat 1a: Walked slowly and hesitatingly to the first "cross-roads"; vacillated here for some time, looking from one side to the other; then went to the right for about 6 inches, and stopped for a full minute or so. Was taken out.

Rat 10: Advanced slowly to the first "cross-roads"; paused, went to the left. Paused at second "cross-roads"; went left again.

Rat 3: Advanced slowly to the first "cross-roads," paused, went left as far as the second "cross-roads"; turned and came back to starting point.

Rat 21: Ran to the first "cross-roads," then returned to the starting point. Repeated this twice. On the next attempt, went to the left

at the first "cross-roads" and advanced as far as the second "cross-roads"; turned back.

Group B (Left)

Rat 6: Advanced slowly to the first "cross-roads," paused; went left to the second; again went left, and advanced a foot; then stopped. Was taken out.

Rat 4: Paused at first "cross-roads," went left; advanced to the second, and went right.

Rat 12: Stopped at first "cross-roads," then went left as far as the second; turned back to starting point.

Rat 22: Hesitated a long time before setting out from starting point. Stopped a long time at first "cross-roads," then went right. Went left at the second.

It is seen from the results that there were four rats that "radically" changed their course at the first bifurcation; and four at the second. (The third "cross-roads" is not considered, by reason of the fact that the grill was visible to the animals when they made a choice at that point.)

It seems to us that this behavior is not without some theoretical significance. What the full implication of these results might be, it would be hazardous to say at present; it certainly argues against a "kinesthetic chain" performance on the part of the rats. Changing from a right to a left turn and vice versa is a qualitative datum which implies more than a mere stoppage of a mechanical process. It would, perhaps, be justified even to say that it argues for the presence of a certain amount of "generalization" on the part of the rat.

CONCLUDING REMARKS AND DISCUSSION

It has been stated already that the above experiments are mere preliminaries. We have tried therefore to be as chary of interpretations as possible. Their purpose is frankly exploratory, and hence they do not present a nicely concatenated series. The very small number of animals used do not justify dogmatic inferences, but we feel that certain definite trends are indicated in these experiments which will bear investigation on

a more extensive scale. Likewise, certain suggestions appear to come out of them which will perhaps give us a better insight into the structure of the learning process.

Certain it is that the white rat does not need a point-to-point correspondence between an old and a new situation, in order to behave adequately in the new situation. It will probably be urged that, in the present series of experiments, in no case was a strictly "novel" situation presented to the animal. The proponent of the conditioned-reflex theory would argue that the rats had been conditioned, not to the whole path, but to the bifurcation; that is to say, whenever the animal was confronted with a wall running at right angles to his course, he had been taught to go to the right or to the left, as the case might be.

This is probably true in some sense. But the very fact that the rats were able to do this argues for a certain capacity for generalization on the part of the rat.[8] In other words, the rats learned that, regardless of direction, distance or the peculiar nature of the path traversed, they were to go to the right or left whenever they came to an alley running at right angles to the one being pursued.

It is very clear that at this point arises the problem concerning the nature of generalization, or the "concept." The problem is a peculiarly subtle one, and, as everyone knows has had a long history both in philosophy and psychology. Whether generalization is in substance a responding to a part of an old stimulus complex in a new setting (a matter of redintegration as Hollingworth would urge) or something fundamentally different, it is difficult to say in this connection. Certainly this problem must be solved before we can hope to understand thoroughly the learning process. The trend of thought, however, among a certain group of psychologists is away from the more atomistic notion that similarity is the mere possession of identical elements by two different complexes.

[8] We have used the term "generalization" advisedly throughout the present paper. A more conservative term undoubtedly would be "position habit." We feel, however, that this is too non-committal and contains within itself no theoretical implications.

Vitiating the argument that the rats were merely reacting to the "bifurcation" throughout the present series of experiments, is the evidence appearing in experiments III and IV in Series II.

In these two experiments, it will be remembered that the path leading to the choice was particularly long and tortuous,—although the rats could do nothing but go straight ahead. Here, as has already been reported, the rats frequently turned around and went back to the starting point long before they had reached the "cross-roads." If the conditioned-reflex argument were strictly true, this should not have happened. The rats should have "followed their noses" until they reached the alley running at right angles to the path they were pursuing. As a matter of fact, however, the rats would often turn around in the middle of a stretch, although quite a few, if not most, of the turnings occurred at corners.

There is, of course, the possibility of visual orientation in terms of nearness or remoteness from the homogeneous walls surrounding the maze. But this seems hardly possible in view of the fact that the animals dashed frantically to and fro in the tortuous path at a break-neck speed. However, a similar series of experiments will be reported later with blinded rats.

The fact of the animal's passing over a sufficient number of "kinesthetic units" just before reaching the "cross-roads," as a possible source of explanation, has been touched upon already. The answer is that there are no "kinesthetic units." By the time the animal arrived at the bifurcation he was approaching in the majority of cases in the strained and cautious manner which has been described,—with the consequence that the kinesthetic values must have been totally changed.

The results given in experiment III (Series III) further corroborate the contention that the matter is much more complex than is usually believed. In that experiment, the animals radically changed their course in the absence of any negatively conditioned stimuli. The two sides of the maze were perfectly symmetrical in every respect. Yet the animals must have possessed an "orientation" of some sort, otherwise they would not have turned.

The method used in this experiment, together with that employed in experiment I of the same Series, seem to us to have some possibilities. In the latter (experiment I), we allow the rat to form a fairly complex habit constituted of a number of "segments" (the word is used advisedly and merely for the sake of brevity); then the first "segment" in the series is changed, with the view of determining whether the remaining ones are in any way affected.

The first-mentioned method (experiment III, Series III), it seems to us, may be used to answer a number of questions; namely, the rôle of "general orientation" as it may enter into animal learning; the nature of "remote conditioning," et cetera. (We have planned to use blinded rats for later work in this connection.)

It may be well to point out, in conclusion, the close agreement between the present results and those reported recently by Muenzinger:[9] that the animal does not depend upon a definite set of stereotyped movements to accomplish its task. His work shows with the greatest possible clearness how futile it must be to "neurologize" in attempting to understand the phenomena of learning.

In attempting to be objective and scientific, we have become too mechanical,—using that word in the sense of the physicist. It would be just as sensible for the physicist to try to understand the behavior of gases and electric fields by studying the direction and velocity of each molecule of gas and the topographical characteristics of each tube of force as it is for the psychologist to try to understand learning through the notion of rigid connections. After all, every province of natural phenomena has a dignity of its own and must be approached and dealt with in its own terms.

Expressed in its most general form, the task of science is to determine the relation between phenomena and their conditions; but such conditions as lowered synaptic resistance, specific connections between distinct neural pathways, and the like, are hardly objects for direct observation at present. Consequently, attempts at explanation upon this basis must necessarily remain

[9] Muenzinger, Karl F. Plasticity and mechanization of the problem box habit in guinea pigs. Journal of Comparative Psychology, vol. viii.

gratuitous. It is, therefore, our hope in later experiments[10] to investigate systemmatically the *conditions* under which the phenomena of learning occur on the one hand and, on the other, to attempt on the basis of experimentation a description of the learning process itself in terms of objective categories such as space, time, energy, equilibrium, maxima and minima.

[10] We take advantage of the page proof to indicate that *all* the experiments reported in this paper have been repeated with over 50 rats, and the present results amply confirmed. These, together with some interesting variations of the above experiments will be reported in a later paper.