JOURNAL OF ANIMAL BEHAVIOR

VOL. 1.

JANUARY-FEBRUARY, 1911.

No. 1.

THE DISCRIMINATIVE ABILITY OF THE PAINTED TURTLE

D B CASTEEL

Contributions from the Zoological Laboratory of the University of Texas, No. 106

FOUR FIGURES

INTRODUCTION

In the experiments herein recounted an endeavor has been made to obtain an accurate measure of the ability of turtles of the species *Chrysemys marginata* to discriminate between lines of different width and direction and patterns of different form. The evidence for or against such discrimination has been obtained by establishing in the minds of the turtles associations between certain kinds of lines and patterns and certain pleasant or unpleasant experiences. The reward for successful choice was food; as punishment for failure the electric shock was used.

Experiments by various investigators upon a fairly large number of animals have shown that associations between light and darkness, black and white and intermediate shades may be established in a number of cases. In relatively few instances have such discriminative associations been established for patterns of different form.

To the systematic zoologist no phenomena in nature are more evident than the occurrence of those slight differences in shape and markings which separate species of the same genus and closely related genera. For the comparative psychologist the question must often arise, Are the higher animals capable of

visually appreciating these slight differences in form and marking? Are they capable of using them as signs of specific identity? Whether or not such visual discrimination, if it exists, is partly or entirely subordinate to ability to distinguish through the sense of smell, hearing or touch is another question.

If we attempt to analyse the method by which an animal is able visually to recognize familiar objects it may well be supposed that the impressions which it gains are either general or particular. As men recognize familiar forms and faces at a distance without definitely considering or perceiving the finer details of feature and expression, so animals by observing gross outlines and characteristic movements may draw conclusions as to the nature of the forms around them. Such generalized recognition of familiar objects may be considered, in part at least, to have resulted from an educational process. Its acquisition is the result of long association with the objects in question. Throughout this association an appreciation of certain finer distinctive differences, whether consciously or subconsciously manifest, has been a fundamental factor in producing in the animal mind a concrete appreciation of the object's identity in terms of the whole.

With the human mind such processes are of common occurrence. A stranger first met with is afterward recognized by the recollection of some peculiarity which has been impressed upon us. With further acquaintance we forget the peculiarity or it becomes subconscious, while recognition is based on the broader lines of general association. The systematic entomologist, by laborious examination of detailed structure, differentiates between closely related species of insects hitherto unknown to him. But if he specializes upon the group, his recognition of the various familiar species forming it in time becomes almost intuitive,—he knows them "by sight" without consciously analysing their differential markings.

In the realm of animal intelligence it might be difficult to prove directly that such generalized recognition of individuals and objects was the result of a gradual mental development in which discrimination by appreciation of detail gradually led to a more generalized appreciation of difference. It is possible, however, to subject the animal to tests which will indicate in how far it is able to make fine visual discriminations, and if

ability in this respect is evident, it may be concluded that such visual powers have played some part at least in bringing to the mind of the adult animal a realization of the nature of its more intimate surroundings. With the results of such an investigation this paper is chiefly concerned.

DESCRIPTION OF APPARATUS

The apparatus used in all tests is similar in nature to the electric-box apparatus of Yerkes¹ though somewhat modified to make it more adaptable to the habits of turtles. It is shown in relief in Fig. I and in ground plan with boxes removed in Fig. II. The large oblong box in which all of the other apparatus is placed (except some of the electrical connections) is of heavy galvanized sheet-iron, 78 cm. long, 38 cm. wide and with sides 16 cm. high. It is divided into three regions: an entrance room at one end, an insulated area at the other, on which the boxes stand, and a runway between. The entrance room can be shut off from the runway by dropping the slide operated by a string which runs behind the screen. The insulation plate upon which the electric and food boxes stand is of beeswax. It stands $4\frac{1}{2}$ cm. above the floor of the large galvanized box. The floor of the runway and entrance room is covered with clean, washed sand, which in the runway is banked up to form a gentle slope leading from the sand covered bottom to the level of the insulation. Water to a depth of 3 cm. covers the bottom of the entrance room and part of the runway. The shallow water and the sandy approach to the boxes are, of course, simply artificial environmental conditions used in an endeavor to simulate natural conditions.

The long metal electrode extending in front of the boxes is kept in electrical connection with the water by means of the wet sand which surrounds it. The two metal plates embedded in the insulation are connected with the switch which is in turn connected with the rheostat. The other pole of the rheostat is connected with the water. By means of the switch the current may be directed to either one of the insulated electrodes. This switch is located behind the screen which conceals the operator from observation. A small peep-hole through the

¹ Yerkes, R. M., *The Dancing Mouse*. New York: The Macmillan Company. 1907.

screen allows the operator to observe fully the actions of the animal without himself being seen or in any way influencing the animal's behavior. Upon each insulated electrode, well

FIG. 1—General view of apparatus.

toward the back, is fastened a piece of cork behind which meat may be placed. The cork is of such shape that it acts as a blind,

making it necessary for the turtle to crawl to the back of the electrode before the food is discovered.

FIG. II—Ground plan of apparatus with boxes removed, showing electrical connections.

The food and electric boxes are of tin, exactly similar in size and shape, their dimensions being, height 26 cm. width 18 cm., depth 17 cm. They are without bottoms, the lower

edges of their sides resting upon the insulation plate. The side toward the screen has an opening at the top sufficiently large for introducing the hand in baiting the box. The side toward the runway has an opening at the bottom sufficiently large to allow the turtle to enter easily. The boxes fit loosely in the end of the large oblong box and can readily be removed or interchanged by the operator. They are protected from the sides of the large box by cardboard insulation.

In a few of the earlier experiments the designs or shades used were painted on the boxes, but for several reasons this method proved unsatisfactory and was discontinued. The boxes most generally used are as exactly alike as it was possible to make them. Their distinctive character is given them by the attachment of pieces of cardboard which bear the desired designs. Upon each box are placed two of these boards. One completely covers the outer surface which faces the runway; the other covers the inner surface directly opposite the opening through which the turtle enters in search of food. This latter is immediately behind the cork blind which conceals the food and is intended to give continued emphasis to the design after the outer surface of the box has passed from view. These design boards are fastened to the boxes with small clips and can readily be removed. In practice it was customary to change them from one box to another during or between a set of trials to avoid the chance that the boxes themselves, through some unnoticed peculiarity of form or odor, might aid in influencing the choice.

During most of the experiments the electric current used was taken from a commercial circuit, being reduced to a proper degree by use of a rheostat. The severity of the shock used was varied considerably for different individual turtles. As a rule a shock of very slight degree, one not unpleasantly perceptible to the moistened fingers of the operator, was most effectual.

GENERAL METHODS AND CHARACTERISTIC REACTIONS

All of the turtles upon which observations were made were kept in an aquarium and tamed for from three to six months before experiments were undertaken. This is particularly necessary when dealing with a reptile. *Chrysemys* is probably one of the most tractable water turtles, yet some individuals never

become sufficiently docile to allow of satisfactory experimentation. Most of my turtles, however, finally became so tame that they could be handled gently without alarm and would take food readily, even while being held in the hand. A well conditioned *Chrysemys* is a voracious feeder and if not allowed to gorge unduly will be eager for a daily ration of food. It is an active turtle and when well tamed will swim or crawl rapidly to the edge of the aquarium in hope of food whenever anyone approaches. For these reasons it makes a fairly satisfactory experimental animal. Feeding can be used as a reward in the formation of associations and tests can be conducted with a fair degree of rapidity. These statements, however, apply only to turtles which are well tamed and in a satisfactory physiological state. No animal is more unsatisfactory or taxes the patience of the operator more severely than a disgruntled turtle, whether its sulkiness arises from fear or from physical disability.

In describing experiments the term "trial" is used to express one individual attempt to choose between electric and food box. A series of successive trials, usually ten in number and immediately following each other, is denominated a "test." As a rule one test per day was given and upon successive days. In certain cases they were given less often, particularly when a turtle's eagerness for food became lessened. As may be noted from the tables, twenty trials were sometimes given at a test. It was thought that a larger number of trials per day might give better results, but the records show no more than a proportionate acceleration in learning. In all cases an effort was made to subject the animal to tests and trials occurring with a fair degree of regularity.

In practice the turtle to be experimented upon was gently removed from the aquarium and placed in the entrance room. The operator then retired behind the screen having assured himself that the boxes were properly placed and baited and the electrical apparatus adjusted as desired. Food was always placed in both boxes so that its odor, if appreciated, might not serve as a clue. By pulling a string from behind the screen the slide was then raised between the entrance room and the runway and the turtle thus given opportunity to approach the boxes. This might occur immediately or be somewhat delayed

according to the inclination of the animal. If the turtle was eager for food it would usually swim rapidly into the runway, crawl up the sandy "bank," making choice the while of the box into which it would enter. If it entered the "right" box it received no repulse but continued on to the back of the box, found the meat hidden behind the cork blind, turned around, scrambled out of the box and down the bank into the water. Here it might stop to eat the meat or might continue on to the entrance room, in which case the slide was immediately dropped and the operator rearranged the boxes. If it remained in the runway while it was eating the meat or afterward, it was urged to enter the entrance room and the slide was dropped before another trial.

If the turtle chose the "wrong" box it received an electric shock at the entrance to the box immediately upon touching the electrode upon the floor of the box with its fore feet or snout, its hind feet being in contact with the long electrode in front of the boxes or with the wet sand. As a rule this caused it to jump backward though it might or might not retire to the water. If the turtle remained in the runway it was, as a rule, replaced in the entrance room and the slide dropped before another trial was given. However, at the beginning of its training, a turtle would at times be allowed to remain in the runway until it found the "right" box and obtained the food from it, though the trial was counted as "wrong" if it at any time approached the electric box sufficiently near to receive an electric shock.

It was considered that a turtle had learned any particular problem when it was able to make a perfect record of correct choices in three successive tests of ten trials each.

The relative position of food and electric boxes was changed with irregular sequence during each series of trials so that learning by an appreciation of regular alternation might be avoided. If no change of position was made between two trials the boxes were lifted and replaced that lack of noise might not give a clue.

Full records were kept during the progress of each experiment showing the relative positions of the boxes at each trial, the time consumed in making each choice, the success or failure of the trial and miscellaneous data regarding the actions of the individual throughout its experimental history. The descriptions of the experiments and the appended tables are summarized from these records.

The above account is a very general one. Many variations occurred in the behavior of turtles during the course of the experiments. Different turtles would differ greatly in the methods by which they seemed to attack the problem, and any individual turtle might vary its course of procedure greatly from time to time. Some of the more accomplished turtles would go through the apparatus with machine-like precision, going straight for a box when the slide was lifted and straight back again into the entrance room after getting their reward or electric shock. But such action was more characteristic of turtles that were nearing perfection in any particular experiment. Such automaticity probably resulted from several rather definite causes. The individual had become, through numerous trials, well accustomed to travel and retravel a beaten path. As a rule its mistakes were few and its mental poise was not continually disturbed by annoying shocks. The most tractable, possibly the most "intelligent" turtles, showed greatest regularity of behavior at this time. Seemingly nervous, erratic turtles, those which appeared never to become entirely tame, showed lack of automaticity. A direct return to the deeper water of the entrance room by a turtle that has succeeded in securing the bait is a natural action, since *Chrysemys* appears unable, or at least unwilling, to tear up and swallow its food unless its mouth is beneath the water.

Unfortunately for the patience of the operator many of the turtles, particularly during the earlier tests of an experiment, were prone to hesitate and wander around in both the entrance room and the runway. Or an individual might leave the entrance room and remain quietly in the runway before the boxes for some time, seemingly deliberating before making a choice. That this was not always mental deliberation upon the particular problem in hand the writer is fairly convinced, for the result of such hesitation was about as likely to be disaster as gain.

Turtles upon receiving the electric shock were diversely affected by it. After a few such experiences some were rendered so nervous and wild that their withdrawal from experimentation was necessary. Others were at first thus affected but gradually became accustomed to the experience or reacted favorably under lessened stimulus. Some were simply rendered

sulky and refused to approach the boxes at all or even to leave the entrance room. Some, after each shock, would dart back quickly, turn and scurry away from the box, but were apparently eager to try the experiment again. Others would withdraw slightly from the electrode and would soon after, if allowed, try the same box again or slowly move over to the other box. Any individual might exhibit during the course of an experiment one or several of the idiosyncrasies above noted.

But the most troublesome form of behavior from the standpoint of the operator was the development of a habit of right or left turning. This tendency of an animal always to go either to the right box or to the left, no matter how irregularly their relative positions were changed, might appear at any time during the course of its training. The habit might become firmly fixed or merely be transient; but if not quickly overcome usually put an end to that animal's usefulness for experimental purposes. As a rule such turtles soon became sulky, since they received a large number of shocks.

DESCRIPTION OF TURTLES

The turtles used in all of the experiments were the Western Painted Turtle, *Chrysemys marginata*. This familiar turtle is semi-aquatic in habit, spending much of its time in the water where it may be found crawling over the bottom in search of food, darting through the water in pursuit of more active prey, or floating idly on the surface with head and neck extended. Upon warm days the turtles often leave the water, crawling up the bank or upon protruding logs where they lie basking in the sun. A more extended account of their habits is given by Newman².

Except for certain lines and markings *Chrysemys* is not a conspicuous turtle. The carapace is dark olive-green in shade with somewhat lighter markings separating the scutes. The marginal scutes bear dark red and yellow blotches. The plastron is bright yellow. The ground color of the head, neck and legs is similar to that of the carapace, dark olive-green; but the sides of the head and neck are conspicuously striped with bright yellow and red markings, longitudinal in direction, the yellow

² Newman, H. H., The Habits of certain Tortoises, *Jour. Comp. Neur. and Psych.*, 1906, vol. 16, No. 2.

predominating. The appearance of these conspicuous lines first suggested to the writer the possibility that *Chrysemys marginata* might readily distinguish between differences in line markings since a linear design forms so prominent a feature in the decoration of this species.

All of the individuals used were collected around Ann Arbor, Michigan, where much of the work was done. Those shipped to Texas did not well undergo the hardships of the journey, nor have they since reacted as satisfactorily as before the trip. For this reason it has been necessary to discontinue the experiments somewhat earlier than had been planned, since their continuance with apparently abnormal animals would vitiate the results of the entire work.

Fifteen turtles were used during the course of the experiments but the records of only seven will be given. For various reasons the results obtained from work on the others do not justify publication. Some sickened and died before the completion of a series of tests; others became sulky, lost appetite, were sluggish or developed permanent habits of right or left turning. The following data refer to those directly mentioned in this paper:

TURTLE NUMBER	Length of Carapace	Width of Carapace.	Sex.
1 ..	62 mm.	54 mm.	Female.
4 . . .	106 mm.	82 mm	Female.
8	112 mm.	87 mm	Female.
9	92 mm.	80 mm	Female.
10	133 mm.	97 mm	Male.
11	98 mm	76 mm.	Female.
13	128 mm.	97 mm	Male.

RESULTS OF EXPERIMENTS

The experiments may be divided into three groups, each group being characterized by the nature of the test to which the animals were subjected. At the beginning of the work the writer desired to obtain some estimate of the ability of *Chrysemys* to form associations. For this purpose the Black and White Discrimination tests were tried, since similar experiments had been conducted by other workers with several other animals. The results of these tests do not bear so particularly upon the problem in hand but are here given for the sake of those who care to make comparisons. The other two groups, those show-

ing the results of tests for Pattern and for Line Discrimination, form the major portion of the work.

BLACK AND WHITE DISCRIMINATION

In these tests the boxes used were painted black and white respectively. Tests with turtles Nos. 1 and 2 were conducted without the use of the electric shock for punishment, food being the only incentive to success and forcible return to the entrance room without reward the only punishment. The apparatus used with these turtles was somewhat different from that already described, being less elaborate and, of course, lacking all electrical connections.

Turtle No. 1 was given, as a rule, ten trials in succession every other day. On several days the turtle was sluggish and a fewer number of trials necessary. In a few instances more than one day intervened, necessitated by the animal's lack of eagerness and activity. It was fed in the white box only. In this experiment no preference tests were taken. The results, given in table 1, show that an association between the white box and food was clearly established. The result of the tests for memory is also to be noted.

Turtle No. 11 was fed in the black box. It was induced to enter this box twelve times before the actual tests were begun. In all other respects it was treated in a manner similar to No. 1. Its record, given in table 2, shows but two perfect tests although the general average of successful trials is good. The two memory tests, taken twelve and twenty-one weeks after the last test of the series, are not perfect though as good as that test.

Turtles Nos. 8, 9, and 13 were tested with black and white boxes during the latter course of the work for the sake of obtaining additional evidence for or against this type of discrimination. Preference tests were made in all cases and the electric shock was used as punishment. Both No. 8 and No. 9 had, in a previous experiment for pattern discrimination, been accustomed to entering black boxes on which white patterns were displayed. Their decided preference for black may thus be explained. In both cases the food box was white so that the former preference had to be overcome. No memory tests were taken. The records of these turtles for black and white are found in tables 3 and 4.

Turtle No. 13 was decidedly the most unsatisfactory animal

TABLE 1

TURTLE NO. 1, BLACK AND WHITE
DISCRIMINATION*Fed in white box*

TEST.	RIGHT	WRONG
1	8	2
2	2	3
3	10	0
4	2	0
5	7	3
6	10	0
7	9	1
8	9	1
9	8	0
10	9	1
11	8	2
12	9	1
13	8	2
14	10	0
15	10	0
16	8	2
17	10	0
18	10	0
19	9	1
	<u>156</u>	<u>19</u>

Memory test after 6 weeks, 10 right,
0 wrong.

TABLE 3

TURTLE NO. 8, BLACK AND WHITE
DISCRIMINATION*Result of preference trials Black 34,
white 16. Fed in white box*

TEST	RIGHT	WRONG
1	4	6
2	3	7
3	4	6
4	8	2
5	7	3
6	7	3
7	5	5
8	10	0
9	10	0
10	8	2
11	9	1
12	10	0
13	10	0
14	10	0
	<u>105</u>	<u>35</u>

TABLE 2

TURTLE NO. 11, BLACK AND WHITE
DISCRIMINATION*Fed in black box*

TEST	RIGHT	WRONG
1	9	1
2	8	2
3	8	2
4	9	1
5	9	1
6	8	2
7	9	1
8	7	3
9	9	1
10	8	2
11	7	3
12	9	1
13	10	0
14	10	0
15	8	2
	<u>128</u>	<u>22</u>

Memory tests: After 12 weeks, 8
right, 2 wrong; after 21 weeks, the
same

TABLE 4

TURTLE NO. 9, BLACK AND WHITE
DISCRIMINATION*Result of preference trials Black 16,
white 4 Fed in white box*

TEST	RIGHT	WRONG
1	3	7
2	2	8
3	3	7
4	4	6
5	8	2
6	6	4
7	8	2
8	5	5
9	7	3
10	9	1
11	10	0
12	10	0
13	8	2
14	8	2
15	10	0
16	10	0
17	10	0
	<u>121</u>	<u>49</u>

TABLE 5
TURTLE NO. 13, BLACK AND WHITE
DISCRIMINATION

*Result of preference trials: Black 16,
white 24. Fed in black box*

TEST	RIGHT	WRONG
1	7	3
2	4	6
3.	3	7
4	6	4
5	5	5
6	3	7
7	6	4
8	5	5
9	6	4
10.	3	7
11.	4	6
12	6	4
13.	4	6
14	6	4
15	5	5
16	7	3
17	6	4
18.. . . .	7	3
19	6	4
20.. . . .	7	3
21.. . . .	6	4
22	4	6
<hr/>		<hr/>
116		104
<hr/>		<hr/>

used in any of the experiments described. It was a large, slowly moving, rather sulky animal, extremely difficult to tame and apparently in need of but little food. It early developed a habit of right turning, and at no time during its 220 trials showed consistent improvement. As compared with some others, notably No. 10, it illustrates well the marked difference in behavior which different turtles may show. Its record is given in table 5.

PATTERN DISCRIMINATION

As the sequel will show the above heading should rather read *lack* of pattern discrimination. The patterns used, reduced one-half in size, are shown in Fig. III. Their areas are equal. It may well be argued that the choice of patterns was unfortunate and that designs more markedly different should have been used. The history of but two turtles will be given here. Several others were tried but through seeming lack of ability

to profit by their experiences they received so large a number of shocks that they were rendered sulky and work with them had to be discontinued. In several cases, as shown in table 6, the white designs were placed on pendulums and caused to swing slowly back and forth in front of the black boxes in the hope that the moving object would attract and concentrate the attention of the animal. As far as could be observed the results were no more satisfactory. Preference tests were taken in all cases and the electric shock administered for failure. As is shown in tables 6 and 7 only negative results were obtained for discrimination between the two patterns used.

FIG. III—Designs used in experiments on Pattern Discrimination. Reduced one-half

TABLE 6
TURTLE NO. 8, PATTERN DISCRIMINATION
Result of preference trials: Pattern A, 19; pattern B, 21. Fed in pattern A box

TEST	RIGHT	WRONG
1	4	6
2	2	8
3	7	3
4	5	5
5	0	3
6	6	4
7	1	4
8	5	5
9	6	4
10	4	6
11	5	5
12	6	4
13	3	7

TEST.	RIGHT	WRONG
14	6	4
15	7	3
16	3	7
17	6	4

Swinging pattern introduced.

18	4	6
19	4	6
20	2	8
21	7	3
22	7	3
23	7	3
24	1	9
25	7	3
26	7	3
27	6	4
	<u>128</u>	<u>130</u>

TABLE 7
TURTLE NO. 9. PATTERN DISCRIMINATION
Result of preference trials: Pattern A, 19; pattern B, 31 Fed in pattern A box

TEST	RIGHT	WRONG
1	10	5
2	7	3
3	5	5
4	5	5
5	4	6
6	4	6
7	4	6
8	5	5
9	6	4
10	9	11
11	9	11
12	9	11
13	11	9
	<hr/> 88 <hr/>	<hr/> 87 <hr/>

LINE DISCRIMINATION

The most definite and satisfactory results were obtained in testing for this type of discrimination. The experiments may be divided into two groups:

- I. Discrimination between two lined boxes on which parallel lines of equal width run horizontally on one box, vertically on the other.
- II. Discrimination between two lined boxes on which the parallel lines run in the same direction on both boxes but are of different width.

In all cases the amount of black and white on the faces of the boxes was the same. Great care was taken that the faces of the boxes exhibiting the lines should show no other difference which might aid the turtle in making a choice. The electric shock was used for punishment and preference tests were taken in all cases.

GROUP I

Experiments in line discrimination under the conditions described for Group I were conducted as follows:

The boxes were faced with cardboards bearing parallel lines, black and white, each 8 mm. in width. On one of the boxes the lines ran vertically, on the other horizontally. Fig. I illustrates the apparatus arranged for this experiment. Preference tests were taken and the box showing the lesser number of

entrances was chosen as the food box. Discrimination was then established by a series of tests using difference in the direction of the parallel lines as the criterion of selection. If discrimination was satisfactorily established with the lines 8 mm. in width, the cardboards bearing these lines were then removed and boards bearing lines but 4 mm. wide were substituted on both boxes. If discrimination was fairly maintained after this reduction in the width of the lines they were then further re-

FIG. IV.—Graphic representation of the widths of lines used in the experiments on Line Discrimination. The sides of the boxes facing the runway were covered with lines of the widths shown.

duced to 2 mm. on both boxes. No lines narrower than 2 mm. were used in the Group I experiments. At each reduction the number of black and white lines on the faces of the boxes was doubled though the amount of black and white surface remained the same. Fig. IV illustrated graphically the various widths of lines used in the Line Discrimination experiments.

The histories of turtles Nos. 4 and 10 illustrate the results of the horizontal-vertical line experiments. No. 10 showed much greater speed in acquiring the association than No. 4. This latter turtle became sulky upon reduction in the width of the lines to 2 mm. No. 10 was in every way my most satisfactory animal. It learned the problem fairly rapidly, showed perfect memory for 8 mm. lines two weeks after learning them,

and was able to make distinction with a fair degree of accuracy when the lines were reduced to 2 mm. In the series of six tests (shown in table 8) with lines 4 mm. wide an average of 95 per cent of the trials were correct. When the lines were reduced to a width of 2 mm. on both boxes the first five tests resulted in 80 per cent of the trials being correct. With a continuance of 2 mm. line tests this percentage was lowered in five tests to an average of 68 per cent. It would thus appear that 2 mm. is about the limit of this turtle's discriminative ability for line markings running in different directions. Turtle No. 4 was long in learning the difference between the 8 mm line boxes. Its first five tests with 4 mm line boxes gave a record of 80 per cent correct choices, and this was raised to 90 per cent in the five succeeding tests. With reduction of lines to 2 mm. the average of successful trials dropped to 54 per cent when the sulky disposition of the animal brought the experiment to an end.

TABLE 8
TURTLE NO. 10. VERTICAL AND HORIZONTAL LINE DISCRIMINATION
*Result of preference trials Vertical 18,
horizontal 22. Fed in vertical*

<i>Lines 8mm wide</i>			<i>Lines 4mm. wide</i>		
TEST	RIGHT	WRONG	TEST	RIGHT	WRONG
1.	5	5	1.	10	0
2.	2	8	2.	9	1
3.	4	6	3.	9	1
4.	4	6	4.	10	0
5.	10	10	5.	9	1
6.	11	9	6.	10	0
7.	15	5			
8.	16	4		57	3
9.	18	2			
10.	9	1			
11.	10	0	<i>Lines 2mm. wide</i>		
12.	10	0	1.	10	0
13.	20	0	2.	6	4
	134	56	3.	8	2
			4.	9	1
			5.	7	3
<i>Memory test, two weeks</i>				46	10
	10	0			
			<i>Lines 2mm. wide (cont.)</i>		
			1.	6	4
			2.	8	2
			3.	4	6
			4.	8	2
			5.	8	2
				34	16

TABLE 9
TURTLE NO. 4, VERTICAL AND HORIZONTAL LINE DISCRIMINATION

*Result of preference trials: Vertical 43,
horizontal 57. Fed in vertical box*

<i>Lines 8mm wide.</i>			<i>Lines 4mm. wide</i>		
TEST	RIGHT	WRONG	TEST	RIGHT	WRONG
1.	1	9	1.	8	2
2.	1	9	2.	8	2
3.	2	8	3.	7	3
4.	4	6	4.	9	1
5.	5	5	5.	8	2
6.	5	5			
7.	5	5		40	10
8.	5	5			
9.	1	9			
10.	2	8			
11.	4	6	<i>Lines 4mm. wide (cont.)</i>		
12.	1	9	1.	9	1
13.	3	7	2.	9	1
14.	5	5	3.	9	1
15.	4	6	4.	9	1
16.	5	5	5.	9	1
17.	4	6			
18.	8	7		45	5
19.	8	2			
20.	6	4			
21.	10	0	<i>Lines 2mm. wide</i>		
22.	10	10	1.	5	5
23.	9	1	2.	8	2
24.	5	5	3.	6	4
25.	17	3	4.	3	7
26.	15	5	5.	5	5
27.	18	2			
28.	19	1		27	23
29.	19	1			
30.	9	1			
31.	7	3			
32.	17	3			
33.	16	4			
34.	9	1			
35.	10	0			
36.	10	0			
37.	10	0			
	289	166			

GROUP II

While the results of the foregoing experiments indicate that turtles can learn to discriminate between two series of lines running in different directions, even though these lines are reduced in width to but 2 mm., they do not necessarily show that the turtles are able to discriminate between individual

lines of that width. Since in the previous experiments all of the parallel lines on one box ran vertically and all on the other horizontally, appreciation of difference might simply mean that the turtle discriminated between the general direction taken by the whole series of lines, and would be able to do this until the lines were so reduced in width that only gray surfaces were discerned. The results thus far given are of themselves interesting in that they indicate the ability of these turtles to appreciate the difference between fairly narrow line markings which run in different directions; but they do not serve as an accurate measure of the turtle's ability to distinguish between lines of different width, nor do they give us an exact idea of the extent of the animal's ability to distinguish relative widths of different lines.

So it seemed desirable to conduct another series of experiments in which the lines on the faces and backs of the boxes all ran in the same direction, either vertically or horizontally, but differed in width on the two boxes.

In these tests the turtle was first given choice between two boxes, one of which bore lines 8 mm. wide and the other lines much narrower (1 mm. in one experiment, 2 mm. in the two others described). The records of turtles Nos. 10, 8 and 11 will be presented. Upon both of the boxes used in tests with No. 10 the parallel lines ran vertically; upon those used with Nos. 8 and 11 they ran horizontally. Unfortunately, after establishing discrimination between 8 mm. and 2 mm. lines with turtles No. 8 and No. 11, it was necessary to discontinue the tests. Their records are found in tables 11 and 12.

Turtle No. 10 was carried much farther. It is possible that the former experiences with line boxes which this turtle underwent may, to some extent, have so familiarized it with a similar problem that its performance with these boxes would average better than the rule. No. 10 was started with boxes bearing lines 8 mm. and 1 mm. in width respectively. When this combination was learned the 8 mm. box was refaced with boards bearing lines 4 mm. wide. The choice then lay between a box faced with 1 mm. lines and one faced with 4 mm. lines. The 1 mm. lines had indicated the electric box in the preceding tests and were so retained, while the 4 mm. lines replaced the 8 mm. width on the food box. In fifty trials with these lines 96 per

cent of the entrances were correct. The box with 1 mm. lines was then faced with boards bearing 2 mm. lines and a grade of 94 per cent correct was made in fifty trials. In this series the 4 mm. lines still indicated the food box while 2 mm. lines marked the electric box. The 4 mm. lines were next exchanged for a series 3 mm. wide, so that the problem before the turtle was to choose between two boxes bearing lines on their faces which differed but 1 mm. in width. The 3 mm. lines were on the food box, the 2 mm. on the electric box. The first fifty trials of this combination resulted in 82 per cent of the choices being correct and the next fifty trials of the same problem resulted in a grade of 92 per cent correct.

As will be noticed, the changes of line width were alternated

TABLE 10
TURTLE No. 10, DISCRIMINATION
BETWEEN LINES OF DIFFERENT WIDTH

Lines 8, 4 and 3mm. were on the food box All lines vertical

<i>Lines 8mm. and 1mm. wide</i>			<i>Lines 4mm. and 2mm. wide</i>		
TEST	RIGHT	WRONG	TEST	RIGHT	WRONG
1..	2	8	1	8	2
2..	3	7	2	9	1
3	6	4	3	10	0
4..	9	11	4	10	0
5	9	11	5	10	0
6	12	8			
7	16	4		47	3
8	18	2			
9	10	0			
10.	9	1	<i>Lines 3mm. and 2mm. wide</i>		
11	8	2	1..	6	4
12....	9	1	2	9	1
13..	10	0	3	8	2
14....	10	0	4	9	1
15	10	0	5	9	1
	141	59		41	9
<i>Lines 4mm. and 1mm. wide</i>			<i>Lines 3mm. and 2mm. wide</i>		
1	8	2	1	10	0
2	10	0	2	9	1
3	10	0	3..	10	0
4	10	0	4	9	1
5	10	0	5	8	2
	48	2		46	4

from food to electric box so that the turtle always had one box similar to one in a previous series of tests. This arrangement doubtless aided the turtle in maintaining a high average of correct selections. The tests were carried no farther than the 2 mm.-3 mm. combination since it was felt that these lines were sufficiently similar in width to indicate a high degree of discriminative ability. The tabulated results of No. 10's tests are found in table 10

TABLE 11

TURTLE NO. 8, DISCRIMINATION
BETWEEN LINES OF DIFFERENT WIDTH

*Lines on both boxes horizontal 8mm.
lines on food box*

<i>Lines 8mm. and 2mm. wide</i>		
TEST	RIGHT	WRONG
1 . .	5	5
2 . .	7	3
3 . .	6	4
4	3	7
5	8	2
6	6	4
7	7	3
8	7	3
9	8	2
10	14	6
11	6	4
12	9	1
13	5	5
14	8	2
15	7	3
16	9	1
17	9	1
18	10	0
19	10	0
20	10	0
154		56

TABLE 12

TURTLE NO. 11, DISCRIMINATION
BETWEEN LINES OF DIFFERENT WIDTH

*All lines horizontal. 2mm. lines on
food box*

<i>Lines 8mm. and 2mm</i>		
TEST	RIGHT	WRONG
1	6	4
2	5	5
3	4	6
4	5	5
5	9	1
6	8	2
7	8	2
8	6	4
9	8	2
10	7	3
11	6	4
12	10	0
13	7	3
14	7	3
15	9	1
16	10	0
17	10	0
18	10	0
135		45

INCIDENTAL RESULTS

As an aftermath to work on any problem in animal behavior, whether under natural surroundings or experimental control, there may always be gathered certain facts and conclusions not primarily sought in the investigation, yet often bearing important relations to it or yielding interesting data of a more general character. Such results will now be noted.

Individuality. My turtles exhibited distinct individual differences

in their mode of behavior under experimental conditions. A few of these have already been noted. Some turtles failed partially or completely to solve problems which others acquired with little seeming difficulty. Such cases of individual failure to learn appear to have been dependent upon two factors: individual lack of mental ability or lack of tractability. It is common knowledge that an animal with a surly disposition cannot be taught tricks. Any turtle that refuses food, retires within its shell upon slight provocation and shows a pronounced disposition to sulk is useless as an experimental animal. Almost any wild adult turtle will act in this manner when first handled but with proper care should gradually become more tractable. However, some of my turtles never became accustomed to captivity and these were finally discarded. Others would respond most satisfactorily for a time and then gradually or suddenly lose interest or become sulky. Such turtles might or might not change in disposition and be useful for later experiments. Without doubt turtles also differ greatly in mental ability. Some appeared willing enough to learn, were cheerful and active, yet did not succeed in learning as rapidly as others.

The persistence of individual characteristic movements. In addition to individual mental characteristics of a general nature some of the turtles showed certain definite peculiarities which were expressed by distinctive movements and reactions. No. 10 almost invariably stopped upon entering the food box and insisted on biting the cork behind which the meat was placed. This was the one persistent "stupid" action of this turtle throughout its experimental history. Occasionally it would simply stop before the cork and crane its neck around the blind until the food came into view. Then it would either advance and proceed to take the food or would bite the cork again before doing so. It seemed continually to labor under the delusion that the reward might most easily be obtained by tearing away the intervening obstruction; at least such an explanation presents itself as a plausible human interpretation of this habit. No other turtle acted in the same way.

Directness or indirectness of approach and entrance into the boxes varied in different cases. As has before been intimated, physical quickness was not necessarily associated with mental alertness or deliberate movements with dullness. Neither was the converse true. The most active turtles were just as likely to choose unwisely as the deliberate ones, and vice versa. But this quality of agility of movement or its reverse usually mani-

fested itself throughout a turtle's performances and was characteristic of the animal. There were a few exceptions to this general rule, cases of sulkiness or sluggishness resulting from ill health or too frequent punishment.

The tendency toward right or left turning was of frequent occurrence during the course of the experiments. Some turtles never acquired it, others for a short time only, but in most cases when it once became established its permanency was assured. The writer has no explanation to offer for the initial cause of such a habit, but merely suggests that once such a tendency is well started its continuance is assured by the potency of kinaesthetic sensation and association. Yerkes³ long ago showed the facility with which land tortoises learn the windings of a simple maze, and in some early experiments with *Chrysemys* I obtained results which indicate that this water turtle learns such problems with comparative ease. As Watson⁴ has shown for the rat, the ability of an animal to learn a maze is largely dependent upon the kinaesthetic sense,—it is a matter of muscular appreciation of distance and direction. Once it is established all other senses are subordinate to it. In the same way it may be supposed that once a tendency toward turning in the direction of a right or left box is (for some unknown reason) established, it will tend to persist even though other senses warn against such procedure.

Mental instability. The mind of the turtle is erratic. A glance over the tables will show instances of pronounced failure closely following successful tests. One day the turtle will be near perfection and upon the next will record a series of failures. Such lapses may occur well toward the end of a series of tests otherwise excellent. I am convinced that these seasons of forgetfulness would continue to occur at irregular intervals no matter how long the training of the animal was continued. With any animal whose mental capabilities are no more highly developed than those of the turtle it is scarcely to be expected that attention to the problem at hand will always be alert or that memory will always serve as a reliable guide.

Influence of former experiences. Much has been written of recent years regarding the influence of past experiences upon animal behavior, and of the necessity of a thorough acquaintance with the past histories of animals subject to experiment. One

³ Yerkes, R. M., *The Formation of Habits in the Turtle*, *Pop. Sci. Mo.*, 1901, vol. 58, p. 519.

⁴ Watson, J. B., *Kinaesthetic and Organic Sensations: their rôle in the reactions of the white rat to the maze*. *Psych. Rev. Monograph Supp.*, 1907, vol. 8, No. 2.

section of the present work illustrates definitely the effect of such experience upon the animals concerned. This is found in the pronounced preference of turtles Nos 8 and 9 for black boxes as the result of having participated in a former experiment in which the boxes were painted black to emphasize a white pattern. Had this former experience not been known, and had the turtles in the black-white tests been fed in black boxes without preference tests, the results would probably have given an erroneous idea of these turtles' mental ability. This is, of course, a rather special case, but it serves as a reminder that in dealing with such illusive qualities as mental characteristics the utmost caution must be taken if errors of judgment are to be avoided. On these grounds the results obtained with Nos. 1 and 11 in the black-white tests and also their memory tests are open to question since no preference tests were here taken.

In discussing No. 10's record for discrimination between lines of different width it was suggested that the relative ease with which it discriminated between lines 2 mm. and 4 mm., and 2 mm. and 3 mm. in width might partly be explained by the fact that immediately before these tests it had passed through a large number of tests of a somewhat similar nature; in other words, that its former experience had to a certain extent prepared its mind to appreciate the latter problem. This is merely a suggestion and no definite claims are made that the animal's mind was more acutely receptive through having previously solved somewhat similar problems. There is far from being sufficient evidence upon which to base statements of this turtle's ability to profit by such educational processes.

The relation of time to successful trials My work with *Chrysemys* shows conclusively that for this animal any calculation of mental ability based upon the time taken by the turtle on its trips from entrance room to food or electric box can give no accurate measure of its progress in learning. This is particularly true if several individuals are classed together and compared, and it also applies to a comparison of the performances of any one individual if compared at different periods during the progress of an experiment. Not only do different individuals vary greatly in the speed with which they traverse the runway and make choice of the boxes, but any individual's speed may

vary enormously, often independently of the failure or success of its choices. It is true that first attempts are usually deliberate and that unsuccessful turtles may be rendered inert through continued punishment, but aside from these considerations the above statement is correct. Without attempting to make too detailed a classification, it may be said that some of the following factors determine the time consumed by a turtle in making its trips from entrance room to box:

- (1) temperament of the individual, which would remain fairly constant but would differ greatly if different individuals were compared;
- (2) physiological state, varying for the individual during a series of tests and dependent on general health, unavoidable fluctuations in temperature and amount of food taken, though efforts were made to equalize feedings;
- (3) temporary mental state, varying for the individual during a series of tests, as sulkiness and inertness caused by an unfavorable physiological state or by undue sensitiveness to punishment.

For the above reasons the time records are deemed of little value and are not given in the published tables though they were taken in all the experiments.

SUMMARY AND CONCLUSIONS

Turtles of the species *Chrysemys marginata* were tested for their ability to discriminate between, (a) black and white; (b) two patterns of different shape; (c) two series of parallel lines of equal width but running in different directions; (d) two series of parallel lines of different width running in the same direction.

Associations were established by the use of food and electric boxes except in two experiments where the electric shock was not used as punishment for failure. The apparatus employed was similar in construction to the electric-box apparatus of Yerkes, though considerably modified for adaptation to the habits of turtles.

Negative results only were obtained in the experiments for pattern discrimination. It is felt that these results are not

conclusive, since the patterns used are somewhat alike in general symmetry

In the black-white tests discrimination was established with four turtles, while one other turtle failed to show improvement in 220 trials.

Two turtles learned to discriminate between two series of parallel lines 8 mm. wide, one vertical and the other horizontal in direction, and showed a fair degree of discrimination when these lines were reduced to 4 mm. in width. One of these turtles did well with a further reduction of the lines to a width of 2 mm. on each box

Two turtles learned to discriminate between two series of parallel horizontal lines 8 mm and 2 mm in width respectively. One turtle learned first to discriminate between two series of parallel vertical lines 8 mm and 1 mm. wide, next between lines 4 mm and 1 mm wide, then between lines 4 mm. and 2 mm. wide, and finally showed an excellent average of discrimination between lines 3 mm and 2 mm. in width.

Chrysemys does not learn rapidly. An average taken of all the experiments shows that about 183 trials were necessary to establish discrimination. If one experiment is omitted in which 455 trials were given, the average is reduced to 154 trials. In these calculations the three final perfect tests are not counted, neither are tests with reduced lines considered, only those line experiments being taken in which discrimination was first being established.

Two of the memory tests are surprisingly good but are subject to question, no preference tests having been taken. The third, showing perfect memory two weeks after the vertical-horizontal line tests is unquestionably accurate. These results indicate a fair degree of retentiveness.

The amount of evidence at hand does not justify general conclusions regarding the relative intelligence of turtles of different age or different sex

The turtles studied exhibited marked individual differences in disposition and in mental ability.

More particularly from the results of the line experiments it may be concluded that *Chrysemys* is able to appreciate differences in the direction of line markings even though the lines be narrow, and differences in the width of lines even though these

be slight in amount. These results suggest that the discriminative faculty thus shown may have been an important factor in the development of the mind of the growing turtle and that in the common activities of its daily life the individual's behavior may often be determined by its ability to appreciate differences of direction, though but lightly marked, and to distinguish accurately between slight differences of extent.