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The Journal of
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VOLUME XVII MAY, 1907 NUMBER 3

# CONCERNING THE INTELLIGENCE OF RACCOONS.

BY

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(*Professor of Psychology, University of Oklahoma.*)

WITH TWO FIGURES.

CONTENTS.



## INTRODUCTION.

This paper is a report of experiments which were made with the raccoon, Procyon lotor, to determine what type of associations it is able to form, the complexity and permanency of its associations, and to ascertain whether mental images and a tendency to imitate are present in this animal. The paper as originally planned contained also observations on the senses, instincts and habits of raccoons, together with comparisons of their behavior with that of other mammals under similar experimental conditions. These observations, as well as most of the tables on "Learning to release fastenings," have necessarily been omitted from this article. I am greatly indebted to Dr. R. M. YERKES for valuable criticisms of the experimental results and for many suggestions for the preparation of this paper.

In all I have had six young raccoons under observation, four males and two females. The descriptions refer in the main to the four individuals which were received July 3, 1905. With these individuals experiments were made twice each day during

the remainder of the summer and almost daily from September to the following May. Subsequently, series of new experiments and repetitions of old ones were given at irregular intervals. During each series of experiments, however, the successive tests were made on consecutive days, so that the conditions of hunger and fatigue might be as nearly uniform as possible. The four raccoons must have been, at the time I secured them, about eight weeks old. Comparisons with the other two, Nos. 5 and 6, whose age I definitely knew, make the above estimate fairly accurate.

The four raccoons are designated by the numbers 1, 2, 3, and 4 respectively. The reader should remember that No. 4 alone is a female. When no ambiguity results, I shall use the word "animals" as a synonym for the word raccoons, or, in other connections, for the expression "dogs and cats." This usage, however, does not imply the opinion that different mammals are alike psychologically.

It was my purpose to use tests so similar to those already used in the case of other animals that I might learn by comparisons the place of the raccoon in the scale of mammalian intelligence. This purpose was rather strictly adhered to except in the experiments to test visual discrimination and the presence of visual images. I am not aware that the card-showing device and my method of using it have been employed by other investigators.

## LEARNING TO RELEASE FASTENINGS.

The method employed in the experiments with fastenings was that used in the laboratory by THORNDIKE[1] in his study of cats and dogs. The peculiar facility of the raccoon in the use of his forepaws and his tendency to investigate objects by touch suggested at once that he might learn readily to operate simple fastenings.

Before proceeding to a description of the fastenings used, and the tabulated records, I may say that I do not believe that my raccoons can fairly be called "victims" of experimental conditions. As long as they continued to suckle, or until August 30, 1905, they were fed from a bottle twice each day until fully satisfied. During August, bits of apple, lumps of sugar and water were added to their

[1] THORNDIKE, E. L. Animal Intelligence. *Psychological Review Monogr. Suppl.*, vol. 2, no. 4. 1898.

bill of fare. From August 30 to the present time the animals have been fully fed and given fresh water once each day. They had to work hard for their food and it is possible that their growth may have been retarded slightly, but I think that this was not the case, for a table of their weights during the period shows a fair increase with age. The year-old raccoons apparently are not quite full grown. The animals have been kept in a room 14 by 10 feet, in which they could climb about on several rolls of poultry wire which were hung on the walls. They had there a nest of hay. Two windows, in which they frequently sat, were open in summer. They could climb about, and they were frequently let out to follow me over an open field, climb nearby trees, or play about the house. *Since their eighth week they had never experienced any other environment.* No one of the four ever showed a tendency to pace up and down in the windows barred (?) with poultry wire. Raccoon No. 6, however, did this by the hour, and if chained by the neck he would continue to pace to and fro at the end of his tether. This is often observed in captive raccoons. That no restlessness ever appeared in the four would seem to be evidence of their general contentment and of nearly normal conditions in their unusual environment.

The animals worked well and, although they possibly might have formed certain associations more rapidly under the stimulus of what THORNDIKE calls "utter hunger," I believe that my results indicate approximately their normal rate of learning. The cases of slow work, due to approaching satiety, were noted and valued accordingly. Readers of the tables will note that the loss of time due to fatigue or satiety is small in many cases, for the animals often work merely for the sake of working, or, more probably, playing. Too great hunger results in much eagerness to secure food and this seems invariably to prolong the time of escape from the experiment box. This is to be observed in the case of the first trial each day for each animal.

*Description of Fastenings.*—In the following descriptions the dimensions of the boxes are given in inches; length, breadth and height being stated in order. The doors varied much in size and in their position in the front of the box. Some were high in the front, others low; some were in the middle from right to left, others at one side. Since none of these variations delayed the animal's attack on the fastenings, I soon ceased attempting to construct

uniform doors. Some doors were hinged at the bottom, others at the right or left side. This variation also seemed to have little effect on the animal's work, for, after experience in one or two boxes, he seems to attack fastenings rather than doors, unless as happened once, shaking the door would release it. In that case, the door was attacked in about one-half the total number of trials.

My difficulty with single or double fastenings was not in making one sufficiently easy for the raccoon to operate, but rather in making one difficult enough.

Box 1. 20″ x 10″ x 13″. This box had a door in front, hinged at the right (looking outward), and fastened by a button at the left. The door opened outward the instant the button was turned to a vertical position. This box had solid sides and back but the front was made of upright slats 1¼ inches apart. This fastening is very similar to KINNAMAN's[2] A 1, and it corresponds to THORNDIKE's Box C, save that the door did not drop inward. Had the raccoon's forepaw been bruised or even rapped sharply by the falling door he would have hesitated to open it again.

Box 2. 14″ x 13″ x 26″. This box had a door in the front six inches from the bottom. It swung outward, was hinged at the right and fastened by a vertical bolt at the top. To this bolt was fastened a cord which passed over a pulley, then down through the top of the box and ended in a loop which hung near the side of the door. Pulling down on the loop raised the bolt and allowed the door to swing open. This box, which we may call "Loop at front," is comparable with THORNDIKE's Box A, "O at front."

Box 3. 26″ x 14″ x 14″, had entirely closed sides with the exception of the front, which was made of vertical slats about one inch apart. On a level with the floor of the box and in the middle from right to left was a front door. This door was hinged at the left and fastened at the right by a horizontal bolt, to which was attached a string which ran in a horizontal position parallel with the front of the box but outside it. The door could be opened by reaching through between the upright slats and clawing the cord which was attached to the bolt. A loose piece on top of the box enabled the experimenter to put the raccoon through the top and then to close the opening by replacing the piece. This is designated in the tables as "1st put-through box," because of the kind of learning it was designed to test. I have compared it with THORNDIKE's Box E, "String outside."

Box 4. 14″ x 13″ x 26″, "Loop at back." This was similar to Box 2, "Loop at front," with the addition of a second pulley at the back of the top of the box. The cord passed over both pulleys so that the terminal loop hung in the back of the box. The door was six inches above the floor of the cage. This box is comparable with THORNDIKE's Box B, "O at back," save that the string could not be clawed where it passed along the top of the box. The only way to open the door, therefore, was to pull downward on the loop.

Box 5. 14″ x 13″ x 26″, "2d put-through box," two fastenings. This was Box 2 with a button added. To open the door it was necessary both to pull the loop and turn the button. Either might be done first. A door was also added at the side of the box through which the experimenter could push the animal into the cage or through which the raccoon could walk into the box. This side-door extended down to the floor. Two raccoons, No. 4 and No. 3, were put through the acts necessary to open the door, the other two were not put through. I have compared this with THORNDIKE's Box J, "double."

Box 6. 14″ x 13″ x 26″, two fastenings, was Box 5 except that the loop was now hung in the center. This change was made to test whether the raccoons "would claw at the place where the loop had been," whether this arrangement would change the order in which acts were performed, and whether they would associate this loop with the loop in the other position.

Box 7. 32″ x 20″ x 20″, two fastenings. Both the sides and the top of this box were made of slats so as to admit light. The door in the middle of the front, hinged at the bottom, swung, or rather fell, outward when the fastenings were released. The latter consisted of a button at the right of the door and a bolt at the top operated by a loop in the back part of the box. The raccoons went into the box through a door opposite the front door. This box was much larger than the preceding ones so that the

[2]KINNAMAN, A. J. Mental Life of Two Macacus rhesus Monkeys in Captivity. *American Journal Psychology*, vol. 13, pp. 98-148, 173-218. 1902.

relative positions of loop and button were changed. The object was to see whether these changed positions would delay escape or whether the fastenings would be at once attacked as if recognized in the new positions. This box also has been compared with THORNDIKE's Box J, "double."

Box 8. 32″ x 20″ x 20″, three fastenings. This was Box 7 with an added loop. Thus we had loop 1 at the left side of the back part of the box, loop 2 at the right side of the back, and button 1 at the right side of the door. I have compared this with THORNDIKE's Box L, which consisted of "A (O at front), D (string), I (lever)." It is also comparable with KINNAMAN's F 31.

Box 9. Four fastenings. This was Box 8 with an added button at the left side of the door, "button 2."

Box 10. 26″ x 13″ x 14″. The ends and back of this box were entirely closed. The top and front were closed with slats only. In the middle of the front was a door hinged at the left. The door was fastened with a thumb-latch which could be released with slight pressure. The bar of the thumb latch would fall back in place unless the door was pushed out a little. This is comparable with THORNDIKE's Box G, "Thumb-latch."

Box 11. Five fastenings. This was Box 9 plus the thumb-latch which had been learned singly. There were, therefore, 2 buttons, 2 pulleys, and 1 latch. The latter had to be operated last lest its bar fall back into the catch.

Box 12. Six fastenings. A third bolt was added to Box 11 but the cord from it extended to a treadle or platform which extended across the right end of the box. Depressing the raised end of this treadle released the bolt.

Box 13. Seven fastenings. This was Box 12 with the addition of a horizontal hook at the left side of the door. For convenience I used the following notation in recording: 1 = button 1, 2 = button 2, 1′ = loop 1, 2′ = loop 2, 5 = thumb-latch, 6 = treadle, 7 = hook.

Box 14. Hook. 26″ x 13″ x 14″. A door hinged at the right and fastened with a horizontal hook was placed in the middle of the front. The animals were put into the box through a door in the back. I have compared this with KINNAMAN's Box 12, "Horizontal hook."

Box 15. 50″ x 20″ x 20″, one fastening. Imitation. This box was divided into two equal compartments. A door at the back admitted an animal to either compartment and a door in the partiton allowed me to change a raccoon from one compartment to another. The right compartment only had a door in front, which was fastened by means of an old-fashioned barn-door latch. This consisted of a wooden bolt which might be pushed to and fro from either side of the door by means of a pin which passed through the bolt and through the door. Pushing the bolt to the right unfastened the door and it could then be pushed open. The plan was to place a raccoon in the closed compartment and let him see another open the door and get out. After this had been done many times the observer was to be let into the other compartment in order that I might observe whether he had learned by seeing the other open the door. All sides and the partition were made of poultry wire so that I might count only those times the imitator apparently saw the act performed and so that he could readily see the performance.

Box 16. Imitation. This was Box 15 plus a second latch placed below the first one. This was a difficult box to open because pushing either latch to the left fastened the door. In the early trials of course the animals pushed the latches first to one side, then to the other.

Box 17. 10″ x 10″ x 4″. Imitation. This box had solidly closed sides. A three inch square was sawed out of the top and replaced to close the opening. Round holes at the corners of this square enabled the raccoon to claw it out and he could then reach into the box and get food. The animals secured food by getting *into* this box, instead of getting out of it.

Box 18. 36″ x 24″ x 14″. Varying means to an end. An opening was made in the center of the top large enough for the raccoon to go in and get food. This opening could be closed and fastened. The box, which had no bottom, rested on a foundation of a single row of bricks. Removing a brick enabled the animal to crawl through the foundation. The object was to see whether the animal would change *promptly* from one opening to the other when the opening through which he had been going was closed. If so, perhaps there was some notion of apple-in-box instead of the imageless coupling of a fixed set of muscular movements with a fixed sense impression of the box.

Box 19. 21″ x 18¾″ x 20″, two fastenings. A door in the middle of the front, hinged at the bottom, was fastened by a bolt at the top, operated by a loop inside the cage. It was also fastened by a stick leaning against it from the outside. In addition it had to be pushed open. This is the same as THORNDIKE's Box J.

Box 20. 21″ x 18¾″ x 20″, one fastening. Same as Box 19 except that the bolt was removed. Thus the door was fastened only by a stick leaning against it from the outside.

Box 21. 20½″ x 11″ x 11½″, three fastenings. This box had a door in the middle of the front, hinged at the bottom and fastened by a lever at each side and also by a wooden plug which was thrust obliquely

into a hole in the door frame. The box had entirely closed sides. The raccoons were taught to go into this box to get food. At first both levers had to be pushed up but later they were arranged so that considerable force would push them downward. The plug was very difficult to draw. I have compared this with THORNDIKE's Box K.

*Observations on Reactions to Fastenings.*—The raccoons learned very readily to perform a certain act in a particular situation. This learning is doubtless of the trial and error type, yet when a latch has been operated a few times there is probably present in the animal's mind a distinct memory image of the act, including a memory of its difficulty. Experiments with colored cards, to be described later, gave evidence in support of this opinion. At first I supposed that, as was true in THORNDIKE's work with cats, the raccoons would be found to learn chiefly from the stimulus of hunger. As already stated, however, they soon showed a tendency to unfasten latches and set themselves free from the mere pleasure of performing the act. This motive was not strong enough to overcome the discouraging difficulties of a box of six or seven fastenings, but the tables show so-called "play trials" for all boxes of fewer fastenings. The term "play trials" means, then, that though the animal unfastened the latches and escaped from the box, he refused to eat or drink milk on coming out or at best merely tasted the milk and turned away from it. Generally this work was deliberately done, but often rapidly. It seemed, therefore, that this tendency to be occupied was the motive for some of the raccoon's normal learning and careful records were kept of all play trials. In Table I, I have indicated the cases that were certainly play trials with italics, but the cases which were certain to the observer were fewer than the actual number, for as the raccoon's hunger was gradually allayed he worked partly for the mere pleasure of doing the work and partly from hunger. This is shown in the longer times taken to escape toward the close of each day's work. When the animal showed any eagerness for food, the reaction was recorded as a hunger trial even though play trials had preceded it. The tables show that this was unusual, the rule being that play trials began only when hunger began to be satisfied. Even when using the most complicated fastenings I did not employ "utter hunger." I usually gave the raccoons considerable food after I had finished the day's experiments. In several trials with the raccoons, when they were young, I was able to get one to work, which otherwise would not do so, by bringing

another near the door of the cage. As they grew older this was of no use.

Under ordinary experimental conditions the motives from which a raccoon learns are, therefore, hunger, an apparent desire to be occupied, called by several writers curiosity, and in the young, loneliness.[3]

One may ask, were not the play trials actuated by a desire to escape from the narrow confines of the box? I cannot say so with certainty, for all four raccoons would go into a box willingly enough unless it took prolonged work to escape. In that case it was difficult even to put them in, and they developed a tendency to snap at the experimenter's hand before he could withdraw it from the box. Evidently the memory of previous hard work to escape was the cause of this resistance, for with easy fastenings the animal would re-enter the box time after time and then deliberately work the latches as a part of an aimless activity which included toying with loose objects, reaching out with the forepaws through the slats or trying to pull dust or straws into the cage. A change of food from meat to sugar at this moment would often stimulate the animal to escape instantly. Without some such stimulus as this the animal might not come out of the box when the door swung open or it might come out very slowly. Reluctance to re-enter a box being in direct proportion to the difficulty of its fastenings, I can but believe that the raccoons felt no sense of confinement in a box which they knew how to open very quickly. At any rate their behavior toward re-entering easy boxes was the *exact reverse of that toward re-entering difficult ones.*

The conditions which prevented quick working of the mechanisms and consequently delayed the forming of an association were too great eagerness due to hunger, approaching satiety and distraction of attention.

(1) *Eagerness.*—In most cases the first attempt each day, or each half-day, required more time than succeeding attempts even though the animal had operated the mechanism quickly many times before. The eagerness seemed in most cases to amount to great excitement. In the first trial the animal seemed to fall back on primitive impulses. It made many ineffective movements. In the second trial each day it seemed to depend on memory, and often made but one movement for each latch.

[3] I do not mention the motives of pain, danger, etc., as they were not employed in this study.

(2) *Approaching satiety* usually, but not always, inhibited quick work. The animals seemed to form associations more rapidly when their work was deliberate.

(3) *Distraction of attention* inhibited all work. The animals never seemed to work a latch as a *purely* reflex performance. Consequently, I never could get them to claw where a loop had been or when the door was open, as THORNDIKE's cats did. The nearest approach to this occurred with Box 3. This box had its fastening at the right of the door (looking outward), while Box 1 had a button at the left and the loop of Box 2 hung at the left side of the door. The doors of Boxes 1 and 2 swung to the right, the door of Box 3 swung to the left. No. 4 clawed four times (first, second, third and tenth trials) at the left side of the door (125 experiences in preceding two boxes). No. 3 *went to* the left side of the door the first four trials in the morning and the first, second and fourth trials in the afternoon of his first day's experience in this box (200 trials in preceding boxes). A third raccoon, No. 2, clawed twice at the left side of the door after 132 experiences in the preceding boxes. Therefore, after six days of work with latches at the left side of the door, seven is the maximum number of times an animal *went to* that side of the door in the new box, and four the maximum number of times an animal clawed at that side. In all future new boxes the animals seemed to pick out the new latch and work directly at that, as if experience led them to attack movable objects within the box, or else objects which gave a click or other sound when operated. Only the buttons were noiseless. These facts, with others to be mentioned, indicate, I think, that the raccoon's learning to operate a latch includes something more than the mere mechanical coupling up of a certain instinctive act with a given situation.

In each day's or half-day's work, there was usually a slow success due to eagerness, several rapid ones due to hunger without too great eagerness, and finally several reactions, which gradually became slower, in which the stimulus was but little more than a native desire to be occupied. Most of the latter are recorded as "play trials."

I give in Table I the time in seconds for the first forty trials in each of seven boxes. As these results are typical those with other fastenings are omitted. Where the results obtained with other boxes are mentioned in the text the records are quoted with

sufficient fullness, I think, to verify the deductions made from them.

A light vertical line following a figure indicates the termination of one-half day's experiments, a heavy line indicates the termination of a day's experiments. Unoccupied spaces *preceding figures indicate the number of times a raccoon was put through the act of operating a fastening*, for example, No. 4 was put through Box 5 four times the first half day. The records show that putting through is not a great obstacle to the raccoon's learning as it seems to be in the case of cats. The times were originally taken in seconds and fifths, but in this table the nearest whole number of seconds is given. For example, No. 2's first two records in Box 1 were 45.6 and 41.8 instead of 46 and 42 seconds.

It we take the average of the times required for all first and second trials with single fastenings for the raccoons not put through the act, we find that they stand approximately in the ratio of 3 to 2 (Boxes 1, 2, 3, 4). KINNAMAN'S results show that the male monkey's first and second trials in the "Button," "Vert. Hook," "Bolt," and "String and Nail" boxes (I omit the T-Latch Box, as its first time is unusually long), when averaged are approximately in the ratio 2 to 1 (strictly 156 : 74). After having been trained in seventeen boxes the monkey reduced the average time of second trials to one-fourth that of first trials.

Among THORNDIKE'S records for cats there are many failures on second trials, and he insists on the *extreme gradualness* of the formation of associations in the animals. In rapidity of forming associations with single fastenings the raccoons, therefore, stand next to the monkeys. Had we records for four monkeys instead of one, the ratios would probably be still more nearly the same.

The table shows that often a raccoon may operate a fastening quickly two or three times, after which there follow immediately longer times. The case seems to be like that of a man who may find a house in the city once by fortunate accident, but only after he has had to search for it does he *know* where it is in relation to its surroundings.

The time records for the raccoons show greater and more numerous variations than those for cats, or even those for monkeys. Perhaps this is due to the fact that the cats were utterly hungry and the rhesus monkeys did not exhibit play trials.

## TABLE I

Time in seconds for trials 1 to 40.

| Box Fastening. | Raccoon. | 1 | | | | 5 | | | | | 10 | | | | | 15 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Box 1, Button | No. 1 | 27 | 56 | 4 | 24 | 8 | 11 | 45 | 360 | 10 | 10 | 29 | 41 | 40 | 14 | 18 | 24 |
| Box 1, Button | No. 2 | 46 | 42 | 309 | F | 5 | 39 | 13 | 25 | 45 | 41 | 129 | 23 | 15 | 19 | 11 | 10 |
| Box 1, Button | No. 3 | 12 | 12 | 12 | 75 | 10 | 60 | 130 | F | 60 | 80 | 57 | 51 | 20 | 27 | 10 | 3 |
| Box 1, Button | No. 4 | 300 | 10 | 65 | 345 | 135 | 12 | 10 | 4 | 80 | 12 | 5 | 10 | 10 | 20 | 55 | 15 |
| Box 4, Loop at back | No. 1 | 62 | 24 | 13 | 12 | 4 | 8 | 3 | 2 | 6 | 4 | 3 | 3 | 10 | 5 | 4 | *214* |
| Box 4, Loop at back | No. 2 | 150 | 20 | 12 | 50 | 6 | 3 | 4 | 5 | 3 | 9 | 2 | 9 | 2 | 7 | 3 | 2 |
| Box 4, Loop at back | No. 3 | | | | | | | | | | 7 | 7 | 17 | *47* | *133* | *233* | 11 |
| Box 4, Loop at back | No. 4 | | | | | | | | | | | | | | | | |
| Box 5, 2d Put-through Box. | No. 1 | 46 | 25 | 15 | 4 | 3 | 3 | 9 | 4 | 5 | 6 | 5 | 5 | 4 | 21 | 3 | 14 |
| Box 5, 2d Put-through Box. | No. 2 | 51 | 10 | 26 | 24 | 9 | 2 | 3 | 3 | 4 | 6 | 3 | 2 | 2 | 2 | 3 | 3 |
| Box 5, 2d Put-through Box. | No. 3 | | | | | 20 | 8 | 4 | 5 | 17 | 8 | 4 | *909* | -11 | 7 | 4 | 4 |
| Box 5, 2d Put-through Box. | No. 4 | | | | | 4 | 4 | 3 | 2 | 7 | 3 | 3 | 13 | 6 | 5 | *3* | *3* |
| Box 9, Four Fastenings | No. 1 | 45 | 24 | 16 | 10 | 7 | 6 | 18 | 8 | 9 | 8 | 7 | 18 | 25 | 63 | 11 | 24 |
| Box 9, Four Fastenings | No. 2 | 29 | 15 | 19 | 15 | 7 | 8 | 23 | 28 | 12 | 15 | 6 | 6 | 6 | 16 | 16 | 11 |
| Box 9, Four Fastenings | No. 3 | | | | | | | 20 | 16 | 12 | 25 | 12 | 16 | 496 | 40 | 44 | 28 |
| Box 9, Four Fastenings | No. 4 | | | | | | | 16 | 18 | 11 | 12 | 10 | 10 | 119 | 25 | 20 | 50 |
| Box 10, Thumb-latch | No. 1 | F | F | F | 6 | F | 6 | 59 | 173 | 158 | 7 | 6 | 2 | 1 | 1 | 1 | 1 |
| Box 10, Thumb-latch | No. 2 | 30 | 153 | 7 | 21 | 4 | 7 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 3 | 1 |
| Box 10, Thumb-latch | No. 4 | 18 | 7 | 7 | 31 | 14 | 9 | 6 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 |
| Box 14, Hook | No. 1 | F | | | | | | 3 | 7 | 19 | 10 | 87 | 10 | 5 | 6 | 2 | 1 |
| Box 14, Hook | No. 2 | 75 | 39 | 12 | 19 | 4 | 7 | 1 | 7 | 14 | 4 | 7 | 3 | 5 | 8 | 5 | 9 |
| Box 14, Hook | No. 3 | 545 | 23 | 16 | 2 | 6 | 6 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Box 14, Hook | No. 4 | | | | | | | | | | | 231 | 62 | 23 | 5 | 4 | 5 |
| Box 13, Second Attempt* | No. 1 | 11 | 165 | 86 | 106 | 43 | 72 | 85 | 45 | 24 | 29 | 26 | 22 | 89 | 48 | 28 | 22 |
| Box 13, Second Attempt | No. 2 | 35 | 20 | 13 | 14 | 661 | 186 | 38 | 37 | 24 | 24 | 35 | 44 | 15 | 45 | 64 | 29 |
| Box 13, Second Attempt | No. 3 | 31 | 746 | 296 | 482 | 601 | 223 | 56 | 39 | 37 | 22 | 27 | 49 | 32 | 19 | 20 | 57 |
| Box 13, Second Attempt | No. 4 | 71 | 12 | 27 | 38 | 24 | 17 | 33 | 19 | 15 | 139 | 34 | 35 | 14 | 21 | 29 | 31 |

*In the first attempt with Box 13 all the raccoons failed on the "hook." They were therefore tried with the hook alone in Box 14.

TABLE I—Continued.

| | | | 20 | | | | | 25 | | | | | 30 | | | | | 35 | | | | | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 32 | 6 | 30 | 10 | 8 | 5 | 6 | 8 | *12* | *14* | *13* | *21* | *25* | 6 | 28 | 4 | 4 | 1 | *15* | *34* | *36* | *9* | *13* |
| 43 | 14 | 21 | 9 | 10 | 13 | 19 | 15 | 9 | 8 | 7 | 19 | 6 | 8 | 6 | 75 | 14 | 18 | 22 | 4 | | | | |
| 3 | 5 | 6 | 4 | *3* | 9 | *24* | *7* | *14* | *3* | *9* | *20* | *7* | *143* | 71 | 21 | 1 | 1 | 1 | 3 | 16 | 9 | 12 | 4 |
| 75 | 39 | 4 | 57 | 57 | 17 | 3 | 2 | 13 | 4 | 4 | 8 | 50 | 7 | 6 | 5 | 6 | 5 | 95 | 1 | 35 | 3 | 2 | 2 |
| *19* | 5 | 7 | 8 | 5 | 4 | 3 | 27 | 15 | *336* | 6 | 10 | 5 | 3 | 3 | 3 | 4 | 3 | 5 | 4 | 3 | 4 | 3 | *434* |
| 3 | 5 | 5 | 9 | 6 | 8 | 2 | 3 | 3 | 1 | 2 | 3 | 5 | 4 | 3 | 91 | 4 | 20 | 5 | 8 | 2 | 2 | 3 | 6 |
| 10 | 12 | 13 | 2 | 8 | 591 | 7 | 5 | 2 | 1 | 2 | 2 | 2 | 6 | 6 | 4 | 31 | 4 | 12 | 14 | 2 | 15 | 3 | *22* |
| | | | | | | 48 | 21 | 75 | *149* | *23* | *263* | | | 23 | 16 | 44 | 5 | 485 | 15 | 14 | 22 | 11 | 18 |
| 7 | 4 | 4 | 4 | 5 | 4 | 3 | 10 | *149* | 5 | 4 | 5 | 4 | 3 | 7 | 10 | 3 | 4 | 5 | 13 | 4 | 5 | 10 | 9 |
| 3 | 7 | 3 | 3 | 4 | 8 | 3 | 4 | 8 | 2 | 2 | 5 | 6 | 3 | 2 | 3 | 1 | 1 | 2 | *12* | 11 | 3 | 2 | 9 |
| 3 | 3 | 4 | 3 | 3 | 11 | 15 | *12* | 3 | 2 | 2 | 3 | 4 | 15 | 17 | *153* | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 3 |
| 23 | 4 | 11 | 8 | 11 | 5 | 4 | 7 | 3 | 3 | 12 | 5 | 2 | 4 | 3 | 173 | 3 | 5 | 4 | 5 | 5 | 9 | 5 | 4 |
| 13 | 15 | 15 | 8 | 9 | 7 | 7 | 9 | 6 | 16 | 9 | 7 | 9 | 13 | 7 | 11 | 7 | 7 | 7 | 8 | 7 | 5 | 7 | 6 |
| 13 | 11 | 13 | 6 | 13 | 5 | 13 | 7 | 14 | 17 | 6 | 5 | 9 | 7 | 22 | 6 | 8 | 8 | 12 | 13 | | | | |
| 11 | 87 | 7 | 9 | 7 | 12 | 8 | 12 | 5 | 6 | 8 | 5 | 15 | 6 | 10 | 7 | 11 | 12 | 5 | 478 | | | | |
| 18 | 865 | 26 | 27 | 9 | 8 | 10 | 12 | 15 | 10 | 985 | 17 | 15 | 17 | 6 | 6 | 6 | 6 | 5 | 7 | 8 | 11 | 28 | |
| 2 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 1 | 4 | | |
| 1 | 1 | 2 | 1 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | | | | | | | | | | |
| 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 |
| 13 | 17 | 10 | 2 | 4 | 3 | 3 | 2 | 2 | 4 | 2 | 3 | 2 | 2 | 2 | 6 | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 60 | | |
| 1 | 1 | 2 | 1 | 1 | 1 | 17 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 | 21 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 |
| 30 | 38 | 15 | 23 | 16 | 20 | 18 | 226 | 154 | 19 | 49 | 21 | 25 | 386 | 35 | 97 | 26 | 50 | | | | | | |
| 18 | 25 | 15 | 25 | 26 | 17 | 11 | 18 | 11 | 42 | 23 | 24 | 15 | 16 | 14 | 17 | 14 | 27 | 10 | 22 | 19 | 16 | 13 | 30 |
| 19 | 44 | 40 | 22 | 19 | 40 | 18 | 19 | 45 | 61 | 27 | 8 | 18 | 31 | 181 | 55 | 22 | 93 | 39 | 55 | 133 | 19 | 34 | 17 |
| 30 | 48 | 82 | 14 | 14 | 25 | 30 | 17 | 15 | 48 | 17 | 8 | 23 | 11 | 12 | 45 | 16 | 14 | 27 | 56 | 13 | 16 | 15 | 12 |

*Complexity of Associations.*—It was my purpose to compare the complexity of the associations a raccoon is able to form with those formed by monkeys. I therefore combined new fastenings with those already learned until in Box 13 I came very near the limit of their abilities. In Box 21, I also tested the animals' ability to operate three hitherto untried fastenings and I changed the plan from coming out to be fed to going into the box for that purpose. The animals all succeeded in learning to work seven fastenings: namely, two buttons, two bolts lifted by a pull on each of two loops hung in different parts of a large box, one thumb-latch, one bolt raised by the animal's mounting a platform and a horizontal hook placed at the left side of the door. The thumb-latch had to be worked last. The raccoons thus learned a combination of seven latches. The rhesus monkey did the same, but no doubt the raccoons were given more trials. The average time required for the first trial in boxes of two to seven fastenings, inclusive, is 65 seconds, for the second trial, 44 seconds. KINNAMAN[4] gives 25.5 as the average of first trials in similar combinations and 16.5 as the average of second trials. Thus, for both raccoons and monkeys working with groups of fastenings, the time required for the second success is but two-thirds the time for the first. The anomalous case of raccoon No. 3 in Box 13 in which he required only thirty-one seconds for the first trial, and seven hundred forty-six for the second, has not been included in the average, for to include it would have been to let one peculiar case be equal to eighteen ordinary cases. His third trial is two hundred ninety-six seconds. This case of No. 3 in Box 13 is an example of the fact already mentioned that a raccoon may operate a mechanism quickly once or twice before his actual learning begins.

In boxes of two to seven fastenings there is almost no tendency to follow a routine order in undoing them. Occasionally a definite order may appear one day and another the next in the same box, but neither is followed very closely. Several hundred experiences in Boxes 12 and 13 failed to establish a definite order. The raccoon often seems to begin with the first fastening which attracts his attention. With more than four fastenings each animal showed a tendency to forget a certain one of them, for example, one button or one loop throughout the day's training, or perhaps for two successive days. The case seems not unlike that

[4] *Amer. Jour. of Psychol.*, vol. 13, p. 118.

of a man who makes the same mistake each time in adding a long column of figures. Not only was no routine order followed, but often the raccoons worked one or more fastenings more than once, never, however, was a latch operated after the door was open. The temptation is strong to say that the raccoon has no memory of having already released a latch, since he operates it a second time. I think this interpretation of the animal's conduct incorrect, however, for in Boxes 11 to 13 inclusive, in which a thumb-latch had to be released last, it was operated almost twice as many times as any other fastening. The animals would work one or two latches, then try the thumb-latch, and so on. This indicates that the animal had a distinct association of the opening of the door *immediately after the depression of that latch*, that is, *the perceptual factor of the opening door was a part of the association.* No such perception was possible after the release of any other of the latches so they were worked at random because *in the past* each of them had resulted in the opening of the door. If the door did not open they were worked again. Surely it is asking too much of the animals to expect them to know that each latch when released partly unfastens the door although the door does not move until the last latch is worked. Such a view would demand of the animals either reasoning or a human being's knowledge of bolts and pulleys. His association, his idea, if he has one, is that the last act opens the door. It is noticeable, too, that the two buttons and the hooks which could be seen to be out of the way when unfastened were not operated a second time nearly so often as the loops and platform which presented no perceptible change of place after having been depressed. Consequently it seems quite as fair to argue that the raccoon pulls a loop a second time because no desired result perceptible *to him* followed the first pull, as to urge that he pulls it a second time because he has no memory of having pulled it the first time.

Since, therefore, so far as the animal can see, only the final act opens the door and gains the reward of food, the conditions of the experiments were probably quite unfavorable to the acquisition of a fixed order in performing the acts. Combination locks, the second element of which could not be unfastened until the first had been operated did not entirely obviate this difficulty in experiments with monkeys (see KINNAMAN, p. 124), so it remains to add to this device some means of making the effect of releasing

each fastening perceptible to the animal. It might at least be arranged that each act should bring the animal nearer to the food. Until this has been done we cannot confidently assert that an animal cannot learn to perform a series of acts in a fixed order.

In Box 21, which had three hitherto untried fastenings and in which the plug was extremely difficult to draw, all the raccoons failed in their first and second attempts. The average time required for their first success was 132 seconds, for the second, 85 and for the third, 37. Some failures followed the third trial in the records of all except No. 3. The records in this box serve to show the rate of learning of raccoons compared with the more slowly formed associations of cats.

All the raccoons showed a tendency to abbreviate their acts. They would merely turn toward a loop without clawing it or make a slight motion toward it without touching it.

Only rarely did one of the raccoons press down two buttons simultaneously. In Box 12, however, raccoon No. 3 was observed to try to pull a loop while standing on the platform whose depression raised another bolt. The next day he succeeded several times and finally settled down to doing both these acts at the same moment. A few days later No. 4 had also combined these two acts, and thereafter she did both simultaneously in about one-half the trials. The other two raccoons never combined these acts. Often the thumb-latch and one button would be worked simultaneously; but this, we believe, was a mere physical convenience, since the animal could press on the latch with one forepaw and depress the button with the other without changing the position of its body.

*Variability.*—I have shown that in a series of acts no routine order was established. Was there variation in the method of performing the act? Box 14 was fastened with a horizontal hook which could not be raised with the paw and was therefore very difficult for the animals to learn. All except No. 2 lifted it with the nose; he did the act with his teeth for thirty trials and only twice the first half-day with his nose, and six times the second half-day, up to the twentieth trial. That time he raised the hook with his nose and continued to do so thereafter. He was escaping by means of the mouth reaction in the average time of two and one-half seconds, so he had fully mastered the mechanism before changing thus abruptly to the muzzle reaction. All of the rac-

coons turned a button once or twice with the nose in early trials then settled down to working it with the paw. In acts so difficult to learn that the animal *had to be* put through them, there was no change from the act put through to one accidentally hit upon.

The raccoons were observed to operate fastenings with either the right or left paw or with both at once. We may say in general that the first successful act was not always stamped in because it was not always the most convenient. Sooner or later the more convenient was substituted for the more awkward performance, and the change was sometimes abrupt. We cannot say, of these animals, therefore, that a given situation has power fatally to evoke the formerly successful act. No. 2's behavior at least was entirely unpredictable. Wherever else in psychology we find the employment of two different means to the same end we account for it by means of an image or notion. But we may speak of this later.

### MEMORY FOR FASTENINGS.

As I built up combinations of fastenings from those which the raccoons had already learned, it was not possible to give memory trials for single fastenings with a time interval sufficiently long to find the limit of their power to remember such acts. Intervals of three or four days or of two weeks showed no appreciable forgetting. After completing work with Box 13, however, I allowed an interval of one hundred and forty-seven days to elapse. This box had seven fastenings and was very difficult for the raccoons to master. At the end of this period No. 3, No. 2 and No. 1 were again tried in this box. Only the first succeeded in working all the fastenings and releasing himself. He undid the seven fastenings and came out of the box in 34, 28, 131, and 182 seconds, successively. The other two worked nearly but not quite all the fastenings, the horizontal hook being most frequently missed. This period, therefore, may be regarded as very near the limit of the raccoon's memory for the most complex motor associations he is able to form. It seems likely that No. 3's superior memory for this box was due to the extreme difficulty he encountered in mastering it. No. 2 had had more trials in Box 13 than No. 3 and he is fully as intelligent an animal, yet No. 3, whose difficulties were very great at first, reached the extremely low minimum time

of seven and two-tenths seconds and remembered the combination better. Were raccoon No. 3 a human being, we should have no hesitation in saying that he had to give closer attention to the mechanism in order to learn it. If the learning were nothing more than the formation of a habit, No. 2, who had had more experiences with the combination, should have been superior in operating it after a long time interval. Additional memory tests will be described in connection with the tests of discrimination.

## DISCRIMINATION.

*Visual Discrimination.*—In the tests of visual discrimination no attempt was made to determine whether the raccoons distinguished colored objects by differences in color or by differences in brightness. In fact, the greater number of trials required to distinguish two colored objects as compared with the number required to distinguish white from black is, in so far, evidence that the animals were reacting to brightness alone and that the diminished difference in brightness rendered discrimination more difficult. The tests for discrimination of colored objects presented in succession led naturally to a test for the presence of visual images and this question was investigated rather than that of color-vision. I hope in the future to test color-vision. Meanwhile, where colors are named in this and succeeding sections it will be understood that colors exclusive of brightness differences are not implied.

In the first tests a modification of the apparatus used by KINNAMAN in his study of the color perception of monkeys was employed. Two ordinary drinking glasses were covered on the convex surface with papers of different colors. Of one pair, one glass was covered with white paper, the other with black; of another pair, one was covered with red, the other with green. The black and white papers were of Milton Bradley manufacture and were of the same intensity respectively as his black and white Maxwell disks. The red and green also were the Bradley standard colors.

In the experiments a bit of food was placed in one glass and the glasses were then brought into the view of the animal and placed side by side on the floor, from six to thirty inches apart in different trials. An assistant set the raccoon free facing the two glasses. The animal came to the glasses and secured the food. He was returned to the assistant, food was put in the same glass

as before and their positions from right to left were reversed. This reversal was made in each successive trial at first, then the feeding glass was left in the same place twice in succession, then three times, so that neither position nor illumination should influence the choice. The usual distance between the two glasses was six or eight inches, for beyond this distance the animal seemed to get his eyes fixed on one of the glasses and to go straight to that one. His reaction was influenced by the direction of his gaze at the moment he was set free. This seems unusual, yet it appeared regularly whenever the glasses were placed from twelve to thirty inches apart. The distance from the point at which the raccoon was set free to the glasses was eight feet.

No. 4 and No. 1 were tried with black and white. Food was always placed in the black glass. No. 4 was given 25 trials the first day, 68 the second and 50 the third; No. 1 was given 25 trials first day and 100 the second. Thus both were practically perfect toward the close of the second day's test.

TABLE II.

| | *No. 1.* | | *No. 4.* | |
|---|---|---|---|---|
| No. of trials. | Black. | White. | Black. | White. |
| 1–10 | 4 | 6 | 5 | 5 |
| 11–20 | 5 | 5 | 4 | 6 |
| 21–30 | 6 | 4 | 5 | 5 |
| 31–40 | 4 | 6 | 5 | 5 |
| 41–50 | 5 | 5 | 6 | 4 |
| 51–60 | 3 | 7 | 8 | 2 |
| 61–70 | 6 | 4 | 9 | 1 |
| 71–80 | 7 | 3 | 9 | 1 |
| 81–90 | 10 | 0 | 9 | 1 |
| 91–100 | 9 | 1 | 10 | 0 |
| 101–110 | 10 | 0 | 10 | 0 |
| 111–120 | 10 | 0 | | |
| 121–130 | 10 | 0 | | |
| 131–140 | 10 | 0 | | |

After five days without practice No. 4 in fifty trials went directly to the black forty-five times. On the third, seventh, tenth, fourteenth, twentieth and twenty-second trials she went to the white.

Two days later No. 1 was perfect in fifty trials, and after an interval of five days in 46 out of 50. The animals, therefore, learn to discriminate black from white in from seventy to ninety trials.

No. 2 and No. 3 were tried with red and green glasses. Food was placed in the latter. No 2 was given approximately 120

trials per day for five days; No. 3 approximately 140 trials each day for 5 days. The number of trials per day varied slightly with the degree of the animal's hunger.

TABLE III.

| | *No. 2.* | | | *No. 3.* | |
|---|---|---|---|---|---|
| No. of trials. | Green (right). | Red (wrong). | No. of Trials. | Green (right). | Red (wrong). |
| 1–100 | 52 | 48 | 1–100 | 54 | 46 |
| 101–200 | 50 | 50 | 101–200 | 54 | 46 |
| 201–300 | 51 | 49 | 201–300 | 53 | 47 |
| 301–400 | 68 | 32 | 301–400 | 64 | 36 |
| 401–500 | 84 | 16 | 401–500 | 52 | 48 |
| 501–595 | 87 or 91$\frac{1}{13}$% | 8 | 501–600 | 55 | 45 |
| | | | 601–690 | 75 or 83$\frac{1}{3}$% | 15 |

It is evident from these tests that many more trials are required to learn to distinguish red from green, than to discriminate black from white. As already stated, this may be evidence of a response to difference in brightness alone.

At this point I devised a "card displayer" by which the two colors could be shown in succession instead of simultaneously; it was also necessary to arrange the experiment so that it could be carried on by one person (Fig. 1).

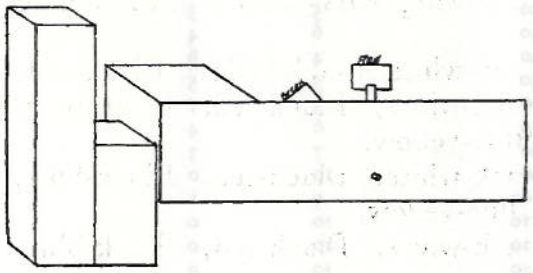

FIG. 1.

The front of the card-displayer consisted of a board twelve inches high. A round pin or pivot on which two levers could be turned was inserted in a hole near the lower edge of the board. In the upper ends of these levers colored cards were fastened so that raising one of the levers to a vertical position displayed red, for example, raising the other displayed green. During one test red would be on the forward lever one inch in front of the other, during the next test on the rear lever. The animal could not, therefore, react to the position of the cards. On account of the diffi-

culty of one person alone having to display the colors, feed the raccoon and keep the record, my notes are not perfectly reliable in respect to the exact number of times required for the mastery of each pair of colors. Consequently when a pair of colors seemed to have been mastered, each animal was given a final test of either twenty-five or fifty trials, an experienced assistant keeping the record. If out of twenty-five trials there were at least twenty-three correct reactions, or out of fifty trials at least forty-five, I assumed that the colors were discriminated. In most of these final tests the raccoon never failed to react to the right (food) card and never attempted to react to the wrong one. The response demanded of the animal was that he mount a box $2\frac{1}{2}$ feet high by means of another 15 inches high which served as a step to the first, when the food-card was displayed, and that he refuse to go up when the other card appeared. If he started up but returned at once after a second look at the no-food card, the reaction was recorded as correct. If he did not come back immediately from the lower box, the reaction was recorded as incorrect. On the other hand, he was required to go to the top of the two steps when the food card was displayed.

According to the above standard the animals learned to discriminate the following pairs of cards of different colors and intensities.

No. 4. Black-white, Black-yellow, Black-red.

No. 3. Black-white, Black-red, Black-blue, Black-yellow, Black-green, Blue-yellow.

No. 2. Black-white, Black-red, Black-blue, Black-yellow, Black-green, Blue-yellow.

No. 1. Black-white, Black-red, Black-blue, Black-yellow, Black-green, Red-green.

By this method also it always required many more trials for the discrimination of red from green, or blue from yellow than for the discrimination of black from white, or of black from the colors. The female, No. 4, though given many trials, did not succeed in discriminating red from green, nor blue from yellow, hence in this case the brightness difference seemed too slight to serve as a means of distinguishing the colors. Further evidence that No. 1 distinguished cards of different colors and intensities is given on p. 256. The fact of his discrimination of the series white, orange, blue, from the series blue, blue, blue, whether each series was

shown alternately or twice in succession is mentioned on p. 257, and the reactions of all three males to similar series are recorded on p. 259. These tests of visual discrimination may be regarded merely as experiments preliminary to the test for visual images.

One peculiarity in the behavior of the raccoons should be emphasized. When they were discriminating well their eyes were never more than 18 inches from the colored cards, more often within a foot of the cards and still more often within three inches, *i. e.*, the animal took a position with his forepaws on the front board of the card displayer and looked intently for the card to appear. I have never seen the animal look at the card from a distance of several feet and respond to it. This shows the difficulty of such discrimination, and it may indicate that the distance for perceiving color or brightness is extremely short. If this be so, the apparent inability to see two glasses when placed 30 inches apart and at a distance of eight feet from the animal is accounted for.

*Discrimination of Sounds.*—I endeavored to ascertain the ability of the raccoons to discriminate a high from a low tone and to form the association of being fed at the sound of the high note. The response expected of the raccoon was that he mount the high box to be fed on hearing the food signal. While pure tones should have been used it was, for practical reasons, impossible to do so. I therefore sounded the highest note, $A_1$, possible with an ordinary A French harp or harmonica, then the lowest, A″. For the first few trials the hand was extended toward the high box when the food signal was given and the animal fed when he climbed upon the box. When this aid was withdrawn it was found that No. 1 was practically perfect in responding to the high tone and in refusing to respond to the low one. No. 2 had not mastered the association. His record after the first few trials in which the hand signal aided him is as follows:

TABLE IV.

| *No. 2.* High-tone, food signal. | | | *No. 2.* Low-tone, no-food signal. | | |
|---|---|---|---|---|---|
| | Right. | Wrong. | | Right. | Wrong. |
| 1–50 | 37 | 13 | 1–50 | 34 | 16 |
| 51–100 | 44 | 6 | 51–100 | 38 | 12 |
| 101–130 | 27 | 3 | 101–150 | 48 | 2 |
| | | | 150–200 | 50 | 0 |

The animals had completed the visual discrimination tests before they were tried with this pitch discrimination.

*Discrimination of Forms.*—For experiments in the discrimination of forms and sizes the card-displayer already described was used. Cards of different forms or of different sizes were substituted for cards of different brightness and color. In the tests for form discrimination the animal was fed when a square card 6 x 6 inches appeared and not when a circular one 6 inches in diameter was shown. If the animal formed an association between the square card and food so that he went to the top of the high box to be fed when that card was shown and refused to go up when the circular card appeared, we may say that he discriminated. My purpose was to test the discrimination of two objects widely different for the human eye, not to test the delicacy of discrimination.

The results for form discrimination given by No. 2 and No. 1 appear below. Both animals had already discriminated differently colored cards by this method, so that attention to the cards was well established and the form test proved to be very easy.

TABLE V.

| | *No. 1.* | | | | *No. 2.* | | | |
|---|---|---|---|---|---|---|---|---|
| | Square. | | Circle. | | Square. | | Circle. | |
| | Right. | Wrong. | Right. | Wrong. | Right. | Wrong. | Right. | Wrong. |
| 1–50 | 38 | 12 | 35 | 15 | 43 | 7 | 41 | 9 |
| 51–100 | 47 | 3 | 47 | 3 | 42 | 8 | 39 | 11 |
| 101–150 | | | | | 48 | 2 | 44 | 6 |

As a matter of fact, these two cards differed in size as well as in form, but for sensation (barring judgment) I thought this circle to have more nearly the value of the square than one of exactly equal area. However, anyone who will compare two circles with radii of 3 and $3\frac{7}{20}$ inches respectively will, I think, find their visual difference very slight.

*Discrimination of Sizes.*—No. 2, No. 3, and No. 4 were tested in the discrimination of sizes by the method used in the form discrimination. Two square cards $6\frac{1}{2}$ x $6\frac{1}{2}$ and $4\frac{1}{4}$ x $4\frac{1}{4}$ inches were used. They were first shown alternately, then in varying order. The rapid learning which occurred is due to much previous training in brightness discrimination by this method. It is evident that each animal began to form the association within the first fifty trials, and that learning not to respond to the small card proceeded more slowly than learning to go up when the large card

appeared. The cards were not shown simultaneously, but in succession. Thus, remembrance of the card just shown was required for a successful response. On presenting the larger card the animal was fed, if he climbed to the top of the large box.

TABLE VI.

| | *No. 2.* | | | | *No. 3.* | | | | *No. 4.* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Large. | | Small. | | Large. | | Small. | | Large. | | Small. | |
| | Right. | Wrong. | Right. | Wrong. | Right. | Wrong. | Right. | Wrong. | Right. | Wrong. | Right. | Wrong. |
| 1-50 | 47 | 3 | 44 | 6 | 29 | 21 | 33 | 17 | 43 | 7 | 35 | 15 |
| 51-100 | 45 | 5 | 32 | 18 | 48 | 2 | 29 | 21 | 43 | 7 | 31 | 29 |
| 101-150 | 47 | 3 | 39 | 11 | 44 | 6 | 38 | 12 | 47 | 3 | 28 | 22 |
| 151-200 | 39 | 11 | 38 | 12 | 47 | 3 | 34 | 16 | 44 | 6 | 35 | 25 |
| 201-250 | 49 | 1 | 47 | 3 | | | | | 49 | 2 | 37 | 23 |
| | | | | | | | | | 48 | 2 | 48 | 2 |

## IMITATION.

Experiments were made to test whether the raccoons imitate one another and whether they would come to perform an act from seeing the experimenter do it. Briefly, I found that the animals not only do not imitate one another, but that they do not pay the slightest attention to one another except when playing, or fighting, or when biting each other gently for the sake of mutual scratching. I give an example of the experiments for the sake of criticism. The method may be inadequate. Experiments arranged so as to attract the animal's attention to the thing to be learned may still reveal imitation.

The raccoons did, in two forms of experiment, seem to acquire an impulse to do an act from seeing me do it. In one, the act was so easy that the evidence is almost worthless, but in the other the act was so difficult that it would seem to be evidence for either imitation or the presence of ideas or both. In other cases, however, the animals failed to learn from seeing me operate a mechanism.

No. 1 had learned to open Box 16, whose door was fastened by two horizontal wooden bolts, primitive barn-door latches. Throwing both of these to the right released the door; throwing one or both to the left fastened the door. The box was a difficult one to open, for having once thrown a latch to the right the chances were that the raccoon's next movement would throw it to the left.

The box had two compartments separated only by a partition of poultry wire. The imitator facing this partition was near the door so that it was *possible* for him to see the work of No. 1, in opening it. No. 4 first failed in three minutes. She was then put in the imitator's compartment while No. 1 opened the door 18 times. No. 4, however, did not see him do it. She was put in the same compartment with No. 1 and still I could never be certain that she saw his acts. She was then held and saw the experimenter open the door during several series of ten trials each. She continued to fail when left to try alone. Subsequently, I held the animal so that he certainly saw the work of the raccoon he was to imitate. When the door was opened both came out and were fed. No. 4, No. 3 and No. 2 did not learn to open the door from seeing No. 1 do it or from seeing the experimenter do it.

As a further test of imitation I taught No. 2 to claw the small block out of the opening in the top of Box 17. No. 1 was then given opportunity to learn by imitating No. 2. He did not watch No. 2's work. He was then held so that he could not fail to see it. After this he followed No. 2 to the box each time and soon learned to dive into the box as soon as No. 2 pulled out the block and get the food before No. 2 could do so. Left to open the box for himself, he did not even go to it. He was then held and saw the experimenter remove the block three times. Then he began to claw at the block while it was being removed. He did this twice more and then was perfect in the performance of the act.

No. 3 failed after four minutes to remove the block though he clawed at it somewhat. Apple was then placed in the box and he was loosed just in time to see the experimenter remove the block. He reached in and got the apple. This was repeated ten times. He then clawed out the block instantly though it had been put in tightly. No. 4, however, did as well with no chance to imitate. Evidently the act is too easy to learn to be of much value as a test of imitative ability.

The card-displayer, however, afforded a more difficult task than I would have planned for the animals deliberately. After having had some six weeks of experience in distinguishing a black from a white card and in distinguishing complementary colors, each of the four raccoons developed a tendency to reach over the front board of the apparatus and claw up the colored cards. This tendency was encouraged and finally they would claw up the right (food)

card and go to the high box to be fed, or, having clawed up the wrong (no-food) card they would claw it down. The cards could not be seen until they had been lifted up and they were difficult for the animal to raise. Therefore there were many errors. So far as imitation is in question, the important point is that the raccoons did begin to do, or try to do what they had seen done by the experimenter. Before they began this they had learned to watch the cards and the movements of the trainer's hands very closely indeed. Therefore, the animals either imitated or else from their impatience to see the right card come up there sprang the idea that they themselves might make it come up. This, however, may be all there is in intelligent imitation. I stimulated their impatience by moving the cards slowly, and the clawing soon began. The whole problem, in the case of these animals, may be one of attracting their attention to the thing to be done. Perhaps seeing a thing done often enough will set free in them an impulse to do it just as being put into a box will arouse an impulse to go into it. An important question to ask is, What free impulses is the animal capable of acquiring? Thus far we have at least two: an impulse to enter a box into which it has always been lifted; and an impulse to claw up color cards which it has previously merely seen raised. Such impulses must accompany ideas acquired from the experience of being lifted in and of seeing the card raised.

This card-displayer test of imitation has an advantage over those with latches, inasmuch as the animal did not at first fail. He simply passed from seeing a thing done to doing it himself.

Since the raccoons do seem to develop a tendency to do an act they see done by an experimenter, it seems possible that were one raccoon made dependent on another for all his food he might develop a tendency to imitate the food-getting acts of the other. There is good reason to doubt, however, whether even a young raccoon can be taught to watch another. The animal's *life* depends upon his finding and getting food *before* another of his kind gets it, not *with* that other or *after* him, for nature puts but one bit of food in a place for raccoons and I should say also for chicks, dogs and cats. The bone must be seized and escaped with *before* another gets it, if another animal be near. Hence nature puts a premium on attention to the bone and punishes with hunger any tendency to watch another animal getting food. Therefore, I think it unlikely that imitation of another will ever appear in

these animals in connection with the food-getting impulse. Almost all experiments so far employed in laboratories have depended on hunger as a stimulus. Perhaps a new motive should be searched for to test the presence of imitation. Such an opinion certainly seems warranted by the behavior of raccoons. I think the same is true of dogs, cats, and chicks. In monkeys, however, KINNAMAN (p. 121) elicited two examples of undoubted imitation of one rhesus by another, in connection with food-getting, and apparent cases of "instinctive imitation" were numerous. May this difference not be attributed to the fact that monkeys' live in groups or droves and search for stores of food rather than for single bits as the raccoon does?

## LEARNING FROM BEING PUT THROUGH AN ACT.

The evidence for THORNDIKE's most far-reaching conclusions concerning the mental life of cats and dogs seems to be based on their behavior in experiments in which they were put through the act to be learned. In view of his conclusions it would seem highly important that this question be tested carefully for as many of the higher animals as possible.

On page 67 of "Animal Intelligence" THORNDIKE says: "A cat has been made to go, into a box through a door, which is then closed. She pulls a loop and comes out and gets fish. She is made to go in by the door again, and again lets herself out. After this has been done enough times, the cat will of her own accord go into the box after eating the fish. It will be hard to keep her out. The old explanation of this would be that the cat associated the memory of being in the box with the subsequent pleasure, and therefore performed the equivalent of saying to herself, "Go to! I will go in." The thought of *being in*, they say, *makes her go in. The thought of being in will not make her go in.* For if, instead of pushing the cat toward the doorway or holding it there, and thus allowing it to itself give the impulse, to innervate the muscles, to walk in, you shut the door first and drop the cat in through a hole in the top of the box, she will, after escaping as many times as in the previous case, *not* go into the box of her own accord. She has had exactly the same opportunity of connecting the idea of being in the box with the subsequent pleasure. Either a cat cannot connect ideas, representations, at all, or she has not the power of progressing from the thought of being in to the act of going in. The only difference between the first cat and the second cat is that the first cat, in the course of the experience, has the impulse to crawl through that door, while the second has not the impulse to crawl through the door or to drop through that hole. So though you put the second cat on the box beside the hole, she doesn't try to get into the box through it. The impulse is the *sine qua non* of the association. The second cat has everything else, but cannot supply that. These phenomena were observed in six cats, three of which were tried by the first method, three by the second."

On p. 73 he writes: "Presumably the reader has already seen budding out of this dogma a new possibility, a further simplification of our theories about animal consciousness. The possibility is that animals may have *no images or memories at all, no ideas to associate.* Perhaps the entire fact of association in animals is the presence of sense-impressions with which are associated, by resultant pleasure, certain impulses, and that therefore, and therefore only, a certain situation brings forth a certain act."

So definite and convincing is his evidence for this failure to learn by being put through an act in the case of dogs and cats, that

I supposed at the outset that my experiments to test this hypothesis in the case of raccoons would be few and perfectly confirmatory of THORNDIKE's view. But the behavior of the raccoons on the second and later days of my experiments soon indicated that this confirmation might not be forthcoming. It will be recalled that similar experiments of THORNDIKE's[5] on monkeys were inconclusive, and that the monkeys experimented with by KINNAMAN could not be handled. I took pains, therefore, to handle the young raccoons as much as possible, and they showed no objection to it for many months. Then one refused to be handled.

On the second day of my experiments with the female, No. 4, in Box 1 (button), and much to my surprise, she turned, on the thirty-third trial, and went quickly back into the box. She opened the door in six seconds, came out, was fed for a moment from the bottle and then immediately re-entered the box. Now possibly the reader is saying, "Yes, this is the phenomenon observed by THORNDIKE in cats which were pushed toward the door or held near the door." This is not the case. This young raccoon had been picked up by the nape of the neck, lifted quickly through the door and dropped on the floor of the box. When thus held the four legs of the animal hang down limp as they do in the case of a kitten carried in the mouth of its mother. This fact makes this method of holding and lifting the animal most convenient. There was no innervation of her own muscles. Four days later when tried in this box she went in on the second, third and fourth trials.

No. 3, the second raccoon tried in this box, went in himself on the twenty-second, twenty-third and twenty-fourth trials. He also had been lifted into the box on the preceding trials. On the forty-fifth and from the forty-seventh to the fifty-first trials, inclusive, he re-entered the box. On the fifty-second trial he started back but turned at the door and did not go in again that day. Subsequently, he went in regularly until his hunger began to be satisfied. During his last eighty-five trials in this box he re-entered it of his own accord eighty-two times. On the seventy-first trial, and several times thereafter, he was held near the door to make him go in but this was not done with any one of the animals until they had gone in spontaneously frequently enough to show that it was an established part of the reaction. Moreover, the hold-

[5] THORNDIKE, E. L. The Mental Life of the Monkeys. *Psych. Rev. Monogr. Suppl.*, vol. 3, no. 5. 1901.

ing was done simply to make them go in when their hunger was partially satisfied. Up to that time they were eager to go in, after having done so several times. These remarks apply to boxes with from one to four or five fastenings. In connection with experiments with Box 13, I several times whipped No. 3 to make him go in, for the box was very difficult to unfasten. This was done, however, only after he had gone into the box repeatedly.

If this behavior is to be used as evidence of the presence of ideas, then the reluctance of the animals to enter the boxes when they were not hungry, and when the box was difficult to unfasten is quite as significant as the fact of their getting in spontaneously at first.

No. 2 started back into Box 1 on the eleventh trial and went back into the box on the thirty-ninth, fifty-sixth, sixty-seventh, sixty-ninth and seventieth trials. The next afternoon he went into the box and came out to be fed before I could close the door. I fed him a little, and he went back. After this the usual thing was for him to go into the box when hungry. Until after the seventieth trial nothing was done to encourage No. 2 to go back. My object was to see whether the animal would turn and go in instantly entirely of his own accord. I did not even wait for him to go in; unless he returned promptly to the box, he was lifted into it.

No. 1 went into the box first on the fifty-seventh trial. After that he was held at the door six times and went in. Thereafter he went in regularly.

These results are radically different from those obtained by THORNDIKE in his experiments with cats. Since four raccoons exhibited this reaction, it is safe to conclude that any raccoon which has been lifted into a box and allowed to come out and be fed will sooner or later go in of his own accord, and further that he will go in before the one-hundredth trial and probably before the seventy-fifth trial, as my four animals did. The behavior of these animals forces one to believe that it dawns on the animal that he can hurry the matter of getting food by rushing back into the box and coming out again. The association here involved not only what the animal *had done* but also something *which had been done to it*. It may very well be doubted, however, whether lifting the animal about taught it anything. I should say rather that it had an image of the interior of the box as the starting point of the food-getting process and an idea of going back to recommence the pro-

cess. This idea lost all motive power as soon as hunger was allayed.

This difference between the behavior of the raccoons and the cats, occurring as it did with Box 1, led me to modify the succeeding experiments so as to test further the animal's ability to learn without innervating its muscles. In Box 2 the door was placed six inches above the floor to see whether this would prove to be an obstacle to going back into the box. No. 4 did not begin to go in of her own accord until the fifty-first trial, but she did so very often thereafter. No. 3 went into the box on the first trial, that is, before he had ever been put into it, notwithstanding the difference between the positions of the doors and the size of the boxes. One may explain this behavior, which occurred often afterward, either by association by similarity or by inability to distinguish the differences between the two boxes. My opinion is that the open door at once suggested the usual act of going in. Probably it was the same door to the raccoon. This, however, is a crude association by similarity. "Similarity is partial identity." The differences are entirely unnoticed. No. 2 re-entered the box on the second trial; No. 1 on the fifth.

Box 3 was arranged to test further this difference between raccoons and cats. In the first place an opening in the top of the box was covered only by a loose piece of board and the plan was to put the raccoons into the box through this opening, to see whether they would learn this indirect way of entering. Then No. 4 and No. 3 were put through the act of opening the door. This was done by holding the animal, taking its paw and placing it on the string then pressing it down until the bolt was withdrawn and the door opened. No. 2 was not put through the act and No. 1 was not worked in Box 3

A low step was placed at the end of Box 3 to enable the animals to climb more easily to the top of the box. The order of procedure was as follows: The raccoon came out of a door in the front, was fed, went around to the end of the box, mounted by the step, to the top of the box and dropped through the opening into the box.

We may discuss first the act of going in. On the seventeenth trial No. 4 went in. On the eighteenth she was held on the box and went in. On the nineteenth she climbed upon the box. On the twenty-first she was put on the box and went in, and so on to

the twenty-eighth trial, in which she may have been helped by the motion of the experimenter's hand in the direction of the opening. No. 3 after the fifth trial went in when placed on the box. On the eighteenth trial he re-entered the box from the floor of the room, and later he went by way of the step and the end of the box. On the twenty-seventh trial he climbed up over the front of the box and dropped into the opening in its top, thus substituting a direct for a roundabout way. No. 2 went in when put on the box after the eighth trial. From the twelfth trial he went in when put on the step, and from the twenty-second trial he went in from the floor of the room. In the extract from "Animal Intelligence" already quoted THORNDIKE says, "So, though you put the second cat on the box beside the hole, she doesn't try to get into the box through it." This description certainly does not suit the behavior of raccoons.

Having shown that raccoons learn to go into a box by being dropped in through a hole in the top, we have yet to answer the question, will the raccoon learn to operate a fastening, to perform a complicated act, by being put through the motions necessary to do the act? In order to make trial of this I decided first to put two of the animals through the act of opening cages and let two of them learn it by trial. If the average time of the first success for those put through should be shorter than the average time for those not put through, it would be fair to conclude that the putting through facilitated learning. In order to make the evidence especially strong I selected for most of the putting through experiments the two raccoons which, up to this time, had shown themselves slowest in learning the mechanisms, Nos. 3 and 4. It seems to me, therefore, that much weight must attach to the averages. The average time required for the first success in each of eleven boxes by the animals which were put through the act is 41.6 seconds; by those not put through 90.2 seconds or more than twice the former average. The results are shown in Table VII.

In Table VIII the animals which were put through *failed to escape by their own unaided efforts*, but succeeded after being put through. I have other instances of this.

It will be seen that in two of the eleven boxes the averages favor those not put through. Box 3 shows an average of 85 seconds for those put through and of but 26 seconds for those not

TABLE VII.

| | Number of Times Put Through. | Time of First Success. | Average for Those put Through. | Average for Those not put Through. |
|---|---|---|---|---|
| *Box 3. Single* | | | | |
| No. 4 | 8 | 162 sec. | | |
| No. 3 | 5 | 9 | 85 sec. | 26 sec. |
| No. 2 | none | 26 | | |
| *Box 4. Single* | | | | |
| No. 4 | 22 | 48 | | |
| No. 3 | 10 | 7 | 27 | 106 |
| No. 2 | none | 150 | | |
| No. 1 | none | 62 | | |
| *Box 5. Double* | | | | |
| No. 4 | 4 | 4 | | |
| No. 3 | 4 | 20 | 12 | 51 |
| No. 2 | none | 57 | | |
| No. 1 | none | 46 | | |
| *Box 6. Double* | | | | |
| No. 4 | none | 16 | | |
| No. 3 | 7 | 5 | 7 | 12 |
| No. 2 | none | 12 | | |
| No. 1 | none | 10 | | |
| *Box 7. Double* | | | | |
| No. 4 | 6 | 21 | | |
| No. 3 | 6 | 27 | 44 | 159 |
| No. 2 | none | 22 | | |
| No. 1 | none | 296 | | |
| *Box 8. Triple* | | | | |
| No. 4 | 6 | 24 | | |
| No. 3 | 6 | 25 | 24 | 39 |
| No. 2 | none | 62 | | |
| No. 1 | none | 16 | | |
| *Box 9. Four Latches* | | | | |
| No. 4 | 6 | 16 | | |
| No. 3 | 6 | 20 | 18 | 37 |
| No. 2 | none | 29 | | |
| No. 1 | none | 45 | | |
| *Box 11. Five Latches* | | | | |
| No. 4 | 6 | 30 | | |
| No. 3 | 6 | 39 | 34 | 24 |
| No. 2 | none | 36 | | |
| No. 1 | none | 12 | | |
| *Box 12. Six Fastenings* | | | | |
| No. 4 | 6 | 134 | | |
| No. 3 | 6 | 23 | 78 | 199 |
| No. 2 | none | 364 | | |
| No. 1 | none | 34 | | |

TABLE VIII.

| | Failed by Own Efforts After. | Number Times Put Through. | Time Required for First Success. | Average for Those Put Through. | Average for Those Not Put Through. |
|---|---|---|---|---|---|
| *Box 10. Thumb-latch* | | | | | |
| No. 1 | 840 sec. | | | | |
| No. 1 | 90 | | | | |
| No. 1 | 75 | 3 | 6 sec. | 10 sec. | |
| No. 1 | 120 | 1 | 6 " | | |
| No. 4 | | 6 | 18 " | | |
| No. 2 | | none | 30 " | | 30 sec. |
| *Box 14. Hook* | | | | | |
| No. 4 | 600 | 9 | 231 | 117 | |
| No. 1 | 1920 | 5 | 3 | | |
| No. 3 | | none | 545 | | 310 |
| No. 2 | | none | 75 | | |

put through.. This is due to No. 4 alone, however, for No. 3 (put through) made a record of 9 seconds, while No. 2 (not put through) made a record of 26 seconds. Box 11, with its five fastenings, gave an average of 34 seconds for those put through, as against 24 seconds for those not put through. This is due to No. 1's remarkably short time, 12 seconds, on the first trial, and to No. 3's difficulty in learning the box. The full record of No. 3's learning makes Box 11 give rather conclusive evidence in favor of putting through. After being put through six times No. 3 succeeded with Box 11 eighteen times consecutively. The next morning he failed after twenty-five minutes to pull one of the loops, though he worked the other fastenings. Although he was evidently already hungry and worked hard to escape he was left untried for two hours to see whether increased hunger would help him. When next tried he failed after eleven minutes, was put through ten times and succeeded in forty seconds, then in forty-four, then in twenty-nine, and so on. The next morning he failed after seven minutes, was put through six times, then succeeded in twenty-three seconds. The next morning he failed in five minutes, was put through twice and then succeeded in thirty seconds. The next morning he failed on the same loop, was put through once and succeeded always thereafter, steadily reducing his time. Now this is, in many respects, the poorest record for No. 3 or for any other of the raccoons and I fancy the reader is

saying, "This one case outweighs all your averages. Do you not see that the animal was hindered rather than helped in learning by being put through?" The answer is, of course, why should not his eighteen consecutive successes, unaided after the first six trials, have stamped in the reaction? Each morning he failed once more (he almost always failed on loop 1, a fastening he had already learned). He failed, also, no matter how long I waited for him. But *he never failed immediately after he had been put through, and each of his successes following the putting through was quick.* The fact is the box was very complex for him, he would forget a fastening, be put through, then not fail again that day. The next day the difficulty would reappear. He was very slow to learn this box, but remembered it longer than did any of the others. The point I would emphasize is simply that putting through after a failure certainly and always resulted in making the next trial a success. It seemed, as we say of human beings, to refresh his memory. Would he have failed as frequently and during so many days had he been forced to learn by trial and error, not obtaining food at all until he succeeded, be it a day or a week? I think he would not have failed as frequently after the first success. No doubt the putting through caused him to depend upon it. I do not believe that putting through has nearly so much stamping-in power as a self-innervated movement. It has not for man. A man may be told how to make a shot at billiards but only practice in making the shot will fix it. A player having made the shot once, as directed, may at that time succeed. In later trials he will make it sometimes very awkwardly. So with our animals. Often the first success does not require the longest time either for those put through or for those which innervate their own muscles. These short first times and longer later ones are sufficiently frequent to show a marked difference between the learning of dogs and cats and that of raccoons. I think, finally, that putting through helps a raccoon to succeed in trials immediately following the experience of being put through, and that this is a mental effect. It establishes a transient association. Trial and error forms more stable and permanent associations—a reflex affair simply.

The description of No. 3's learning in Box 11 should make it clear that the averages in that box deserve but little weight. They differ by only ten seconds. But, however that table be counted,

the averages and the number of individual cases in favor of learning by being put through are too widely different from those against it to be ascribed to chance. The experiments from which these data are taken were continued for three months.

One who observed the experiments closely might state what appears at first to be a very strong argument against our conclusions. For example, in Box 5, which had two fastenings, I called the order in which the animal was put through the two "direct," the other possible order "reverse." No. 4, who was put through, did the acts in the reverse order roughly two-thirds of the times, and No. 3 probably three-fourths of the times. I *did not* succeed in establishing the order in which I had put the animal through. This is a serious objection until we compare it with the behavior of the animals which were not put through. Let us examine the records of No. 2 and No. 1 for July 19, 1905, calling that order, "direct" in which the animal attacks the fastenings for three consecutive times. No. 2, on the morning of that date, followed the direct order eleven times after he established it. In the afternoon he did it in the reverse order thirteen out of fourteen trials. I will quote from my record of his work the next morning. "Direct, reverse, direct, reverse, direct, reverse, reverse, reverse, direct, reverse, direct, reverse, reverse, direct, reverse, reverse, reverse." This is typical. On the morning of July 19, No. 1 did the act eleven times in the direct order and five in the reverse. In the afternoon twice in the direct and seven times in the reverse order. The fact is the raccoons never mechanize the order of their performances into a settled routine. Therefore if at this point of study I were asked the question, Did the animals perform the same act you put them through? I should answer, they did and they did not. They were put through most of these acts with one forepaw. They did the act with that paw, with the other forepaw and with both forepaws and exactly the same is true of those who learned the fastenings by trial and error. The question, however, may be changed to, Can the animal be made to learn the act you put him through and to employ no other? Yes, it happens that this can be easily done with these animals.

A more decisive test of the value of putting through would be, of course, one which answers the question, Does the raccoon, by being put through an act, learn to operate a mechanism which it had failed to learn by its own efforts?

No. 1 in his first work in Box 10 failed because he worked two slats loose and kept attacking them. He first failed in fourteen minutes; was put through, then failed in one minute and thirty seconds; was put through and failed in one minute and fifteen seconds and was put again through. He then did the act in six seconds. He afterward failed once, was put through and did the act in six seconds. This is, as shown above, the usual condition. The putting through helps to a quick success but does not insure permanency unless repeated more times than a reflex performance.

Box 14 was most difficult for it was fastened with a horizontal hook which had to be lifted vertically, and the raccoon cannot well lift an object vertically with his paw unless he can stand directly above it. There remained but three possible ways to lift the hook, namely, with the teeth, with the nose, or with the back of the head. The latter was done but three times in all; I think this was because in this case the animal could not see the hook become free and fall. It was really a quick and convenient way of lifting the hook. While No. 3 and No. 2 succeeded in this box, the other two raccoons failed. No. 4 failed after *ten minutes* of steady clawing. She was put through ten times by lifting the hook with her nose. She then lifted the hook with her nose after three minutes fifty-one seconds, again in sixty-one seconds, then in twenty-three, then in five, four, five and one seconds successively. Before being put through No. 4 did not attack the latch directly. It was a black hook, the box was of rather dark wood and all preceding latches had been more conspicuous both in position and color. After being put through she worked directly at the latch. If one objects that No. 4 should have succeeded in less than three minutes, I can only reply that the hook was a difficult fastening, that this is the first time the raccoons had to learn to work with the nose and that I am quite willing to grant that little or no *skill* comes from putting through. Finally, let me add that No. 4 always worked the latch with the nose, by the act she had been put through.

No. 2 also failed on the horizontal hook. To make it a certain failure I waited thirty-two minutes while he worked steadily. I put him through five times by raising the hook with his nose. He then succeeded in three and four-tenths seconds, then in seven and two-tenths, and so on. Supported by the averages of the table above, these two examples make it certain that raccoons *can learn*

*an act from being put through it, even though they have failed to learn it by their own efforts.* My own opinion is that No. 1 learned the exact act by being put through. No. 4, it is true, *may* have learned only the place to attack. To urge this objection, however, amounts to saying that the animal must have got some idea or image of the place or hook from being put through, for surely no reflex act is established in an animal whose muscles are limp. Had I not held my hand beneath her muzzle she would have let it hang down and it would not have raised the hook. So in this case especially the act of putting the animal through with uninnervated muscles gave her a motive or impulse to innervate the muscles. Personally I should judge that the hook lifting with a click and noisily falling, not more than an inch in front of the raccoon's eyes, was fully as well attended to as the place of attack. No. 1 also did not vary once from the act of lifting the hook with his nose. This is important when we compare it with the work of those not put through. I record in Table IX the trials and methods of lifting the hook of No. 2 and No. 3.

TABLE IX.

*No. 2.*

1st half-day.

1. Done with mouth.
2. Done with mouth
3. Done with mouth
3. Done with mouth.
4. Done with mouth.
5. Done with mouth.
6. Done with mouth.
7. Done with nose.
8. Done with mouth.
9. Done with mouth.
10. Done with mouth.
11. Done with mouth.
12. Done with nose.

13 to 18 incl. Done with mouth.

2d half-day.

1. Done with mouth.
2. Done with side of nose.

3 to 11 incl. Done with mouth

12. Done with nose.

13 to 15 incl. Done with mouth.

16 to 18 incl. Done with nose.

19. Done with mouth.
20. Done with nose, and always so thereafter.

Total with mouth, 30 times.
Total with nose, 8 times.

*No. 3.*

1. Done with foreleg (not paw).
2. Done with head.
3. Done with head.
4. Done with head.
5. Done with nose, and continued in this way.

It is evident, therefore, that the best method for the animal is to lift the hook with its nose. I have now shown why we should change the question, Does the animal learn the act you put him through? to the question, Can he be made to do so? If the act which he is put through is the one which will remain the easiest and most convenient for him throughout the tests, irrespective of

his position in the box, he will never vary from it. If not, he will employ your act when his position makes it convenient and he is looking at the latch you began with. He will also vary from it very often but not a whit more often than a raccoon not put through will vary from the act he seems to establish in his early trials. Moreover, an animal may begin a new way sometimes after a hundred or more trials, for example, No. 4 combined acts 1 and 6 in Box 13 after several hundred trials; No. 3 combined them much earlier; No. 2 after mounting the platform in Box 13 many times took to lifting it with both paws. When it was dropped the jerk in addition to the weight of the platform would raise the bolt. This was an awkward method and, while it occurred almost consecutively during three days' work and now and then for some time longer, it was gradually relinquished.

It would seem that enough experimental evidence has been presented to show that the raccoons do learn without innervating their own muscles. But the opposite condition as found by THORNDIKE in cats, namely, that they learn by "trial and error" only, has been made to support so important conclusions concerning the mental life of animals, that I shall risk taxing the reader's patience with a further recital of experimental tests.

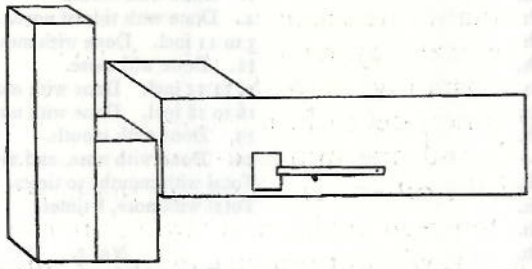

FIG. 2.

In these experiments I used the card-showing device already described, but I placed a lever holding a color on the front side of the apparatus so that the animal might learn to lift it himself. This could be done either by the nose or the paws. It was easiest at the beginning of the ascent to raise the lever with the nose but hard to elevate it thus completely. It required a vigorous toss of the head to make the lever reach the point where it would not fall back. On the other hand, while difficult to start with the

paws, it was easy to finish the ascent by that method. The disadvantages of these ways of lifting the lever were, therefore, nearly equal. Can one raccoon be taught to lift the lever with his nose, another with his paws, thus proving that more than one kind of reaction can be taught the animals by putting them through? And can they be put through the acts enough times to establish the habit in addition to what has been described as an apparent mental effect which is readily forgotten?

All the raccoons were first given trials to determine whether they would hit upon the act of raising the lever. All came to the apparatus and watched it closely. Previous experience had aroused their interest. None, however, lifted the lever nor did I expect it, for the animal was free alone in the room, and while all the individuals clawed at colors back of the board none had ever done so in frontof it.

On May 24, 1906, No. 1 was put through sixty times by lifting the lever with his nose. He was then given an opportunity to do so unaided. If he failed within approximately thirty seconds, the lever was raised and he was fed. This was done fifteen times. The seventh time he came and looked at the card when it was down, on the ninth and fourteenth he pushed at it with his nose, and on the eleventh with his paws. Although he had not mastered the performance he seemed to have made a slight approach toward it. The next day he was put through ninety-five times and succeeded instantly in performing the act on the ninety-sixth. On the ninety-seventh, ninety-eighth, one hundredth, one hundred-seventh and one hundred-tenth trials he failed, but he succeeded in all the other trials between the ninety-sixth and one hundred-tenth (fourteen in all), and always after the one hundred-tenth. On July 11, without practice in the meantime, he was perfect in the performance of the act. No. 3 learned as did No. 1, although more slowly. He did not fail after his first success, although at first, for ten trials, he lifted the lever only half way up. These ten attempts I rewarded but later he was forced to give the lever a strong toss to get food. In the cases of both No. 1 and No. 3 the movement they were put through was the one they followed uniformly.

On June 1, 1906, No. 2 was put through the act of lifting this lever with his paw one hundred times. He then did the act with his paw forty-five times in succession. On June 7, he did it fifty

times without error and on July 11 he was still perfect although without practice meanwhile. As No. 2 pursued one method throughout, and No. 1 and No. 3 the other, it cannot be said that our only crucial tests consist of reactions with the nose which are so forced and unnatural as to be poor evidence.

As to the establishment of a habit, the records are ambiguous. No. 2 was as perfect after being put through one hundred times as he would have been after eight or ten accidental successes. The other two, with more experience, were less perfect. They did not learn the toss I gave the lever, but expected food for raising it only a trifle and letting it drop back. Withholding the food brought the complete reaction.

I must explain how the raccoons showed that they expected food after the abortive performances. On raising the lever the animal stood with his forepaws on top of the front board to be fed. After every abortive effort he would take this position, then, as food was not forthcoming, he would drop to the floor and dive under the lever again with his nose. All the animals added to this reaction the act of clawing the lever down into the horizontal position so that it might be raised again. The experimenter merely had to feed the animal each time the lever was raised, and the work thus became very rapid.

Let us summarize this long section:

(1) All the raccoons began, of their own initiative, to run back into boxes into which they had hitherto been lifted.

(2) All learned to go up to the top of a box and drop through a hole into the box after having been lifted into the box repeatedly.

(3) All, after having learned to go to the end of a box, up a step and thence to the top of the box, by being lifted through these several stages of the ascent, learned to abbreviate the act by climbing directly up the front to get to the hole in the top of the box.

(4) No matter how well the animal had learned the through-top reaction, if the front door, out of which he had just come, was not closed behind him he would dodge back through that as the quickest way to re-enter the box.

(5) All four raccoons learned to undo a fastening by being put through the act. They did not in general duplicate the act they were put through, but neither did they in general duplicate the act of their first success, or of their first three consecutive successes, when these were attained by their own efforts.

(6) They could be made to duplicate the exact act they were put through by the arrangement of apparatus so that other acts were more difficult. The duplication was then perfect in all trials.

(7) The average time required for the first success after being put through is very much less than the average time for the first success by trial and error. This was true in nine out of eleven boxes and with the color showing device.

(8) Finally, the animals learned acts by being put through them which they repeatedly had failed to learn when unaided. In all these cases the act was a duplicate of that which they had been put through.

## ON THE PRESENCE OF MENTAL IMAGES.

It would seem that nine-tenths of the experimental evidence for the absence of ideas in dogs and cats comes from their inability to learn from being put through. The experiments were almost identical with some of those described above. If inability thus to learn is evidence against the presence of ideas, then ability to do so should be equally strong evidence for it. We are, therefore, already embarked on the discussion of the presence of ideas in raccoons. It seems to me that animals which, so far as we know at present, are utterly unable to learn save by innervating their own muscles must be devoid of ideas or at least "of a *stock* of images which are motives for acts." This conclusion of THORNDIKE'S is, I think, of the utmost value to those who experiment with animals, and the evidence against it in the case of cats is meager in the extreme. Therefore, I must first urge the reader to compare point by point the behavior of cats and raccoons in put-through experiments, and to note *the radical difference at every point.*

We may now consider what further evidence of the presence of mental images is furnished by the raccoons and what behavior of theirs seems to show a lack of images.

*Recognition of Objects.*—Some of the observations of this are commonplace enough. First, on the fifth day after I received the raccoons one of them climbed to a box, then to the top of a barrel on which the bottle of milk had been placed. When lifted down he at once repeated the performance. A day or so later, another,

No. 3, recognized the bottle at a distance of two feet and went to it. He was given milk, and went to the bottle again. This bottle was small and round and was almost completely covered by the hand of the experimenter when he was feeding a raccoon. Were it the whole situation the animal was reacting to, why should he not have come to me, the source of all his food, instead of making for the bottle as soon as he saw it. The act in No. 3's case was far too definite to be an accident. I think that he recognized the red rubber nipple. All of the animals now go directly to the bottle if it is set down at all, so it must be hidden. I varied the experiment by lowering the bottle into the room through a window when the raccoons were lying at rest in a remote corner. Within a minute all were clinging to the bottle and struggling to get at the nipple. Next I lowered a small piece of wood, the size of the nipple and wrapped with red cloth to appear like the nipple. All came to it. Two tried to suck it. At first they seemed unable to distinguish it from the nipple. Perhaps this indicates that they do not rely greatly on the sense of smell. When tried thus again they merely played with the piece of wood.

When working with Box 12 (six fastenings), No. 4 refused to go into the box. She was switched twice to make her do so. After this, showing her the whip would make her go in.

A case of direct searching for the bottle may now be mentioned. On being released from the large cage in which they were confined during experiments, No. 4 went directly toward the corner of the room where she had some days before found the bottle. The total distance was ten feet, but she could not have seen the bottle until she came around a box within two feet of it. All the other raccoons were seen to do this.

No. 3 was reluctant to go into a complicated box and he formed the habit of biting when I attempted to lift him into it. I held him and thrust a finger down his throat, then whipped him. For five days afterward he would growl, snap at and retreat from me though still on good terms with my assistant, Mr. ERWIN.

*Forgetting.*—After three days without practice in Box 2, No. 4 seemed almost to have forgotten how to work it. There was no directness in her movements and her time records were poor. A period no longer than three days should show no influence of this sort on a well established reflex, and all records agree, I believe, in indicating that a period of some weeks or months would not

suffice to show any great falling off in the skill of dogs and cats.

In complicated boxes all the raccoons had periods of forgetting one fastening only. Sometimes this fastening was forgotten during two or three days. Often my notes read as follows. "Aug. 5, Box 11, Dolly (*i. e.*, No. 4), forgot loop 2 today in three out of four consecutive trials. Jack (*i. e.*, No. 1), forgot button 1 almost invariably *except when he pulled loop 1 first. In those cases he turned button 1 next.*" Does this not give us an important distinction between a reflex and an association? The reflex has but one cue, an association many. Jack did not forget button 1 when he pulled loop 1 first. This had become partly habit because I had built the box up from two fastenings and when it had two he usually pulled the loop first, then turned button 1. Later when I was reviewing Box 13 after periods of one hundred forty-four and one hundred forty-seven days respectively, each of the animals (except No. 3) failed on some particular latch or two latches, not on all, nor on one latch in one trial and another in another. If they had settled down to a routine order of working this box, I venture to say that not one of them would have failed after two hundred days or longer. The recall(?) in this case would have been, like that of a boy in swimming for the first time since the preceding summer, perfect. No. 3's work gives evidence of this. He alone gave a pair of duplicate performances in Box 12 (six fastenings). Thus, on August 18, in the twelfth trial he worked the fastenings in the following order:

(12) 5–2′–2–5–6 & 1′–5–1–5[1]
(13) 5–2′–2–5–6 & 1′–5–1–5.

The eighth and ninth trials were almost duplicates and there were other partial duplicates. After one hundred forty-seven days without practice No. 3 alone escaped from Box 13, which was Box 12 with one added fastening. I attribute his success entirely to the superior mechanization of his performance. KINNAMAN says of monkeys, "When the group consisted of two or three fastenings the monkey soon adopted a regular routine which he rarely failed to follow." I infer from this that the monkey did not do so with more than three fastenings. The raccoons did not with only two fastenings. I have show that No. 2 followed

[1] "6 & 1" means both latches simultaneously.

one order predominantly in the morning, and the reverse in the afternoon of the same day, and in general with two fastenings the two orders appeared alternately. Consequently I should say that the monkeys are superior to the raccoons as habit-formers. The raccoons operated almost as complex mechanisms, but they could not reduce the performance to routine. Finally, if the natural history books are to be believed, trappers, in order to ensnare the raccoon depend not on his habits but on his instincts. The trap is not put where he habitually enters the stream, for he enters all along it; instead a bright swinging object is hung over the trap so that in reaching for it he steps on the trigger. Finally: a corollary of the proposition that there are two types of learning, namely, learning by trial and error and learning by means of ideas, should be that there are two types of forgetting, distinguished especially by their time intervals. This, our records seem to show when compared with those for dogs and cats.

*Variability.*—In addition to having no fixed order for groups of fastenings, the raccoon changes his method of reacting to a single fastening. I have shown that which paw he uses depends on his position with regard to the latch to be unfastened (*cf.* p. 225). As already stated, No. 2, who had learned perfectly to lift the horizontal hook with his mouth finally changed to lifting it with his nose. Finally, raccoons which have done two acts separately hundreds of times may suddenly come to do them simultaneously. No. 3 and No. 4 depressed the platform and pulled loop 1 in Boxes 12 and 13 at the same time. Others occasionally worked the thumb-latch and a button at once, and sometimes two buttons were depressed simultaneously.

*Association by Similarity.*—If a latch similar to another be added to a group of fastenings, but in a different place, it may be attacked and worked first. I cannot say certainly that this is untrue of a dissimilar fastening for, while it was not the fact with the horizontal hook, the wooden plug or the platform as a platform, it would probably have occurred with the thumb-latch had I not first used it singly. The vertical cord leading down to the platform was jumped at directly and vigorously pulled by No. 1 as soon as he saw it, as if he thought it another loop; later he learned to jump upon the platform. He also worked a second barn-door latch before the first one, with which he was familiar. The second was two inches above the first. All the animals would

pull a second loop with one direct pull, though it was in a different part of the box, and the same is true of a second button placed on the opposite side of the door from the first. Now, no one can meet the argument that this is not the noticing of similarity but a failure to notice differences and I have said above that Jack attacked the platform cord "*as if* he thought it another loop." We may ask, however, Why he did not so attack the horizontal hook or the wooden plug? It will not do to reply that they were in new places. It may answer to say that they were more difficult, but even then they should have been *attacked*, by one of the raccoons first, even if unsuccessfully. All this is no doubt inconclusive. I may say, however, that the raccoons did not give the same experimental warrant for this dialectic reply that cats do. That is, unlike cats, they did *not* paw at the place where the loop had been nor did they claw at the loop or button when the door was open. I tried moving the loop from place to place in the boxes. Not once even did they claw where it had been; instead they attacked it at the new place with one direct movement. I removed from the box one loop and then another. Each of the raccoons would come to the place where the loop had hung and look up through the slats in the top of the box. Once I had left the loop lying on the top. It was seen by the raccoon, clawed back into the box, and then pulled. With each of the boxes I tried leaving the door open. The raccoons came directly out with no movements in the direction of the fastenings.

*Reluctance and Expectancy.*—All of the raccoons when hungry were eager to re-enter a box of two, three, or four fastenings. They could escape from these quickly. But they were very reluctant, even when hungry, to enter a box of five, six or seven fastenings. The small piece of meat they received as a reward seemed to have its effect eclipsed by the memory of the difficulty of escape. I regularly had to put them in Box 13, though they knew the way. Sometimes they resisted strongly by laying hold of the sides of the door and sometimes by snapping at the hand of the experimenter at the moment they were dropped into the box.

No raccoon would willingly re-enter a box of from one to four fastenings after his hunger was satisfied. One may say that in this case the sensations of satiety and weariness did the work, yet no one who saw the animals resist being put into a box failed to credit them with a rather distinct memory of the difficulty of escape.

In common with other animals, the raccoon expects food when he has done the thing which usually brings him food. All would come and look up at me on escaping from the box. I tried to test this at some length. An inclined plane of poultry wire was made and No. 3 was fed when he climbed to the top of it. After a few trials the plane was extended twenty-eight inches. When he reached the former terminus he stopped and looked at the experimenter. The plane was again lengthened with the same result. He always failed to go beyond the old point on the first trial, but on the second he would pause at that point, look about and then go on.

*Varying Means to the Same End.*—While No. 3 was on top of Box 16 a piece of apple was dropped through the top. He started down the back side of the box to get it. The door at the back was closed so he came slowly around the long cage into the front door, through which he had never entered before but through which he had escaped, and got the apple. This was repeated. He was fifteen seconds coming around the cage, but three or four seconds were wasted in trying to reach through the wire to get the apple. When this was repeated again, he was twenty seconds coming around but did not reach through, as the apple was too far from any side of the cage for him to reach it. In this case he certainly would have entered the cage at the back had the door been open. As it was closed, he came around to the front door. Furthermore, in the third repetition, he would have tried to reach the apple through the wire had it not been too far away.

In the above examples No. 3 may have seen the apple all the time, though this is doubtful. Box 17 was such that food placed in it could not be seen from outside. It was ten inches square and four inches high, with closed sides. A three inch square was sawed out of the top. This piece could be put in place again thus closing the opening. A staple was fixed in the center of the piece sawed out, so that it might be clawed out and away from the opening, which it fitted closely.

The plan was to throw bits of apple into the box through the opening in its top, allow the raccoon to reach in and get the apple several times, then cover the opening with the piece which had been sawed out. After this had been done with No. 4 she *instantly* clawed out the block. She seemed to work as if actuated by a thought of apple in the box. It was not done by random clawing,

nor could she smell or otherwise perceive the piece of apple in the box. Her work was based entirely on the former experiences of having found apple in the box when open. No. 3 clawed directly at the block but failed to dislodge it; tried once more and succeeded.

I now varied the experiment by using Box 18. This was large and had a square sawed out of the top large enough to permit the animal to crawl through the top. No. 1 secured food twenty-five times by going through the top. The box had no bottom and instead of resting directly on the floor it rested on a row of bricks. Removing one of these made an opening under the lower edge of the box through which the raccoon might crawl. The opening in the top was now closed and nailed fast. No. 1 was freed, went to the top of the box and tried to claw out the block. He then walked about the room then tried the block again. He then went to the opening made by removing the brick, stopped a moment, then crawled in. Total time, 100 seconds. Thus No. 1 learned to go in by either the upper or lower opening, but when the one through which he had been fed last was closed, he would hesitate a moment, then go to the other. Finally the side opening was closed and over the opening in the top was placed end-wise a cylinder eighteen inches high made of a roll of poultry wire. No. 1 was freed. He walked around the roll of wire which thus fenced in the opening in the box. He then climbed up the outside of this roll and down the inside of it, into the box. The time from his release until he entered the box was thirty seconds. No. 4 went directly into the lower opening at the first trial; time, seven seconds. No. 2 failed to go in through the roll of poultry wire. Thus all but he turned almost directly from the opening, which they knew and found closed, to another opening and entered through that one. They could not see the apple for it was dark inside the box, nor could they smell this particular piece of apple for the room was full of the odor of apple. It seems to me that they must have retained an image of "apple-there." I should not urge this point, however, if I did not think that the following experiments give substantial evidence of the presence of visual images.

In concluding the description of experiments in discriminating cards of different colors and intensities, I pointed out that successful reactions demand that the raccoon compare a color which has

just *disappeared* with one now present. Either this or else the animal must keep track of the number of times the colors are shown, going up every other time when the colors appear alternately, every third and fourth time when they appear by twos, etc. This second explanation violates the law of parsimony, of course, and was eliminated by the fact that I secured series of perfect reactions when the colors were shown at random. When I changed for the first time from alternate showing to twos, or from twos to threes, there resulted confusion and errors quite sufficient, I think, to show that the animals distinguish one movement from two or two from three (a species of counting). As this was of no avail when the colors were shown at random, I also believe that the animal must have retained some sort of image or visual impression of the absent color and reacted to it. The experiment now took a form which shows this more clearly. Spontaneously several of the raccoons had been clawing the "no-food" card down and sometimes they clawed the "food" card up. Finally, all but No. 4 became fairly proficient in this. I quote one of the records made by No. 1 (Jack), after much training.

TABLE X.

| Trial. | Green. | Red. | Remarks. |
|---|---|---|---|
| 1 | * | — | .....He clawed green up and was fed. |
| 2 | * | — | .....He clawed green up and was fed. |
| 3 | * | — | .....He clawed green up and was fed. |
| 4 | * | — | .....He clawed green up and was fed. |
| 5 | * | — | .....He clawed green up and was fed. |
| 6 | * | — | .....Put red up, looked at it, then put it down, then put green up. |
| 7 | * | — | .....Put red up, then put green up. |
| 8 | * | — | .....Put red up, then put it down. |
| 9 | * | — | .....Leaving red up, he put green up. |
| 10 | * | — | .....Put red up and left it up, then put green up. |
| 11 | * | — | .....Put red up, then down, then put green up. |
| 12 | * | — | .....Put red up and left it up, then put green up. |
| 13 | * | — | .....Put red up and left it up, then put green up. |
| 14 | * | — | .....Put red up, then down, then put green up. |
| 15 | * | — | .....Put green up. |
| 16 | * | — | .....Put red up and left it up, then put green up. |
| 17 | * | — | .....Put red up and left it up, then put green up. |
| 18 | * | — | .....Red up, then down, then green up. |
| 19 | * | — | .....Put red up then green up. |
| 20 | * | — | .....Put red up and down twice, then green up. |
| 21 | * | — | .....Green up. |
| 22 | * | — | .....Green up. |
| 23 | * | — | .....Red up, then down, then green up. |
| 24 | * | — | .....Put green up. |
| 25 to 30 incl. | * | — | .....Put green up. |

"April 19, 1906, Jack. Apparatus, card-displayer as usual. Colors green and red. Fed at green. Green in front and shown first. It is to be shown three times and Jack fed if he responds; then red is to be shown three times and he will not be fed. This order to be maintained except when Jack interrupts it by clawing up colors."

No. 2, No. 3 and No. 4 also made very fair records, but never quite so good as those of No. 1.

When the animal thus reacts perfectly to red and green, and in addition busies himself in clawing the red card down and the green card up, surely his discrimination of the two is perfect. Now we are forced to ask, *Why should he put the red card down if it did not fail to correspond with some image he had in mind,* and why when he put the green up should he leave it up and go up on the high box for food *if the green did not correspond with some image he had in mind?*

The reader may ask why the animal did not always claw up the right card if he knew the right one. The colors could not be seen when the cards were down behind the front of the displayer, nor could I place them where they would be seen, else as soon as the green card was exposed the animal would go up for food repeatedly without further clawing.

Using the card displayer, I now arranged two situations which were identical so far as present sense stimuli were concerned. The only difference was one which had to be remembered, for a moment at least. Three levers were placed on the displayer. One on being raised displayed white, another orange, another blue. The plan was to display white, orange and blue consecutively, then display the same blue three times. I fed the animal if he climbed upon the high box on being shown the series white, orange, blue, and did not feed him after the series, blue, blue, blue. No. 1 was taught to react properly in this experiment. I then changed the two series to white, blue, red, food; and red, red, red, no food.

This I taught to No. 2, No. 3 and No. 1. The records of their learning, in groups of fifty trials each, appear below. The later records show that there was almost complete mastery of the situation, though I never *completely* inhibited the animals' tendency to start up on seeing white or blue which were precursors of the red which meant food. Thus the animals all anticipated

red on seeing its precursors, which in itself seems good evidence of ideation. Many times, however, they turned back after starting at blue or white and looked for the red, then climbed up once more, thus showing that the red was not a neglected element of the situation but an expected color which they generally waited to see, but sometimes were too eager to wait for. Because of this frequent turning back and waiting for red, I am certain that going up to white and blue in the later trials was due to expectation of red to follow. Not so in the earlier trials with No. 2 and No. 3. Their numerous early errors at blue were due to the fact that they had heretofore been trained with two colors, hence they went up most frequently at the second. Although in the case of the two-color training the colors were presented in varying order, the food color must always appear next after the no-food signal so that the one, two, relation was deeply fixed. Furthermore, at the beginning of the two-color tests the "food" and "no-food" signals were given alternately. No. 1, on the other hand, had been previously trained with three colors and now although blue, his former food signal, was placed second as a no-food color, he made the mistake of reacting to it only ten times in the first fifty because *it was not third*, while he did go up to the final "no-food" red twenty-seven times *because it was third*. It seems certain, therefore, that raccoons are able to learn to distinguish one object or movement from two and two from three, a species of counting not differing from that which anthropologists ascribe to primitive man (see Table XI).

In the fourth group of fifty trials it will be noticed that No. 1 failed to respond four times, while two is the maximum number of preceding failures in any group of fifty. This occurred because in this and succeeding groups I gave each series of colors twice The previous alternate showing of each series caused hesitation and failure to go up. I think his behavior also distinctly showed doubt. In the same group of reds he stayed down 37 times, while in the next group he stayed down only 28 times. May not the difference of 9 trials be ascribed to his uncertainty? It will be seen that this change of order increased his mistakes in reacting to white, blue, and the first two reds. All the mistakes accredited to first red after the one hundred-fiftieth trial are reactions to the fourth red which, of course, had to be recorded as occurring as the first red of a second series. All this, I think, shows that introducing the new order, each

series twice, was puzzling to the animal and caused him to react to the fourth red and to increase the number of "no reactions."

Finally, every doubtful case was recorded against the animal; thus if a raccoon started up just as red, after white and blue,

TABLE XI.

*No. 1.*

| Experiment. | White. | Blue. | Red. | Failed. | Red. | Red. | Red. | Perfect. |
|---|---|---|---|---|---|---|---|---|
| 1–50 | 2 | 10 | 36 | 2 | 6 | 9 | 27 | 8 |
| 51–100 | 0 | 5 | 43 | 2 | 3 | 8 | 34 | 5 |
| 101–150 | 1 | 5 | 43 | 1 | 1 | 3 | 23 | 23 |
| 151–200 | 0 | 2 | 44 | 4 (shown twice) | 0 | 6 | 7 | 37 |
| 201–250 | 0 | 2 | 43 | 5 (shown twice) | 1 | 10 | 11 | 28 |
| 251–300 | 3 | 5 | 39 | 3 (shown twice) | 1 | 9 | 8 | 32 |
| 30–350 | 0 | 13 | 36 | 1 (shown twice) | 7 | 6 | 8 | 29 |
| 351–400 | 0 | 1 | 49 | | 2 | 2 | 2 | 44 |

*No. 2.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1–50 | 11 | 20 | 19 | | 3 | 18 | 28 | 1 |
| 51–100 | 4 | 22 | 23 | 1 | 6 | 16 | 25 | 3 |
| 101–150 | 2 | 29 | 19 | | 2 | 30 | 17 | 1 |
| 151–200 | 5 | 34 | 11 | | 1 | 10 | 26 | 13 |
| 201–250 | 2 | 5 | 41 | 2 | 2 | 7 | 32 | 9 |
| 251–300 | 4 | 21 | 25 | | 3 | 9 | 17 | 21 |
| 301–350 | 2 | 7 | 41 | | 3 | 4 | 21 | 22 |
| 351–400 | 5 | 23 | 22 | 351–381 | 0 | 0 | 0 | 30 |
| 401–450 | 9 | 7 | 32 | 2 | | | | |
| 451–500 | 7 | 15 | 28 | | | | | |
| 501–540 | 6 | 8 | 25 | 1 | | | | |

*No. 3.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1–50 | 11 | 19 | 19 | 1 | 10 | 20 | 19 | 1 |
| 51–100 | 10 | 18 | 22 | | 10 | 18 | 22 | 0 |
| 101–150 | 6 | 16 | 27 | 1 | 4 | 25 | 15 | 6 |
| 151–200 | 5 | 14 | 30 | 1 | 0 | 8 | 19 | 23 |
| 201–251 | 2 | 19 | 25 | 4 | 3 | 7 | 12 | 28 |
| 251–300 | 1 | 18 | 31 | | 2 | 4 | 10 | 34 |
| 301–350 | 3 | 8 | 36 | 3 301–327 | 0 | 0 | 2 | 25 |
| 351–400 | 2 | 5 | 43 | | | | | |
| 401–426 | 3 | 1 | 22 | | | | | |

came into view, it was counted as a response to blue unless the experimenter *saw* the animal look at the red. Therefore, the animals might now learn three new cards more quickly. Their previous training on the other hand made them very attentive to the cards and was greatly in their favor. Untrained raccoons probably could not do nearly so well, but these undoubtedly did a trifle bet-

ter than the records indicate. The point at issue, however, is not the rate of learning, but merely the question whether these animals did learn to discriminate two situations in which *the present sense stimuli* were identical, namely, two red cards. I set as an arbitrary standard of mastery twenty-five successive perfect responses. More than this was attained with No. 1, giving each series once, and again giving each series twice. I attained it for the series of reds with both No. 2 and No. 3, and so nearly attained it with the other series that no doubt remains of their practical mastery of the situation.

This appears more clearly if we realize that had the animal climbed up at every card of the white-blue-red series, he would have made one hundred mistakes and only fifty correct responses in fifty trials. Yet the animal was very eager to go up on the box. All the food he ever had when colored cards were shown he received at that place. With this chance for mistakes the record seems conclusive.

Does the method of the experiment warrant the claim that the animal *retains* an image of the cards which just preceded red? For No. 1, success meant first, that he respond to red preceded by white and blue, now both out of sight, and that he refuse to respond to red preceded by two reds, now both out of sight. Later he must refuse to respond to six reds in succession, but continue the old response to white-blue-red now given twice in succession. Certainly no counting can enter here. The other two learned the alternate order as rapidly as No. 1 in the light of his previous three-color training. Therefore his work is typical.

The behavior of all three animals happens to be more conclusive than the records of their learning, for each one, on seeing the first red, would drop down from a position with both forepaws on the front board to stand on all fours on the floor in front of it and merely glance up at the succeeding reds. As soon as the white appeared, however, the animal would lean up against the front board, claw down the white and the blue but *never the final red*. Moreover he kept his eyes directed on the point at which these colors appeared and promptly clawed them down. Now does not the law of parsimony demand that these reactions be explained as due to visual images with which the animal compared the appearing card? The turning back and looking for the final color, when the impulse to start up is strong, and the few failures to respond at all,

in most of which the animal seemed not to have remembered what colors had preceded the red, suggest that it does.

It may still be objected, that retaining an image while you raise three or even six colors is hardly retention at all, so short is the time. Of course the fact that the animals made steady and rather uniform progress for six days would show that the impression was not effaced in twenty-four hours. No. 1, however, was given a review of his first three-color work after an interval of eighteen days. He did not respond to the three blue cards at all and made but one mistake in twenty trials to the series white-orange-blue, though he did *start* up at orange six times. The visual images of the colors must therefore have been retained for eighteen days with sufficient clearness to permit successful responses. As No. 1 does not differ from the others in memory power this result may be accepted as typical. We are, therefore, forced to believe that the raccoon retains visual images.

## SUMMARY.

1. In the rapidity with which it forms associations the raccoon seems to stand almost midway between the monkey and the cat, as shown by the numerical records for those animals. In the complexity of the associations it is able to form it stands nearer the monkey.

2. Long practiced motor associations show a good degree of permanence; others are very transient. The raccoon presents two types of learning and two types of forgetting.

3. The raccoon discriminates forms, sizes, and tones. It also discriminates cards of different colors and intensities, but it probably responds to the latter quality alone.

4. I have no evidence that the raccoon imitates its fellows. Long attention to the experimenter's movements apparently arouses in the animal an impulse to attempt the act itself, but this impulse may be entirely spontaneous.

5. The raccoon certainly learns various acts from being put through them (see summary, p. 248).

6. My experiments indicate the presence of visual images.