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A TEST OF ONE ASPECT OF CONTIGUITY THEORY[1]

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Guthrie's theory of learning holds that temporal contiguity of stimulus and response is a necessary and sufficient condition for learning. The apparent effectiveness of reward as a determiner of learning is explained as being due to "removal from the situation." That is, response to the reward precludes further response to stimuli that have already entered into association with the rewarded responses, and thus preserves the "correct" associations in the same way that physical removal from the situation would. A direct test of this proposition involves removing the animal from the situation and observing whether or not the last response made before removal is learned. Removal may be physical (**3**) or it may involve removal of a class of stimuli (**4**). Results tend to be ambiguous because of the difficulty of saying, on the one hand, that removal was *immediate*, or, on the other hand, that removal had no primary or secondary rewarding characteristics. There are, however, implications inherent in the theory of learning by contiguity which lead to deductions that afford an indirect test, and such a test is presented here.

In applying contiguity theory to the learning of a simple T maze, one would expect that *S* would learn the incorrect turn after once having made that choice. As *S*s always tend to repeat the responses last made in a stimulus situation, contiguity theory is confronted with explaining how *S* learns the correct turn and "unlearns" the incorrect one. The problem is that of showing how outcomes of choices affect behavior at the spatially and temporally separated choice point where learning is displayed. In terms of contiguity theory this can only occur through the formation of associations involving stimuli which are operative both in the goal box and at the choice point. One way in which this may occur has been suggested by Guthrie and involves proprioceptive chaining. The relevant stimuli may be exteroceptive, interoceptive, or proprioceptive; this need not be specified for the present account, but for convenience of exposition we may assume that the stimulus consists of a light over the goal box which is visible at the choice point. According to the principle of contiguity, the light must become a cue for responses made in its presence and therefore must become associated with the approach responses made by *S* in making its first rewarded choice. By responding to the reward *S* is immediately removed from the stimuli in the maze and the approach responses are "preserved" intact as the last responses to that situation. On subsequent trials these responses are elicited by the light at the choice point and *S* is always led to the correct box.

In this manner the theory adequately explains how learning by strict contiguity of stimulus and response may be extended over spatial and temporal voids in fixing the correct response. Why then is the incorrect turn not similarly repeated after once having been made? In order to answer this question contiguity theory must necessarily hold that the last responses made after an incorrect choice are not conducive to repeating the choice. In contrast to the last responses to the lighted, rewarding choice, the incorrect choice results

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in last responses that are random and variegated in direction. As these responses occur in the presence of darkness, they will be elicited on subsequent trials at the choice point if *S* orients toward the unlighted box. However, because of the indeterminate nature of these responses, they will not necessarily lead *S* back to the unrewarded choice. For example, the last responses to the unrewarded box are often those of escape, and when elicited on subsequent trials lead *S* to the alternative or correct box. These responses take precedence over the original associations of approach because of their later attachment to the stimulus of darkness (**2**, p. 96). In this way the incorrect turn is "unlearned" by the interference of these new, incompatible associations, and *S* learns the maze.

Now it becomes evident that such an explanation based on last responses may be investigated in a situation in which last responses are similar after both rewarded and unrewarded choices. If last responses of a variegated nature result in "unlearning" of unrewarded choices on subsequent trials, they should similarly affect rewarded ones. If *S* were retained in the goal box after reward, further interfering responses would be made and associated with stimuli (e.g., the light) which had previously been associated with approaching the reward. These last formed associations would now tend to be dominant and should interfere with the "correct" approach movements which are elicited at the choice point, slowing the learning of the correct turn. It is the purpose of this investigation to test this contiguity explanation by comparing learning with, and without, this element of delay after reward.

Method

Subjects.—Forty-two male albino rats, 90 to 180 days old and experimentally naive, were used. They were divided into two groups of 21 rats each, as described below.

Apparatus.—The apparatus consisted of a conventional T maze with 30-in. arms, 6 in. in depth and 4 in. wide. The goal boxes were slightly modified by equipping them with drop bottoms. This modification was intended to standardize removal of all *S*s and insure removal at a given time. The only illumination in the room was a 7-w. bulb over the rewarded goal box. This was controlled by a double-throw, double-pole toggle switch mounted on the shield, making it possible to alternate the light dependent on the box to be rewarded.

Procedure.—All *S*s were randomly assigned to a control or experimental condition and to the box in which they were to be rewarded. The order in which *S*s received their one trial per day was held constant throughout the experiment in order to stabilize the 23-hr. deprivation from day to day. The reward consisted of a $\frac{1}{8}$-gm. pellet of their regular laboratory chow diet. The control *S*s were removed from the goal box immediately after consuming the pellet, whereas *S*s in the experimental group were retained for 60 sec. after consuming the reward. This delay was determined by a pilot group and selected as one in which all *S*s had finished grooming and had engaged in further (interfering) responses. In order to equalize time spent in both boxes, the control *S*s were retained in the unrewarded box for 45 sec. in the event of a wrong turn and the experimental *S*s for 105 sec. The 45-sec. delay was mean consumption time for the $\frac{1}{8}$-gm. pellet as determined by pilot study. All *S*s were run until the slowest had attained five successive correct choices.

Results

In terms of the contiguity interpretation of interference from the delay, there is an antecedent expectation that the delayed *S*s' performance should differ from that of the nondelay group in the following respects: (*a*) The delayed group should show fewer successful (rewarded) choices; (*b*) they should require more trials to reach a level of proficiency; (*c*) they should display less "stereotypy" (tendency to repeat the choice of the previous trial); and (*d*) they should require more time to attach relevant cues to relevant responses, significantly increasing the running time of the maze.

The first three assumptions were tested by *t* tests of significance and yielded values of .53, 1.00, and .85, respectively. A *t* of 2.02 was needed for the .05 level of significance. The

mean latencies for the two groups were compared by graph and t test ($t = .31$) and found to show no significant difference. As an additional precaution against overlooking differential group rates of learning, the number of animals per group making correct turns on successive trials is compared in Fig. 1. It is worthy of note that the levels of proficiency are comparable at any given trial as well as at termination. This further exemplifies the lack of difference between the groups also indicated by the statistical measure. However, it must be noted that these different approaches to the data are not independent measures.

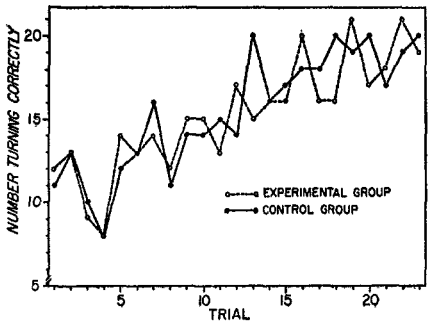

FIG. 1. Group performance on successive trials

DISCUSSION

From the foregoing analysis it is apparent that the results are not in accordance with expectations from contiguity theory. There are at least two possible explanations from the contiguity position: (*a*) If the reward was insufficient to terminate the sequence of behavior which led to it, there would be no ensuing interference, merely a continuation of the sequence. In this instance, this explanation could have accounted for the equality of the groups only if there had been no learning. (*b*) Reward serves to terminate sequences and/or change the state of the organism sufficiently that subsequent acts are allied with a different stimulus pattern (1, p. 53). If this were the case in this investigation, the interference would have failed to develop as a result of delay after reward since the subsequent responses would have been allied with a stimulus state other than that associated with approaching the choice point. The random behavior in the empty goal box in this instance would get associated with the same stimuli which are operative at the choice point, whereas random behavior following reward would be associated with a different set of stimuli. The data presented here cannot answer this argument, but the results of other investigations indicate that it cannot be applied. For example, we can be fairly certain that the rats would still have learned had they been run under conditions of massed practice, rather than one trial per day. Furthermore, in the Skinner box an animal consumes a comparable reward and immediately returns to the lever for another. Both considerations suggest that within 1 min. after consumption of reward, the rat is returned to approximately the same stimulus state that had previously evoked the correct response.

SUMMARY

It was shown that contiguity theory leads to the prediction that delay in the goal box after reward should retard learning. This deduction was tested by comparing performance in a T maze of a group removed from the goal box immediately after consuming the ⅓-gm. reward with a group retained in the box for one additional minute after reward. With 21 rats per group, there was no evidence of the difference predicted by contiguity theory.

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