Prolonged duration of the "novelty effect" following prolonged exposure to a single discriminandum*

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Rats were exposed for approximately 1 month to a single stimulus mounted on the home cage wall. During discrimination training, half of the Ss had the exposed figure as the positive stimulus and half the exposed figure as the negative stimulus. Control Ss had no pattern mounted on the wall. The results indicate that when the exposed figure was the positive stimulus, the Ss made significantly more errors than the control Ss, but when the exposed figure was the negative stimulus, the Ss made significantly fewer errors. These results are consistent with the exploratory literature, which suggests that exposure to a stimulus will reduce the invitational properties of that stimulus relative to a more novel stimulus and thereby will affect the probability of selecting one stimulus over another, at least for a period of time, in a discrimination task.

The literature on exploratory behavior suggests that exposure to a single stimulus will reduce the tendency to explore the exposed or more familiar stimulus and will increase the tendency to explore the more novel stimulus under conditions where the familiar and novel stimulus are presented together and the animal is "free" to select either of the two stimuli. It remains to be demonstrated that the tendency to approach the more novel stimulus might have any significant effect in a learning situation, such as discrimination learning.

An experiment by Walk, Gibson, Pick, and Tighe (1958) found that exposure to a single stimulus does affect discrimination learning but not in the way that is suggested by the literature on exploratory behavior. The exploratory literature, it seems, would predict that the individual would tend to approach the novel stimulus over the familiar stimulus at least for a period of time. If the individual was rewarded for approaching the novel stimulus, learning would be faster, but if the S was rewarded for approaching the familiar stimulus, learning would be slower. Walk et al found, however, that compared to controls, Ss that were exposed to a single stimulus learned faster irrespective of whether they were rewarded for approaching the exposed or the more novel stimulus. They did find a slight "novelty effect" but, although statistically reliable, the effect was transitory and had no significant effect on speed of learning the discrimination.

The experiment reported in this paper was undertaken in order to determine whether a more prolonged novelty effect could be produced and whether, as a result, the course of discrimination learning would be altered in the direction predicted by the exploratory literature. The possibility that a more prolonged novelty effect can be produced is suggested from the observation that stimuli differ, among other ways, in terms of their ability to elicit exploratory or approach responses. Some stimuli

possess more of what Berlyne (1960) calls "arousal potential" and what Dember and Earl (1957) call "goal-properties" or "complexity." If an organism is exposed for a sufficiently long period of time to a stimulus high in arousal potential or complexity, satiation should occur for that and possibly similar stimuli, thereby effectively altering the ability of that particular stimulus to elicit exploratory or approach responses in the immediate future. When such a stimulus is then paired with a stimulus that is not only novel but high in arousal potential or complexity, the novelty effect should not only be strong but should persist for some time: the duration being governed by the speed with which the organism satiates for the arousal or complexity properties of the novel stimulus.

The stimuli used in the present study were selected because they have been used in a number of studies investigating various parameters of exploratory behavior and have been found to elicit reliably approach or exploratory responses (e.g., Dember, Earl, & Paradise, 1957; Sackett, 1967; Franken, Kolb, & Wenger, 1969). Some of the Ss were exposed to one of the stimuli of the pair while others were exposed to the other member of the pair. If the stimuli selected for this study do, in fact, possess greater amounts of "arousal" or "complexity," learning should be significantly faster when the novel stimulus is the rewarded stimulus and significantly slower when the familiar stimulus is the rewarded stimulus.

METHOD

Subjects

The Ss were 24 male hooded rats, 111-123 days old at the time of testing.

Apparatus and Stimuli

The apparatus was a standard Wisconsin General Test Apparatus illuminated by two 20W fluorescent bulbs. The foodwells in the 13 x 15 in. formboard were 1 in. in diam. In

*This research was supported by Grant APA-170 from the National Research Council of Canada.

order to test the animals in their home cage, the cage was transported to the test room and placed adjacent to the formboard. A screen was lowered between the cage and the formboard between trials.

The patterns that were mounted on the cage wall during the exposure period and the patterns used in the discrimination task were $3 \times 3\frac{1}{2}$ in. and made by fixing white "counter-top" material to 20 ga tin plates and then overlaying the white with black plastic electrician's tape. The vertically divided stimulus (VD) had $1\frac{1}{2}$ in. of white on the left and $1\frac{1}{2}$ in. of black on the right, while the vertically striped stimulus (VS) started with $\frac{3}{8}$ in. white on the left and alternated white and black. The stimuli had a base 3×3 in. which covered the foodwells.

Design

There was a period of preexposure which lasted 28 days. Following preexposure, the rats were pretrained in order to teach them the responses that were necessary to operate the apparatus. On completing pretraining to a predetermined criteria, all rats were given discrimination training.

Preexposure Phase

Twenty-eight days prior to discrimination training, each rat was housed in a cage 18×9 in. high, constructed from 1×1 in. 16-ga galvanized cage wire. The cages were set in wood chips on galvanized metal trays, and each cage had a water bottle and a food dish. Two cages were placed side by side inside an enclosure that measured $24 \times 24 \times 12$ in. high. These enclosures were placed on tables at one end of the colony room. The stimuli to which the Ss were exposed were placed on the side of the cage so that the stimuli were back to back for the two adjacent animals. The purpose of putting two cages side by side was to simulate more closely the "social" type of conditions that other rats normally experience in the colony room.

The stimuli were located on the outside of the cage wall in approximately the middle of the 18×9 in. wall. The stimuli were a short distance away from the cage wall and were positioned at a slight angle (1 in. at the base, 1.5 in. at the top, and 1 in. above the base of the wire cage so as to prevent wood shavings from obstructing any portion of the stimuli). This position of the stimuli was employed in order to make the rats' perspective of the stimuli during testing and preexposure as similar as possible. The stimuli were sloped back in testing, because it was found that unless they were sloped in this way, an abrupt push at the bottom of the stimulus would sometimes result in the stimulus falling forward rather than simply sliding backwards on the formboard.

In the last 2 weeks of the preexposure phase, the rats were placed on a 22-h food deprivation and 2-h ad lib feeding schedule. During the 2-h feeding, pellets of rat food were simply placed in a food container attached to the wall opposite the stimulus. A water bottle was mounted at one end of the cage. The position of the water bottle was constant for all Ss.

A third of the rats were exposed to the VD stimulus, a third to the VS stimulus, and a third had no stimulus (NS) for a period of 28 days prior to training. The stimuli were removed from the cage just prior to testing and were not returned.

During both pretraining and testing, the rats were transported to the test room in their home cage as well as allowed to work from their home cage. In order for the rats to work in the WGTA, it was necessary to modify slightly their home cage. The 1-in. vertical bar that was directly in front of each of the two discriminanda was removed. This gave the rat a 2-in. wide and 1-in. high opening to work from. While this opening is small, the rat was able to displace the discriminanda with its nose or paw, retrieve the food and at the same time was prevented from leaving the home cage through this opening.

Pretraining Phase

Pretraining began by allowing the rats access to a reward from either foodwell, both of which were uncovered. After the rat had taken food 15 times (with a maximum of five times per day) from each foodwell, two white pretraining discriminanda were introduced 1 in. behind the foodwells. They were gradually moved forward until the rat had to displace the discriminanda to obtain the reward. Discrimination training began when the rat had displaced both pretraining discriminanda five times. If the rat made the first five trials to one side, the remaining five trials were "forced" (i.e., only one discriminandum could be displaced).

Discrimination Training Phase

In the training phase, half of the Ss in each exposure group were required to approach the stimulus to which they had been exposed while half were required to approach the more novel stimulus and to avoid the stimulus to which they had been exposed. Half of the nonexposed rats had to approach the VD and half the VS stimulus. All rats were trained for 10 trials a day. The sequence was a 20-trial Gellermann series, using a modified correction procedure. If an animal made an error (the negative stimulus was displaced) the formboard was pulled back, the displaced card again placed over the foodwell, and the formboard was moved forward. In this way, a trial was completed only after a S made a correct choice.

Training was completed when each rat reached the probability criterion outlined by Grant (1946). This criterion contended with the problem that the probability of a rat reaching criterion increased over trials. The criterion used for each successive block of trials was: Trials 0-45, 5 correct trials in a row followed by 12 correct out of 15; Trials 46-95, 6 correct trials in a row followed by 12 correct out of 15; Trials 96-145, 7 correct trials in a row followed by 12 correct out of 15; Trials 146-195, 8 correct trials in a row followed by 12 correct out of 15. The reward during the discrimination phase was four .045-g Noyes food pellets.

RESULTS

In this study, a procedure was used whereby a trial ended when the S received a reward. One purpose of this procedure was to ensure that all Ss received the same amount of food reinforcement each day so that differences among groups could not be attributed to differences in amount of reward. Another reason for using this procedure for determining the end of a trial was to minimize any tendency toward position responding. Lawrence (1949) used a similar method for essentially the same reasons.

Since a correction procedure was used, error data were analyzed. Figure 1 shows the number of errors per day for the three conditions of preexposure. Visual inspection of the learning curves indicates the preexposure treatment produced the effect predicted by the exploratory literature. ANOVA on the total errors indicated that these differences were reliable ($F = 6.53$, $df = 2/18$, $p < .01$). Duncan's range test indicated that rats which had the preexposed figure as the positive stimulus made significantly more errors than control rats while rats that had the preexposed figure as the negative

Fig. 1. Mean number of errors per day for each of the three conditions of exposure. "Approach" refers to the condition where the Ss had to approach the exposed stimulus; "avoid" refers to the condition where the Ss had to avoid the exposed stimulus, and "control" refers to the condition where there was no prior exposure.

stimulus made significantly fewer errors than the controls ($p < .05$).

There was a significant Exposure Conditions by Stimuli interaction (i.e., complexity), ($F = 3.67$, $df = 2/18$, $p < .05$). Analysis of the simple effects indicated that there was a significant difference between the exposure conditions for the VS stimulus condition ($F = 8.86$, $df = 2/18$, $p < .01$) but not for the VD stimulus condition. Also, there was a significant difference between the VD and VS stimulus groups of the approach condition ($F = 9.03$, $df = 1/18$, $p < .01$) but not for the control or the avoidance conditions.

There was a significant days effect ($F = 39.61$, $df = 9/162$, $p < .005$) as well as a significant Preexposure Conditions by Days interaction ($F = 4.27$, $df = 18/162$, $p < .005$). Since the amount of food reward was the same for all animals on all days, a significant difference on successive days should reflect, to some degree, how long the "novelty effect" persisted. To guard against the possibility of increasing the tendency to detect a difference by using a pooled error score, independent estimates of error variance were made for each day. Since 10 Duncan's range tests were used, a corrected error rate was required. The corrected error rate for $.05 = 1(1 - X)^{10}$, where X is .0051. The results of these analyses indicated that all three groups differed significantly on Day 1, that the control group and the approach group differed significantly on Day 2, and that none of the groups differed thereafter.

DISCUSSION

The results of the present study indicate that exploratory properties of stimulus can play a significant

role in determining the choice behavior of organisms in a simultaneous discrimination task. The results indicate that learning is faster when the organism is rewarded for approaching a stimulus which is not only novel but possesses some degree of complexity. Similarly, learning is slower when the organism is rewarded for approaching a very familiar stimulus under the conditions where a novel stimulus is paired with that familiar stimulus.

It is clear from the present experiment that differential reinforcement is not responsible for the differences. While differential reinforcement is undoubtedly important, other factors are operating to determine the final outcome. This point has been made some time ago by Harlow (1949, 1953). We will not review Harlow's arguments but simply point out that the present results are in clear agreement with Harlow's suggestion that exploratory variables are one important source of errors in simultaneous discrimination tasks.

This study bears on the question of why novelty sometimes has a transient effect and sometimes a very persistent effect. The work on exploratory behavior has clearly demonstrated that stimuli differing in complexity will elicit differential approach responses (e.g., Sales, 1968) and, further, that if a shift in preference occurs, it is toward the more complex (e.g., Thomas, 1969). Dember and Earl (1957) have suggested that stimuli differing in complexity possess differences in ability to maintain an exploratory response and, further, that conditions such as exposure will produce a change in the ability of that stimulus to elicit exploratory responses in the future. According to Dember and Earl, exposure to a stimulus can increase, under certain conditions, the individual's complexity level and as a result the discrepancy between the stimulus and the individual (the condition necessary for motivating exploratory responses) can go to zero. A similar idea has been suggested by Berlyne (1960). "Arousal potential," according to Berlyne, is that property of stimuli which not only elicits but maintains the exploratory responses. As the organism becomes familiar with a stimulus, the exploratory responses to that stimulus decrease. If another complex stimulus is paired with that stimulus, it may maintain a differential exploratory tendency for some time, depending on the amount of complexity or arousal potential of the new stimulus. It is interesting to note that in the human research habituation is slower to a complex as opposed to a simple stimulus (Ames, 1966; Caron & Caron, 1969; Cohen, 1969).

There are other studies in the experimental literature which indicate that a change or discrepancy from a familiar stimulus can be important in learning a discrimination. Forgas (1958a, 1958b) found, for example, that discrimination learning was faster to those forms which are less similar to the ones in the rearing cage. Kerpelman (1965) studied the effects of preexposure for the different length of time and concluded that "the longer the stimulus is viewed, the less it will continue to reinforce the perceptual change drive."

While these studies and the study reported in this paper are in general agreement with the exploratory literature, the present study failed to find the differentiation effect that was found by Walk, Gibson, Pick, and Tighe (1958). This may simply indicate that for certain kinds of stimuli, exposure does not produce any further differentiation. This finding raises the important question of whether animals must actually learn to discriminate (i.e., do animals actually learn to see differences between the stimuli). It is clear in the case of the present experiment that the animals had little difficulty in detecting differences as they demonstrated a clear preference for the more novel stimulus on Trial 1. If we took the initial few trials as our measure of the animal's ability to discriminate between the stimuli, we would have to conclude that a high degree of ability to discriminate existed right from the beginning. There is the possibility that initially the animals differentiated between the stimuli on the basis of novelty and that at a later time they shifted to a more invariant cue. This would explain why there were such large differences in the beginning of training but little or no difference toward the end of training.

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(Received for publication November 3, 1972;
revision received June 20, 1973.)