Oddity learning in the squirrel monkey[1]

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Four squirrel monkeys were trained on the following problems in the order given: (1) one-odd, (2) complex two-odd, (3) 200 oddity problems with five trials per problem, (4) a median of 87 oddity problems with a reversal of the odd object on Trial 4, and (5) 60 oddity problems with reversals of the odd object on Trial 3, 4, or 5. All Ss learned the one-odd within 61 trials. Three Ss reached criterion on the two-odd (median = 800 trials) and the remaining S performed well. The Ss improved on Trial 1 performance in oddity set (51% correct on first 40 trials vs 81% correct on last 40). In oddity training with reversals on Trial 4, the performance on Trial 1 was not affected, and there was only temporary disruption of Trial 4 performance; reversals on Trials 3, 4, or 5 had no significant effect. Results are discussed in terms of the evidence necessary to conclude that an animal is using oddity as his cue.

Oddity learning has been studied in a variety of experimental paradigms. Perhaps the simplest version of oddity learning is what Levinson (1958) called the "one-odd" problem. The one-odd problem is no more than a multiple-choice simultaneous discrimination problem (French, 1965), and it is not possible to conclude without further testing whether the S responded to the oddness of the rewarded object or to its physical properties per se. The "two-odd" problem in Levinson's terminology (1958) represents the more often used test of oddity learning. The two-odd problem is derived from a stimulus pool of two identical pairs of different objects (e.g., two triangles and two circles). On a given trial, the S sees three of the objects chosen at random and presented in random positions. Robinson (1933) was the first to use the two-odd problem, and she suggested that her monkey (*Macaca fascicularis*) eliminated position, color, and form preferences and gradually formed a response patterned to the odd object. French (1965) noted, however, that it may have been possible that Robinson's monkey learned a specific response to each configuration, and the implication is that one could not state conclusively that the monkey responded to oddity per se. Perhaps the only experimental design which enables one to conclude that a S responds on the basis of oddity is the oddity learning-set experiment. In the best application of this design, the monkey is given a series of oddity problems where each problem is presented for only one trial (e.g., Levine & Harlow, 1959, with the *Macaca mulatta*). In this design, successful performance is possible only if the Ss respond to oddity.

The only published work on oddity learning in the squirrel monkey apparently used the one-odd paradigm (Woodburne & Rieke, 1966) on a series of seven problems; all monkeys were responding approximately 90% correctly at the end of 60 trials of each problem. In an unpublished work[3] on three squirrel monkeys, it was reported that marked improvement was seen in criterional training (20 correct in a span of 25 trials) of eight problems administered successively. The animals were then trained on a series of one-trial oddity problems to a level that indicated "oddity achievement was about 70%."

The present work was done without the knowledge of Martin's (1966) study, and it had been the aim of this study to investigate some of the variables in oddity problem learning in the squirrel monkey as well as to determine conclusively whether or not the squirrel monkey was capable of oddity principle learning.

SUBJECTS

Four experimentally naive adult male squirrel monkeys *(Saimiri sciureus)* were used. The monkeys had been captured in the wild (precise origin unknown), and they were purchased from a commercial supplier.

APPARATUS AND GENERAL PROCEDURES

The Ss were trained and tested in a modified Wisconsin General Test Apparatus (WGTA) with a gray stimulus tray containing three foodwells (5/8 in. diam, 1/4 in. deep) that were 6 in. apart. The discriminanda either were constructed of balsa wood or were selected from brightly colored plastic toys.

General procedures for all problems were (1) reinforcement with currants, (2) intertrial intervals of 30 sec, (3) 10-sec response intervals, and (4) a limit of 40 trials per day in all phases of pretraining or oddity training except the two reversal series where 36 trials per day were given. Training was conducted in an air-conditioned room that was illuminated only by a 25-W bulb mounted in the top center of the WGTA. The air conditioner provided an effective masking noise and a constant temperature of 75°F.

Pretraining

Five stages of training were used prior to the introduction of the one-odd problem. These were: (1) E randomly baited one of the foodwells while S was permitted to observe. The baited well was left uncovered, and S was allowed to respond to the baited foodwell. This procedure was continued until S responded correctly on a total of 25 trials. (2) E randomly baited one of the foodwells while S was permitted to observe; then, still in the visual field of S, E covered the baited well with a balsa block (1 x 2 x 2 in., painted gray). The tray was advanced, and S was given time to respond. Training was continued until S responded correctly on 25 trials. (3) E randomly baited one of the foodwells and covered it with the gray block out of the sight of S. Training was continued until S responded correctly on 25 trials. (4) E randomly baited one of the foodwells and covered it with a white balsa block. A black block was placed over one of the two remaining wells. The white block was always reinforced (100%), and the black block was never reinforced. Ss were trained to a 90% criterion of 36 correct responses in 40 consecutive trials. (5) E randomly baited one foodwell and covered it with the white block. The remaining two foodwells were covered with black blocks. Only the white block was reinforced (100%). Training was continued until S reached the criterion of 36 correct of 40 consecutive trials. It may be noted that this would be a one-odd problem had it not been presented as an extension of Pretraining Stage 4.

One-Odd Form Problem

The discriminanda in this problem were a white isosceles triangle (1 x 4 base x 2 in. high, balsa wood) and two white circles (2½ in. diam x 1 in. high). The triangle was positioned randomly and it was always reinforced. Training was continued to the criterion of 36 correct in 40 consecutive trials.

Variation of Two-Odd Form Oddity

The principal difference between this and conventional two-odd problems was the inclusion of brightness as a variable. In this task, the three stimuli on a given trial were alike in brightness, but the odd item on a given trial differed in form from the two like items. Black pairs of crosses (3 in. vertical x 2¾ in. horizontal x 1 in. thick) and black pairs of diamonds (3½ in. vertical x 1¾ in. horizontal x 1 in. thick) and white pairs of crosses and white pairs of diamonds served as the discriminanda. On a given trial, then, S may have seen two black crosses and a black diamond, two black diamonds and a

black cross, two white crosses and a white diamond, or two white diamonds and a white cross. The four problems were given in a random order, with the restriction that no problem was given more than once within a three-trial sequence. Baiting of foodwells was randomized with the restriction that no single foodwell was baited more than three times in succession. The Ss were trained to the criterion of 36 correct in 40 successive trials.

Oddity Learning Set

The discriminanda were selected from brightly colored plastic toys that could vary in hue, brightness, size, and form. From a pool of 96 objects, one was randomly selected, and an identical object was matched with it. The odd item was then selected randomly. Each new oddity problem was drawn from the original stimulus pool of 96 objects. The only restriction was that no object was allowed to serve as the odd item more than twice in a single session. The odd item could differ from the like items on one or more of the hue, brightness, size, and form properties.

The Ss were given eight problems per day and a total of five trials per problem. Each S was trained on 200 problems.

Oddity Reversal 1

Seven months after the completion of oddity-learning-set training, all Ss were retrained on the original problems used in oddity learning set until they reached a criterion of six out of eight correct responses on Trial 1 for 2 consecutive days. The number of problems required to reattain criterion ranged from 120 to 136.

At this point in training, the Ss were continued on the original learning-set problems plus new problems generated in the same fashion as the earlier ones However, the odd object was now reversed on Trial 4; for example, if the S was rewarded for responses to a teacup in the presence of two identical saucers on the first three trials, he was rewarded on Trials 4 though 6 for responses to one of the saucers now presented with the original teacup and a matching teacup. Training was continued to a criterion of five correct out of six responses on both Trials 1 and 4 for 2 consecutive days.

Oddity Reversal 2

Training in this task was similar to Oddity Reversal 1 except that the reversal could now occur on the third, fourth, or fifth trials. All Ss were given 60 six-trial problems; six problems were given each day. Within a day, reversals were scheduled to occur twice for each of the designated reversal trials; however, the order of selection of the reversal trial was random.

RESULTS

All Ss reached criterion on the one-odd problem within 61 trials. Three Ss reached criterion on the variation of the two-odd problem (S 2 taking 800 trials, S 3 taking 714 trials, and S 5 taking 827 trials); however, S 4 only approached criterion in 1,200 trials (80% correct in the last 120 trials). The most relevant summary of the data in oddity learning set is based on Trial 1 performance. The Ss showed a mean change of 51% correct responses on Trial 1 during the first 40 problems to 81% correct responses on Trial 1 of the last 40 oddity problems. In Oddity Reversal 1, the Ss continued to show a high level of correct responses on Trial 1 (mean of 86%), but they showed a gradual acquisition of correct responses to the reversal on Trial 4 beginning with 31% correct during the first fifth of training and finishing with 84% correct in the last fifth of training; the animals were trained on a median of 87 problems in Reversal 1. Finally, in Reversal 2, the Ss responded consistently correctly on Trial 1 (mean of 90%) as well as on the reversal trials (mean of 86%).

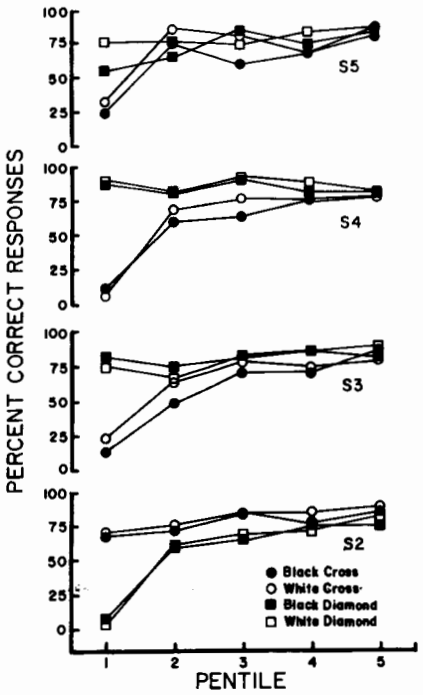

Fig. 1. Vincent curves of acquisition for each S on each configuration of the two-odd problem. Data points are percent correct responses per problem as a function of fifths of trials to criterion. The symbols indicate the reinforced object.

Figure 1 shows the individual performances of the Ss on the separate configurations of the variation of the two-odd problem. The curves suggest that three of the animals were markedly superior in performance during the first fifth of training when the diamond was reinforced, and one S showed superior performance during the first fifth of training when the cross was reinforced. It may be seen that brightness made no apparent difference.

The chi-square test for k-independent samples (Siegel, 1956) indicated significant differences in errors as a function of the left, center, or right positions on the two-odd problem ($p < .005$). A total of 411 errors was made on the center position, 331 on the right, and 296 on the left. There were no significant differences in errors as a function of position on the oddity set or oddity reversal problems.

DISCUSSION

All animals quickly mastered the one-odd form problem. The data were comparable to those of Woodburne & Rieke (1966) in their study of oddity learning in the squirrel monkey. The Ss in the present work required extensive training in the variation of the two-odd situation, but three Ss reached the 90% criterion and the remaining S was terminated at a high level of correct performance (approximately 80% correct in the final 120 training trials). All Ss showed mastery of the oddity principle by successful performance on the oddity-learning-set problems. Additionally, the successful performance on the learning-set problems was only temporarily disrupted by reversals of the odd item on the third, fourth, or fifth trials of a six-trial problem.

The data suggested that there was little, if any, transfer of correct responses from the one-odd to the two-odd task. It is suggested that the Ss were responding to the form differences in the one-odd problem rather than to the odd object per se. Similarly, there was not complete transfer of correct responding from the two-odd problem to the learning-set problems. The Ss responded correctly on only 51% of the first trials of the first 40 learning-set problems; chance in the three-choice task is assumed to be 33%. However, during the last 40 learning-set problems, the Ss responded correctly on 81% of the trials. Reversal of the odd object on the third, fourth, or fifth trials did not seriously disrupt correct performance. Therefore, it is concluded that the squirrel monkey is capable of mastering the oddity principle.

It may be recalled that French (1965) questioned whether Robinson's (1933) monkey had mastered the oddity principle or whether the monkey had learned the specific stimulus configurations. The data in Fig. 1 suggest that the monkeys in the present study learned certain aspects of the stimulus configurations in the variation of

the two-odd problem before they learned others. Specifically, it may be seen that three of the Ss responded correctly at a high level to the diamonds in the initial fifth of training, but their performances when the crosses were odd were much poorer in the initial fifth of training. The remaining S responded correctly initially at a higher level to the crosses than to the diamonds. The data suggest that all Ss learned to respond to the odd diamonds or the odd crosses at different rates. It is suggested that the monkeys did not use oddity as the basis for responding in the early phases of the two-odd problem. The relatively low amount of transfer from the two-odd to the learning-set problems suggests that an incomplete mastery of the oddity principle was evident at the conclusion of two-odd training. It is perhaps unfortunate that the present work reinforced a triangle in the one-odd problem; this may have contributed to a preference for the triangular portion of the diamonds in the two-odd problem resulting in the initial high level of correct responding by three of the Ss when the diamonds were odd.

It should be noted that had the monkeys not shown the different rates of acquisition to the odd diamond and odd cross configurations in the two-odd problem, one would still be unable to state conclusively that the Ss had the oddity principle. It could be argued that the Ss learned the specific stimulus configurations with equal facility.

Figure 1 suggests that brightness was not a variable in acquisition of the two-odd configurations. However, significant differences in the number of errors as a function of position of the odd object on the tray were seen. The center position was associated with the most errors, and the fewest errors were made when the odd object was in the left position. However, no significant differences in errors as a function of stimulus position were seen in oddity-set learning or the oddity-set problems with midproblem reversals of the odd object. French (1965) summarized several studies that suggest that the center position of the odd object is associated with the most errors; however, he also cited studies where the center position had no effect. It may be that the extensive training of the Ss in the present study enabled them to develop efficient visual scanning techniques, thereby reducing the number of errors at the center position.

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NOTES

1. The present work was based in part on the MS thesis of the first author from the University of Georgia.

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3. Martin, M. Unpublished project, 1966. Cited by D. M. Rumbaugh. The learning and sensory capacities of the squirrel monkey in phylogenetic perspective. In L. A. Rosenbloom and R. W. Cooper (Eds.) *The squirrel monkey.* New York: Academic Press, 1968. Pp. 256-318.