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Oddity and dimension-abstracted oddity (DAO) in squirrel monkeys

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Four squirrel monkeys were trained on 10 pretraining oddity problems and a series of 6 conceptual oddity and dimension-abstracted oddity (DAO) tasks. These six tasks were presumed on logical grounds to comprise six levels of difficulty and were administered in the presumed order of difficulty. All tasks were performed significantly better than chance, but performances on tasks 1, 2, and 4 were better than those on tasks 3, 5, and 6. Discussion considered the kinds of evidence that are necessary for demonstrations of conceptual oddity and DAO performances as well as the implications of the present results for the presumed hierarchy of conceptual oddity and DAO tasks used here.

The oddity problem has a long history of use in animal psychology, where it has been viewed as a test of conceptual or abstracting ability (see French, 1965; Strong & Hedges, 1966, for brief reviews of the literature). Additionally, the oddity problem has been used to study the cognitive development of children (e.g., Lipsett & Serunian, 1963; Vaughter, 1975), and oddity and dimension-abstracted oddity (DAO) are significant aspects of the Halstead Category Test (Halstead, 1947), a widely used test in the assessment of human brain damage.

The distinction between oddity and dimension-abstracted oddity (DAO) is that in oddity the nonodd stimuli are identical, whereas in DAO, the nonodd stimuli are not identical, but they share properties that make them more similar to each other than to the odd stimulus. Bernstein (1961) appears to have been the first to use DAO with nonhuman animals. His results indicated that monkeys (*Macaca mulatta* and *Macaca nemestrina*) and apes (*Pan troglodytes* and *Pongo pygmaeus*) are capable of performing DAO successfully and that apes performed better than monkeys; the apes ranged from 530 to 640 trials to criterion and the monkeys ranged from 940 to 2060 trials to criterion. Strong, Drash, and Hedges (1968) confirmed Bernstein's find-

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ings with rhesus monkeys and chimpanzees. Apparently, these are the only studies that have used nonhuman animals and DAO problems. Thus, the principal purpose of the present work was to determine whether the squirrel monkey is capable of performing DAO.

When the dimensions color, form, and size are used, six logically distinct types of tasks—three oddity and three DAO—may be constructed (see Methods section for details). There is also some *a priori* basis to suggest that these tasks may constitute six levels of difficulty (Thomas, 1980). A second point of interest in the present study was to consider the results in the context of the hypothesis that the tasks comprise six levels of difficulty.

EXPERIMENT

METHOD

Subjects

Four wild-born, adult male squirrel monkeys (*Saimiri sciureus*) were used. One (78-I-4) was obtained in an exchange of monkeys with a colleague in 1978; the other three (79-1, 79-2, 79-3) were obtained in a similar exchange in 1979. Prior to the exchange, their previous experience in research was limited to measures of general activity, in some cases following the administration of low doses of amphetamine. Subsequent to the exchange, 78-I-4 had been trained to discriminate between stimuli (black figures on white cards) that had either linear or curvilinear borders; responses to the linear stimuli were reinforced. The other three monkeys had received no training subsequent to the aforementioned exchange. The monkeys were housed in individual cages in a colony room with controlled temperature (24–27°C) and humidity (50–70%) and with timer-controlled light onset at 8:00 A.M. and light offset at 8:00 P.M. local time. Testing was done during the light phase. The monkeys received a normal diet of Wayne monkey food (24% protein), which was supplemented regularly with fresh fruits. Water was continuously available.

Apparatus, general procedures, and pretraining

The monkeys were trained in a locally constructed version of the Wisconsin General Test Apparatus (WGTA). Our WGTA does not include the typical one-way mirror viewing system but uses an angled mirror mounted on the inside of the door nearest the subject. When the door is raised, this permits the experimenter to view the subject's responses but not its approach to the stimuli; this precludes biased movements of the stimulus tray that might occur as the result of viewing the subject's approach or orientation to the stimuli. The stimulus tray was 36 cm across the front by 26.5 cm from front to back and was painted gray. Three food wells, each with a diameter and depth of 1 cm, were drilled with their centers being 2 cm from the front edge of the tray. The food wells were 11 cm apart, and there were 7 cm between the centers of the outside food wells and the sides of the stimulus tray.

The stimuli were taken from a pool of approximately 400 wooden and plastic objects and varied in color, form, and size. The construction of the DAO problems requires stimuli that might, for example, share color and form but not size, or they may share form and size but not color, etc. Some useful stimuli were toys from Playskool, Inc.—Stacking Barrels, Nesting Eggs, and Building Cups—and from Child Guidance Products—Learning Tower and Kitty in the Kegs. The Nesting Eggs, when separated, form a series of hemispheres and hemiellipsoidal objects.

Testing was done in the illumination provided by a 75-W incandescent bulb mounted in the top-center of the WGTA. The monkey was tested in its home colony room by moving its home cage to an empty slot on the cage rack adjacent to the WGTA. Screens prevented the other monkeys in the room from observing ongoing testing. With the door between the monkey and the interior of the WGTA closed and with the door between the experimenter and the interior of the WGTA opened, the stimuli and reinforcers were set for each trial. Then, in succession, the experimenter's door was closed, the monkey's door was opened, and the stimulus tray was advanced slowly towards the monkey. The monkey was allowed 30 sec in which to respond. Following a response, the monkey's door was closed while the stimulus tray was pulled to the rear of the WGTA. A 30–60 sec interval was used between trials.

The following pretraining procedures were used:

1. For several days prior to their introduction to the WGTA, each monkey was fed a few currants (the reinforcers) by hand in its home cage.

2. On the first day of training using the WGTA, the monkey was allowed to retrieve 10 currants, one trial at a time (with WGTA doors being operated in normal sequence), from an open food well. Then, it was allowed to retrieve 10 currants, one trial at a time, from a food well that was partially covered by a stimulus object. Finally, it was allowed to retrieve 10 currants, one at a time, from a food well that was covered completely by the same object. The food well containing the reinforcer was selected randomly throughout all pretraining and training sessions.

3. On the second day using the WGTA, the monkey was given an oddity problem in which the two nonodd stimuli were identical and in which the odd stimulus differed from the nonodd stimuli in color, form, and size. Twenty trials were administered in which the odd object only partially covered the food well containing the reinforcer. Then on the same day, 20 trials were administered in which the odd object covered the food well completely. Training was continued on this problem on succeeding days at a rate of 40 trials/day, until a significant "run" (with $p < .01$) of successive correct responses was seen (see Grant, 1946; Thomas & Crosby, 1977, for details concerning the "runs" analysis). It may be useful to the reader to

Table 1. Trials to criterion for each monkey on the 10 pretraining problems

Problems		Monkeys			
Number	Type	78-I-4	79-1	79-2	79-3
1	O0-N3	64	54	52	46
2	O1-N3	21	57	28	50
3	O2-N3	37	42	9	8
4	O0-N3	19	11	22	10
5	O2-N3	39	95	44	27
6	O0-N3	28	65	41	38
7	O2-N3	13	9	19	10
8	O1-N3	8	10	8	12
9	O2-N3	82	107	118	127
10	O1-N3	9	9	8	8

know that a run of 8 successive correct responses is required to obtain significance at $p < .01$ if 100 + trials have accrued (the exact limit is between 100 and 150 trials; below 1000 trials, our table was computed in increments of 50). A run of 9 is required to obtain significance at $p < .01$ up to 300 + trials, a run of 10 up to 850 + trials, a run of 11 up to 2600 + trials, and a run of 12 up to 7700 + trials. These values apply only to problems where the probability of a correct response by chance on a given trial is ⅓.

4. Following the attainment of criterion on the first oddity problem and continuing at a rate of 40 trials/day, nine additional pretraining oddity problems were administered, one at a time, each to the criterion of a significant run ($p < .01$) before the succeeding problem was administered. During pretraining, the 10 oddity problems were selected randomly from the three types of oddity problems (see below). The types of oddity problems used in pretraining are indicated in Table 1.

It may be noted that oddity problems such as these described thus far (where the same three objects, two nonodd and one odd, are used until criterion performance is seen) may be learned without using the oddity concept. The animal might learn to associate the specific properties of the odd stimulus with the reinforcers, or it might learn the three specific configurations of the problem (symbolically: AAB, ABA, BAA) as they relate to the reinforcement sites. Since the three potential bases for solution are confounded, we do not regard the problems described thus far to be part of the demonstration of conceptual oddity.

Conceptual oddity and DAO training

Using the dimensions color, form, and size, six types of oddity and DAO tasks may be constructed. Examples of these may be seen in Figure 1. As may be seen, a system of nomenclature has been proposed that denotes (a) the number of properties shared by the odd and the nonodd objects and (b) the number of properties shared by the nonodd objects. For example, O0-N3 indicates that among problems of this type, the odd object (O) shares zero properties (0) with the nonodd objects (N) which share all three properties (3). Thus, in this type of problem, any of the three properties may serve as the basis for the subject to distinguish between the odd and the nonodd objects; hence, there are three *relevant* cues. Since no properties are shared by the odd and nonodd objects, there are no *constant* cues, and since no properties vary in a noninformative way, there are no *ambiguous* cues.

On the other hand, consider for example problems of the O1-N2 type. In the example shown in Figure 1, the odd and nonodd objects share size as cue (denoted by O1), and the nonodd objects also share color (N2 denotes the sharing, in this case, of size and color). Thus, size is a constant cue and color is the relevant cue; form in this example varies among the objects in a noninformative way, hence it is an ambiguous cue. It should be emphasized that the examples shown are *only* examples of the types of problems. In the present study, all cues were allowed to vary in all possible ways consistent with the type of problem being given at a particular time.

On strictly logical grounds, it is reasonable to suggest that among the three types of oddity problems, a task with three relevant cues should be easier than one with two, which, in turn, should be easier than one with only one relevant cue. Among the three types of DAO tasks, the relevant cue differential should make the O0-N2 task easier than the O1-N2 task. However, the differential in ambiguous cues would be more likely to account for the relative difficulty of the O1-N2 and O0-N1 tasks, with the latter being the more difficult; such appears to be the case upon visual comparison of these two types of problems, and Harlow (1958) cited data to suggest that problems become more difficult as the number of ambiguous cues increases. Thus, among oddity tasks or among DAO tasks, the ordering of hypothetical difficulty as suggested here seems reasonable. However, it is not clear what the hypothetical order of difficulty, if any, should be between the O2-N3 and O0-N2 tasks. The O0-N2 task has two relevant cues to one for the O2-N3 task, but the O0-N2 task has an ambiguous cue, whereas, the O2-N3 task does not. Judging from examples of the two types of tasks, discriminations within the O0-N2 task *appear* more difficult; in any event, it was hypothesized that the O0-N2 task would be more difficult than the O2-N3 task.

Training typically progressed at a rate of 40 problems/session, one session/day, 5 days/week. The principal exception was a period of 18 days of nontesting, which occurred approximately midway through the study (the winter vacation). There was also a change of experimenter at this time, from TF to RKT. The changes did not appear to affect the monkeys' performance significantly. Beginning with oddity/DAO training, a correction procedure was used as follows. If a monkey responded incorrectly on a problem, it was repeated until the monkey responded correctly or until a total of five correction trials had been given. The initial error was scored, and a record was kept of the number of repetitions that occurred.

New problems were generated for each trial (except during the correction procedure as noted in the preceding paragraph). Given the conditions necessary to construct a given type of problem (particularly the DAO prob-

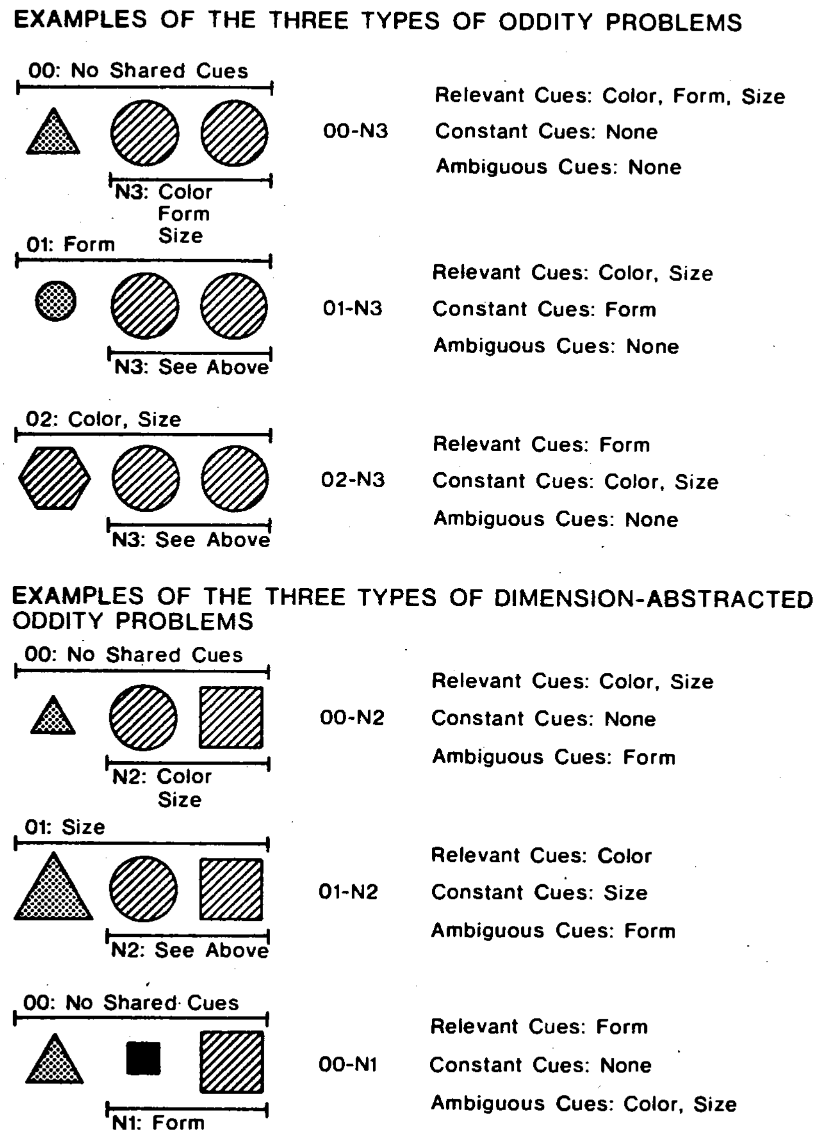

Figure 1. Illustrated examples of the six types of oddity and dimension-abstracted oddity problems based on variations of color, form, and size

lems) and our somewhat limited time and resources, strict random construction of problems was not followed. However, we tried to be careful to prevent biases from occurring. With the DAO problems, the order of the relevant cues (e.g., color-form, color-size, color only, size only, etc.) was determined randomly within a given task, except that each type of cue or cue combination was made to occur equally often. Initially, it was planned that training on a given task would continue until the joint-criterion of 36 correct in 40 successive problems *and* a significant run ($p < .01$) was seen. This was done with the O0-N3 task. However, it was then decided that if a monkey failed to reach criterion on a given task within a maximum of 10 sessions (400 problems), training on that task would be terminated and training on the next task would begin.

RESULTS

Before presenting the results, it should be noted that the significant runs (see Grant, 1946; Thomas & Crosby, 1977) during pretraining were determined on the assumption that the 10 problems were independent. However, it was then decided that the more appropriate assumption might be that the problems during pretraining and training were not independent. Thus, during training, we followed the assumption of nonindependence and determined each significant run as a function of the total number of trials that had accrued to the end of the run beginning with the first trial of oddity pretraining. A result of following the assumption of independence of the problems in pretraining was that some runs that were significant at $p < .01$ are not significant at this level under the assumption of nonindependence. This discrepancy is deemed to be inconsequential to the present study, particularly since the more conservative procedure was used to determine significant runs during conceptual oddity and DAO training. Actual probabilities associated with most of the significant runs in the present work were much less than .01.

Pretraining

The four monkeys took an average of 37 trials to criterion per problem on the 10 pretraining problems. Performances ranged from an average of 9 trials to criterion seen on the 10th problem to 109 trials to criterion seen on the 9th problem. The 9th problem was an O2-N3 one involving green plastic cylinders where a relatively small size difference between the odd and nonodd objects had provided the relevant cue. Another O2-N3 problem (see Table 1, problem 7) involving orange cylinders with a larger size difference had been performed in a mean of 13 trials to criterion. These and other results in pretraining may be determined from Table 1.

Conceptual oddity and DAO training

All monkeys met the joint-criterion of 36/40 correct and a significant run at $p < .01$ in a single session on the O0-N3 task; this was attained in a mean of 970 trials. It may be recalled that training on succeeding tasks was limited to 10 sessions or 400 trials per task. Only one monkey attained the joint-criterion on the O1-N3 task, none attained it on the O2-N3 task, two attained it on the O0-N2 task, and none attained it on the O1-N2 and O0-N1 tasks. Despite the lack of attainment of the joint-criterion on most tasks, the general level of performance was quite good and the poorest performance seen (monkey 79-2 on the O0-N1 task) was well above chance (assumed to be 13.3 correct responses in 40 trials). These and other results may be seen in Table 2.

To consider the hypothesis that the six tasks comprise six levels of difficulty, a one-way, repeated-measures analysis of variance was done using the mean numbers of correct responses/session. Monkey 79-1, who died following the completion of seven sessions on the O2-N3 task, was excluded from this analysis. Additionally, it was believed that the most appropriate comparisons involving the O0-N3 task should be based on the last 10 sessions of training (it may be recalled that this was the only task administered by design to the point that the joint-criterion was met). The mean numbers of correct responses/session for the three monkeys used in the analysis of variance on the last 10 sessions of the O0-N3 task were 32 for 78-I-4, 31 for 79-2, and 30 for 79-3. Their overall performances on the O0-N3 task as well as the other tasks may be seen in Table 2.

There was a significant difference among monkeys' performances on the six tasks, $F(5, 10) = 14.63$, $p < .001$. Comparisons among individual tasks were done following Keppel's (1973, pp. 408–411) recommendations and using the difference score formula which he presented. There were significantly fewer correct responses/session on the O0-N1 task compared to all other tasks ($p < .05$). There were also significantly fewer correct responses/session on the O1-N2 task than on the O1-N3 and O0-N2 tasks ($p < .05$). No other differences between tasks were found. It may be noted, however, that there is the suggestion in the findings that the O2-N3 task may have been more difficult for squirrel monkeys than the O0-N2 task. This suggestion is based on the observations that (a) two of three monkeys met the joint-criterion within the 10 sessions limit on the O0-N2 task whereas none did on the O2-N3 task and (b) the monkeys performed significantly better on the O0-N2 task than they did on the O1-N2 task, whereas the difference in performance on the O2-N3 and O1-N2 tasks was not significant.

Table 2. Five performance measures for the monkeys on the conceptual oddity tasks

Monkeys	Correct trials/session Mean	Correct trials/session Range	Significant runs	Attained joint-criterion[a] Yes/No	Attained joint-criterion[a] Trials
		O0-N3			
78-I-4	30	19-36	12	Yes	1160
79-1	29	18-36	8	Yes	1000
79-2	29	20-36	12	Yes	1200
79-3	28	15-36	4	Yes	520
		O1-N3			
78-I-4	32	26-34	7	No	
79-1	31	27-34	9	No	
79-2	31	27-34	4	No	
79-3	31	28-36	4	Yes	360
		O2-N3			
78-I-4	28	23-35	2	No	
79-1[b]	25	21-30	1	No	
79-2	25	19-29	1	No	
79-3	31	29-33	3	No	
		O0-N2			
78-I-4	30	23-36	2	Yes	200
79-2	29	24-32	3	No	
79-3	33	30-36	5	Yes	280
		O1-N2			
78-I-4	25	21-29	2	No	
79-2	26	21-33	1	No	
79-3	28	20-34	5	No	
		O0-N1			
78-I-4	22	18-29	0	No	
79-2	21	17-26	0	No	
79-3	25	20-30	1	No	

[a]The joint-criterion was 36 correct in 40 successive trials *and* a significant run ($p < .01$) of successive correct responses in the same session.
[b]This monkey died after completing seven sessions on this task.

DISCUSSION

The present study reaffirmed the squirrel monkey's ability to perform oddity (Noble & Thomas, 1970; Thomas & Boyd, 1973) and showed, apparently for the first time, that the squirrel monkey can perform DAO. It will be useful to address the question of what constitutes conclusive evidence that an animal is performing oddity on a conceptual basis.

The best demonstration of oddity as a test of abstracting or conceptual ability is to present new stimuli on each trial or, if problems are administered for more than one trial, to base the evidence on first-trial performances. Otherwise, the subject might choose the odd stimulus on the basis of having learned its specific properties or having learned the specific configurations (e.g., ABB, BAB, BBA).

Despite earlier discussions of what constitutes a conclusive test of an animal's use of the oddity concept (French, 1965; Noble & Thomas, 1970; Strong & Hedges, 1966; Thomas & Boyd, 1973), investigators continue to report inconclusive new data as evidence for the "oddity concept" (e.g., Urcuioli, 1977; Zentall & Hogan, 1975) or to interpret inconclusive older data (Wodinsky & Bitterman, 1953) as evidence for a "relational" solution (Bitterman, 1979). Carter and Werner (1978) and Premack (1978) provided detailed criticisms of Urcuioli's and Zentall and Hogan's studies with pigeons. Some of these criticisms apply also to Wodinsky and Bitterman's (1953) study with rats as well as to the studies of Pastore (1954, 1955) with canaries and of Warren (1960) with cats. Bitterman (1979) suggested that the results of transfer tests provided the evidence that the rats (in the earlier Wodinsky & Bitterman study) had learned oddity relationally. While this may be true (as it may have been true of the other studies in question here), it is nevertheless *possible* that the transfer tests merely demonstrated a learning set to recognize efficiently the *specific* stimuli or configurations associated with reinforcement. Since it is feasible to test canaries, cats, pigeons, and rats with new objects on each trial, it is suggested that this be done to remove any doubt about their abilities to use the oddity concept.

In fact, Strong and Hedges (1966) have tested cats and raccoons (along with some primate species) on one-trial oddity problems. Although rhesus monkeys, chimpanzees, and humans performed successfully, it was concluded that the cats and raccoons did not perform better than chance after 4800 trials. However, it should be noted that Strong and Hedges used only nine distinct stimuli in the construction of their oddity problems. Since each session consisted of 48 trials, presumably the same stimulus might have been differentially associated with reinforcement several times within a session. Thus, it is possible that the conflicting associations of stimuli with reinforcement were detrimental to the acquisition of the oddity concept by cats and raccoons. It is suggested that these species be studied again using a larger pool of distinct stimulus objects.

Langworthy and Jennings (1972) examined first-trial performances by rats on a series of 30 oddity problems. They concluded that rats "could learn the abstract relation of oddity" (p. 487); however, this conclusion is questionable. Based on first-trial performances on the last five problems by 11 rats, *apparently* 69% of those 55 responses were correct (the heading of the table in which the 69% figure appears is "Percentage of the 11 experimental *S*s making correct responses"; however, 69% cannot be obtained on that basis). Whether 69% is statistically significant may be questioned in that measures of statistical significance were not provided and what constituted chance is unclear. Ordinarily, chance in a three-stimulus oddity problem might be expected to be 33%. However, in Langworthy and Jennings's study, the odd stimulus was never in the center position. Thus, it is reasonable to ask whether chance might best be said to be 50% and whether this was significantly different from 69%.

Questions may be raised, also, regarding the appropriate basis for determining chance in the present work.[1] We accepted chance as being 0.33, because a *random* selection of one of the three objects on each trial, given that the correct object may appear in any of the three locations, should result in correct choices on an average of 0.33 of the trials. However, if the difference between the odd and nonodd categories was perceived immediately (i.e., at the onset of training) but the subject responded randomly between them, it might be argued that chance was 0.50 rather than 0.33. We prefer to continue to view *chance* as being 0.33, but we acknowledge that to argue that the animal has learned that oddity is uniquely associated with reinforcement may require evidence that it chooses the odd stimulus on significantly more than 50% of the trials or that its runs of correct responses are assessed against 0.50 as the basis for determining chance rather than 0.33.

In view of this belatedly recognized argument, we have reconsidered our data from the point of view that a reliable demonstration of the use of oddity or DAO must show that the level of responding to the oddity or DAO stimuli was significantly greater than 0.50. First, as Table 2 shows, all four monkeys met the criterion of 36 correct in one 40-trials session (hereafter 36/40) on the O0-N3 task and two of three monkeys met this criterion on the O0-N2 task. The monkey who failed to achieve the 36/40 criterion on the O0-N2 task did show a run of 18 successive correct responses during one session of the O0-N2 task ($p < .005$; this and all ps reported in this paragraph were determined on the assumption that chance was 0.50). Although only one monkey met the 36/40 criterion on the O1-N3 task, each of the four monkeys had at least one significant run of successive correct responses, with the highest $p < .025$. No monkey met the 36/40 criterion on the O2-N3 task and only one had a significant run of correct responses ($p < .002$), but the best-session performances were well above 50%, ranging from 72.5% to 87.5% (see Table 2). On the O1-N2 and O0-N1 tasks, only one monkey (79-3) had significant runs; he had runs of 16 ($p < .015$) and 19 ($p < .0021$) on the O1-N2 task and a run of 18 ($p < .0041$) on the O0-N1 task. In summary, even with the more conservative basis for estimating chance, there is strong evidence that squirrel monkeys can perform O0-N3 and O1-N3 oddity and O0-N2 DAO successfully, and there is additional evidence that at least one monkey performed well some of the time on the O1-N2 and O0-N1 DAO tasks.

Apparently, the only previous studies which tested DAO with nonhuman animals were those of Bernstein (1961) and Strong, Drash, and Hedges (1968). Both studies included humans as well as rhesus monkeys and chimpanzees; Bernstein also tested pigtailed monkeys and an orangutan. Differences between the two studies preclude close comparison, but it may be noted that all subjects met criterion in Bernstein's study (90% correct in a single session of 20 or 30 trials) but only subjects with previous oddity-learning experience met criterion on the DAO task in the study of Strong et al. (90% correct for two consecutive 30-trial sessions). Although there were notable procedural differences between the study of Strong et al. and the present one, the two studies are more comparable than is the present study to Bernstein's. In this regard, it was of interest to note that only oddity-experienced rhesus monkeys learned DAO in the Strong et al. study; this suggests that the squirrel monkeys in the present study might not have performed successfully on the DAO tasks had they not received the prior oddity training. However, it might be noted also that Strong et al. used only problems comparable to the O0-N1 problems in the present work. It remains to be determined whether oddity-naive rhesus monkeys might have performed more successfully on DAO problems of the O0-N2 or O1-N2 types.

Contrary to the hypothesis that the order in which the six oddity and DAO tasks were administered corresponds to the order of task difficulty, some findings suggested that the third task may have been more difficult than the fourth task for these monkeys. This interpretation must be tempered, of course, by the lack of control for order effects, a control which was not possible here owing to an insufficient number of available naive subjects and to the time required to run just one order. One must acknowledge the possibility of negative carry-over effects on the tasks on which the poorer performances were seen. Negative carry-over seems unlikely in view of the findings that first-session performance on the O2-N3, O1-N2, and O0-N1 tasks were medians of 67.5%, 67.5%, and 52.5% correct, respectively. Nevertheless, there may have been negatively interactive effects among the tasks which cannot be assessed without data from other orders of task administration. The decline in performance seen on the fifth (O1-N2) and sixth (O0-N1) tasks might be attributed to a general decline in motivation to perform, especially after several months of continual testing, except that (a) the monkeys rarely failed to respond in the allotted 30 sec, (b) they responded, if necessary, through several correction trials to gain the incentive, and (c) they always consumed the incentives, apparently eagerly. We suggest that the performances declined on the third, fifth, and sixth tasks because they were more difficult. However, we realize that further tests of the "order of difficulty hypothesis" will be necessary to substantiate our interpretation of the data.

Notes

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1. The discussion in this paragraph was suggested by a reviewer of this manuscript.

References

Bernstein, I. S. The utilization of visual cues in dimension-abstracted oddity in primates. *Journal of Comparative and Physiological Psychology,* 1961, *54,* 243–347.

Bitterman, M. E. Discrimination learning. In M. E. Bitterman, V. M. LoLordo, J. B. Overmier, & M. E. Rashotte, *Animal learning: Survey and analysis.* New York: Plenum Press, 1979.

Carter, D. E., & Werner, T. J. Complex learning and information processing by pigeons: A critical analysis. *Journal of the Experimental Analysis of Behavior,* 1978, *29,* 565–601.

French, G. M. Associative problems. In A. M. Schrier, H. F. Harlow, & F. Stollnitz (Eds.), *Behavior of nonhuman primates* (Vol. 1). New York: Academic Press, 1965.

Grant, D. A. New statistical criteria for learning and problem solution in experiments involving repeated trials. *Psychological Bulletin,* 1946, *43,* 272–282.

Halstead, W. C. *Brain and intelligence: A quantitative study of the frontal lobes.* Chicago: University of Chicago Press, 1947.

Harlow, H. F. The evolution of learning. In A. Roe & G. G. Simpson (Eds.), *Behavior and evolution.* New Haven: Yale University Press, 1958.

Herrnstein, R. J. Acquisition, generalization, and discrimination reversal of a natural concept. *Journal of Experimental Psychology: Animal Behavior Processes,* 1979, *5,* 116–129.

Keppel, G. *Design and analysis: A researcher's handbook.* Englewood Cliffs, N.J.: Prentice-Hall, 1973.

Langworthy, R. A., & Jennings, J. W. Odd ball, abstract, olfactory learning in laboratory rats. *The Psychological Record,* 1972, *22,* 287–490.

Lipsett, L. P., & Serunian, S. A. Oddity-problem learning in young children. *Child Development,* 1963, *34,* 201–206.

Noble, C. S., & Thomas, R. K. Oddity learning in the squirrel monkey. *Psychonomic Science,* 1970, *19,* 305–307.

Pastore, N. Discrimination learning in the canary. *Journal of Comparative and Physiological Psychology,* 1954, *47,* 389–390.

Pastore, N. Learning in the canary. *Scientific American,* 1955, *192,* 72–79.

Premack, D. On the abstractness of human concepts: Why it would be difficult to talk to a pigeon. In S. H. Hulse, H. Fowler, & W. K. Honig (Eds.), *Cognitive processes in animal behavior.* Hillsdale, N.J.: LEA Publications, 1978.

Strong, P. N., Jr., Drash, P., & Hedges, M. Solution of dimension abstracted oddity as a function of species, experience, and intelligence. *Psychonomic Science,* 1968, *11,* 337–338.

Strong, P. N., Jr., & Hedges, M. Comparative studies in a simple oddity learning: I. Cats, raccoons, monkeys, and chimpanzees. *Psychonomic Science,* 1966, *5,* 13–14.

Thomas, R. K. Evolution of intelligence: An approach to its assessment. *Brain, Behavior & Evolution,* 1980, *17,* 454–472.

Thomas, R. K., & Boyd, M. G. A comparison of *Cebus albifrons* and *Saimiri sciureus* on oddity performance. *Animal Learning and Behavior,* 1973, *1,* 151–153.

Thomas, R. K., & Crosby, T. N. Absolute versus relative class conceptual behavior in squirrel monkeys (*Saimiri sciureus*). *Animal Learning & Behavior,* 1977, *5,* 265–271.

Urcuioli, P. J. Transfer of oddity-from-sample performance in pigeons. *Journal of the Experimental Analysis of Behavior,* 1977, *25,* 195–202.

Vaughter, R. M. A developmental investigation of oddity and matching. *Journal of Genetic Psychology,* 1975, *126,* 177–186.

Warren, J. M. Oddity learning in the cat. *Journal of Comparative and Physiological Psychology,* 1960, *53,* 433–434.

Wodinsky, J., & Bitterman, M. E. The solution of oddity problems by the rat. *American Journal of Psychology,* 1953, *66,* 137–140.

Zentall, T. R., & Hogan, D. E. Concept learning in the pigeon: Transfer to new matching and nonmatching stimuli. *American Journal of Psychology,* 1975, *88,* 233–244.