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Conceptual conditional discrimination in *Saimiri sciureus*

ROGER K. THOMAS and R. STEPHEN KERR
University of Georgia, Athens, Georgia 30602

The present work introduced a task which superimposed a tray brightness, stimulus-response contingency on previously acquired, highly successful, one-trial oddity performance. Continuing with new one-trial oddity problems, the new contingency was that responses to the odd objects were rewarded on a white tray and responses to the nonodd objects were rewarded on the black tray. Since there is no opportunity to learn specific stimuli or stimulus patterns, successful performance may be interpreted as having a conceptual basis. All monkeys achieved criterion (90% based on 18/20) and statistically significant performances ($p < .001$). Discussion considered the appropriate nomenclature to describe a conceptual conditional discrimination task and the necessary evidence to justify a conceptual interpretation of conditional discrimination behavior.

Conditional discrimination has been described as a measure of concept formation (e.g., Maier & Maier, 1970) or complex processes (e.g., Riopelle & Hill, 1973). A simple, but typical, example of conditional discrimination might be one in which the appearance of a circle and a triangle on a white background has the circle as the rewarded object, but when they appear on a black background, the triangle is the rewarded object. More complex examples have been used. For instance, Spaet and Harlow (1943) trained rhesus monkeys (*Macaca mulatta*) to choose the odd item among brass doorbell buttons or T-shaped objects on a yellow tray and to choose either of the nonodd items on a black tray. However, when three buttons appeared on the yellow tray, the left one was correct and when three Ts appeared, the right one was correct; these positional contingencies were reversed on the black tray. The monkeys were eventually successful in responding to randomly presented trials of the six types. Perhaps the ultimate conditional discrimination experiment was done by Nissen (1951), who trained a chimpanzee (species unspecified) to perform successfully on 16 concurrently presented conditional discrimination problems.

Nissen (1953) also described two potential solutions for conditional discrimination problems. The following quotation refers to both solutions as well as the principal methodological distinction between them. "As long as problem-solution involves a fixed and invariable number of stimuli, the possibility of response to specific stimulus-combinations or patterns remains. Only when this possibility has been ruled out will there be a compelling need for the concept of the conditional stimulus as a predisposing set" (p. 281).

Address reprint requests to Roger K. Thomas, Department of Psychology, University of Georgia, Athens, Georgia 30602.

The quotation, then, poses the two solutions as (a) the acquisition of specific responses to the specific stimulus configurations vs. (b) some form of conceptual solution. The methodological distinction rests on the opportunity for the first solution to occur. If that opportunity exists, then a conceptual interpretation could not be conclusively suggested. Eliminating the possibility of specific configuration learning appears to require successful performances on the first trial or the only trial of a specific conditional discrimination. The large number of trials, 4,320-6,840, taken by Spaet and Harlow's (1943) monkeys to master the complex conditional discrimination task described previously suggests the likelihood that those animals learned the specific configurations; it may be noted that Spaet and Harlow did not suggest a conceptual solution. Similarly, Nissen's (1951) chimpanzee, which mastered 16 concurrent, conditional discriminations, required 15,796 trials. Nissen suggested that the chimpanzee may have learned the specific configurations. Gollin and Liss (1962), who studied children, and Barge and Thomas (1969), who studied squirrel monkeys (*Saimiri sciureus*), reported evidence to suggest specific configuration learning in their investigations of conditional discrimination.

It was the purpose of the present work to introduce a conditional discrimination task which might better permit interpretations that the animal had used conceptual processes. This task involved training the monkeys first to a 90% criterion of correct responses on five-trial oddity problems followed by training to the same criterion of performance on one-trial problems using a gray background. Then, continuing with new one-trial oddity problems, a new tray background contingency was introduced. In this final stage of training, a white tray was the cue that responses to the odd object would be rewarded,

and a black tray was the cue that responses to either of the nonodd objects would be rewarded. The possibility of specific configuration learning was precluded, since new oddity problems appeared on each trial.

METHODS

Subjects

Three adult male squirrel monkeys (*Saimiri sciureus*) were used. These were three of the four squirrel monkeys used approximately 2 years previously in an oddity learning experiment by Thomas and Boyd (1973). The monkeys were naive prior to the Thomas and Boyd experiment, and they had received no training subsequent to that experiment. The monkeys were individually housed. They were fed a maintenance ration of Purina Monkey Chow 25 immediately following each training session, and they regularly received a supplement of fresh fruit.

Apparatus, General Procedures, and Pretraining

The monkeys were trained and tested in a modified Wisconsin General Test Apparatus (WGTA) which was fitted with a gray stimulus tray containing three foodwells, 16 mm in diameter, 6 mm deep, and 153 mm apart. In the conditional discrimination task, the gray tray was removed and a white and a black tray were used. The discriminanda either were constructed of balsa wood or were selected from plastic toys which varied in shape, size, and color.

General procedures for all problems were (a) reinforcement with currants or pieces of raisin, (b) intertrial intervals of 30 sec, (c) response intervals of 10 sec, and (d) no more than 40 trials per day. Training was done in a temperature- (24°-27°C) and humiditiy-controlled (50%-70%) room that was illuminated during testing only by a 25-W bulb mounted in the top center of the WGTA. The animals were given the five stages of pretraining described by Noble and Thomas (1970). These are designed to facilitate the animal's adjustment to the apparatus and response requirements.

Oddity Training

The five stages of pretraining, the oddity learning set problems, and the one-trial oddity problems had been given these animals in the Thomas and Boyd (1973) experiment. Their administration here constituted, essentially, a replication of their earlier training except that this time the stimulus pool was larger (124 vs. 96), criterion was more stringent (90% vs. 80%), and an oddity reversal series which was given earlier between the five-trial oddity learning set series and the one-trial oddity series was omitted.

Oddity learning sets. The discriminanda were selected from a stimulus pool of 124 white, black, or gray balsa wood forms and plastic toys. An object was selected randomly and matched with an identical object. Then the odd object was selected randomly from those remaining, with the restriction that no object appear as the odd one more than twice per session. The odd object might differ from the nonodd ones on form, size, hue, brightness, or saturation. Each stimulus group was presented five times, and the position of the odd object was determined randomly among the three positions. Training was to the criterion of 90% correct in 40 consecutive trials. Eight five-trial problems were presented in one session per day.

One-trial oddity. After they reached criterion on the oddity learning set series, the animals were given 20 new one-trial oddity problems per daily session until they responded correctly on 90% of 20 consecutive problems.

Conditional Discrimination

After they reached criterion on the one-trial oddity series, the tray brightness variable was introduced as a conditional cue. Continuing with newly generated oddity problems, responses to the odd object were reinforced on the white tray and responses to either of the nonodd objects were reinforced on the black tray. The order of presentation of the trays was determined by the Gellermann (1933) series. Simulated exchange of the trays occurred behind the WGTA door on the trials when an actual change did not occur in an effort to maintain consistent auditory cues. The monkeys were trained to the criterion of 90% correct in 20 consecutive trials. Because one monkey (SS 49) had 95% correct in the first conditional discrimination session, he was retested the next day, using new problems and with both experimenters in attendance. The monkey again responded correctly on 95% of the trials.

Table 1
Trials to Criterion for Each Monkey on the Three Experimental Tasks

Tasks	Subjects SS 47	SS 48	SS 49
Oddity set (36/40)[a]	480	520	520
One-trial oddity (18/20)[a]	20	60	20
Conditional discrimination (18/20)[a]	60	200	20

[a] *criterion required*

RESULTS

All monkeys attained the 90% correct criterion on all tasks. Trials to criterion for each monkey on the oddity learning set, the one-trial oddity series, and the conditional discrimination series may be seen in Table 1. To assess whether these criterion performances exceeded chance, Grant's (1947) probability tables were used. Grant's Table II shows the probabilities associated with "runs" of successive correct responses as functions of the total number of

Table 2
First Significant "Run" of Correct Responses/Total Trials to the End of the Run, the Longest Significant Run During the Criterion Block of Trials/Total Trials to the End of the Run, and Associated Probabilities that the Runs Occurred by Chance

Tasks	Subjects SS 47	SS 48	SS 49
Oddity set			
First run /total	15/135	15/120	10/70
p value	< .005	< .005	< .001
Criterion run/total	26/479	16/520	32/515
p value	< .01	< .01	< .01
One-trial oddity			
First run/total	12/20	12/18	7/7
p value	< .001	< .001	< .001
Criterion run/total	12/20	12/59	7/20
p value	< .001	< .001	< .005
Conditional discrimination			
First run/total	11/16	14/16	18/18
p value	< .001	< .001	< .001
Criterion run/total	17/58	15/200	18/18
p value	< .001	< .005	< .001

**See text*

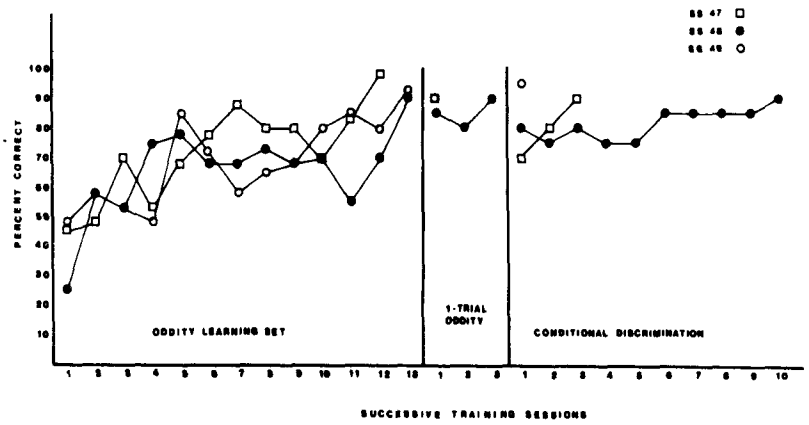

Figure 1. Percent correct responses for each monkey on each of the three principal tasks as a function of successive training sessions/task.

trials taken to the end of a run of a given length. Our Table 2 shows the length of the first significant run (using $p < .01$ as the minimum alpha level) expressed in relation to the total number of trials taken to the end of that run, the longest significant run during the block of trials in which criterion was met over the total number of trials taken to the end of that run, and their associated p values for the three experimental tasks. In most instances, the reported ps are conservative, because Grant's table did not include runs greater than 10.

Figure 1 shows the acquisition curves for each of the monkeys on the three experimental tasks. As might be expected, there was nearly complete transfer from the oddity learning sets to the one-trial oddity problems. The conditional discrimination data, also shown in Figure 1, suggested considerable transfer from the one-trial oddity problems to the conditional discrimination problems, as no animal had fewer than 70% correct in any session. SS 48, who required 10 sessions to achieve the 90% criterion, never had fewer than 75% correct in a session.

DISCUSSION

The squirrel monkey may be said to be capable of successful conditional discrimination performance under conditions which preclude learning specific stimulus configurations and which permit a conceptual-solution interpretation. To discuss these results, it may be useful to consider some previous suggestions concerning conceptual nomenclature.

As might be expected, the definitive discussions of conceptual behavior have been in the context of human performances. Some definitions of conceptual behavior contain qualifiers which exclude nonhuman animals from consideration (e.g., Hunt, 1962). Thus, it is recognized, but not considered in detail, that some might question the applicability to nonhuman animals of aspects of the following discussion. On the other hand, much of the following involves logical or operational definitions which do not discriminate between humans and nonhumans. Conceptual behavior, as defined here, refers to selective responses to stimuli which are consistently correct in terms of predetermined and discoverable reinforcement contingencies but which do not depend upon prior experience with the specific stimuli presented on a given trial.

Haygood and Bourne (1965) described the two principal features of concepts as being attributes and rules. Rules refer to the ways in which attributes (e.g., color, form, size) are combined or otherwise elaborated to define a concept. The rules refer to logical connectives such as affirmation, negation, conjunction, disjunction, etc. The performance of the monkeys in the conditional discrimination paradigm of the present work appears to meet the conditions of a biconditional rule.

Millward (1971) described the biconditional rule verbally as "A if and only if B" (p. 940), and he illustrated this rule by an example in which A was "small" (vs. medium and large) and in which B was "circle" (vs. triangle and square). With this example, as Millward demonstrates, the biconditional rule identifies the relevant stimuli as "small circle" (following "A if and only if B") *and* medium and large triangles and squares (following the equivalent statement for recognizing contingency patterns under the biconditional rule, '*not* A if and only if *not* B'). Millward stated the latter rule symbolically rather than verbally, hence, the single quotation marks. Applying the biconditional rule analogously in the present work, if A is 'odd stimulus' and B is 'white tray,' then odd objects on the white tray meet the condition "A if and only if B," and nonodd objects on the black tray meet the condition 'not A if and only if no B.'[1]

As Figure 1 suggests, the performance of SS 49 indicates immediate success in selecting stimuli deemed to be correct according to the biconditional rule, and the other two monkeys performed at a high level of success from the onset of the conditional discrimination task. By way of a possible explanation,

it may be recalled that prior mastery of the oddity concept was essential to the conditional discrimination task. The oddity concept was acquired much more slowly and presumably thoroughly, especially when one considers that these monkeys had mastered it 2 years previously. It is suggested that the oddity concept was so well assimilated that the introduction of the tray brightness contingency required only a slight adjustment on the part of the responding monkey. Additionally, any response that the monkey emitted provided immediate and relevant feedback.

One might expect, against the background of the extensive oddity training, that erroneous responses on the conditional discrimination task would tend to be inappropriate selections of the odd object, namely, when the objects appeared on the black tray. SS 47's first 6 errors and 10 of 12 total errors were of this type. Twenty-two of 33 errors committed by SS 48 were incorrect selections of the odd object. Since SS 49 made only one error (an inappropriate choice of the nonodd object on Trial 19), it is suggested that his early choices were fortuitously correct and that he immediately incorporated the feedback resulting from those choices.

There has been at least one other experiment (Riopelle & Copelan, 1954) with monkeys (*Macaca mulatta*) trained on a conditional discrimination task where the interpretation that a conceptual solution was used is justified. It may be noted, however, that Riopelle and Copelan's discussion did not include a description of the nature of the conceptual solution. Riopelle and Copelan presented two objects on a tray of one color and rewarded responses to one of the objects. After six or eight trials, the tray color was changed, and the object to be rewarded was reversed. After 12 or 14 trials, a new problem with different objects but not necessarily different trays was introduced. Following several stages of training, the last stage of training introduced six new tray-color pairs, and perfect performance was seen. This perfect performance with the new trays precludes the possibility that specific stimulus patterns had been learned and thus permits the conceptual interpretation. Using Millward's (1971) analysis, Riopelle and Copelan's final phase of training may be said to provide evidence for the use of a conditional conceptual rule. Such a rule was stated by Millward (1971) as "if A then it must be B" (p. 940). In Riopelle and Copelan's experiment, A might represent a change in the tray to be presented and B represents a change in the object to be selected.

Without detailing the evidence here, many claims for conceptual behavior in nonhuman animals have been based on paradigms which do not preclude the subjects' having performed successfully by merely learning which specific stimuli were rewarded or some other nonconceptual solution. Such evidence pertaining to the oddity concept has been examined by Strong and Hedges (1966) and Thomas and Boyd (1973). Since paradigms are available for most categories of conceptual behavior which preclude the possibility of the subject's simply learning the specific stimuli to be rewarded, it should no longer be acceptable to claim conceptual behavior based on an inconclusive paradigm.

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NOTE

1. However, it is also possible to view the task as one with two concurrent conditionals, e.g., if white, then odd and if black, then nonodd.

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