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Length Judgments by Squirrel Monkeys: Evidence for Conservation?

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The purpose of this study was to investigate the applicability of Piaget's theory and methods to the study of conservation in nonhumans. Four monkeys were trained to make sameness–difference judgments of length (yellow rectangular blocks) before and after transformations of distance. Several controls were used to insure that (a) the monkeys did not merely learn specific stimulus properties or patterns and (b) the monkeys attended to the stimuli before and after transformation. A generalization test that used green cylinders was also given. Two monkeys achieved stringent and statistically significant ($p < .01$) criteria of performance on both tests, and they showed significant generalization in the fewest possible trials. Methodological questions regarding the relevance of the present work to Piaget's concept of conservation were discussed.

Piaget's developmental psychology has focused on the ontogenetic development of the human, particularly of cognitive structures and skills. However, a comprehensive view of his work reveals it to be a biologically based theory of epistemology (e.g., Piaget, 1971a, 1971b). Therefore, it is appropriate that Piaget's theories be considered also in the context of phylogenetic development. Object permanence, the principal structure of the sensorimotor period, has been shown to develop incompletely in cats (*Felis domestica*; Gruber, Girgus, & Banuazizi, 1971) but completely in two species of monkeys, the squirrel monkey (*Saimiri sciureus*; Vaughter, Smotherman, & Ordy, 1972) and the rhesus monkey (*Macaca mulatta*; Wise, Wise, & Zimmerman, 1974).

Jolley (1972) reviewed much of the nonhuman primate learning literature in the context of Piaget's stages of cognitive development and suggested that primates function at some subperiods of the concrete-operational stage, but she provided no evidence on the question of the capacity of primates for conservation. An essential prerequisite for conservation is the ability to make sameness–difference judgments. Perhaps, the most appropriate demonstration of sameness–difference judgments in nonhuman primates in the context of conservation was that of Czerny and Thomas (1975). Their squirrel monkeys (*Saimiri sciureus*) successfully judged the sameness of or the difference between two objects when the only reliable cue was that derived from the objects' volumes.

The present work assessed the squirrel monkey's ability to judge length in an experimental design intended to incorporate the relevant features of a conservation task. Specifically, the monkey was required first to indicate that two objects (rectangular yellow blocks), slightly separated but with ends congruent, were perceived as "same," then one of the objects was transformed in distance, and the subject was again expected to respond "same." Several control procedures were used, and a generalization test using green cylinders was given.

Methods

Subjects

Four wild-born, adult male squirrel monkeys (*Saimiri sciureus*) that had previous experience were used. Their most recent (9 months prior to the present

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work) and relevant experiences were reported by Czerny and Thomas (1975). The monkeys were housed in a temperature-controlled (24–29 °C) and humidity-controlled (50%–70%) room with a controlled light–dark cycle (12 hours each). The animals were fed a maintenance ration of Purina 25 Monkey Chow daily, following the training session. This diet was supplemented with fresh fruit twice per week.

Apparatus, General Procedures, and Pretraining

A modified Wisconsin General Test Apparatus was fitted with a gray metal stimulus tray with two food wells 20 mm in diameter, 160 mm apart, and 30 mm from the edge nearest the monkey. The food wells were covered with small hexagonal gray cups that were hinged to open away from the monkey. Reinforcers were delivered beneath these cups, and the food wells could be reloaded during the transformation interval without detection. General procedures included using (a) currants as reinforcers, (b) intertrial intervals of 30 sec, (c) response times of 10 sec, and (d) a maximum of 40 trials per day. Pretraining was designed to train the monkeys to respond to the right food well when the stimuli were the same length and to the left food well when they were different lengths. This response differed from that in their previous training (Czerny & Thomas, 1975), and six stages of pretraining were necessary to achieve it.[1]

Sameness–Difference Length Judgments

The stimuli were yellow rectangular blocks, 12 mm high, 20 mm wide, with lengths ranging from 25–150 mm in 25-mm increments. In the following, a trial refers to each stimulus configuration to which the monkey responds. A trial pair refers to the initial presentation of the stimuli followed by the transformation. Twenty trial pairs were given each day. The most relevant trial pairs for Piagetian conservation are those where the monkey is shown two equal lengths in horizontal orientation that are slightly separated and with the ends aligned. The monkey was reinforced for responding to the food well on his right, thereby indicating that he judged them to be the same. One of the blocks was now moved laterally so that the two blocks overlapped in their lengths by about half. The monkey was again reinforced if he responded to the right food well.

To insure that the monkey did not merely learn to respond to the right regardless of the stimuli and that he attended to both trials of a trial pair, it was necessary to include several control procedures. Half the trial pairs began with randomly selected equivalent lengths, and half began with stimuli (randomly selected) differing in length but with ends aligned on one side. After the initial presentations and responses, half the trials involved straightforward transformations; that is, one of the objects was simply moved laterally and the monkey was again allowed to respond. However, as described so far, it is obvious that the monkey need not attend to the posttransformational trial. He might merely learn to respond on the second trial as he had on the initial presentation. To insure that he attended to the second trial of a trial pair, it was sometimes necessary to switch one of the objects so that the potential for a changed situation on the second trial of a trial pair would exist. Thus, on half the trials that began with equivalent lengths and half those that began with different lengths, the experimenter performed the transformation with another stimulus object in hand. On half these trials a switch was made for the transformed object, but on half the trials the switch was only faked. When a switch involved initially equivalent lengths, the result of the switch was a difference pair, and vice versa.

A day's training included 10 initially same presentations, 5 of which were followed by straightforward transformations and 5 were followed by either a switch or a faked switch (the number of each was balanced over sessions). Similar procedures were used with 10 daily presentations on initially different stimuli. Except for these numerical restrictions, the order of stimulus presentations was randomly determined. The animals were required to meet two criteria of (a) 36 correct responses in 40 successive trials (90%) and (b) 18 correct responses in 10 successive trial pairs involving the equivalent stimuli and straightforward transformation. It was also planned that training would be terminated if the monkey failed to meet the two criteria in 500 trial pairs.

Generalization Test

Following criterion performance on the previous task, the monkeys were tested with pale green, wooden cylinders. The cylinders had a diameter of 13 mm and ranged in length from 25 to 150 mm in 25-mm increments. Other than this change in stimulus objects, training continued as before.

Results

Only two monkeys achieved the two criteria. The longest run of correct responses during the criterion block of trials as a function of the total trials to the end of that run and the associated probabilities of chance occurrence of the run are as follows.

	Saimiri sciureus 44	*Saimiri sciureus* 45
Criterion run/total	22/667	18/399
p value	< .01	< .01

Similar data for the two successful animals' performances on the generalization test are as follows.

	Saimiri sciureus 44	*Saimiri sciureus* 45
Criterion run/total	24/26	27/56
p value	< .001	< .005

[1] Details will be supplied on request.

The probabilities were taken from Grant's data (1947). It may be noted that the two monkeys met the criteria in the fewest possible trials on the generalization test.

Although the other two monkeys did not meet the criteria, one had 80% correct on the 12th day. Had the conventional .05 alpha level been used, this monkey might have had one significant run (18/698). However, his grand mean was 58% correct, with 49% correct during the last 5 sessions. Comparable data for the other unsuccessful monkey were 88% correct on Day 11, three runs which met the .05 alpha (9/58, 12/372, 13/426), a grand mean of 64%, and a mean of 62% correct during the last 5 days.

Discussion

The present work shows that squirrel monkeys are capable of correct sameness–difference judgments of length before and after transformations of distance. It is recognized that area and volume were also systematic cues that may have provided the basis for the monkey's judgments. However, since the task was analogous to some of Piaget's length tasks and since length conservation appears in humans prior to area and volume conservation, the present data are discussed in terms of length.

A question to be asked is whether there was an opportunity to learn specific stimulus properties or patterns. Specific objects could not be used as reliable cues, as an object might be part of a sameness pattern on one trial and of a difference pattern on another trial. There were 108 different stimulus patterns possible. It seems unlikely that the monkeys could have met criterion in the number of trials taken (400 and 680) on the basis of learning specific patterns. To support this suggestion it can be noted that Spaet and Harlow's (1943) monkeys (*Macaca mulatta*) required 4,320–6,840 trials to perform successfully on six separate patterns presented concurrently, and Nissen's (1951) chimpanzee (species not specified) required 15,796 trials to master 16 unique patterns presented concurrently. Therefore, while it is logically possible, it is highly unlikely that the two successful monkeys here learned the specific pattern-reinforcement contingencies.

The distinguishing event in conservation is the subject's judgment of the invariance of the stimuli despite transformations of them. An important question is whether the subject who judges correctly before and after a transformation does so on the basis of being a good perceptual "estimator" (see Gelman, 1972) or whether the subject also includes the knowledge derived from the transformation. To answer this question the experimenter must usually have the subject's verbal explanation. However, the verbal explanation may be regarded equivocally even by Piaget (see Elkind, 1968, pp. 464–465), and others have argued that the judgments and not the verbal explanation should provide the evidence for conservation (Brainerd, 1973).

The controversy about judgments versus explanation must be resolved before there can be any conclusion about conservation in nonhuman primates. At least it may be said that the squirrel monkey is capable of making correct judgments about length equivalence before and after transformations in distance and under conditions designed to require the subject's attention to the stimuli before and after the transformation. It cannot be said whether the monkeys attended to the transformation per se. However, neither may it be said, in the typical conservation test, that a human attended to the transformation, unless that information was obtained or inferred from a verbal explanation.

Should information about the role of the transformation be found necessary to the evidence for conservation, some means of obtaining this information from nonhuman subjects would have to be devised. Such a nonverbal method might be desirable in assessments of human conservation owing to the difficulties of obtaining standardized and unambiguous verbal reports.

Other objections to the present work might stem from the extensive training that was given to the monkeys. The extensive training is necessary merely to "ask" the nonhuman subject the questions of interest. Certainly, the human subject has extensive "training," but its exact nature is rarely

known, as most of it occurs prior to the testing situation.

The foregoing has reiterated questions that bear on the operational meaning of Piagetian conservation. We believe that Piaget's theory provides a useful theoretical structure in which to investigate the phylogenetic development of intelligence and that acceptable operational criteria for assessing conservation in different species should be established.

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