OPERANT CONDITIONING OF GOATS¹BERNICE M. WENZEL, BASIL A. BALDWIN,²
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A procedure is described for establishing an operant response in goats. The operanda are two lucite panels which can be transilluminated. The goats press the panels with their muzzles and are reinforced with whole oats. All six subjects showed reliable and accurate performance in brightness discrimination, including cessation of responding during time-out periods.

The impetus to establish a laboratory for work with goats stemmed from the species' unusual pattern of cephalic circulation (Andersson and Jewell, 1956) which is particularly appropriate for studies of the effects of injecting various substances into the brain's arterial supply via exteriorized carotid loops (Baldwin, Wenzel, and Tschirgi, 1963; Wenzel, Baldwin, and Tschirgi, 1963). Because of the special interest in behavioral effects, it was necessary to devise suitable apparatus and procedures to study goat behavior in the laboratory. The general technique of operant conditioning (Ferster, 1953; Skinner, 1957) seemed most appropriate. The purpose of the present paper is to describe the operant task used and to present results for the first group of goats learning a brightness discrimination.

Few studies have been reported on the operant behavior of goats. Liddell's (1934) work, primarily with sheep, has dealt exclusively with classical defensive conditioning. Andersson and Wyrwicka (1957), Wyrwicka, Dobrzecka, and Tarnecki (1959), and Wyrwicka and Dobrzecka (1960) have studied operant responses as indicators of hunger and thirst associated with stimulation of hypothalamic nuclei. Self-stimulation, requiring switch closure by the goat, has been studied by Persson (1962). Bell (1963) measured taste preference thresholds, but no training of the goats was required. The goat has also been used as a sub-

ject in physiological studies by a number of investigators. In none of these experiments, however, has any effect on operant behavior been investigated.

METHOD

The original intent was to use lever pressing as the operant response. It soon became apparent that, although goats do use their front feet frequently to step on objects in front of them, these movements are so gross that it is difficult to shape a satisfactory response. In addition, the goats' legs are so strong that such equipment must be undesirably sturdy. Accordingly, it was decided to take advantage of a different response that goats make without training, *viz.*, the tendency to use their mouths to remove small bits of paper fixed to vertical surfaces. A device was constructed to present two movable panels which the goat could press with its muzzle, thus making possible the use of automatic programming and recording equipment.

Subjects

Six adult female goats, of Nubian, Alpine, and Saanen breeds were selected for a reasonable degree of alertness and responsiveness.

During non-experimental hours, the Ss were housed in individual pens in a vivarium room adjacent to the laboratory. The pens, 5 ft by 2½ ft, were designed so as not to restrict movement severely. The walls are 3 ft high, and the top open. Originally, a cover of widely-spaced slats was used that did not interfere with standing but made it impossible to leap out. This precaution proved unnecessary. One end of each pen is a door, while the other contains an opening to a feed bin and water bucket. Straw bedding covers the removable trays un-

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der the pens. Whenever a goat is not needed in the laboratory for a period of several weeks, it is moved to a large outdoor enclosure on a ranch several miles away. This procedure has been found to be extremely beneficial; prolonged indoor confinement seems to reduce both general motivation and resistance to disease.

Apparatus

Training was done in a sound-shielded enclosure which is an audiometric examination room manufactured by Industrial Acoustics Company. The inner dimensions are approximately 7 ft by 7 ft. Inside the chamber are a restraining stand and the stimulus-response panel. All programming and recording equipment is outside the chamber.

Fig. 1. Goat in working position on stand.

The stand on which the *S* works is shown in Fig. 1. The floor is slotted so that urine and feces will pass through. Subjects mount the stand on a ramp equipped with wooden strips to serve as steps. The stand is fitted with an assembly of iron pipes $1\frac{1}{4}$ in. in outside diameter, permitting the attachment of various accessory equipment for physiological investigations and also holding *S* in place. Two vertical pipes along each side of the neck restrain the *S*. The distance between the two vertical pipes may be readily adjusted for each *S*. The *S* has complete freedom of movement up and down but cannot leave the stand.

The response manipulanda are two clear lucite panels, 3 in. high by 2 in. wide, inserted flush into a black lucite panel which forms the front side of a wooden box housing the stimulus lights. The response panels are hinged at the top and adjusted so that a depression of about $\frac{1}{4}$ -in., requiring about 60 g force, oper-

ates a microswitch. In the box behind each response panel are two $7\frac{1}{2}$ -w lamps, wired to allow switching between two degrees of brightness. The position of the box is readily adjustable for animals of different sizes.

A metal dish is located under *S*'s head. Tubing connects the dish to a reservoir of whole oats mounted on the chamber wall behind the stand. A solenoid releases about 0.85 g of oats which slide down through the tube into the dish. The delivery of oats, therefore, is immediately preceded by the sounds of the solenoid and of the hard oats rolling into the metal dish.

Procedure

It is not feasible to deprive ruminants of food for any significant time. Not only do they retain nutritive material in their digestive tract for long periods, but also absence of sufficient quantities of proper food is injurious to the maintenance of the correct gaseous composition of the gastro-intestinal environment. Goats normally prefer oats over alfalfa. We found that an adequate daily supply of alfalfa and water did not inhibit the animal from eagerly eating oats whenever offered. Present results show that oats served as an effective reinforcer without benefit of a deprivation regimen.

From two days to six days had to be devoted to adapt the *Ss* to solitude in the test chamber. All adjusted easily and quickly to being restrained on the stand, but their first reaction to solitude in the chamber was hyperactivity and bleating. The experimenter had to stay in the chamber with them at first, then gradually moved outside. Sometimes the *S* would not remain quiet with the chamber door closed until several days elapsed. Eventually, *S* relaxed when alone in the closed test chamber.

Response shaping began as soon as *S* seemed adjusted to the stand, and while *E* was still in the chamber. For most animals, a response was shaped by the end of the second session and for some, the first time *S* was put on the stand. Magazine training was usually very simple, for as soon as *S* was shown the oats in the dish, it ate them immediately. Shaping involved putting a small piece of masking tape, which *S* ate readily, on one illuminated lucite panel. As *S* approached the panel, reinforcement delivery was triggered by hand. As *S* worked to remove the tape, thus pressing the panel several times,

oats were delivered again by hand. Usually, this experience leads to increased approaches to the panel, and shaping continues rapidly so that manual triggering of reinforcement delivery can soon be abandoned in favor of automatic delivery on a FR 1 schedule.

For training in brightness discrimination, one panel was illuminated at full brightness. A response on this panel was followed by reinforcement, while any response to the dark panel was not reinforced. The position of the illuminated panel was changed at random intervals approximating $\frac{1}{2}$ to $1\frac{1}{2}$ min. Whenever the change occurred, it was simultaneous with the delivery of reinforcement. Many reinforcements were delivered, of course, without a change in the position of the stimuli.

Once the S was responding steadily, the other panel was illuminated dimly. The panel with the bright light alternated with that of the dim light in the same manner as described above for the unlighted panel. At this time, also, the reinforcement ratio was usually increased, either to FR 2 or 3, or to VR 2.5. A further increase to VR 5 was made gradually, and finally, VR 11 was attempted.

Time-out (TO) periods were introduced, during which both panels were unlighted and a DRL procedure was imposed necessitating a 1-min period of no responses before the panel lights returned. The TO periods alternated with 1- to 2-min periods of normal procedure. In this way, Ss were accustomed to the conditions that were anticipated during the subsequent physiological studies, so that they would stand quietly during interim periods without the brightness stimuli.

Training sessions lasted about $\frac{1}{2}$ hr, and were held at approximately the same time each day. Recordings were made of correct and incorrect responses, responses during TO, and each change in the position of the two stimuli.

RESULTS AND DISCUSSION

All six goats quickly learned the panel-pressing response and established quite stable response rates appropriate to the schedule of reinforcement. Some cumulative records are shown in Fig. 2 to illustrate the degree of stability achieved. Each goat had a characteristic rate within the range between 40 and 60 responses per minute. The oldest goat had the lowest rate.

Fig. 2. Sample records from two goats. Upward slashes indicate reinforcements. The line at the bottom shows the location of the positive stimulus, *i.e.*, when the line is deflected upward the brighter panel was on the left and when the line is deflected downward the brighter panel was on the right.

All but one S performed the original discrimination, *i.e.*, bright light *vs.* dark, with 91-98% mean accuracy in the first three or four sessions; the remaining S had only two sessions with this condition and performed at 75%. When the discrimination was changed to bright *vs.* dim light, Ss continued to perform at better than 90%, frequently reaching 98 or

99%. The introduction of TO sometimes resulted in a slight drop in accuracy. The use of different reinforcement schedules from VR 2 to VR 5 had little effect on accuracy or steadiness of work, but no *S* maintained a satisfactory rate with VR 11. This schedule was tried unsuccessfully with all *Ss*. Their output decreased, although accuracy remained intact. Possibly, an FR schedule as high as FR 11 could be used, for it seemed to be the longest intervals in the VR 11 that especially produced slowing.

The high percentage of correct responses accurately reflects *Ss*' performance ability in this test of brightness discrimination. The procedure finally used prevented artificial inflation of the error count, which had been observed to occur with pilot animals using a slightly different procedure. As described above, the position of the correct stimulus changed only when reinforcement was delivered. As soon as the oats were released, the *S* stopped working to eat, so that errors due simply to response-chain inertia were prevented. Once an *S* was responding rapidly on one position, it appeared difficult for it to stop suddenly and to change to the other. Therefore, if the lights had changed between reinforcements, more errors would have been made artifactually. It is subjectively obvious when watching the animals perform that they select the correct stimulus under either procedure of reversing sides, but are simply unable to reverse the side of responding instantly.

Panel-pressing behavior during TO assumed two forms. Two *Ss* maintained a fairly high rate during the early sessions but reduced it essentially to zero by the fourth session. The other four *Ss* made no responses at all during TO throughout the first session in which they were introduced, but began responding slightly in some later session varying from the second to the fifth. This belated occurrence of responding lasted only for one or two sessions, and then the frequency during TO returned to zero and remained there. For many sessions all *Ss* made no responses at all during TO. Goats are perfectly capable, then, of inhibiting responses entirely for at least 1 min.

The ease with which *Ss* adapted to the situation, the speed with which they learned to respond appropriately to visual stimuli, and their retentiveness were all very impressive. The eagerness with which they went to the

experimental room is notable. They ran down the hall from their pens, entered the laboratory, climbed the ramp onto the stand, and put their heads in position with little or no urging. After many weeks away from the laboratory, work was typically resumed at a very high level of accuracy. Klopfer (1963) has reported similar findings with swine.

The general procedure described here seems very promising for adaptation to a variety of situations. At present, we are studying pattern discrimination by projecting different designs onto the lucite panels with the aid of read-out projectors. The fact that rapid learning, stable responding, and great accuracy can be obtained without specific deprivation or loss of body weight is of considerable interest. It is also advantageous for those physiological experiments that are best conducted on a normally nourished animal.

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