INSTRUMENTATION & TECHNIQUES

Performance of rats on a discrimination operant alley task discriminated

WILLIAM T. GREENOUGH¹ and BARRY W. GODOLPHIN,
University of California, Los Angeles

An automated discriminated operant alley apparatus is described. Data from four rat strains indicate that the light-dark choice is learned by both pigmented and albino rats. The task requires a minimum of experimenter time and allows initial acquisition to be recorded without the interference of a shaping procedure.

With some notable exceptions (e.g., McGaugh & Petrinovich, 1956), free operant appetitive learning situations described in the literature have been based on a bar-press response (Bitterman, 1966, reviews a number of automated tasks). Generally this response requires a certain amount of shaping or pretraining. The present paper describes an automated operant light-dark discrimination apparatus in which the operant is rapidly learned with no formal pretraining or shaping aside from adaptation to the apparatus. This requires a minimum of time to be spent by the E in preparing Ss for training, precludes the introduction of experimenter and handling effects into the learning process, and allows recording of the initial stages of learning. Further, the rapid acquisition of the running response indicates that the task may require an operant of higher probability than a lever manipulation (Premack, 1965), allowing discrimination learning to begin early in the training procedure. The apparatus resembles in some respects various earlier nonautomated discrete trial appetitive discrimination tasks (e.g., Grice, 1948; Spence, 1945).

METHOD

Subjects

The Ss were 16 Long Evans and nine Wistar albino rats obtained from Simonsen Laboratories, Gilroy, Calif.; four Fisher albinos from Charles Rivers Laboratories, Wilmington, Mass.; and four Sprague Dawley albino rats from Berkeley Pacific Laboratories, Berkeley, Calif. The Ss were 50 to 65 days of age at the beginning of deprivation.

Apparatus

The apparatus, consisting of two parallel alleys connected at each end to a goal box, is diagrammed in Fig. 1. Inside dimensions are: goal boxes, 6 in. wide x 7 in. long; each alley, 4½ in. wide x 16 in. long; tapered transition sections, 5 in. long. All walls are constructed of ½ in. plywood and are 6 in. high. The floor of the apparatus is made of four stainless steel plates separated from the walls and from each other by ¼ in. and supported from below by ½ in. plastic feet. This allows occasional boluses to drop below the floor plates where they will not interfere with recording. Each end plate forms the floor of a goal

Fig. 1. Cut-away view of apparatus: dimensions given in text. Cups are similar to those supplied with Davis Scientific Instruments LR-130 liquid pump.

box, a transition section, and one end of each alley. Each side plate forms the floor of the center half of an alley. Each goal box has a clear plastic cover. Transition sections and alleys are covered by a single, hinged clear plastic cover which supports two .34 cp cue lights (GE 1819). When the cover is in place, each cue light shines through the plastic into the center of the alley beneath it. An opaque cover over each bulb blocks the light in all other directions. The entire apparatus, except for the floor plates, is painted flat black.

The S's task is to proceed from one goal box through an alley to the opposite goal box. A response is recorded when S's forepaws complete a circuit between the end plate of the active goal box and the side plate of either alley. If the animal chooses the correct alley, liquid reinforcement (0.1 ml of 0.05% saccharine) is delivered into a ¼ in. diam conical plastic cup centered near the floor on the end wall of the goal box. Reinforcement is controlled by a Valcor (No. 3700-6) adjustable solenoid valve working against a 3 ft head of liquid. The amount of liquid reinforcement can be varied by adjusting the stroke of the valve, the water head, and the length of the electrical pulse to the solenoid. Separate valves are used for each goal box.

A schematic of the electrical circuit is shown in Fig. 2. Programming is controlled by a two bank stepping switch, K1; each step represents a single trial. The sequence is repeated every 26 trials. The right bank of the stepper controls K3 which

Fig. 2. Wiring diagram. "North" and "South" arbitrarily designate opposite ends of apparatus. K1—Automatic Electric type 45 rotary stepping switch, 2 bank, 26 contact, indirect drive; K2—Potter and Brumfield KA14DY 3PDT relay; K3—Potter and Brumfield KA11DY 2PDT relay; S1—Cutler Hammer 8373K22C DPDT toggle switch; Pulse Formers—Davis Scientific Instruments 253 V or equivalent; Counters—Davis Scientific Instruments 263 Counter Panel or equivalent; Timers—Davis Scientific Instruments 252 Electronic Timer Panel or equivalent; Cue Lights—General Electric 1819.

alternates the active goal on successive trials. If, as shown in the figure, the "north" end of the apparatus is active, the +28 V supply is connected to the north end plate and the corresponding reinforcement valve is connected to the reinforcement timer. A correct response will cause this timer to operate the north valve to deliver reinforcement.

Whenever S completes the circuit between the active end plate and the side plate of the alley through which he is moving, an imperceptible (about $4 \mu\text{A}$) current passes through his body. This current is amplified to drive a sensitive relay which in turn drives a pulse former relay. The pulse former insures that the other elements in the system will operate, and is set for a time longer than that of the reinforcement timer. The amplifier is shown in Fig. 3. Any of a variety of commercial units, although more expensive, would work as well (e.g., Davis Scientific Model 313 Micro Sensor).

The upper set of contacts of each pulse former indicates the position of the S. The lower set of contacts are connected in parallel and cause the stepper to advance whenever S responds. Occasionally a large rat will have his tail on the end plate he is leaving when he completes the circuit to the active goal box. This causes an additional response to be scored as the stepper advances. To prevent this, a hold off timer delays application of +28 V to the opposite end plate until S's tail has had time to clear (about 1 sec).

The left bank of the stepper controls K2 which determines which alley is correct. In Fig. 2 the left alley is correct, and a

Fig. 3. "Sense amplifier," animal detector circuit; Transistors—2N338 or equivalent (BV_{CE} , $BV_{CB} = 45 \text{ V}$; $h_{FE} = 40$; $P = 125 \text{ mw}$); Relay—Allied Control TS 154-C-C; Resistor—5-megohm, $\frac{1}{2}\text{W}$.

response in this alley will complete the circuit to the correct response counter and the reinforcement timer. A response in the right alley operates the incorrect counter. The top set of contacts of K2 synchronizes cue lights with the correct alley. Manual switch S1 controls the light-dark reinforcement contingency; in the position shown, the lighted alley is correct.

Procedure
The Ss were routinely gentled by brief daily handling for one or two weeks before beginning training. Three or four days prior

Fig. 4. Mean shuttle responses per minute for the four strains.

to formal training, Ss were placed on a 23½ h water deprivation schedule. On the last two days before formal training, Ss were allowed 30 min free exploration in the apparatus in groups of two or three with a standard 250 ml laboratory water bottle mounted such that the spout protruded into the apparatus through a hole between the goal box cover and the alley cover.

Training was carried out in a dark room. On the first two formal training days, both goal boxes contained a reinforcement at the beginning of the session. Thereafter, Ss were placed in the correct alley such that they would be rewarded on the first trial of each day (not scored) by running forward. Since Ss generally show a dark preference in this apparatus, they were routinely trained to light correct. A training session lasted 30 min for the first four days and 20 min thereafter. The Ss not maintaining at least 50 responses per day from Day 4 were discarded. One Fisher and one Long Evans rat failed to meet this criterion.

RESULTS AND DISCUSSION

The shuttle-like operant is established relatively rapidly, developing to essentially asymptotic performance after two days of formal training. Figure 4 shows the average number of responses per minute (correct and incorrect combined) for the four strains tested.

The discrimination is established somewhat more slowly, although most Ss had learned to choose the lighted alley by the fifth day of training. Figure 5 shows the mean of the individual percentages of correct responses for the four strains. The gradual rise in the curves is to some extent a function of averaging, since many Ss show a sudden jump in per cent correct on one day which is maintained thereafter. Similarly, the fact that the groups as a whole rarely exceed 80% correct is partially a function of

Fig. 5. Average of individual percentages correct for four strains.

including poorer learners in the average (e.g., two out of the 15 Long Evans rats failed to exceed 70% correct during the entire seven sessions), but the less than ideal performance results mainly from a warm-up effect. That is, animals who previously demonstrated a high level of discrimination performance often tended to average about 50% correct for the first 1 to 2 min of each daily session, but averaged nearly 100% correct thereafter. A continuous record, or a printout of 5 min blocks, might more closely represent individual performance.

Analysis of the relative levels of performance of the various strains was not carried out due to the small numbers of Sprague Dawley and Fisher rats tested. The data indicate, however, that all of the strains were capable of learning the task.

REFERENCES

- BITTERMAN, M. E. *Animal learning*. In J. B. Sidowski (Ed.), *Experimental methods and instrumentation in psychology*. New York: McGraw-Hill, 1966, 451-484.
- GRICE, G. R. The relation of secondary reinforcement to delayed reward in visual discrimination learning. *Journal of Experimental Psychology*, 1948, 38, 1-16.
- MCGAUGH, J. L., & PETRINOVICH, L. An apparatus for the study of instrumental learning in the rat. *American Journal of Psychology*, 1956, 69, 660-663.
- PREMACK, D. Reinforcement theory. In D. Levine (Ed.), *Nebraska Symposium on motivation*, 1965, 13, 123-180.
- SPENCE, K. W. An experimental test of the continuity and non-continuity theories of discrimination learning. *Journal of Experimental Psychology*, 1945, 35, 253-266.

NOTE

1. Now at the University of Illinois, Urbana. The first author was supported by United States Public Health Service Mental Health Training Grant 5 T 1 MH-666-9. This work was carried out at the Neurobiochemistry Laboratory, Veterans Administration Center, Los Angeles, Calif. The authors wish to acknowledge the valuable assistance of Arthur Yuwiler.