DOUBLE DISCRIMINATION AVOIDANCE WITH A SINGLE STIMULUS¹

J. D. KEEHN

ALCOHOLISM AND DRUG ADDICTION RESEARCH FOUNDATION, TORONTO

Four white rats were trained to avoid electric shocks by depressing a bar after the onset of a stimulus and releasing it after termination of the stimulus. All subjects acquired the behavior of holding the bar in the presence of the stimulus and releasing it in the absence of the stimulus, but one animal almost always required a "priming" shock. The others exhibited a high level of shock avoidance.

Rats exposed to shock-escape or shock-avoidance training procedures in a bar-pressing situation frequently exhibit sustained bar-holding behavior (Dinsmoor and Hughes, 1956; Feldman and Bremner, 1963; Hurwitz, 1967; Hurwitz and Dillow, 1967; Keehn, 1967*b*; Migler, 1963 *a, b*). Part of the well-known difficulty in training rats with discriminated avoidance procedures to press a bar (D'Amato and Schiff, 1964; Hurwitz, 1964; Meyer, Cho, and Wesemann, 1960; Myers, 1959) has been attributed to this holding behavior, insofar as animals which bar-hold are occasionally shocked while holding the bar (Keehn, 1967*c*). There are several ways of surmounting this difficulty: one is to remove the bar from the animal (Christopherson and Denny, 1967; Cole and Fantino, 1966) and another is to remove the animal from the bar (Kintz and Bruning, 1967). These methods interfere with the free emission of behavior and also introduce variables which are difficult to specify and control. Other methods, which do not introduce these liabilities, have been devised for controlling bar-hold durations. In one, bar-holding was differentiated from long to short durations (Keehn, 1967*c*, Exp. 3); in another, bar-pressing and bar-releasing were conditioned by a "double discrimination" procedure in which shocks avoidable by each of these responses were signalled by different stimuli (Keehn, 1967*a*). The present paper reports an experiment in which the double discrimination procedure was used with only one

stimulus: occasions for bar-pressing and bar-releasing were signalled by the onset and offset of a single stimulus.

METHOD

Subjects

Four experimentally naive, male, laboratory bred albino rats were used. They were about 150 days old at the beginning of the experiment and had been handled extensively in infancy and for about 15 min each daily for two weeks before the experiment. They were maintained in individual home cages with free access to food and water.

Apparatus

The experimental chamber was a Grason-Stadler two-bar rat box type E3125D divided longitudinally by a wooden partition so that only one bar was available to a subject. A subject's working space was 5 in. wide, 11½ in. long and 7⅝ in. high, approximately. A 2-in. wide bar protruded ⅝ in. into the chamber about 3½ in. above floor level. A white stimulus light was located slightly above and about 1½ in. to the right of the bar. A weight of about 22 g on the bar was sufficient to activate automatic programming and recording equipment. A Grason-Stadler shock generator was used to apply brief (0.3 sec) scrambled shocks to the grid floor of the chamber. The generator output was set at 1 ma.

Response records were collected on a Gerbrands cumulative recorder arranged to step once for about every 0.2 sec that the bar was depressed. Shock and signal onsets were registered on magnetic counters as well as on the

¹Reprints may be obtained from the author, Alcoholism and Drug Addiction Research Foundation, 344 Bloor St. West, Toronto 4, Ontario, Canada.

cumulative records. All programming and recording were controlled by electronic circuitry located in an enclosed closet in the experimental room. The experimental chamber was enclosed in a ventilated enclosure, Grason-Stadler Model No. E3125AA.

Procedure

Thirty seconds after an animal was placed in the experimental chamber a stimulus (S_1) was presented. If the animal did not press the bar within 5 sec of the onset of S_1 , brief (0.3 sec) shocks occurred at 5-sec intervals until the bar was depressed. Shocks were postponed the whole time the bar was held down, but began again 5 sec after it was released unless it was pressed again in the interim. Shocks, therefore, were avoidable either by continuous bar depression or by bar-presses and releases at the rate of one per 5 sec or greater. Termination of S_1 was not under the subject's control.

To shape bar-pressing or holding, the experimenter interrupted the train of shocks whenever a subject approached the bar during Session 1. Once bar holding in the presence of S_1 was established the stimulus was terminated by the experimenter for various lengths of time. If a subject held the bar down for as long as 5 sec in the absence of S_1 the train of shocks began and continued until the bar was released. During Sessions 1 through 3, each of which lasted between 30 and 90 min, the periods of S_1 onset and offset were varied according to the performance of a particular animal. From Session 4 to Session 17, stimulus S_1 was ON and OFF for alternate 30-sec periods for 100 min, except that at the end of Session 11 ON-OFF stimulus periods of 15 sec and 60 sec were introduced in the cases of D1 and D2. The standard procedure, then, was as follows. Stimulus S_1 was alternately ON and OFF every 30 sec. When the stimulus came ON a subject had 5 sec in which to press the bar without getting shocked, and it could continue to avoid shock either by holding the bar depressed or by releasing the bar and pressing it again within 5 sec. When the stimulus went OFF, a subject had 5 sec in which to release the bar without getting shocked, and it could continue to avoid shocks either by refraining from pressing the bar or by pressing the bar and releasing it within 5 sec. A subject could avoid shocks by holding the bar depressed con-

tinuously for the 30 sec that S_1 was ON and releasing it for the 30 sec that S_1 was OFF, or by pressing and releasing the bar at least once every 5 sec, regardless of the presence or absence of the stimulus. Stimulus S_1 was a light-noise combination, the onset of which was the signal for bar-holding for Subjects D1 and D2, and for bar-releasing for D3 and D4. The light was provided by red and white 6-w lamps; the noise was a 1000 cps tone of medium intensity.

RESULTS

All subjects adopted the behavior of holding and releasing the bar in the presence and absence of S_1 respectively, rather than that of pressing the bar at regular intervals. The average amount of time each subject spent holding the bar depressed per 30-sec S_1 ON and 30-sec S_1 OFF period in Sessions 4 through 17 is shown in Fig. 1. For animals D1 and D2, the S_1 ON periods correspond to LIGHT-TONE ON periods; for animals D3 and D4, S_1 ON corresponds to times when light and tone were OFF. All animals show bar-holding and bar-releasing appropriate to the experimental contingencies. A typical stable performance of D1 is shown in Fig. 2. The figure shows a cumulative bar-holding record and was produced on a recorder which stepped once for about every 0.2 sec that the bar was

Fig. 1. Mean seconds each animal spent bar-holding per 30-sec period of S_1 presence and absence in Sessions 4 through 17. For D1 and D2 presence and absence of S_1 were LIGHT-TONE ON and LIGHT-TONE OFF respectively. These conditions were reversed for D3 and D4.

Fig. 2. Cumulative bar-holding record of D1 for the whole of Session 9. Each excursion of the pen represents about 100 sec bar-holding time. The lower trace shows onsets and offsets of S_1 .

held down. Shocks are shown by oblique blips on the cumulative record, and the presence of S_1 is indicated by the elevated portions of the lower, horizontal trace. "Warm-up" is exhibited by the solid blocks of shocks delivered to the animal at the beginning of the session,

when it failed to press the bar during several S_1 presentations. After "warm-up", the animal received shocks on 13 occasions when it failed to press the bar within 5 sec of S_1 onset, and on one occasion when it failed to release the bar within 5 sec of S_1 offset. Occasions when

Fig. 3. Cumulative bar-holding record of D1 for the end of Session 11. Each excursion of the pen represents about 100 sec bar-holding time. The lower trace shows onsets and offsets of S_1 , which was ON for 30 sec and OFF for 30 sec up to A, ON and OFF for 60 sec from A to B and after C, and ON and OFF for 15 sec each from B to C.

the animal released and pressed the bar during S_1 ON periods are observable in the first excursion of the cumulative record, but typically the animal made one press-hold response after S_1 onset, and one release response after each S_1 terminated.

The effect of varying S_1 onset and offset durations is shown in Fig. 3. The portion of the record between points P and Q depicts only a modification in recording technique in which the pen reset with every stimulus change. This modified method of recording

permits observation of release response latencies, but press response latencies are not easily visible because of the scale of the graph. Stimulus onset and offset periods, shown by the lower trace, were 30 sec each up to point A, 60 sec each from A to B, 15 sec each from B to C and 60 sec each from C to the end of the record. None of these temporal changes affected control of the animal's bar-pressing and releasing exercised by S_1 . The only shock received by the animal throughout the 33 min of the session covered by the figure is shown

Fig. 4. Cumulative bar-holding records of each animal over the first 15 min of Session 17. Each excursion of the pen represents about 100 sec bar-holding time. The lower trace shows onsets and offsets of S_1 .

by the oblique blip at the beginning of the record.

Not all of the animals were as proficient as D1 in avoiding shocks, although they all exhibited the same pattern of holding and releasing behavior. Cumulative bar-holding records of all four subjects for approximately the first 30 min of Session 17 are shown in Fig. 4. The records exhibit "warm-up" of both bar-pressing in the presence of S_1 , and bar-releasing in its absence. Shocks shown on the flat portions of the curves and at the beginning of rising portions occurred through failures to press the bar during S_1 ; those shown at the end and along the rising parts of the curves occurred through failures to release the bar in the absence of S_1 . All animals exhibited bar-holding and bar-releasing behavior appropriate to the stimulus conditions, although holding and releasing by D3 were always primed by shock. The other animals avoided many shocks, all of them avoiding better by releasing the bar at the termination of S_1 than by pressing the bar after S_1 onset. Session-by-session data on the percentage of times an animal avoided shocks during stimulus ON and OFF periods through appropriate bar-pressing or bar-releasing behavior are shown in Fig. 5. Data from sessions prior to Session 8 are not included in Fig. 5 because before this session not all animals were under sufficiently good stimulus control for reliable shock-avoidance percentages to be computed from the cumulative records.

DISCUSSION

The acquisition of avoidance bar-pressing and releasing by three of the four subjects adds to the extensive literature (*e.g.*, Herrnstein and Hineline, 1966; Sidman, 1966) showing that termination of an exteroceptive warning signal is not a necessary condition for the acquisition of avoidance responding by the rat. The questions of why one animal's avoidance behavior was so much more proficient than that of the others, and why one animal's performance was so poor, are not answerable from the present experiment.

Although the procedure of changing from S_1 ON to S_1 OFF and *vice versa* on a temporal basis served to make stimulus changes non-contingent upon an animal's behavior, the procedure in practice was less than ideal. This

was because on occasions when animals failed to make the avoidance response appropriate to a stimulus condition, as when no presses were made by D1 during S_1 ON periods for the first few minutes of Session 9 (Fig. 2), and when no releases were made by D1 and D3 during S_1 OFF periods at the start of Session 17 (Fig. 4), they succeeded in avoiding all shocks in the succeeding stimulus condition merely by continuing their previous behavior. Such "adventitious avoidance" typically occurred only at the beginning of sessions, and soon dropped out, but the fact that its occurrence was not under explicit experimenter control is a procedural limitation that cannot be denied. A modification in which the stimulus condition did not change until an animal had emitted the avoidance behavior appropriate to the prevailing stimulation uninterrupted for a specified period has been used with guinea pigs (Webster and Walsh, 1968). The modification produced results similar to those of the present experiment, without the limitations described above.

Fig. 5. Percentages of stimulus periods in which shocks were avoided by bar-pressing and by bar-releasing in Sessions 8 through 17.

REFERENCES

- Christopherson, E. R. and Denny, M. R. Retractable-bar avoidance. *Psychonomic Science*, 1967, 9, 579-580.
- Cole, M. and Fantino, E. Temporal variables and trial discreteness in lever-press avoidance. *Psychonomic Science*, 1966, 6, 217-218.
- D'Amato, M. R. and Schiff, D. Long-term discriminated avoidance performance in the rat. *Journal of Comparative and Physiological Psychology*, 1964, 57, 123-126.
- Dinsmoor, J. A. and Hughes, L. H. Training rats to press a bar to turn off shock. *Journal of Comparative and Physiological Psychology*, 1956, 49, 235-238.
- Feldman, R. S. and Bremner, F. J. A method for rapid conditioning of stable avoidance bar pressing behavior. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 393-394.
- Herrnstein, R. J. and Hineline, P. N. Negative reinforcement as shock-frequency reduction. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 421-430.
- Hurwitz, H. M. B. Method for discriminated avoidance training. *Science*, 1964, 145, 1070-1071.
- Hurwitz, H. M. B. Lever holding under free-operant avoidance. *Journal of the Experimental Analysis of Behavior*, 1967, 10, 551-554.
- Hurwitz, H. M. B. and Dillow, P. V. Avoidance and response duration as a function of the warning period. *Psychological Record*, 1967, 17, 517-524.
- Keehn, J. D. Double discrimination bar-press and bar-release avoidance. *Psychonomic Science*, 1967, 8, 189-190. (a)
- Keehn, J. D. Is bar-holding with negative reinforcement preparatory or perseverative? *Journal of the Experimental Analysis of Behavior*, 1967, 10, 461-465. (b)
- Keehn, J. D. Running and bar-pressing as avoidance responses. *Psychological Reports*, 1967, 20, 591-602. (c)
- Kintz, B. L. and Bruning, J. L. Punishment and compulsive avoidance behavior. *Journal of Comparative and Physiological Psychology*, 1967, 63, 323-326.
- Meyer, D. R., Cho, C., and Wesemann, A. S. On problems of conditioning discriminated lever-press avoidance responses. *Psychological Review*, 1960, 67, 224-228.
- Migler, B. Bar-holding during escape conditioning. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 65-72. (a)
- Migler, B. Experimental self-punishment and superstitious escape behavior. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 371-385. (b)
- Myers, A. K. Avoidance learning as a function of several training conditions and strain differences in rats. *Journal of Comparative and Physiological Psychology*, 1959, 52, 381-386.
- Sidman, M. Avoidance behavior. In W. K. Honig (Ed.), *Operant behavior: areas of research and application*. New York: Appleton-Century-Crofts, 1966. Pp. 448-498.
- Webster, C. D. and Walsh, Maxine G. Acquisition of stimulus control of bar-press avoidance behavior with guinea-pigs. *Psychonomic Science*, 1968, 11, 17-18.

Received 27 October 1967.