Escape response distribution and discriminated avoidance of discontinuous shock¹

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When discontinuous shock is used as the US in a discriminated lever-press escape-avoidance task, a disproportionate number of escape responses are made during on-shock periods. The present study indicates that the response distribution is not due to paced responding. Animals appear to be responding to discrete bursts of shock rather than to the shock series as a whole and for individual Ss, the number of escapes executed to a burst of shock is correlated with avoidance performance during acquisition.

The use of discontinuous shock has been shown to facilitate the acquisition of a discriminated lever-press avoidance response (Hurwitz, 1964; D'Amato, Keller, & DiCara, 1964). It has been hypothesized (D'Amato et al, 1964) that the efficacy of discontinuous shock is due to increased generalization of escape responses to the pre-shock period. With appropriate parameters of discontinuous shock the probability should be high that Ss will execute the response in off-shock periods and such responses, occurring in the absence of shock, should generalize to the pre-shock period where the CS but not the US is present.

D'Amato, Keller, & Biederman (1965) investigated the temporal parameters of discontinuous shock in a study in which three values of off-shock time (.5, 1.0, and 2.0 sec) were combined factorially with three values of on-shock time (.2, .5, and 1.0 sec). In support of the generalization hypothesis they reported that the correlation of mean avoidance performance for each factorial combination group, over the first 100 trials, with the corresponding mean percentage of escape responses executed by those groups in off-shock periods, yielded a rho of .864 ($t = 4.85$; $p < .002$).

A test of the generalization hypothesis by Hess & Shafer (1968) indicated that the occurrence of the escape response in the absence of shock is not a crucial variable accounting for the superior avoidance learning obtained with discontinuous shock procedures. The avoidance performance of an experimental group (which received a .2 sec burst of shock for each escape response executed in what otherwise would have been an off-shock period) was equal to or nonsignificantly better than that of a control group trained under standard discontinuous shock procedure. The results indicated either a negative correlation or no correlation at all between the avoidance performance of Ss and the percentage of escape responses they execute in off-shock periods.

Experiment 1 of the present study was designed to determine correlation of the avoidance performance of individual animals with the percentage of their escape responses executed during either the .2 sec that shock is on or during a .4 sec period composed of the .2 sec on-shock time and the following .2 sec.

D'Amato et al (1965) reported that highest mean avoidance performance over 400 trials was achieved by animals in the .2 sec on-time/2.0 sec off-time group. In contrast to the escape response distribution expected by D'Amato, Keller, & Biederman (1964) under such conditions, the mean percentage of escape responses executed during the off-shock time by this group was 33% although 82% of the escape responses would be expected to fall in the same time period if the responses were randomly distributed.

Two interpretations of these data were suggested by Hess & Shafer (1968). Either Ss are pacing their responses or they are responding to the discrete bursts of shock within the discontinuous shock presentation.

Experiment 2 of the present study is designed to differentiate between these two interpretations.

EXPERIMENT 1

Method. The Ss were 10 male albino Sprague-Dawley rats 80 to 100 days of age when tested. Ss were conditioned in a Scientific Prototype operant

chamber with a 4000 cps tone CS at 50 dB and a .3 mA scrambled US. The ITI averaged 35 sec, while the CS-US interval was 5 sec.

On Day 1 the bar-press was shaped with continuous shock and each S received 50 trials of pretraining with discontinuous shock. On Day 2 each animal received 250 trials of escape-avoidance training. Escapes, avoidances, and percentage of escape responses executed during two periods (a .2 sec on-shock period; and a .4 sec period consisting of the .2 sec on-shock period plus the following .2 sec) were recorded for each block of 50 trials.

The use of a .4 sec on-shock period (.2 sec shock and the following .2 sec) allows the recording of responses completed while shock is on and also many responses begun during the burst of shock but having a latency longer than .2 sec. It should be noted that this .4 sec period designated as an on-shock period is comparable to the .45 sec shock period (.2 sec shock and the following .25 sec) used in the D'Amato, Keller, & Biederman (1965) study.

Results. For the first 150 trials the mean percentage of escape responses executed in the .2 sec on-shock period was 21.09%. Mean percentage of escape responses executed during the .4 sec period was 39.81%. In the last 100 trials these values had increased to 25.93% for the .2 sec period and 47.95 for the .4 sec period. If the responses had been randomly distributed, expected values would be 9% and 18% for the respective periods. The correlation of avoidance scores over the first 150 trials and percentage of escape responses executed in the .2 sec interval yielded a rho of .472 ($t = 1.505$, $df = 8$, $p < .10$). Correlation of avoidances and percentage of escape responses executed in the .4 sec period yielded a rho of .743 ($t = 3.08$, $df = 8$, $p < .01$).

EXPERIMENT 2

Method. The Ss were 16 male Sprague-Dawley rats obtained from Research Animals, Inc., Pittsburgh, Pa., and were 60 to 80 days old when tested. The apparatus described in Experiment 1 was modified to provide a variable length off-shock period within the discontinuous US.

The Ss were randomly assigned to either a control group which received standard discontinuous shock training (.2 sec on, 2.0 sec off) or to an experimental group receiving discontinuous shock training in which the off-shock interval was varied from 1 to 3 sec with a mean off-time of 2 sec. On Day 1 Ss received 50 trials of pretraining as in Experiment 1. On Day 2 each animal received 250 escape-avoidance trials. A .3 mA US was used at all times and the on-time was a constant .2 sec. Escapes, avoidances, escape response latencies, and escape responses executed during the .2 sec on-time period, were recorded.

Results. All response measure data exhibited homogeneity of variance, and t tests revealed no significant differences between the groups. Mean avoidance performance for the control group over 250 trials was 118.1 avoidances while for the experimental group it was 138.6 avoidances.

DISCUSSION

In Experiment 1 a disproportionate number of escape responses, similar to that appearing in the D'Amato, Keller, & Biederman (1965) study, occurred during both the .2 sec on-shock period and in a .4 sec period composed of the .2 sec on-shock period and the following .2 sec. The number of escape responses occurring in the .4 sec period was found, for individual animals, to correlate significantly with avoidance performance.

In Experiment 2, varying the interval between the .2 sec bursts of shock while maintaining a mean off-shock interval of 2.0 sec eliminated the opportunity for S to execute a disproportionate number of escape responses in on-shock periods due to any paced responding. If avoidance performance were related to the opportunity for such paced responding, an avoidance decrement should have appeared for the experimental group. However, no significant differences appeared between groups in either avoidance performance or in the number of escape responses executed during on-shock periods and such differences as did appear were in the opposite direction from that to be expected from a pacing hypothesis.

The Ss appear to be responding with very short latencies to discrete bursts of shock within the shock series. It has been noted in other studies (D'Amato, Keller, & DiCara, 1964; Hess & Shafer, 1968) that Ss in an escape-avoidance situation often approach the bar with the onset of the CS, position their paws

above it, and wait for the shock before responding. The same type of behavior occurs within the discontinuous shock paradigm. S approaches the bar in off-shock periods and responds to a discrete burst of shock with a response latency of less than .4 sec for almost half the escape responses by the end of 250 trials.

Feldman & Bremmer (1963) selectively introduced short bursts of shock to eliminate competing freezing and barholding behaviors from escape responding in an escape-avoidance task. It is our conclusion that a discontinuous shock US is a systematic shaping procedure in which the short bursts of shock have the dual effect of breaking up freezing behaviors while at the same time reinforcing S's successive movements toward completion of the response.

The correlation of avoidance performance with the percentage of escape responses S executes to discrete bursts of shock, may reflect a reinforcement contingency present for such responses. Clearly escape responding is best acquired when the US is terminated by the response rather than before the response is made. Within the discontinuous shock US, escape responses may fall in off-shock periods when US termination and the escape response are not simultaneous. This may be particularly relevant since Ss appear to respond to discrete bursts of shock rather than to the shock series as a whole.

More efficient avoidance behavior might be produced by combining discontinuous and continuous shock procedures. Discontinuous shock would

break up freezing behaviors while continuous shock provided immediate reinforcement of escape responses.

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NOTE

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