Effects of shock intensity on avoidance responding in a shuttlebox to serial CS procedures

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Previous work with a shuttlebox avoidance task has found that when serial CS procedures (e.g., tone followed by lights) are compared to nonserial CS procedures (e.g., tone), the serial procedures result in a longer mean avoidance response latency, with most of the avoidance responses occurring to the last stimulus introduced into the sequence (S_2). The present study was an attempt to determine whether this serial CS delayed-responding effect could be altered by manipulating the shock intensity. Two serial CS procedures (S_1/S_2, S_1/S_1S_2) were tested at three shock levels (0.5, 1.0, and 2.0 mA). Shock level was not found to have a reliable effect on any of the avoidance response indices analyzed. An important difference, however, did emerge between the two serial CS procedures tested. The theoretical implications of the finding were discussed.

The purpose of this paper is to describe an experiment which compared two serial CS procedures across different shock intensities. The shuttlebox avoidance situation, using rats as Ss, served as the learning task. For one of the serial conditions, a two-component serial CS procedure (S_1/S_2) was used, in which the first stimulus (S_1) terminated at the midpoint of the CS-US interval and the onset of the second stimulus (S_2) immediately followed the termination of S_1. For the other serial condition, a two-component serial compound procedure (S_1/S_1S_2) was used, in which a single stimulus (S_1) was presented for the first half of the CS-US interval and two stimuli ($S_1 + S_2$) for the latter half of the CS-US interval.

Previous shuttlebox work (Levis, 1970; Levis & Dubin, in press; Levis & Stampfl, 1972) has determined that, when the above serial procedures are compared to nonserial procedures in which the CS pattern does not change during the CS-US interval, the serial procedures produce longer mean avoidance latencies, with the majority of avoidance occurring after the onset of the last stimulus introduced into the sequence, while nonserial CS procedures result in most of the avoidance responses occurring in the early portion of the CS-US interval. This delayed avoidance-responding effect noted for Ss presented serial CS conditions was interpreted from a generalization hypothesis of fear transference which predicts that less fear will generalize across a given CS-US interval comprising a sequence of different stimuli, as in the serial groups, than when it involves essentially the same stimulus complex, which was the case for the nonserial CS groups.

Additional work has indicated that increased responding to the first component of a serial CS (S_1) can be enhanced by shortening the length of the CS-US interval (Levis & Dubin, in press) or by increasing the stimulus similarity of components within the serial (Dubin & Levis, in press). The present study is an attempt to determine whether shock intensity is a variable that also will affect the percent of responding to S_1 of a serial procedure. The expectation is that as the intensity of shock increases so will the percent of avoidance responding to S_1.

METHOD

Subjects and Apparatus

The Ss were 96 experimentally naive male Blue Spruce rats, reared at the University of Iowa's Department of Psychology colony. They ranged in age at the start of training from 96 to 140 days. Two identical shuttlebox apparatuses, housed in separate sound-attenuated chambers, were used. A detailed description of these shuttleboxes has been reported elsewhere (Levis, 1970). Three pairs of 7½-W 115-V screw-base lamps which flashed twice per second, a tone (4-kHz sine wave), and shock to the grid floor could be independently controlled for each compartment of each apparatus. Ambient noise level, measured by a General Radio sound-level meter (Model 1551-C), was 54 ± 1 dB SPL (setting C) for both boxes. Measurements were made 5.1 cm above the grid of one of the compartments and centered on the midpoint of the compartment. After activation of tone, the sound level for both boxes increased 10 ± 1 dB. Grason-Stadler shock sources with scramblers (Model 1064GS) were set at the source to produce 0.5, 1.0, or 2.0 mA. Avoidance and escape latencies were recorded by a Grason-Stadler printout counter, with resolution of response latencies being obtained to the nearest second. Programming equipment was housed in a separate room.

Procedure

Sixteen Ss were assigned unsystematically to each of six groups. The factorial design was a 2 (CS conditions) by 3 (shock level) manipulation with one within variable (days). The CS conditions used were a serial and a serial compound procedure. For the serial manipulation (S_1/S_2), two CSs were presented (e.g., tone followed by lights), with the offset of S_1 and the onset of S_2 occurring at the midpoint of the 16-sec CS-US interval, dividing the interval into two equal 8-sec time segments. For the serial compound procedure (S_1/S_1S_2), the procedure was the same except S_1 remained on for the entire CS-US interval instead of terminating at the midpoint of the interval, as was the case for the previous group. Ss exposed to each CS condition were divided equally into three subgroups which were exposed to different US intensities, with the shock source being set at 0.5, 1.0, or 2.0 mA.

Each S was given a 30-min adaptation period to the apparatus

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Table 1

CS Condition	Shock Level (MA)	Mean Escape Latency	Mean Avoidance Latency	Mean Trial Latency	Mean Percent of Avoidance to S_1	Trial Number of First Avoidance to S_1	Trial Number of First Avoidance	Trial Number of the 10 Consecutive Avoidances	Total Avoidance
	0.5	1.1	10.8	13.9	11.9	103.9	39.7	177.2	148.8
S_1/S_2	1.0	1.0	11.1	14.8	9.3	168.4	63.8	218.4	104.1
	2.0	1.1	10.7	14.6	11.3	147.6	49.9	212.8	113.4
	0.5	1.3	10.2	14.0	17.1	94.9	30.6	155.1	154.4
S_1/S_1S_2	1.0	0.9	9.6	12.8	21.6	108.1	50.8	149.3	166.8
	2.0	1.1	9.5	13.8	21.2	89.2	51.0	198.4	129.7

immediately prior to the start of the first trial of each training day. Each S received 100 acquisition trials per day on each of 3 successive days. A delayed conditioning procedure was used. An escape response terminated both the CS and US, while an avoidance response terminated the CS and prevented US onset. On escape trials, shock remained on until the rat moved to the opposite compartment. The length of the intertrial interval averaged 60 sec (50-60-70 sec randomized). The type (tone, flashing lights) and order of CS presentation were counterbalanced appropriately within each CS condition. The order of testing Ss was determined randomly.

RESULTS

Four Ss were discarded because of apparatus and E error. They were replaced on the next run. The mean shock duration received on escape trials was computed for each S for each day of training. Table 1 provides the mean shock duration, combining days for each group. Analyses of these data revealed two significant effects: the day effect ($F = 51.7$, $df = 2/180$, $p < .001$) and the Shock by Day interaction ($F = 5.5$, $df = 4/180$, $p < .001$). The mean response latency to shock decreased with each training session. On Day 1 Ss exposed to the 0.5-mA shock level reliably produced longer escape latencies than Ss exposed to either the 1.0-mA ($t = 4.4$, $df = 90$, $p < .01$) or the 2.0-mA level ($t = 3.8$, $df = 90$, $p < .01$). The latter two groups of Ss did not reliably differ from each other. By Day 2 the above difference between groups was erased.

In order to determine whether shock level differentially increased the generalization of fear across the CS-US interval, the following four indices were analyzed, with the means obtained across days appearing for each group in Table 1: (a) mean avoidance latency, (b) mean trial latencies, (c) mean percent of avoidance to S_1, and (d) trial number of the first avoidance to S_1. The main effect of shock level was not significant for any of the above indices. The main effect of CS condition was significant for (a) mean avoidance latency ($F = 15.0$, $df = 1/90$, $p < .001$); (c) mean percent of avoidance to S_1 ($F = 10.4$, $df = 1/90$, $p < .001$); and (d) mean trial number of first avoidance to S_1 ($F = 5.0$, $df = 1/90$, $p < .05$). Index b, mean trial latency, approached significance ($F = 3.5$, $df = 1/90$, $p < .10$). The day factor was not analyzed for Indices a and d, since not every S could be assigned a score for these indices on each day of training. The day effect was significant for Indices b and c ($p < .001$) and a significant Condition by Day effect was obtained for Index c ($p < .05$). The mean total latency decreased over days. The mean percent of avoidance responding to S_1 for the serial CS condition decreased over days, with the mean obtained for each day being 13.8, 13.4, and 5.3, respectively. However, the same index for the serial compound condition showed an increase rather than a decrease over days, with the respective mean for each day being 15.7, 27.7, and 16.5.

In order to assess the effects of shock level on avoidance behavior, the following three indices were analyzed: (e) trial number of first avoidance response, (f) trial number of the tenth consecutive avoidance, and (g) total avoidances. Table 1 provides the means combining days for each of the above indices. An analysis of Index e, trial number of first avoidance response, did not result in any reliable main effects. The comparison between Ss exposed to a 0.5- and 1.0-mA shock level did approach significance ($t = 1.8$, $df = 90$, $p < .10$). Shock level also did not produce a reliable effect on Indices f and g, nor did the CS condition factor, although for Index f, trial number of the tenth consecutive avoidance, the difference did approach significance ($F = 2.9$, $df = 1/90$, $p < .10$). The Ss presented the serial compound condition produced more avoidances, although the difference was not statistically reliable. The number of avoidances did reliably increase over days ($F = 172.6$, $df = 2/180$, $p < .001$).

DISCUSSION

The expectation that, as shock intensity increased, the amount of fear generalized across the CS-US interval, as indexed by our avoidance measures, would also increase was not supported. Shock intensity only affected the mean shock duration on Day 1. However, important reliable differences did emerge between the two serial CS conditions. The serial compound condition (S_1/S_1S_2) produced shorter avoidance latencies, a higher percentage of S_1 responding, and a lower trial number of first avoidance to S_1. These latter findings are consistent with a generalization hypothesis, since greater generalization of fear from the second half of the CS-US interval for the serial compound condition (S_1/S_2) should occur to S_1 than for the serial condition. The reason for this conclusion is that, for the serial condition, only the trace of S_1 is present when S_2 is paired with shock, while, for the serial compound condition, S_1 is directly paired with shock. The above data compliment the finding of the Levis & Dubin study (Experiment I, in press). It is also interesting to note that once asymptotic responding to S_1 is reached for both serial conditions extended training appears to produce an extinction effect to this segment, a finding which is similar in some respects to the inhibition of delay phenomenon first reported by Pavlov (1927).

The lack of a shock intensity effect on avoidance responding is also inconsistent with other findings (Kimble, 1955; Levine, 1966; Theios, Lynch, & Lowe, 1966). A replication of this study using a suppression task where better control over conditioning variables can be obtained may prove a more sensitive index.

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