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SHOCK INTENSITY AND DURATION INTERACTIONS ON FREE-OPERANT AVOIDANCE BEHAVIOR[1]

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Shock intensities (1 to 4 mA) and shock durations (0.3 to 0.75 sec) were concurrently varied over a range commonly used in free-operant avoidance studies using a lever-press response. Response rates were a positive linear function of the log of the product of intensity times duration. Shock rates were a negative linear function of that log. The increase in response rates was primarily due to a selective increase in the conditional probability of making responses with long interresponse times. The disproportionality of receiving shocks early in the session (warm-up) was also a linear function of the log of the intensity-duration product, with increasing disproportionality as the value of the intensity-duration product was increased. Thus, with all measures of the avoidance performance, shock intensity and shock duration combine in a multiplicative fashion to determine the avoidance performance.

Shock-avoidance behavior has been repeatedly demonstrated to be a function of the shock intensity used. In Sidman's (1953) free-operant avoidance paradigm, increases in shock intensity over a range from 0.5 mA to 3.7 mA produced increases in the rates of responding by well-trained rats (Boren, Sidman, and Herrnstein, 1959). In that experiment, each lever depression postponed shock for 20 sec, but upon failure to avoid a shock, a response was required to terminate the shock. Thus, the duration of shock was controlled by the animal and was not constant across different intensity values. The average duration of shock at each intensity value (actually the average response latency upon shock onset) was an inverse function of shock intensity. Subsequently, in studies with shock duration held constant, response rates have been shown to increase as a monotonic function of shock intensity (Powell, 1971; Powell and Mantor, 1970; Riess, 1970). Hayes and MacKinnon (1968) suggested that increases in shock duration had rate increasing effects similar to increases in shock intensity. Riess (1970) manipulated shock durations over a range from 0.05 to 0.3 sec while holding shock intensity constant at 0.5 mA. He found that response rates were a positive monotonic function of shock duration similar to the function obtained by increasing shock intensity at a constant shock duration. Riess did not manipulate both shock intensity and duration in the same experiment. In all of these avoidance experiments, no data have been reported concerning the temporal patterning of responses as a function of intensity or duration. Thus, it is not possible to determine if the rate increases are associated with an increased probability of responses with particular interresponse times.

A common phenomenon observed in avoidance experiments with rats is a persistent tendency for the animal to receive a disproportionate number of shocks early in each experimental session. This phenomenon has been called warm-up (Hoffman, Fleshler, and Chorney, 1961; Powell, 1971; Powell and Peck, 1969). In a signalled avoidance experiment, increases in shock voltage produced no stable changes in the shock disproportionality exhibited (Hoffman, *et al.*, 1961). In an unsignalled avoidance task with 1.0 mA as the shock intensity in one component and 2.0 mA as the value in the alternate component of a multiple

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schedule, Powell (1970) also found no reliable effect of shock intensity on the warm-up phenomenon.

In punishment experiments, the degree of response suppression has been demonstrated to be a linear function of the log of the product of intensity times duration (Church, Raymond, and Beauchamp, 1967). The present experiment sought to determine if intensity and duration combine in the same multiplicative manner to determine shock-avoidance behavior. Shock intensities and durations were concurrently manipulated over a range of values commonly used in free-operant avoidance experiments and the changes in response rates, shock rates, interresponse time distributions, and warm-up were described as a function of the product of shock intensity (in milliamperes) times shock duration (in seconds).

METHOD

Subjects

Two male hooded rats, CR-3 and CR-4, approximately 2-yr old and maintained at 450 g in body weight, served. Both rats had over 1000 hr of history under shock-postponement schedules before the start of this experiment. Food and water were continuously available in each animal's home cage, but unavailable during experimental sessions.

Apparatus

The experimental space was a Lehigh Valley Electronics rat test cage (No. 1417) housed within a sound-attenuating chamber (No. 1417C). A Gerbrand's rat lever requiring 30 g (0.30 N) of force to operate was positioned 1.75 in. (4.2 cm) off the floor and 2 in. (5.5 cm) to the left of the stimulus panel center line. Scrambled shock was delivered by a Lehigh Valley Electronics constant current dc (direct current) shocker and scrambler (No. 1531) to the grid floor of stainless steel rods spaced 0.25 in. (1.0 cm) center-to-center. Shock duration was timed by an electronic timer. The houselight was on during each session and random noise from a noise generator was supplied to the experimental room masking the relay scheduling equipment in an adjacent room. Digital counters recorded the distribution of interresponse times for the last 5 hr of each 6-hr session and the responses and shocks for each hour of the session. The interresponse times were sorted into nine 2-sec intervals (0 to 2 sec, 2 to 4 sec, *etc.*). The tenth interval included all responses with interresponse times over 18 sec.

Procedure

Sidman's (1953) shock-postponement procedure involves two temporal intervals as basic parameters. In the absence of responding, there is a fixed-time interval (the shock-shock or S-S interval) between presentations of electric shocks. Each response postpones the impending shock for another fixed-time interval (the response-shock or R-S interval). In this experiment, both the R-S and the S-S intervals were 20 sec.

Experimental sessions were 6 hr long and conducted alternate evenings. The animals were placed in the experimental chambers and the sessions started at approximately 10:00 p.m. The scheduling equipment automatically switched off after 6 hr and the animals were removed from the chambers in the morning (8:00 a.m.).

Each rat was run at each combination of intensity and duration until a stability criterion was met. This required that the response rates of three of the last five sessions had to be within 0.2 responses per minute of each other, with no consistent change in shock rate over the five days. Thus, the minimum number of sessions at each combination of intensity and duration was five. The shock intensities and durations used, the number of sessions at each combination, and the order of presentation for each animal are presented in Table 1.

RESULTS

Table 1 presents the means and standard deviations of the response rates and shock rates for the last five sessions of each combination of intensity and duration. At any constant shock duration, response rates generally increased and shock rates decreased as the shock intensity was increased. Likewise, at any constant shock intensity, response rates generally increased and shock rates decreased as the shock duration was lengthened. The increasing response rate and decreasing shock rate effects of increasing shock intensity were larger with the larger shock durations for both animals. Similarly, the increasing response rate and de-

Table 1

Rat CR-3

Number of Sessions	*Shock Intensity (mA)*	*Shock Duration (sec)*	*Product mA x sec*	*Mean Resp/min —(± Std Dev)*	*Mean Shock/min —(± Std Dev)*	*Proportion of Resp in first hr —(± Std Dev)*	*Proportion of Shks in first hr —(± Std Dev)*
20	3.0	0.75	2.25	5.34 (0.17)	0.52 (0.06)	0.16 (0.04)	0.32 (0.05)
5	2.5	0.75	1.88	5.18 (0.16)	0.53 (0.07)	0.16 (0.02)	0.29 (0.03)
5	2.0	0.75	1.50	4.48 (0.16)	0.74 (0.06)	0.14 (0.02)	0.28 (0.04)
5	1.5	0.75	1.13	4.18 (0.22)	0.76 (0.14)	0.13 (0.02)	0.28 (0.04)
10	1.0	0.75	0.75	3.20 (0.24)	1.22 (0.15)	0.16 (0.01)	0.19 (0.04)
5	3.0	0.50	1.50	4.80 (0.20)	0.45 (0.07)	0.15 (0.01)	0.28 (0.07)
5	2.5	0.50	1.25	4.74 (0.27)	0.52 (0.09)	0.15 (0.02)	0.28 (0.05)
6	2.0	0.50	1.00	4.40 (0.18)	0.56 (0.05)	0.16 (0.02)	0.20 (0.06)
5	1.5	0.50	0.75	3.76 (0.27)	0.95 (0.10)	0.12 (0.02)	0.26 (0.02)
11	1.0	0.50	0.50	2.98 (0.52)	1.35 (0.33)	0.14 (0.02)	0.22 (0.04)
7	3.0	0.30	0.90	4.06 (0.29)	0.78 (0.15)	0.12 (0.02)	0.30 (0.05)
7	2.5	0.30	0.75	4.78 (0.38)	0.73 (0.14)	0.13 (0.03)	0.29 (0.06)
11	2.0	0.30	0.60	4.14 (0.16)	0.77 (0.05)	0.14 (0.02)	0.24 (0.05)
5	1.5	0.30	0.45	3.64 (0.29)	1.07 (0.14)	0.16 (0.02)	0.18 (0.04)
11	1.0	0.30	0.30	1.42 (0.40)	2.27 (0.28)	0.29 (0.03)	0.12 (0.03)
8	3.0	0.30	0.90	4.40 (0.51)	0.74 (0.20)	0.19 (0.03)	0.19 (0.04)
5	2.0	0.50	1.00	4.30 (0.29)	0.68 (0.06)	0.20 (0.02)	0.18 (0.03)
5	1.0	0.75	0.75	3.10 (0.21)	1.44 (0.11)	0.21 (0.05)	0.13 (0.03)
Pearson product moment correlation (*indicates $p < 0.05$)				0.85 *	0.80 *	−0.48 *	0.63 *

Table 1 (*continued*)

Rat CR-4

Number of Sessions	*Shock Intensity (mA)*	*Shock Duration (sec)*	*Product mA x sec*	*Mean Resp/min —(± Std Dev)*	*Mean Shock/min —(± Std Dev)*	*Proportion of Resp in first hr —(± Std Dev)*	*Proportion of Shks in first hr —(± Std Dev)*
13	3.0	0.75	2.25	6.36 (0.14)	0.24 (0.07)	0.17 (0.01)	0.42 (0.09)
7	3.0	0.50	1.50	5.64 (0.16)	0.58 (0.08)	0.16 (0.01)	0.30 (0.05)
5	3.0	0.30	0.90	4.90 (0.17)	0.92 (0.14)	0.14 (0.03)	0.28 (0.03)
5	2.5	0.75	1.88	5.80 (0.20)	0.54 (0.12)	0.16 (0.01)	0.32 (0.06)
11	2.5	0.50	1.25	5.32 (0.33)	0.43 (0.16)	0.17 (0.02)	0.36 (0.08)
7	2.5	0.30	0.75	4.88 (0.28)	0.58 (0.18)	0.15 (0.01)	0.31 (0.04)
5	1.5	0.75	1.13	5.12 (0.19)	0.54 (0.08)	0.17 (0.01)	0.40 (0.04)
7	1.5	0.50	0.75	4.82 (0.31)	0.48 (0.10)	0.15 (0.01)	0.31 (0.04)
7	1.5	0.30	0.45	4.82 (0.21)	0.80 (0.15)	0.14 (0.02)	0.25 (0.04)
9	1.0	0.75	0.75	5.22 (0.29)	0.70 (0.12)	0.16 (0.01)	0.29 (0.06)
5	1.0	0.50	0.50	4.78 (0.33)	0.92 (0.18)	0.15 (0.02)	0.25 (0.04)
8	1.0	0.30	0.30	Avoidance performance not maintained			
19	1.0	0.75	0.75	4.62 (0.39)	0.99 (0.22)	0.13 (0.05)	0.27 (0.07)
5	2.5	0.30	0.75	5.66 (0.34)	0.37 (0.09)	0.16 (0.01)	0.35 (0.03)
5	3.0	0.50	1.50	5.96 (0.35)	0.30 (0.02)	0.16 (0.01)	0.47 (0.07)
9	4.0	0.30	1.20	5.76 (0.57)	0.32 (0.18)	0.16 (0.01)	0.39 (0.06)
10	4.0	0.75	3.00	6.62 (0.28)	0.16 (0.02)	0.18 (0.03)	0.59 (0.09)
Pearson product moment correlation (*indicates $p < 0.05$)				0.88 *	0.72 *	0.79 *	0.79 *

creasing shock rate effects from lengthening the shock duration were larger with the higher shock intensities. This indicates an interaction between shock intensity and duration. The response rate and shock rate data are summarized in Figure 1 as a function of the product of intensity times duration. The bottom row in Table 1 indicates the correlation coefficient between the intensity-duration product and the response rates and shock rates exhibited. In the present experiment, as can be seen in Figure 1 and Table 1, a product value of 0.3 barely maintained responding by Rat CR-3 and did not maintain avoidance responding by Rat CR-4. Thus, there was a threshold for responding around a product value of 0.3.

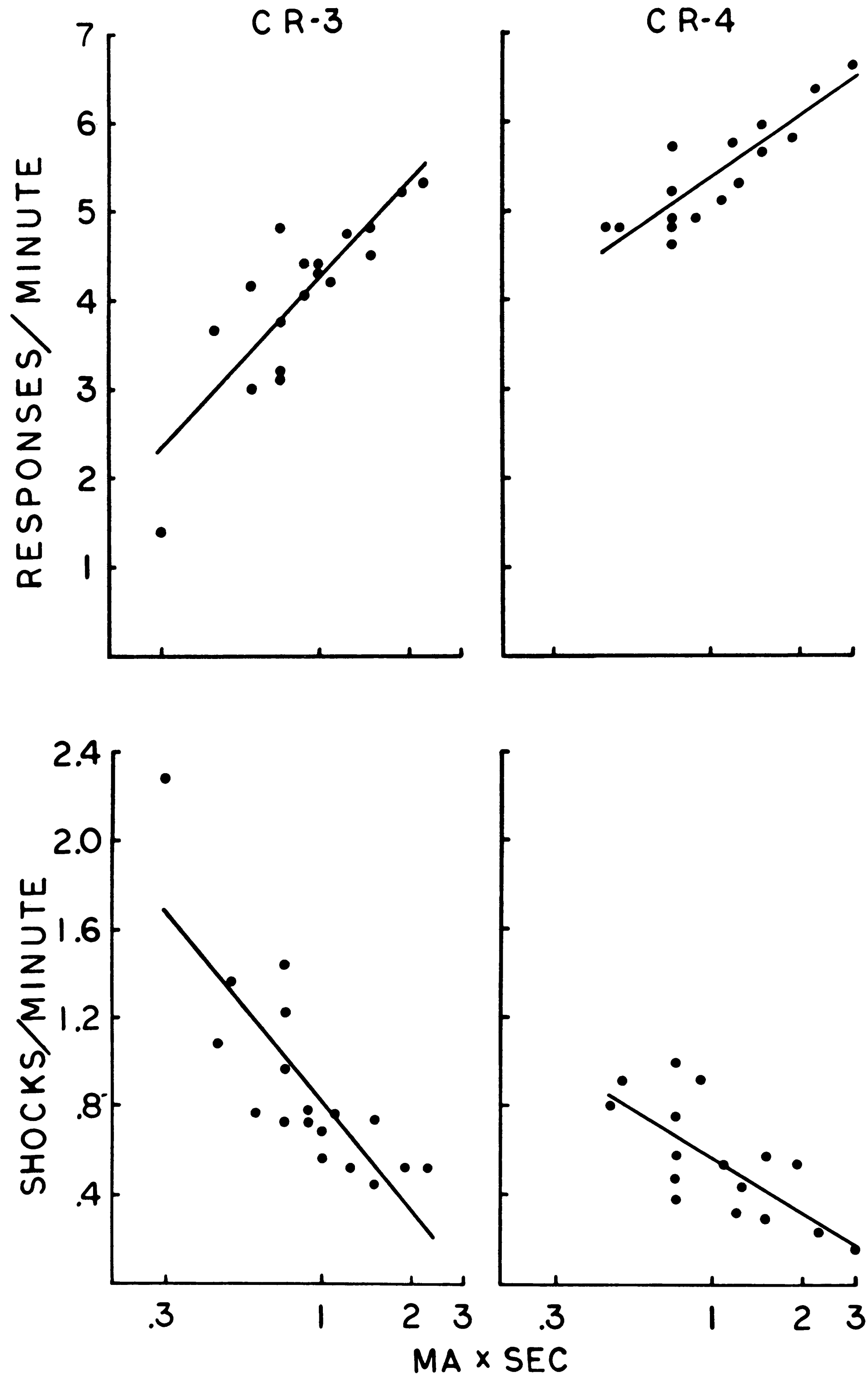

Fig. 1. Responses and shocks per minute plotted as a function of the product of shock intensity (in milliamperes) times shock duration (in seconds). The lines were fit to the data by the method of least squares.

Table 2

Rat CR-3

			IRT Intervals								
Intensity	*Duration*	*Product*	*0-2*	*2-4*	*4-6*	*6-8*	*8-10*	*10-12*	*12-14*	*14-16*	*16-18*
3.0	0.75	2.25	0.23	0.09	0.09	0.09	0.10	0.14	0.21	0.36	0.47
2.5	0.75	1.88	0.20	0.08	0.08	0.09	0.10	0.15	0.23	0.37	0.46
2.0	0.75	1.50	0.21	0.07	0.06	0.06	0.07	0.10	0.17	0.30	0.41
1.5	0.75	1.13	0.16	0.06	0.07	0.07	0.07	0.12	0.18	0.31	0.39
1.0	0.75	0.75	0.13	0.05	0.05	0.06	0.07	0.09	0.14	0.21	0.33
3.0	0.50	1.50	0.15	0.07	0.08	0.08	0.10	0.15	0.26	0.40	0.49
2.5	0.50	1.25	0.14	0.07	0.09	0.09	0.10	0.15	0.24	0.37	0.50
2.0	0.50	1.00	0.13	0.06	0.06	0.06	0.08	0.12	0.23	0.34	0.46
1.5	0.50	0.75	0.15	0.05	0.06	0.07	0.08	0.10	0.15	0.27	0.37
1.0	0.50	0.50	0.10	0.05	0.05	0.06	0.07	0.10	0.15	0.23	0.29
3.0	0.30	0.90	0.11	0.06	0.07	0.09	0.10	0.14	0.22	0.32	0.43
2.5	0.30	0.75	0.14	0.09	0.11	0.12	0.13	0.18	0.24	0.31	0.38
2.0	0.30	0.60	0.13	0.06	0.07	0.08	0.09	0.14	0.22	0.31	0.41
1.5	0.30	0.45	0.12	0.05	0.07	0.08	0.10	0.13	0.17	0.24	0.31
1.0	0.30	0.30	0.13	0.06	0.08	0.10	0.10	0.12	0.15	0.14	0.18
3.0	0.30	0.90	0.11	0.04	0.05	0.06	0.08	0.12	0.22	0.32	0.44
2.0	0.50	1.00	0.12	0.05	0.06	0.07	0.09	0.12	0.21	0.33	0.44
1.0	0.75	0.75	0.10	0.06	0.06	0.06	0.08	0.11	0.16	0.22	0.27
Pearson product moment correlation (*indicates $p < 0.05$)			0.71 *	0.55 *	0.22	0.03	0.02	0.26	0.53 *	0.83 *	0.82 *

Table 2 (*continued*)

Rat CR-4

			IRT Intervals								
Intensity	*Duration*	*Product*	*0-2*	*2-4*	*4-6*	*6-8*	*8-10*	*10-12*	*12-14*	*14-16*	*16-18*
3.0	0.75	2.25	0.16	0.12	0.10	0.11	0.17	0.27	0.40	0.48	0.56
3.0	0.50	1.50	0.24	0.11	0.06	0.04	0.06	0.11	0.22	0.33	0.44
3.0	0.30	0.90	0.24	0.13	0.07	0.03	0.03	0.06	0.14	0.23	0.36
2.5	0.75	1.88	0.28	0.12	0.07	0.05	0.06	0.09	0.20	0.35	0.46
2.5	0.50	1.25	0.16	0.12	0.07	0.04	0.06	0.15	0.28	0.41	0.49
2.5	0.30	0.75	0.17	0.08	0.07	0.04	0.03	0.09	0.18	0.32	0.46
1.5	0.75	1.13	0.20	0.09	0.05	0.03	0.02	0.07	0.17	0.34	0.51
1.5	0.50	0.75	0.15	0.09	0.07	0.03	0.04	0.08	0.19	0.33	0.47
1.5	0.30	0.45	0.23	0.08	0.06	0.04	0.04	0.08	0.15	0.27	0.37
1.0	0.75	0.75	0.27	0.06	0.05	0.04	0.05	0.10	0.18	0.32	0.44
1.0	0.50	0.50	0.26	0.05	0.06	0.04	0.05	0.08	0.14	0.21	0.34
1.0	0.75	0.75	0.20	0.07	0.07	0.07	0.08	0.12	0.17	0.23	0.34
2.5	0.30	0.75	0.18	0.05	0.08	0.11	0.15	0.21	0.31	0.38	0.51
3.0	0.50	1.50	0.17	0.05	0.09	0.12	0.19	0.26	0.34	0.44	0.53
4.0	0.30	1.20	0.13	0.04	0.10	0.15	0.20	0.26	0.33	0.41	0.50
4.0	0.75	3.00	0.13	0.05	0.13	0.19	0.27	0.35	0.45	0.52	0.58
Pearson product moment correlation (*indicates $p < 0.05$)			0.35	0.23	0.67 *	0.58 *	0.62 *	0.66 *	0.75 *	0.80 *	0.74 *

Above this threshold value, response rates were a positive linear function of the log of the intensity-duration product. Conversely, the shock rates are a negative linear function of the log of the product. The standard deviation of the mean shock rates was also a function of the intensity-duration product. When the product became larger, the standard deviation of the mean shock rates became smaller (Table 1).

At each intensity-duration combination, the frequencies of the different interresponse times were averaged over the last 5 hr of the criterion sessions. These frequencies were then converted to Anger's (1963) interresponse time (IRT) per opportunity measure. The IRT per

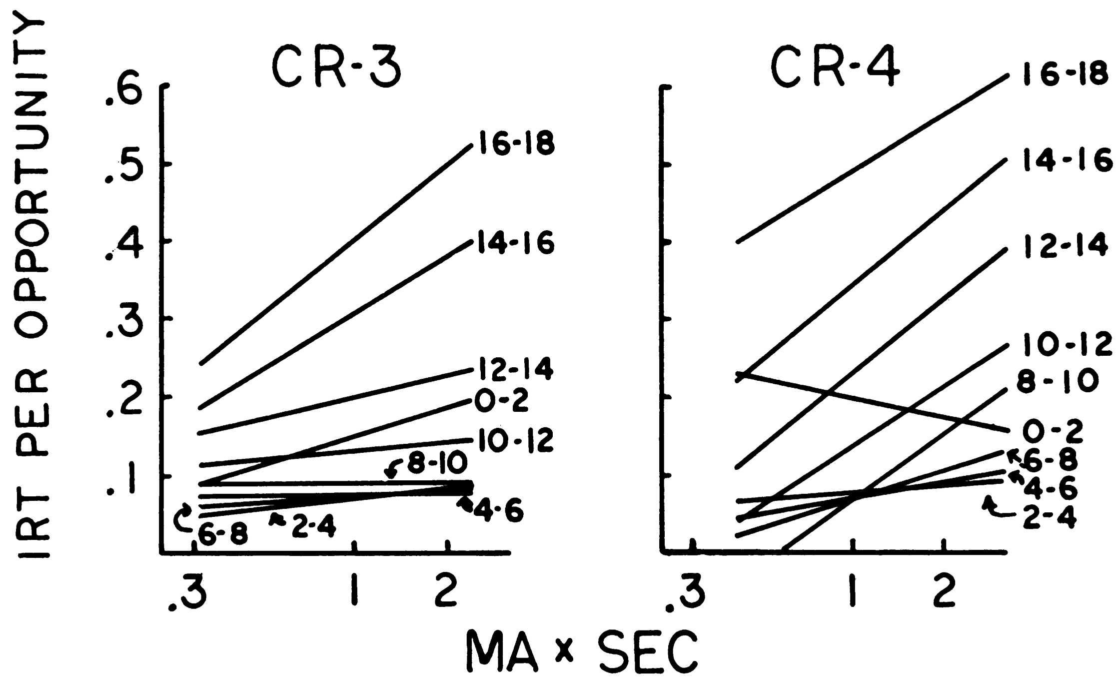

Fig. 2. Least squares regression lines summarizing the relationship between IRT per opportunity values and the intensity-duration product for each of the nine interresponse intervals computed across all intensity-duration combinations. The numbers within the figure indicate the interresponse interval for which the line was determined. For instance, the line labelled 0-2 summarizes the relationship of the IRT per opportunity values of the 0 to 2-sec interresponse class to changes in the intensity-duration product. This figure is derived from the data in Table 2.

opportunity is a conditional probability measure of interresponse interval frequencies. Table 2 presents the mean IRT per opportunity values for each interresponse interval at each intensity-duration combination. The interval for responses with interresponse times over 18 sec was not listed because it, by definition, assumes a value of 1.00. With the exception of the 0 to 2-sec category, CR-3 shows a positively accelerating increase in the probability of making a response with the passing of the R-S interval. CR-4, on the other hand, shows a pattern of decreasing response probability followed by an increasing probability with the passing of the R-S interval. The exact category of transition between the decreasing and increasing patterns was dependent upon the particular intensity-duration product. Generally, as the intensity-duration product increased, the interresponse category with the lowest IRT/OP occurred earlier in the R-S interval. The changes in the IRT per opportunity values of each interresponse time are summarized in Figure 2 as a function of the intensity-duration product. The correlation coefficient between the intensity duration product and the IRT per opportunity values is presented in the bottom row for each animal in Table 2. For each interresponse interval, a line of least squares was calculated in order to describe the relationship between the intensity-duration product and the IRT per opportunity value. For the 0 to 2-sec interresponse interval, CR-3 showed an increasing probability of emitting a response as a function of increasing the intensity-duration product. Rat CR-4 showed just the opposite relation—a decreasing probability as a function of increasing the intensity-duration product. Neither animal exhibited much of a change in the IRT per opportunity values in the 2 to 4, 4 to 6, and 6 to 8-sec intervals as the product was increased. Rat CR-3 showed increases in the IRT per opportunity values in the interresponse intervals above 12 sec and CR-4 in those above 8 sec as a function of the intensity-duration product. Thus, for both animals, increasing the intensity-duration product did not change the conditional probability of making responses with intermediate interresponse times (2 to 12 sec

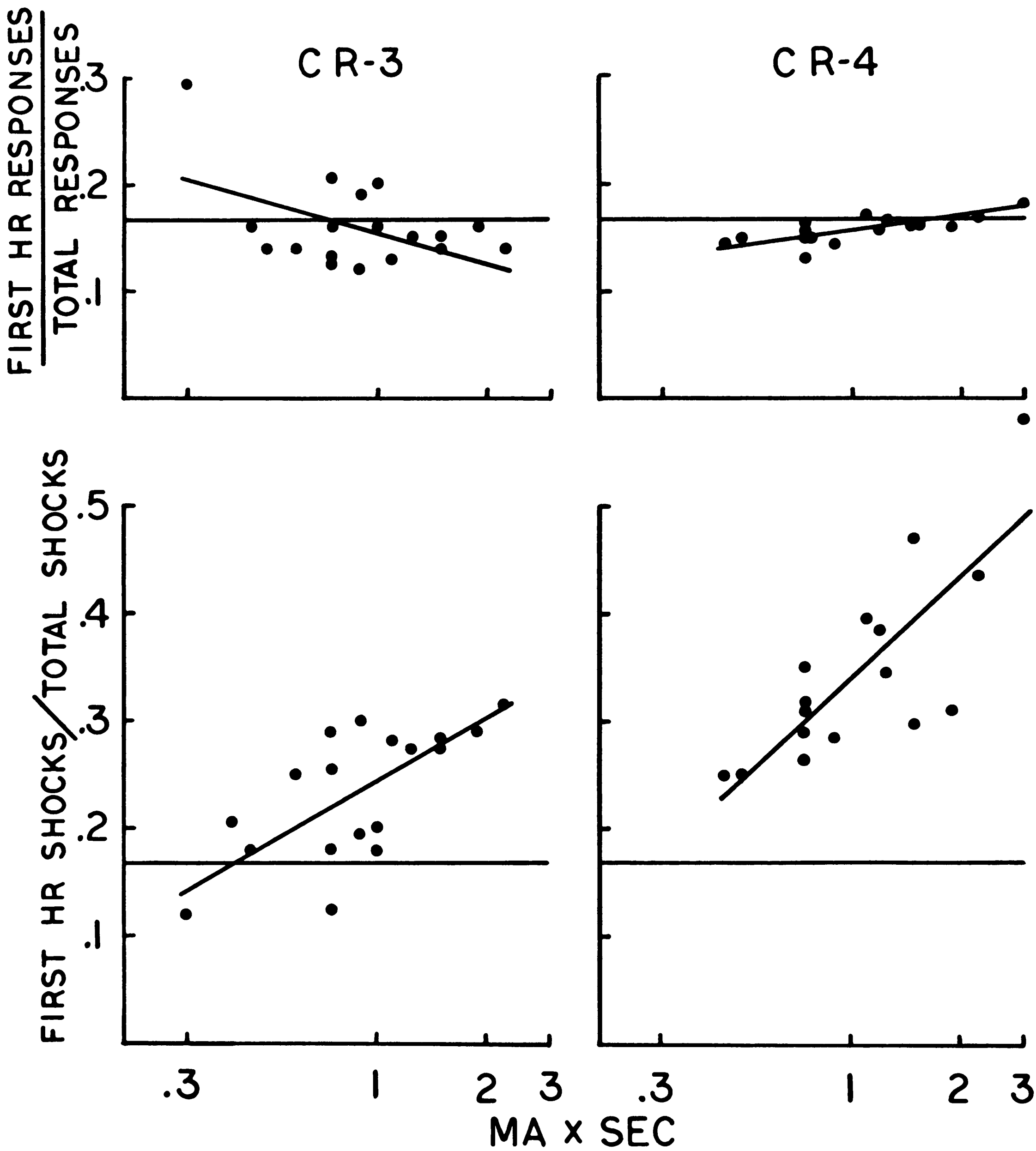

Fig. 3. The mean percentages of the total responses and shocks that occurred within the first hour of the 6-hr session are plotted as a function of the intensity-duration product. The horizontal lines at approximately 17% are what would be expected if the first-hour responses and shocks were proportionate to the total number. The lines were fit to the data points by the method of least squares.

for CR-3; 2 to 8 for CR-4), but did increase the conditional probability of making responses with longer interresponse times (above 12 sec for CR-3; above 8 sec for CR-4).

Analysis of the warm-up phenomenon and its relation to the intensity-duration product is presented in the last two columns of Table 1 and summarized in Figure 3. The number of responses and shocks that occurred in the first hour are divided by the number of responses and shocks in the total 6-hr session. The horizontal lines at 17% indicate the expected value if the first hour responses and shocks were proportionate to the total number.

The correlation coefficient between the intensity-duration product and the proportion of shocks or responses in the first hour are presented in the bottom rows for each animal in Table 1. For both CR-3 and CR-4, the percentage of the total 6-hr shocks that occurred in the first hour increased as a function of increasing the product value. Thus, the disproportionality of shock, the warm-up, became greater as the intensity-duration product became greater. This consistent change in shock disproportionality was not matched by a similar response function. Rat CR-3 showed a slight, but statistically significant, decrease in the percentage of total responses that occurred in the first hour as a function of the intensity-duration product, while CR-4 showed a slight, significant increase in the percentage of total responses that occurred in the first hour.

Figure 4 presents representative cumulative response records for Rat CR-4 from three sessions representing low, medium, and high values of the intensity-duration product. Session 77, with a product of 0.50, began with a period of no responding, then responding was initiated after 10 min had elapsed. The number of shocks (55) received in the first hour divided by the total number (310) from the entire session did not produce a first-hour shock disproportionality (0.18). Session 41, with a product of 1.25, displayed an appreciable first-hour shock disproportionality ($41/115 = 0.45$) but Session 137, with a product of 3.0, exhibited a more marked first-hour shock disproportionality ($40/59 = 0.68$). It is readily apparent from these records that the first-hour shock disproportionality, which is called warm-up, is due to receiving a large number of shocks early in the session, followed by a lower stable shock rate throughout the remainder of the 6-hr session. Thus, it is not due to an improved level of performance late in the session.

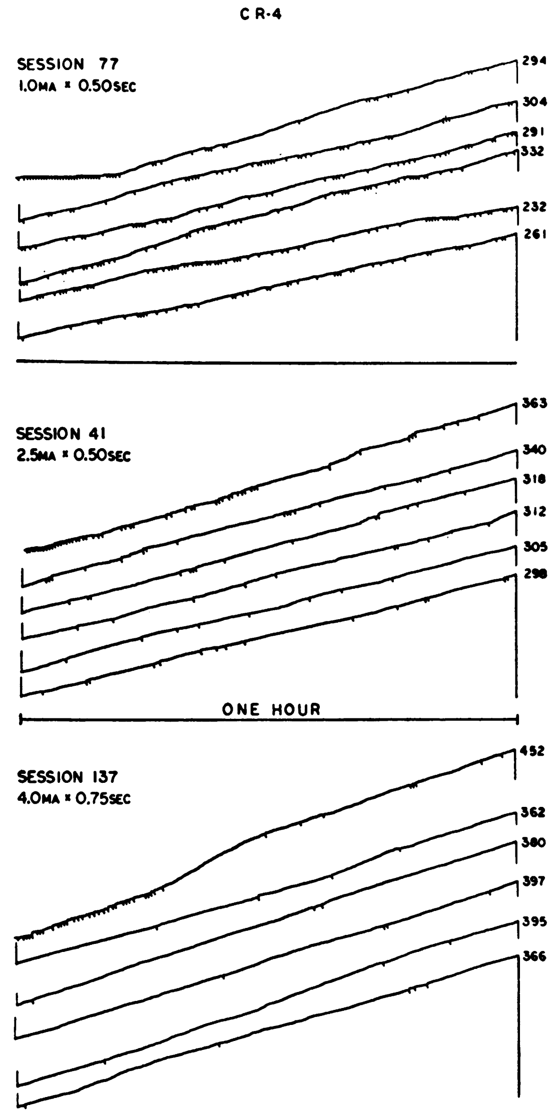

Fig. 4. Representative cumulative response records for Rat CR-4 from sessions with three different intensity-duration products. Each response moves the pen upward, while each shock is recorded by a momentary downward deflection of the pen. Hourly segments were cut apart and are stacked. The top segment for each session is the first hour, the second segment is the second hour, *etc.* The numbers to the right of each segment are the number of responses emitted in that hour's segment. Note that for each session, the shock rates are approximately equal for the second through sixth hours, and there is a much higher rate of shocks in the first hour than in the following hours for Sessions 41 and 137.

DISCUSSION

As others (Boren, *et al.*, 1959; Riess, 1970) have shown, the response rates increased and shock rates decreased as shock intensity or duration was increased. Above a product of 0.3, these changes were a linear function of the log of the product of intensity times duration. Neither rat would respond at product values below 0.3 with the parameters used in the present study. However, it was possible to initiate and maintain responding if the S-S interval was shortened. Riess (1970) reported rats responding at product values below 0.3, but he used an S-S interval of 5 sec, while using a R-S interval of 20 sec. There may also be a difference depending upon what type of shock source is used. Campbell and Masterson (1969, Figure 1-11) report that below 0.2 mA, dc shock is more aversive than ac; between 0.2 and 0.8 mA, there is no difference between ac and dc; while above 0.8 mA, the ac shock is more aversive than the dc. Riess (1970) used an ac shock source while the present study used a dc shock source. Thus, these two differences, the S-S interval shortened and ac or dc shock source, are probably important determinants for maintaining avoidance performance below an intensity-duration product of 0.3. Analysis of the IRT data indicated that the response rate increases and the shock rate decreases as a function of the intensity duration product were due, in both animals, primarily to selective increases in the probability of emitting responses with long interresponse times. However, Rat CR-3 also showed an increased probability, while CR-4 showed a decreased probability of emitting responses with IRTs of 0 to 2 sec as a function of the intensity-duration product. The degree of shock disproportionality, or warm-up, was also a function of the intensity-duration product. As the product increased, the percentage of the total shocks that occurred within the first hour increased in both animals. These results indicate that the intensity and duration of shock, over the range of values tested, combine in a multiplicative fashion to determine the avoidance performance. Avoidance performances similar in response rates, shock rates, IRT distributions, and warm-up, can be produced if the intensity-duration product remains unchanged, even though the particular intensity and duration values may vary. In other words, longer shock durations can substitute for lower shock intensities. This relation between intensity and duration is complementary with the results from punishment studies on response suppression (Church, *et al.*, 1967).

Hoffman, *et al.*, (1961) reported that warm-up was not a function of the shock voltage in a signalled avoidance task. Their study was conducted using animals that were poor avoiders, avoiding only 50 to 70% of the shocks scheduled to occur on the average every 35 sec. The increase from 100 to 300 v also did not produce a stable change in shock rate. The fact that the voltage increase had no effect on the avoidance rate makes it difficult to interpret a similar lack of effect on warm-up. It may be a result of using animals that are such poor avoiders. Powell (1970), using an unsignalled avoidance experiment with different shock intensities (1.0 *vs* 2.0 mA) in each of two multiple schedule components, also reported shock intensity to have no effect on warm-up. Perhaps interactions between components of the multiple schedule precluded the intensity variable from exerting an effect upon the warm-up.

The present data suggest that the intensity-duration product is one variable that determines the degree of warm-up observed with hooded rats. Values of the intensity-duration product could be selected to produce just about any degree of warm-up, from none to a marked amount of shock disproportionality. Powell and his colleagues (Powell, 1971, 1972; Powell and Mantor, 1970; Powell and Peck, 1969) have suggested that the warm-up phenomenon is specific to domesticated laboratory rodents. The present data suggest that studies of avoidance behavior with wild and domesticated rodents should be conducted while varying the intensity-duration product. Then it could be determined if a true qualitative difference exists, or if the difference is merely quantitative and dependent upon the particular shock intensity-duration values used with the different types of rodents.

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