DELAYED ESCAPE FROM LIGHT BY THE ALBINO RAT¹

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Two albino rats were trained to terminate an aversive light for 1 min by pressing a bar. After 19 hr of conditioning they were exposed to successive delays of 1, 2, 5, and 10 sec imposed between occurrence of the escape response and light termination. No stimulus change accompanied the delay interval, and any additional responses made at this time reset the delay timer. For both rats the relative frequency of escape responses with very long latencies increased as the delay interval increased. The modal escape latency, however, remained essentially unchanged for all delay values of greater than 1 sec. "Superstitious" responding was observed during the delay interval.

The behavioral effects of imposing a time delay between a response and its reinforcement have been studied by a number of investigators (*e.g.*, Skinner, 1938; Ferster, 1953; Dews, 1960; and Azzi, Fix, Keller, and Rocha e Silva, 1964). A general finding has been that increasing the delay interval reduces the response rate. Also, the delays are apparently bridged by the emission of "superstitious" responses during the delay interval. The present study attempts to relate these findings to those obtained when response latency, rather than rate, is used as the behavioral measure, and when the removal of an aversive stimulus, rather than the presentation of a positive reinforcer, is delayed after a response.

METHOD

Subjects

Two Sprague-Dawley male albino rats, experimentally naive, were approximately 100 days old at the start of the experiment. Food and water were continuously available in their home cages.

Apparatus

A Scientific Prototype rat chamber (model A100 U) was modified by centering the re-

sponse lever 1 in. above the floor at one end of the cage. The lever required 15 g pressure and a vertical displacement of $\frac{1}{16}$ in. for microswitch closure. A frosted 25 w bulb, centered 11 in. above the cage floor, acted as the aversive stimulus. It provided luminance of approximately 20 ft-candles at floor level (see Kaplan, Jackson, and Sparer, 1965). A water-filled clear glass baking dish was placed beneath the bulb on the clear plastic top of the cage, and, together with an exhaust fan, it limited the heat rise during the experimental session to less than 5° F. Both the rat chamber and the overhead bulb were contained within a wooden sound-attenuating enclosure. All data were recorded on electromagnetic counters.

Procedure

Daily experimental sessions were run for 1 hr. The rats were initially trained to respond by reinforcing successive approximations to the bar-press by immediately terminating the overhead light, which then remained off for 1 min. After shaping of the bar-press response, the animals were exposed to 19 1-hr sessions in which immediate light termination and the 1-min period of darkness followed each bar-release. Responses during the 1-min dark period were without effect.

After the 19 1-hr sessions of escape responding (wherein each bar-release was immediately reinforced by light removal) the delay procedure was introduced. This procedure was as follows: when the light came on and the animal pressed and then released the bar, the

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delay time interval began; at the end of the delay interval the light went out. Any additional responses during the delay interval reset the delay interval timer to zero, and the delay period began timing out anew. Thus, the delay interval specified the minimal time that had to elapse between bar-release and light termination (*c.f.* Dews, 1960; and Azzi *et al.*, 1964). Responses emitted during the dark period continued to have no effect on the schedule contingencies.

Delay intervals of 1, 2, 5, and 10 sec were imposed between the initial escape response and termination of the light. The number of 1-hr sessions spent at each delay value was 12, 4, 15, and 9, respectively; the decision to increase the delay was based on there being no systematic change in escape latencies for three consecutive sessions. After exposure to delays of 10 sec the rats were returned to the 2-sec level for four sessions to obtain an estimate of data recoverability.

Twenty counters recorded the frequency of escape response latencies in 2-sec intervals. Additional escape responses (emitted within the delay interval before light termination) and responses emitted in darkness were also recorded.

RESULTS

The escape responding of both rats was effectively maintained with escape delay intervals of up to 5 sec. At the 10-sec level, however, Rat 40 extinguished while Rat 41 continued to respond.

Figure 1 shows relative frequency distributions of response latency (measured as the time between light onset and the first bar-press) for the final three sessions at each delay value. Two aspects of these distributions

are noteworthy. First, modal latency increases when a 1-sec delay is introduced, but it is little affected by further delay increments. Second, the proportion of responses grouped in the last latency category (greater than 36 sec) rises as the delay is lengthened. It would appear that response latencies under conditions of delayed reinforcement fall into two classes; either about as long as under immediate reinforcement or else greatly extended. That is, if delay intervals imposed between a response and its reinforcement serve to weaken response strength, then this decrement is reflected in an increased relative frequency of very long latencies (greater than 36 sec), but not in a systematic increase of modal latency. It may also be noted in Fig. 1 that despite having undergone extinction at the 10-sec delay interval, Rat 40, as well as Rat 41, made a good recovery of its earlier performance after the 2-sec delay was reintroduced.

In Fig. 2 the mean and median escape latencies for both animals are shown as a function of the length of the delay interval. The increased divergence of these two measures that accompanies delay increments reflects the increased proportion of responses of long latency noted in Fig. 1. From the data of Rat 41 it would appear that both the mean and median latency measures reach asymptotes at about the 5-sec delay level.

The average number of responses emitted by each animal after the delay interval had been initiated but before the light was terminated are shown in Table 1 for each delay value. These additional responses, which reset the delay timer, were more frequently made by Rat 40 as the delay was lengthened; for Rat 41, their number was fairly constant through all of the delay values. Also shown

Table 1
Average Number of Responses Per Light Presentation During
Three Final Sessions at Each Delay Value

Delay Length in Seconds	Responses Within Delay Interval		Responses During Dark Period	
	Rat 41	Rat 40	Rat 41	Rat 40
0	—	—	0.34	0.31
1	0.24	0.15	0.26	0.57
2	0.29 (0.20)*	0.31 (0.23)	0.20 (0.11)	0.62 (0.71)
5	0.20	0.57	0.10	0.56
10	0.36	—	0.13	—

*Numbers in brackets from recovery sessions.

Fig. 1. Relative frequency distributions of response latency for successive escape delay intervals. The isolated data point in each distribution represents the relative frequency of all responses with latencies of 36 sec or more.

Fig. 2. Mean and median escape latencies as a function of the length of the escape delay interval. Recovery sessions are not included.

in Table 1 are the average number of responses emitted by each animal during the 1-min periods of darkness. Responses by Rat 41 during these periods declined as the delay interval was lengthened, whereas those of Rat 40 were more frequent and did not systematically decline.

DISCUSSION

The changes in the distribution of latencies that accompany increments of the delay interval are typical of this measure as effected by a variety of variables. Responding under different levels of food deprivation (Skinner, 1950), different intensities of aversive noise (Barry and Harrison, 1957), and different shock intensities and lengths of shock-off interval (Dinsmoor, Hughes, and Matsuoka, 1958) is frequently characterized by extremely long latencies but a general similarity of modal latency under all values of the independent variable. Similar behavior is also apparent in the studies of Dews (1960, Fig. 1, A, B, C, and D, Fig. 3, A and C) and Harrison and Abelson (1959, Fig. 9 and 12).

In the present experiment, the responses of very long latency appeared to be correlated with changes in the rats' usual response patterns during the delay interval. Visual observation indicated that both animals engaged in stereotyped "superstitious" behavior during the delay interval. Ordinarily, following light onset they pressed the bar and then went to a corner of the cage where they remained, sniff-

ing and nosing about the area, until the delay ended and the light was turned off. But as the delay was lengthened, the rats often appeared to "short-circuit" this chain of behavior. They did this by going to the corner of the cage first, where they remained for some time before they returned to press the bar. Thus, when the chain was disrupted in this manner the latency of the bar-press was very long, whereas when the chain began with a bar-press, response latency was short and relatively invariant across all delay values.

The failure of Rat 40 to maintain responding at the 10-sec delay interval may be attributable to insufficiently stable delay-mediating behavior at the time this delay value was introduced. Ferster (1953) has noted that it is critical that delays be increased gradually to give sufficient time for "superstitious" response chains to develop during the delay interval. As shown in Table 1, Rat 40 made more responses during the delay intervals than did Rat 41, and this behavior suggests a weaker establishment of other, non-competing, forms of delay mediating behavior.

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