finding that response force during extinction frequently dropped below the minimum required by the conditioning procedure until response force decreased and the criterion for extinction was met. Millenson & Hurwitz (1961) showed that during the extinction of sucrose-reinforced responding, high rates of response alternated with increasingly longer periods of no responding. We similarly observed, during avoidance extinction, an exaggeration of the fluctuations in the rate of leverpressing. Extinction of the free-operant avoidance response rate followed a pattern of response "bursts" alternating with increasingly longer periods of no responding (cf. Fig. 3 S_F). Note that response rates frequently dropped below the rate necessary to prevent shock during avoidance training (about four responses per minute) and then increased. The effect of the feedback stimulus seemed to prolong this cyclic pattern.

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trials, concluded that age did not influence the acquisition of this type of task but that younger animals were inferior on retention. Thompson, Koenigsburg, & Tennison (1965), on the other hand, using a criterion of 10 successive avoidances, found that younger animals took longer to acquire the response, but once criterion was reached performed as well as adult animals on retention.

More recently Porter & Thompson (1967) and Riccio, Rorbaugh, & Hodges (1968), using similar but less stringent measures than Thompson et al, claimed support for the Kirby view. However, these two studies are not incompatible with that of Thompson et al as both sets of results show trends in this direction, and in fact Riccio et al do report one significant result. Lack of significance for the other results could well be accounted for by the comparatively small numbers of Ss and large within-group variances evident in these studies. It appears then that the measures of learning used in many of these studies are not necessarily comparable. An equal number of avoidances made by two animals within a preset number of trials may not represent equivalent learning, whereas training both animals to criterion may.

To examine this hypothesis three groups of rats were tested, namely, (1) animals trained to a criterion of 10 successive avoidances, (2) animals yoked to the number of trials given to individuals in Group 1, and (3) animals yoked to the number of avoidances made by each animal in Group 1.

SUBJECTS

Ss were three groups of 10 male albino rats. All were aged from 120 to 140 days.

APPARATUS

The shuttlebox consisted of two compartments, one white and one black, separated by a 2.5 x 8 in. guillotine door.

A steel grid floor through which shock could be delivered ran the length of the floor. Electric timers and appropriate relay circuitry controlled the CS-UCS interval. Response latency was recorded from a photocell set into the walls of the box 0.5 in. from the door on the goalbox side.

CS consisted of door opening plus a 700-Hz tone from a speaker set into the side of the box.

PROCEDURE

Each S was given 5 min to explore the apparatus before being placed in the black start compartment and testing begun. ITIs averaged 75 sec and trials were signaled by the door opening and onset of tone. If S failed to cross (avoid) to the opposite chamber within 5 sec of this, a 2.0-mA shock was delivered until S escaped by crossing to the opposite chamber.

Acquisition measures in avoidance learning*

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Rats were trained to different criteria on a one-way avoidance task in order to examine the comparability of these various measures of acquisition. On two measures of relearning, it was found that Ss trained to a criterion of 10 consecutive avoidances performed better and were significantly less variable than yoked animals that had either been given the same number of trials or trained to the same number of avoidances. No difference were found in extinction.

In comparative studies of learning, various scores have been used as measures of acquisition. The three main approaches have been (1) responses required to reach a specified criterion level; (2) the administration of a set number of training

trials; and (3) the number of correct responses made.

In the acquisition of discrimination-learning sets, Miles (1965) concluded that the first two of these procedures were indistinguishable. With single-problem learning, however, this conclusion may not necessarily apply. For example, in studies of age effects on avoidance learning, Kirby (1963), equating avoidance responses within a set number of

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Fig. 1. Mean percentage correct responses for blocks of five trials for all groups in acquisition, extinction, and relearning (acquisition results are given for the first five blocks of trials).

Avoidance meant termination of the CS and no shock.

Group 1 animals were given the required number of trials to reach a criterion of 10 successive avoidances. Each Group 2 animal was then given the same number of training trials as its Group 1 counterpart, and Group 3 animals were tested until each had performed the same number of avoidances as their Group 1 partners.

All Ss were tested for extinction and relearning 24 h after training. The measures taken were: (1) In extinction, the number of trials to reach a criterion of five successive failures to respond; (2) in relearning, the number of trials taken to reach a criterion of 10 consecutive avoidances (Relearning 1); and (3) the proportion of avoidances to total trials in relearning (Relearning 2).

Extinction and relearning procedures were similar to those in acquisition with the absence of the UCS in extinction. Relearning trials were commenced immediately after extinction.

RESULTS

Figure 1 gives a graphical representation of the mean percentage of correct responses in acquisition, extinction, and relearning for all groups, over blocks of five trials.

Groups were tested for heterogeneity of variance in the extinction and relearning Phases 1 and 2 (Hays, 1963, p. 351). Variances were found to be homogeneous in extinction, but, on both measures of

relearning, Group 1 animals varied significantly less than either Group 2 [i.e., $F(9,9) = 4.69$, $p < .05$ and $F(9,9) = 20.18$, $p < .01$] or Group 3 [$F(9,9) = 3.66$, $p < .05$ and $F(9,9) = 7.46$, $p < .01$].

For this reason all data were transformed by either the Freeman-Tukey or arcsin methods (Winer, 1962) before being analyzed. Raw score means and variances and transformed score means are given in Table 1.

Three one-way analyses of variance were done on the transformed data and these yielded the following results. Extinction: No significant differences existed between the groups [$F(2,27) = 1.00$, $p > .05$]. Relearning 1: Group 1 animals relearned the response in significantly less trials than either Groups 2 or 3 when relearning was classed as the number of trials to a criterion of 10 successive avoidances [$F(2,27) = 3.79$, $p < .05$]. Relearning 2: The difference between the three groups was slightly above significance [$F(2,27) = 2.87$, $p > .05$]. However, a t test between Groups 1 and 2 allowing for heterogeneity of variance showed that Group 1 performed a significantly greater proportion of avoidances in relearning than Group 2 ($t = 2.43$, $df = 9$, $p < .05$). No other differences were significant.

Acquisition scores were also examined by t tests to see if groups had been randomly selected. No significant difference was found in the number of avoidances made by Groups 1 and 2 in acquisition ($t = 1.18$, $df = 18$, $p > .05$) or

in the number of trials given to Groups 1 and 3 ($t = 0.13$, $df = 18$, $p > .05$). The fact that three Ss from each of Groups 2 and 3 reached the criterion level set for their yoked partners in Group 1 further suggests that Ss were randomly allocated to groups.

DISCUSSION

In terms of relearning, training to criterion proved to be a less variable and more efficient measure of acquisition than training animals either to a set number of trials or to a set number of correct responses (avoidances). Hence, if relearning is a valid measure of original learning, these results suggest that, unlike the learning sets situation, the criterion for acquisition is an important factor in comparing performances on a one-way avoidance task.

Extinction scores, although in the expected direction, did not show any significant difference between the groups. This, in part, appeared to be due to the high extinction scores of those animals in the yoked comparison groups that had made at least 10 avoidances. The validity of extinction as a measure of learning has in fact been questioned (i.e., Thieos & Brelsford, 1964), but was included in this study to simulate the measures used in the studies of Kirby (1963) and Thompson et al (1965), etc.

In view of these findings it would seem more valid to equate animals on learning of a one-way avoidance task on the basis of a preset criterion level of responding rather than on a set number of trials or avoidances. This would seem to be an important factor in accounting for the differing results obtained by Kirby (1963) and Thompson et al (1965).

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Table 1
Raw Score Means and Variances and Transformed Score Means
for All Groups on Extinction and Relearning

	Group 1 Control			Group 2 Yoked Trials			Group 3 Yoked Avoidances		
	$\bar{X}$	S ²	$\bar{X}(\text{tr})$	$\bar{X}$	S ²	$\bar{X}(\text{tr})$	$\bar{X}$	S ²	$\bar{X}(\text{tr})$
Extinction	11.5	32.8	6.7	8.4	34.4	5.7	8.6	26.8	5.8
Relearning 1	12.7	4.8	7.2	23.1	131.3	9.4	21.5	196.8	9.1
Relearning 2	85.6	39.3	68.1	74.7	145.2	60.4	79.6	149.6	64.1