results comparable to those described above. A sloped gradient was obtained with the green surround, and the gradient was steeper with the green than with the black surround. The gradients, however, were not significantly different ($F = 1.34$, $df = 4/83$, $p > .05$).

DISCUSSION

Consistent with results commonly reported in the literature (e.g., Newman & Baron, 1965), gradients along the angularity dimension were steeper following differential than nondifferential training. In the Newman and Baron study, however, a flat "gradient" was obtained following nondifferential training to a white vertical line on a green surround while similar training in the present experiment and in the replication produced sloped gradients. There were a number of procedural differences between the two studies; which one accounts for the difference in slope is not known, however.

Evidence reported in the present paper regarding the effect of chromatic surround is difficult to reconcile with the suggestion of Baron (1965) and those of Mackintosh (1965) and Sutherland (1964). According to their formulations, attention to one aspect or dimension of a complex stimulus would be expected to produce inattention to others. Thus it was anticipated, assuming that chroma was more salient than a white vertical line, that attention to a chromatic surround might produce inattention to a line and its angularity during either nondifferential or differential training. The results of this study show that the effect of chroma in the surround upon attention to a line is different with nondifferential and differential training.

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NOTES

1. This paper is based upon a thesis submitted by the second author in partial fulfillment of the requirements for the MA degree at Kent State University, 1966.
2. This interpretation is consistent with the selective attention theories of Mackintosh (1965) and Sutherland (1964).
3. This replication was performed by Lynda S. Doll.

Development and maintenance of FR escape with titrated reinforcement¹

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High fixed-ratio grid escape behavior was developed and maintained when a titrated reinforcement procedure was used in the acquisition of a lower ratio. FR20 developed in one session was maintained as long as 170 sessions. Escape responding remained consistent when the schedule was raised to FR40, FR60, and even FR80.

Few studies investigating escape procedures with rats report success in acquisition or maintenance of consistent behavior with continuous grid shock. Many Es attribute this failure to the methods of shock application and the different shock generators and devices (Dinsmoor, 1967; Hendry & Hendry, 1963). Although it is not denied that a better procedure for shock application is necessary, we believe that a great deal of this problem can be eliminated by the use of modified acquisition training procedures.

Recently a procedure for acquisition training of ratio and interval schedules of negative reinforcement has been reported (Khalili & Daley, 1968). In this procedure the ratio size (or mean interval length) does

not vary during the acquisition period as is common in intermittent schedule training. Briefly the procedure is as follows: After a session of continuous reinforcement (CRF) of escape responding with a 30-sec time-out (T.O.) from shock, the schedule is set at the desired ratio or interval. In the following session all responses, other than the terminal response which produces a 30-sec T.O., will produce a smaller amount of reinforcement (T.O. from shock). The short time-out periods for each response are called titrated reinforcers (TRs), and the TR value is decreased in steps until it reaches 0. A typical set of TR values might be TR10 sec, TR5 sec, TR1 sec, and TR0 sec. TR0 sec is the same as the primary schedule. This procedure of stepwise decreasing CRF for all responses, except the terminal one, is referred to as a *titrated negative reinforcement procedure*.

The purpose of our experiment was to investigate some parameters of acquisition and maintenance of fixed-ratio schedules as well as transitional effects of ratio increases.

METHOD

Six male hooded Long-Evans rats were used. All animals had continuous access to food and water in their home cages.

Fig. 1. Representative cumulative records of FR20 escape acquisition with decreasing TRs within a session (top) and maintenance for 95 sessions. Knees indicated at a.

Fig. 2. Cumulative records of typical transition performance after many sessions on FR20TRO, trained with TR changes within one session.

A Grason-Stadler operant conditioning chamber for small mammals, supplied with a continuously scrambled electric shock to the grid, was housed inside a plywood sound attenuation chamber. The bar as well as the sides of the chamber were connected to the grids. Standard control equipment, consisting of relays, timers, and recording devices were used.

All Ss were shaped by successive approximation to press the bar which terminated a 0.6-mA electric shock. A CRF schedule was then employed in which each response produced a 30-sec time-out from shock.

Fig. 3. Cumulative records of S6 showing TR changes between sessions and subsequent performance. Final rate is lower than within-session changes.

Following one session of CRF training, the schedule determined for each S was put in effect. Ss 1-4 were trained by changing the TR values *within* a session, while Ss 5 and 6 were shaped with *between* session changes. Other differences will be noted below. Criterion for stability was a session of consistent responding with 95% of the response latencies within 0.2 sec, and 90% of the total reinforcement opportunities having been obtained.

RESULTS

Figure 1 illustrates the acquisition and maintenance of behavior on an FR20 negative reinforcement schedule when employing a titrated reinforcement procedure in which TR values are changed within a session. Labels A through F indicate changes in TR values: A = FR20TR10 sec, B = TR3.0 sec, C = TR1.0 sec, D = TR0.75 sec, E = TR0.5 sec, F = TR0.0 sec. All records (except Session 1, Fig. 1) are corrected for the 30-sec reinforcement, but not for the TR values.

Figure 2 shows the performance of S2 at Session 171 on FR20TR0 and subsequent transitions (Ss 1 and 3 were essentially the same). As can be seen, there is little transitional disruption following increases of the ratio size. Session 174 shows maintenance of stable FR40TR0 performance. Session 175 shows an increase to FR60TR0. Session 180 shows 6 days of stability on FR60TR0, and Session 181 shows the same rat on FR80TR0. Here again the behavior is not altogether broken, although strains are evident. The bottom record shows 20 sessions later on FR80TR0. The pattern of behavior is not much different from those of FR80/100 food reinforcement with pauses and knees (Ferster & Skinner, 1957).

Subject 4 was trained with the TR procedure, except that the original schedule was FR40. The performance at FR40TR0 was stable for about 50 sessions. However, the performance of S4 on FR40TR0 was considerably more variable than that of S2 on FR80TR0. In other Ss, not reported here, we have been able to "smooth" the behavior by simply putting in effect a TR0.5 sec for one or two sessions. However, with S4 this procedure failed.

Figure 3 shows the acquisition of FR20 via titrated procedures with TR changes *between* sessions for S6. It also shows two sessions of stable performance. Disruptions were not obvious as TR values decreased. S6 was transitioned from FR20TR0 to FR40TR0 after only 17 sessions. The behavior was considerably less consistent than that of S2, who ran for 171 sessions, and transitional disruptions were present. More than 30 sessions at FR40TR0 were required for the behavior to meet criterion.

DISCUSSION

It appears evident that titrated negative reinforcement procedures produce fast and stable ratio schedules of escape performance at least on FR20 and FR40. TR changes between or within sessions seem to have little effect on the final performance in terms of stability or maintenance. There are small differences in final performance between animals trained with TR changes within or between sessions, the most prominent being a slightly higher rate for those trained with within-session changes.

During acquisition with the TR procedure, we observe not only the development of stable rates of responding with short reaction times but also the response topography necessary to make the final FR contingencies effective at TR0 sec. Higher ratios than those reported here can be sustained through a longer period of acquisition.² That is, the time that each TR value is kept in effect and the size of the decrease in the TR are functional variables in high ratio or interval escape training.

The important points from this study seem to be that given a reliable and fast procedure for developing ratios around FR30 (which the TR procedure is) it is possible to increase ratio size abruptly to large magnitudes and to maintain them. Two features are suggested which seem to be necessary to maximize performance. Initial training at low ratios, 20 or less, and maintaining performance at this parameter, i.e., FR20TR0, for upwards of 100 sessions.

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NOTES

1. Based in part on a paper, "The effects of increased schedule demands as a function of past exposure to ratio requirements in a grid-escape paradigm," presented at the annual meeting of the Utah Psychological Association, Salt Lake City, Utah, December 1968 by J. Khalili. This research was supported in part by a University Research grant to the first author.
2. Khalili, J. Unpublished data, Utah State University Psychology Animal Behavior Laboratory, 1968.