memory, including Nielson's state dependency, but pointed to possible need of a multimechanism approach. However, the results indicate the possibility of using halothane to eliminate pain from cold-immersion studies. Preathesthetized 20-sec Ss tested at 24 h (the usual period in immersion studies) showed no memory decrement. Thus, halothane may prove to be a useful tool in the study of memory.

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Amsel, Hug, & Surridge, 1968; Brooks, 1969) have shown that at least some of the evidence can be accounted for by the frustration hypothesis.

According to the sequential hypothesis (Capaldi, 1967), the aftereffect or stimulus trace occurring on nonrewarded (N) trials becomes conditioned on rewarded (R) trials. Thus, in the sequence NRNR, the animal acquires some habit to run to the N stimulus in that the N aftereffect receives two conditionings. Since from acquisition to extinction there is less generalization decrement of habit strength for partial reward (PR) training than for continuous reward (CR) training, PR is expected to result in greater resistance to extinction.

In order to obtain the PREE in Amsel's system, N trials must first elicit frustration (R_F), which subsequently and in anticipatory form (r_F-s_F) becomes counterconditioned to the approach response ($s_F \rightarrow R_{APP}$). Inasmuch as R_F requires that anticipatory reward (r_R-s_R) be conditioned to the runway cues with some minimum strength, N trials must be preceded by some number of R trials. If PR training consists only of one NRNR sequence, it follows that the first N trial cannot produce R_F . Assuming that the second N trial does produce R_F , it remains questionable whether sufficient $s_F \rightarrow R_{APP}$ counterconditioning could occur on the one remaining R trial to have an appreciable effect on extinction performance. However, if CR training were given after the NRNR sequence, it might be expected to enhance counterconditioning of the available r_F-s_F and produce the PREE. On the other hand, more R trials would not be expected to enhance the PREE, given Capaldi's analysis, since the R trial replaces the N aftereffect and removes the occasion for further conditioning of the N aftereffect.

The present study was conducted to assess the explanatory roles of the frustration and sequential hypotheses in the small-trial PREE by providing interpolated CR training between NRNR or RRRR reward sequences and extinction of an instrumental running response.

METHOD

Ss were 36 male albino rats obtained from Holtzman Farms, Madison, Wisconsin. They were approximately 90 days old at the start of the experiment and were housed individually from the time of their arrival in the laboratory. They were placed on food deprivation approximately 2 weeks before the experiment began. During this period and throughout the experiment, they were given 12 g of Wayne lab chow

The small-trial PREE and interpolated CRF training*

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Rats given four running trials in an NRNR reward sequence did not perform differently in extinction than rats given an RRRR reward sequence. When 16 R trials were interpolated between the initial sequences and extinction, a PREE was observed. The results were interpreted as supporting a counterconditioning but not a sequential model.

The partial reinforcement extinction effect (PREE) following limited training appears readily

explainable by Capaldi's sequential hypothesis (e.g., Capaldi, 1967) but poses difficulty for Amsel's frustration hypothesis (1958, 1962, 1967). Further, Capaldi, McCain, and their associates have amassed a considerable amount of evidence in small-trial situations supporting the sequential interpretation (see Robbins, in press, for a recent review of the small-trial partial reinforcement literature), although some investigators (e.g.,

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Fig. 1. Start, run, and goal speeds over experimental days.

each day. Water was continuously available. Also during this period, Ss were given brief daily handling, but not in association with food. For 7 days prior to the start of the experiment, the Ss were given five 97-mg pellets in their home cages, and on the day before experimentation, they were given alley exploration in groups of three for 5 min. The clocks and doors were operated during this time.

The apparatus was a 6-ft 3-in. black alley, 3 in. wide and 4 in. high, covered with clear Plexiglas. The runway was connected to a 6 x 3 in. gray startbox through a Plexiglas door. A black sheet-metal retrace door was situated 18 in. from the goal end of the runway. Opening the start door activated a Standard Electric timer, which was stopped by the interruption of a photobeam located 12 in. into the alley. Similarly, a succession of five timers was activated on each trial, the remaining photobeams situated 4, 5, 6, and 6 ft 3 in. from the startbox door. The last photobeam was located just over a U-shaped metal foodcup, positioned on the end wall, 1½ in. from the floor; the beam was interrupted to yield the goal-II measure only when S nosed into the cup. Thus, there were five running measures, designated start, run-I, run-II, goal-I, and goal-II.

Ss were given experimental training at four trials per day with approximately 40 min between trials, which was spent in the Ss' home cage. On R trials S received five 97-mg Noyes pellets and on N trials was confined in the goalbox for approximately 30 sec.

On Day 1 Groups CE and CCE

received four R trials. Groups PE and PCE also received four trials, but in an NNR sequence. During Days 2-4, Groups CE and PE were given extinction training. Groups CCE and PCE continued on CR training from Days 2-5 and were on extinction from Days 6-9.

RESULTS AND DISCUSSION

Analyses were conducted over all five measures; however, run-II and goal-II are omitted here, as they provided no new information. Figure 1 shows no evidence for a small-trial PREE. Analyses of variance over the Group by Day by Trials data showed no significant main effects or interactions with groups for any measure; if anything, Group CE was more persistent than Group PE. The absence of the PREE is certainly not what would be expected in terms of the sequential hypothesis, and our finding is contrary to much of the published evidence on the small-trials effects (Robbins, in press). It is possible that differences in amount of preexperimental treatment, such as prefeeding of reward pellets, contributed to this discrepancy. Capaldi & Walters (1970) provided reward pellets in the home cage for 10 days previous to experimentation, and Capaldi, Ziff, & Godbout (1970) prefed their Ss reward pellets for 21 days. Alternatively, it is typical of the preexperimental procedures used by McCain (e.g., 1966) to feed Ss on a table in conjunction with handling, in which case they may be learning to approach food on release from E's hand. Too little is presently known about the effects of these extraexperimental factors, however, and we can only speculate about their possible effects.

The PREE for Group PCE compared to Group CCE is evident in Fig. 1, and this observation was borne out in the statistical analyses in Reinforcement by Day interactions for the start and run measures, $F(3,240) = 2.35$ and 3.14 , $p < .10$ and $.05$, respectively, and a Reinforcement by Day by Trial interaction in the goal, $F(9,240) = 2.68$, $p < .01$. Allowing for the possibility that the PREE for these groups was due to superior terminal acquisition performance by Group PCE, analyses were also conducted over extinction data corrected by performance on the last acquisition day. These analyses confirmed the superior extinction performance by Group PCE.

That the PREE was not demonstrable following four trials, but was after the interpolated CR training, suggests support for a counterconditioning-type model of extinction such as the frustration hypothesis (Amsel, 1967), rather than

either the sequential model (Capaldi, 1967) or the overlearning hypothesis (Brooks, 1969). However, it might also be that vigor of responding must be above some minimal level for the PREE to be detectable. That is, we may not have been able to find the PREE following four trials because of the low and unstable performance of our Ss. Other investigators have obtained higher levels of performance after minimal training. Capaldi, Ziff, & Godbout (1970), for example, showed that after four trials in an NNR sequence, rats ran over 4.5 ft/sec.

Alternatively, it might be that the greater amount of handling received by Groups PCE and CCE contributed to the PREE, although we have neither theoretical nor empirical reason to believe that this is the relevant variable. The handling variable has, in general, been confounded when the effects of number of training trials has been assessed. Again, it is perhaps the preexperimental treatment that deserves further attention in the small-trial effects. In any event, the small-trial PREE requires further research for its complete understanding, and at present no one hypothesis appears to account for all of the data.

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