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The partial reinforcement effect sustained through blocks of continuous water reinforcement

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Thirsty rats received either partial or continuous water reinforcement in Phase I. In Phase II, half of the partially rewarded subjects were shifted to continuous reinforcement while the other half continued to receive partial reinforcement. The continuously reinforced subjects continued to receive the same reinforcement conditions as before. In Phase 3, all subjects underwent extinction. The results showed both a highly significant PREE and a sustained PREE. The need for investigation of known behavioral phenomena as a function of different reinforcers was emphasized.

One of the most reliable phenomena in psychology is that of the partial reinforcement extinction effect (PREE). Subjects receiving partial reinforcement in acquisition typically display slower extinction performance than comparable subjects receiving continuous reinforcement in acquisition. This phenomenon has been consistently found in a great number of studies carried out in different laboratories and with different species (Lewis, 1960; Robbins, 1971; Mackintosh, 1971). Yet, the ubiquitous PREE in instrumental learning situations has been challenged on two occasions. Earlier studies have found that in within-subjects designs, the conventional PREE is either reversed (Pavlik & Carlton, 1965; Pavlik, Carlton, & Hughes, 1965) or absent (Amsel, Rashotte, & McKinnon, 1966; Rashotte & Amsel, 1968; Rudy, Homzie, Cox, Graeber, & Carter, 1970). However, the PREE was found in subsequent investigations of the within-subjects design (Pavlik, Carlton, & Manto, 1965; Rashotte, 1968; Waters & Knott, 1970). Recently, Macdonald and Toledo (1974) provided the second challenge to the generality of the PREE by showing that no PREE was obtained under water reinforcement conditions. Although few studies have used water reinforcement, Macdonald and Toledo cite, with reservations, three such studies in which a between-subjects PREE has been obtained (Gray, Quintâo, Araujo-Silva, 1972; Jenkins & Rigby, 1950; King, 1972). However, a reliable PREE based on water reinforcement in the runway had already been reported by Wilson, Weiss, & Amsel (1955). Feider (1973), using a within-subjects design, failed to find a PREE based on water reinforcement. This result is consistent with the food studies cited earlier, in which the PREE was also difficult to obtain in within-subjects designs.

The lack of a between-subject PREE water reinforcement (Macdonald & Toledo, 1974), supports the recent admonitions made by several investigators concerning the generality of learning laws and principles (Halliday & Boakes, 1972; Hearst & Jenkins, 1974; Seligman, 1970; Shettleworth, 1972). However, in view of the rather solid empirical base of the PREE, it is probably premature to conclude on the basis of one study that the PREE does not occur when water is used as the reinforcer. There were a few unorthodox procedures (to be discussed later), used by Macdonald and Toledo, that could account for the absence of the PREE. Prior to the Macdonald and Toledo study, the only known published study which reported an absence of a PREE based on water reinforcement was a study by Feider (1973) which was a within-subjects design. As stated earlier, the results could, among many things, be a function not of the type of reward but of the particular design used. Obviously, more investigations of this phenomenon using a within-subjects design are needed before any generalizations can be made. The present study was primarily designed to replicate and extend the findings of Macdonald and Toledo by using a sustained PRE paradigm and more conventional procedures such as using a 23½-h water deprivation as opposed to the 47-h water deprivation used by Macdonald and Toledo and running the subjects every day instead of every other day.

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METHOD

Design

The subjects were randomly assigned to either a PR (50%) or CR (100%) water reinforcement schedule in Phase 1. In Phase 2, half of the PR subjects were shifted to CR (Group P-C), while the other half remained on the same PR schedule (Group P-P); the CR subjects (Group C-C) continued on the same reinforcement schedule. In Phase 3, all groups underwent extinction.

Subjects

The subjects were 30 naive male albino rats of the Sprague-Dawley strain, approximately 90 days old at the start of the experiment.

Apparatus

A standard Hunter runway was used. The runway was modified in two ways: First, the guillotine doors separating the

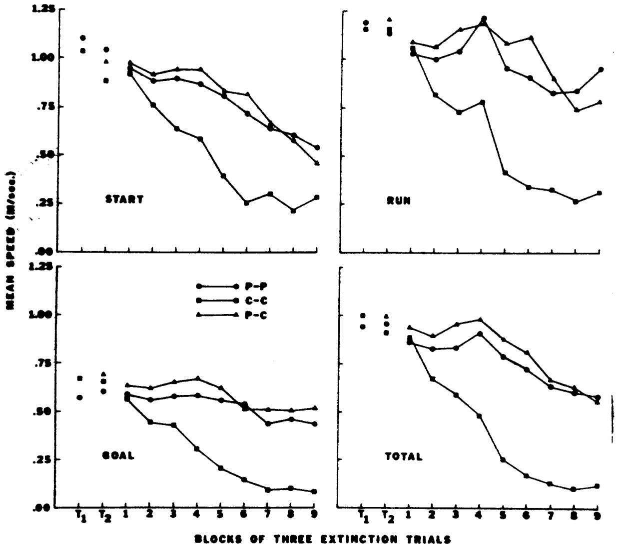

Figure 1. Mean start, run, goal, and total speeds in extinction. T_1 and T_2 stand for the mean running speeds over the last three blocks of Phases 1 and 2, respectively.

start from the run and the run from the goal sections were converted from electrical to manual operation. Second, a black self-sticking plastic coating covered the sides and ends of the runway from the outside. The top remained clear Plexiglas.

Four photocells were used to record start, run, and goal times. The first photocell was located 8 cm into the runway from the start door. The second photocell was located 25 cm beyond the first, while the third photocell was placed 100 cm beyond the second photocell. The distance between the fourth and the third photocells was 25 cm and the reinforcer cup was placed 8 cm into the goalbox. The photocells were connected to electric timers which measured time to the nearest .01 sec.

The lighting was supplied by two 25-W red light bulbs placed approximately 1.5 m over (but not directly above) the runway.

A clear plastic furniture coaster was used as the reinforcer cup; the coaster was 3.2 cm in diam and 6.3 mm deep. The water was placed in the reinforcer cup by means of a needleless hypodermic syringe which also served to measure the magnitude of the water delivered. Flush with the floor of the goalbox, a slot was made in the far wall through which the reinforcer cup was inserted.

Procedure

Upon arrival from the supplier, the subjects were housed individually and received food and water ad lib for 17 days. During this time, the subjects were handled and weighed daily. Twelve days prior to Phase 1, all subjects were adapted to a 23½-h water deprivation schedule which was maintained throughout the study. This was done by allowing each subject ½ h daily access to water in the home cages. Four days prior to Phase 1, all subjects received 2 min free exploration of the unbaited runway with all equipment off and doors up. On the following day, all subjects received 1 min free exploration with the various equipment on. Immediately following removal from the runway, each subject was placed in the goalbox and given 1 cc of water, which was the reinforcer magnitude used in acquisition. Throughout the experiment, each subject was given ½-h access to water in the home cage approximately ½ h after it had been run.

On Day 1 of Phase 1, all subjects received a single reinforced trial. On Day 2, two trials were given. The subjects in the CR schedule received two reinforced trials while those in the PR condition received one reinforced trial followed by one nonreinforced trial. On Day 3 and thereafter, all subjects received three trials per day and were run in squads of three with an ITI of approximately 3 min. The 50% PR schedule was determined randomly for the PR subjects with the restriction that no more than two reinforced or nonreinforced trials occurred in a row. All PR subjects were confined 15 sec in the goalbox on nonreinforced trials. This phase was continued for 14 days (42 trials).

In Phase 2, the subjects in the PR condition were matched on runway performance and divided into two equal groups, (P-P and P-C). The P-C subjects were shifted to a continuous reinforcement schedule while the P-P subjects continued to receive the same intermittent schedule as before. The subjects in the C-C condition also continued to receive continuous reinforcement as in Phase 1. Phase 2 lasted 23 days (69 trials) with an ITI of approximately 3 min. In Phase 3, all three groups underwent extinction. In the event that any subject refused to traverse any particular section of the runway within 30 sec, that subject was gently pushed into the goalbox, and a latency of 30 sec was recorded for that and all subsequent sections of the runway. Extinction lasted 9 days (27 trials); all subjects were confined for 15 sec in the empty goalbox. Throughout the study, start, run, and goal times were recorded and converted to reciprocals for later analysis.

RESULTS

All analyses are based on speed measures (meters/second). Analysis of the data in Phase 1 revealed that no crossover effect was present in any of the four sections of the runway, all $Fs(13,364) < 1$, for the interactions of treatments with blocks. The treatments effect was also nonsignificant, all $Fs(1,28) < 1$. However, the blocks effect was highly significant, $Fs(13,364) = 26.13$, 20.69, 30.18, and 36.71, all $ps < .0001$ for start, run, goal, and total speed, respectively, indicating a clear acquisition effect. There were no discernible differences between the groups throughout Phase 2. The results of separate analysis of variance tests with repeated measures performed on terminal speed performance (last three blocks) in Phasees 1 and 2, reflected stable performances in all measures. For Phase 1, neither the blocks effect [$Fs(1,28) = .002$, 2.19, 1.66, and 2.06, all $ps > .05$] for start, run, goal, and total speed, nor the interaction of blocks with treatments was significant [all $Fs(2,56) < 1$]. Almost identical results were obtained in Phase 2. The main effect of treatments over the last three blocks of Phases 1 and 2 were similarly not significant, $Fs(1,28) < 1$ for start, run, and total speeds; and $F(1,28) = 3.24$, $p > .05$ for goal speed for Phase 1, and all $Fs(2,27) < 1$ for all four measures of Phase 2.

As Figure 1 shows, all four speed measures were highly similar in showing a more rapid decrease in speed for the C-C subjects relative to the P-P and P-C subjects. This was supported by the highly significant Treatments by Blocks interaction effects, $Fs(16,216) = 2.33$, 2.58, 3.91, and 3.77; $ps < .004$, .001, .0001, and .0001 for start, run, goal, and total speed, respectively. The blocks effect was also significant, $Fs(8,216) = 30.62$, 12.1

17.94, and 27.58; all ps < .0001, for start, run, goal, and total speed, respectively. Except for the start speed, which barely reached significance, $F(2,27) = 3.28$, $p = .052$, the treatments effect was highly significant, $Fs(2,27) = 6.75$, 24.37, and 10.23, all ps < .005 for run, goal, and total speed, respectively. Using the total speed as representative of the other three speeds, individual comparisons were made which yielded highly significant results for the difference between the continuously reinforced group and the two partially reinforced groups, $t(18) = 4.12$ and 4.31, both ps < .005, for the P-P vs. C-C and the P-C vs. C-C comparisons, respectively. The difference between the P-P and P-C groups was not significant, $t(18) < 1$.

DISCUSSION

The results of the present study are clear in showing that not only does the PREE occur with water reinforcement but that it is not attenuated by the insertion between acquisition and extinction of a large number of continuously reinforced trials. In both cases, the effect was very strong. The obtained PREE agrees with the many studies using either food (Robbins, 1971) or sucrose reward (Likely, Little, & Mackintosh, 1971; Tombaugh, McCloskey, & Tombaugh, 1971), as well as with the water studies cited earlier (Gray et al, 1972; Jenkins & Rigby, 1950; King, 1972; Wilson et al., 1955). The sustained PRE obtained in this study supports and extends similar findings obtained with food reward (Jenkins, 1962; Leung & Jensen, 1968; Sutherland, Mackintosh, & Wolf, 1965; Theios, 1962). Until now, no investigation of sustained PRE as a function of water reward seems to have been carried out.

The discrepancy in results between this study and that of Macdonald and Toledo could be attributed to several procedural differences. Macdonald and Toledo used a very small magnitude of water reinforcement. With small food reward, either a very weak or no PREE is obtained (Amsel, 1958; Gonzalez & Bitterman, 1969; Hulse, 1958; Roberts, 1969; Wagner, 1961; Yamaguchi & Sukenmune, 1963). The finding of no PREE by Macdonald and Toledo was based on the analysis of start and run times, not on speeds; no goal times were reported. In the first place, it is customary in runway studies to transform the raw data (time or latency) to reciprocal or speed measures in order to normalize the distribution and meet one of the basic assumptions of such a parametric test as the analysis of variance test. Macdonald and Toledo did not transform the latency data but nevertheless used the analysis of variance test to analyze their results. It is conceivable that the absence of the PREE could have been an artifact of the statistical analysis used. For example, one or two very slow rats in the partially reinforced group could have produced the effect. In the second place, the goal speed is usually a more sensitive extinction measure than the start or run speeds, as is shown in this and many similar PRE studies. Moreover, both the intertrial (ITI) and the intersession (ISI) intervals used in this study, 3 min and 24 h, respectively, were considerably shorter than the 15-min ITI and 47-h ISI used by Macdonald and Toledo. Spaced trials have been reported to decrease resistance to extinction (cf. Capaldi, Berg, & Sparling, 1971; Mackintosh, 1970). It is possible that the combined effects of long ITIs and ISIs attenuate the PREE, thus accounting for the failure of obtaining a PREE in the Macdonald and Toledo study.

Yet investigations of the effects of water reinforcements on known behavioral phenomena need to be encouraged since the vast majority of our behavioral principles are based on food reinforcement, a few on sucrose, and a negligible part on water reinforcement. Thus, there is an appallingly small number of studies which investigated the PREE as a function of water reward. Besides the limitations pointed out by Macdonald and Toledo concerning the three studies which obtained a PREE with water reward, only the study by Jenkins and Rigby (1950) which used a Skinner box can be considered a bona fide traditional PRE study. Although the other two studies used the runway, the PREE reported by Gray et al. (1972) was based on a comparison of sham-operated PR and CR subjects. It is not known how the surgical effects interact with the type of reward. The second study (King, 1972) is equally difficult to interpret since, prior to the schedule manipulation, the subjects were subjected to an approach-avoidance conflict which was induced by adding a bitter-tasting substance to the water reward. Apparently, the evidence for a traditional PREE with water reward is based on the results of only three studies, namely, those showing response-rate differences (Jenkins & Rigby, 1950), respsonse frequency differences (Wilson et al., 1955), and those showing speed differences as in the present study.

Current PRE explanations (cf. Amsel, 1958; Capaldi, 1967) can easily account for the present findings. However, for a more thorough understanding of the PRE and other behavioral phenomena, considerably more studies using water and other nonfood reinforcers need to be carried out.

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