Between- and within-subjects PRE in selective responding

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Different patterns of partial reward in one arm of a Y-maze were utilized in an attempt to condition the aftereffects of nonreward to the response of choosing a specific arm on free-choice test trials after a nonrewarded trial. The choice data suggested the operation of two factors: (1) a tendency to choose the arm associated with continuous reward over that associated with partial reward, and (2) the development of associative control over choice behavior by the aftereffects of nonreward.

A convincing number of studies provide demonstrations of stronger performance by Ss receiving a partial percentage of trials rewarded than by Ss receiving consistently rewarded trials, commonly referred to as the partial-reward effect (PRE). A straight runway is frequently used, with evidence for PRE obtained from comparison of running speeds in acquisition (Goodrich, 1959) or extinction (McCain, 1966) of groups of Ss receiving partial or consistent reward.

Although Ss run faster under partial reward conditions, they do not choose an alternative in which reward occurs on an irregular partial percentage of trials over a consistently rewarded alternative in a T-maze (Spear & Pavlik, 1966; Spear & Spitzner, 1967). This is one sense in which a "reversed PRE" is obtained in selective responding. A possible resolution to this apparent lack of comparability between running speed and selective-performance results can be derived from current neo-Hullian analyses of the PRE: These analyses emphasize the point that partial reward schedules involve reward (R) trials following nonreward (N) trials, and suggest that the PRE is mediated in part by acquired association between the reference response and a stimulus trace of nonreward, S_N (Capaldi, 1966), or a stimulus component, s_f , of S's frustration response to nonreward (Amsel, 1958; Spence, 1960). Applied to the choice situation: if the partial reward in one arm is patterned so that an N is regularly followed by reward for a turn into the partial-reward arm, association between S_N (and/or s_f) and the response (e.g., a right

turn) of choosing the partial-reward arm should develop, producing a choice PRE comparable to that obtained with running speed in straight alleys. The present study was undertaken as a test of this derivation. Although maze traversal latencies were recorded in Experiment 1 below, and stem- and arm-traversal latencies were recorded in Experiment 2 below, the analyses of these data are not presented in this report.

EXPERIMENT 1

Subjects and Apparatus

The Ss were 68 female Long-Evans hooded rats, 90-100 days old at the start of experimental pretraining. The apparatus was a Y-maze with an 18-in. stem, 10-in. arms, and 8-in. goalboxes set at 90-deg angles to the maze arms. Ss made a left turn to enter the left goalbox (GB) and a right turn to enter the right GB. Hinged sections of hardware cloth covered the top of the stem, arm, and GB parts of the maze. The entire maze was painted a flat black. A clear Plexiglas sliding retrace door was located 1 in. from the beginning of each maze arm.

Preliminary Training

For 9 days, Ss were handled individually 2-5 min each day. On Day 5, Ss were put in individual home cages, each furnished with a 5 x 7 in. strip of cloth toweling, and placed on a 22½-h food-deprivation schedule that was maintained throughout the experiment. Days 5-9 were allotted for Ss' habituation to the deprivation schedule and apparatus. On apparatus-habituation trials, Ss explored the unbaited maze in pairs for a 3- to 4-min period each day. On Days 8 and 9, Ss were given approximately 9 g of wet mash in their home cages after maze-habituation trials.

Experimental Design and Training

On Day 10, Ss were assigned randomly to either Group C or Group P, corresponding to two experimental treatments. The Ss then received a 14-day series of acquisition training trials, followed by six extinction trials on Day 14. Table 1 presents the schedule of training trials administered to Groups C and P.

Group P Ss received continuous reward in one arm, followed by an NR sequence of partial reward in the other arm. Group C Ss received an RN sequence of trials in the partially rewarded arm. This daily schedule of trials was repeated on each of 13 training days. A single free-choice nonrewarded test trial preceded the final

rewarded trial on Day 3. On Day 14, the nonrewarded trial in the partial reward arm (P-arm) was followed by six free-choice extinction trials. The Group P schedule of trials was designed to condition S_N (or s_f) to the response of turning into the P-arm. The Group C schedule of trials was designed to condition S_N (or s_f) to the response of turning into the continuously rewarded arm (C-arm).

A random one-half of the Ss in each group received partial reward in the left maze arm; the remaining Ss received partial reward in the right maze arm. Training trials were forced by closing the appropriate retrace door. A trial was begun by placing S in the initial portion of the maze stem. On R trials, Ss were permitted 15 sec of exposure to approximately 8 g of wet mash, which covered the bottom of a metal foodcup placed at the end of the GB. On N trials, Ss were run to an empty foodcup and were removed from the GB 15 sec after interrupting the GB photobeam. After being removed, S was placed in a waiting cage of the type used as home cages for the 30-sec intertrial interval. Before each trial, both maze arms were wiped with S's home-cage rag to provide a measure of odor-trail control.

Results and Discussion

A choice response on free-choice trials was recorded when S had moved into a maze arm far enough to permit closing of the retrace door. Figure 1 presents the data obtained from free-choice trials represented as proportions of turns to the C-arm.

Day 3 test trial. Both Group P and Group C Ss chose the C-arm significantly beyond the chance (.50) baseline

Table 1
Training Schedule of Rewarded (R)
and Nonrewarded (N) Trials

Day	Trial	Group P		Group C	
		C-arm	P-arm	C-arm	P-arm
1	1	R		R	
	2		N		R
	3		R		N
	4			R	
2	1	R			R
	2		N		N
	3		R	R	
3	1	R			R
	2		N		N
	3	free choice		free choice	
	4		R	R	
4-13	1	R			R
	2		N		N
	3		R	R	
14	1	R			R
	2		N		N
	3-8	six free choice extinction trials		six free choice extinction trials	

Fig. 1. Mean proportion choice of the C-arm on the free-choice trial during training and on the free-choice extinction trials.

[$t(33) = 3.02$, $p < .01$, and $t(33) = 5.12$, $p < .001$, respectively]. These findings are consistent with the results of similar studies mentioned above employing a random order of N and R trials in the P-arm. A nonsignificant difference [$t(66) = .88$] was associated with a greater per cent choice of the C-arm by Group C Ss.

First extinction trial. Group C Ss again chose the C-arm to a significant extent [$t(33) = 5.48$, $p < .001$]. Group P Ss tended to choose the P-arm. With the tendency to choose the C-arm as one factor (A), a second factor (B) is indicated by the significant difference [$t(66) = 3.58$, $p < .001$] associated with greater per cent choice of the C-arm by Group C Ss. In addition, the difference between Day 3 test trial and first extinction trial per cent choice of the C-arm by Group P Ss was significant² ($z = 3.15$, $p < .001$). The latter two findings suggest that the pattern of N and R trials was a factor (B) in determining choice behavior on the first extinction trial.

Subsequent extinction trials. On the second extinction trial, Group P Ss chose the P-arm to a significant extent [$t(33) = 3.02$, $p < .01$], and a significant difference [$t(66) = 2.98$, $p < .01$] was associated with greater per cent choice of the C-arm by Group C Ss. Neither of these comparisons was significant on subsequent extinction trials—suggesting a rapid diminution of S^N (or s_f) determination of choice behavior in the present study.

One possible factor determining maze behavior in Experiment 1 was thought to lie in the fact that on Trial 2 Group P Ss ran to the arm that was different from the Trial 1 arm, whereas Group C Ss ran to the arm that was the same as the Trial 1 arm. Experiment 2 included additional groups in which Trial 1 reward was varied between left and right arms. Although Experiment 2 was conducted primarily to look at the effect of *same vs different* Trial 1 arm reward on Trial 2 latencies, it does provide an important replication of the choice performance of Experiment 1 under a somewhat different set of conditions.

EXPERIMENT 2

Subjects and Apparatus

The Ss were 96 female Sprague-Dawley rats, 90-100 days old at the start of

pretraining. The maze was the same one used in Experiment 1. Deprivation, handling, maze habituation, and other procedures were the same as in Experiment 1, unless otherwise indicated.

Experimental Design and Training

On Day 10, the Ss were assigned randomly to four groups. Groups P and C had basically the same training as in Experiment 1. Groups VP and VC had basically the same training as did Groups P and C, with the exception that the arm in which Trial 1 reward was received was varied. The arm, left (L) or right (R), in which a given VP or VC S received Trial 1 reward was determined for 4-day sequences by random (nonreplacement) selection from the following 4-day sequences: LRLR,

LLRR, LRRL, RRLR, RLLR, RLRL. In this experiment Group P and Group VP Ss did not receive the extra C-arm reward on the first trial of Day 1, as indicated in Table 1 for Group P, prior to receiving their three trials for that day. This daily schedule of trials was repeated on each of 15 training days. A single free-choice nonrewarded trial preceded the final rewarded trial on Days 2 and 9. On Day 16, the N-trial in the P-arm was followed by six free-choice extinction trials.

Results and Discussion

Figure 2 presents the data obtained from free-choice trials represented as proportion of turns to the C-arm. Significant C-arm

Fig. 2. Mean proportion choice of the C-arm on the free-choice trials during training and on the free-choice extinction trials.

choice by VC and C Ss [$t(23) = 3.24$, $p < .001$, and $t(23) = 4.12$, $p < .001$, respectively] on the very first test trial indicated rapid development of the C-arm preference. A significant Cochran Q test [$Q(2) = 20.74$, $p < .001$] indicated the development of P-arm choice over the two acquisition test trials and the first extinction trial by the Ss of Groups P and VP. Employing a critical value [$t(94) = 1.99$, $p < .05$], Groups P and VP were found to differ significantly from Groups C and VC in mean proportion choice of the C-arm on both acquisition test trials and on each of the first five extinction trials. Thus, a reward patterning effect was apparent and persisted through five extinction trials. The greater persistence of pattern effects in the choice data of this experiment than in Experiment 1 may have been due to differences in number of acquisition trials and/or acquisition test trials. Both experiments produced data

describably as a PRE in selective responding, and provide support for the basic neo-Hullian analyses that predicted these results. Notable is the small amount of training required for the production of reward pattern effects. The choice situation may provide a setting more sensitive to reward pattern variables than the currently popular straight runway.

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NOTES

1. These studies were conducted at the University of Richmond, and a preliminary version of Experiment 1 was reported at the Virginia Academy of Science, 1967. Gary M. Tyson helped run some of the Ss in Experiment 1. Experiment 2 was done as MA thesis research by R. Johnson, directed by R. Patten.
2. The McNemar (1962, p. 55f) repeated-measures test was used.