stability of the control Ss throughout the experiment. Radiation sickness cannot explain the decrement since both Ss ate all food pellets delivered in each session.

Since Ss that are fluid deprived avoid fluids that have been previously paired on a single occasion with ionizing radiation, even when that fluid is the only solution available, it is apparent that radiation-induced aversion produces a motivational state that overrides the thirst motivation produced by 48 h water deprivation. The fact that this same conditioned aversion procedure does not produce a decrement in the high fluid intake levels induced by intermittent food schedules, and that repeated conditioning was required to reduce drinking, clearly attests to the strength of the motivational state induced by intermittent scheduling of food.

REFERENCES

FALK, J. The motivational properties of schedule-induced polydipsia. Journal of the Experimental Analysis of Behavior, 1966, 9, 19-25.

GARCIA, J., KIMELDORF, D., & KOELLING, R. Conditioned aversion to saccharin resulting from exposure to gamma radiation. Science, 1955, 122, 157-158.

GARCIA, J., & KIMELDORF, D. Some factors which influence radiation-conditioned behavior in rats. Radiation Research, 1960, 12, 719-722.

GARCIA, J., KIMELDORF, D., & HUNT, E. The use of ionizing radiation as a motivating stimulus. Psychological Review, 1961, 68, 383-395.

REVUSKY, S., & BEDARF, E. W. Association of an illness with the prior ingestion of novel foods. Science, 1967, 155, 219-220.

SEGAL, E. F., & DEADWYLER, S. Determinants of polydipsia. VI. Taste of drinking solution on DRL. Psychonomic Science, 1965, 3, 101-102.

NOTE

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Activity following partially reinforced trials: Evidence for a residual frustration effect due to conditioned frustration

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Activity measures in an open field were taken following partially and continuously reinforced trials in a straight alley. Not only was there increased activity following nonreinforced trials under conditions of partial reinforcement, but significantly more activity was obtained following the reinforced trials in the partial group than following comparable trials in the continuous group. There was also a significant increase in activity during extinction following continuous reinforcement. Results were interpreted in terms of frustration occurring in the goal box on both *reinforced and nonreinforced trials under partial reinforcement.*

Interpreting the effects of partial reinforcement in terms of a motivational state engendered by nonreward has rested primarily on the demonstration of two effects: enhanced running speeds in the second alley of a double runway following intermittent nonreward called the frustration effect (FE), and enhanced acquisition performance in the initial portions of a single alley under partial reinforcement in the form of a cross-over effect (CE). The FE has been viewed as being due to primary frustration in the first goal box (Amsel, 1958), while the CE has been attributed to conditioned or fractional-anticipatory frustration elicited by alleyway cues (Spence, 1960).

Recently, Gallup & Altomari (1969) found that measures of general activity, in the form of ambulation and number of rears, seemed to indicate increased arousal under conditions of intermittent reward in a single alley. When such measures were taken in a physically separate open-field maze following each trial, significantly more activity was observed following the nonreinforced as opposed to the reinforced trials. Such results would appear analogous to the FE obtained in double runway studies and could be viewed as representing a form of residual frustration, since the energizing effect on behavior in both situations follows nonreward and is independent of cues associated with primary frustration.

Since a number of FE studies (e.g., McCain & McVean, 1967; Wagner, 1959) have found faster partially reinforced running speeds in the second alley following the reinforced as well as the nonreinforced trials, as compared to continuous reinforcement, it would seem reasonable to ask whether activity might be greater in partially rewarded Ss following the reinforced trials.

SUBJECTS

The Ss were 20 experimentally naive male hooded rats from the inbred colony maintained at Washington State University. Animals were housed in two cages of 7 Ss each and one of 6, and were approximately 180 days old at the beginning of the experiment.

APPARATUS

The apparatus consisted of two flat black 55-in. parallel plywood straight alleys which were 4 in. high, with 9-in. start boxes and 10-in. goal boxes which were equipment with standard guillotine doors. Physically separate from the alleys was a white 22 x 22 in. open-field maze constructed of fiberboard. The maze was 12½ in. deep, with the top 4¾ in. consisting of a brown paper barrier. The floor of the maze was divided into 25 squares by thin black lines. Electric counters were used to record activity, and a stopwatch was used to measure trial durations in the open field.

PROCEDURE

Prior to the experiment, all Ss were 23 h food-deprived for 14 days, and were handled individually for 2-3 min over the last 8 days. Ss were also given about 30 min exploration time in their individual waiting cages on each of the last 8 days, and were prefed with 97-mg Noyes reward pellets over the last 7 days. Water was continuously available in the home cages at all times.

Training and testing were carried out over 19 consecutive days. On Day 1 of training each S was given 10 min of free exploration in one of the straight alleys, and the deprivation schedule was shifted to and maintained at 22½ h. During training, Ss were run in either straight alley for four 97-mg Noyes pellets on each of 23 trials. Three trials were run on Day 2 and four trials per day were given on Days 3 through 7 with an intertrial interval of approximately 15 min.

Following training the Ss were randomly divided into two groups. The partial reinforcement (PR) group received food on

Table 1
Means and Standard Deviations of Activity Measures During Acquisition

		Partial Reinforcement		Continuous Reinforcement
		Nonreinforced Trials	Reinforced Trials	
Ambulation	$\bar{X}$	23.15*	21.61	17.56
	SD	7.25	7.47	6.18
Rears	$\bar{X}$	8.34	7.35	5.69
	SD	3.47	3.40	2.66

* *All means were based on 200 observations.*

50% of the trials run each day, while the continuous reinforcement (CR) group received food on every trial. As a control for differential odor cues (e.g., Ludvigson & Sytsma, 1967), the sequence of reinforced and nonreinforced trials was randomized among partially reinforced Ss, and continuous Ss were run randomly interspersed with partial Ss.

After each run, Ss were detained in the goal box for 30-40 sec. Testing procedures began on Day 8 and consisted of four trials per day for 10 consecutive days. During testing S was removed from the goal box and placed into the center square of the open-field maze. Activity was measured over a 60-sec interval which began with the first count of activity. The number of squares traversed and number of rears were taken as measures of activity. Jumps out of the open field were also scored as rears. Only one alleyway was used during testing and the intertrial interval was about 40 min.

Extinction conditions were implemented on Days 18 and 19. All procedures were the same as above except that Ss never received food in the goal box.

RESULTS

A summary of acquisition data for ambulation and rears is presented in Table 1. Results are reported in terms of activity following reinforced and nonreinforced trials under PR, and in terms of the continuously reinforced trials which matched the sequence of reinforced trials in the partial group.

Under conditions of PR the mean number of squares traversed on nonreinforced trials of 23.15 was significantly different from the 21.61 on reinforced trials ($F = 4.85$, $df = 1/360$, $p < .05$) and the overall effect of trials was nonsignificant ($F = 1.63$, $df = 19/360$). The 8.34 mean rears obtained on nonreinforced trials was also significantly greater than the 7.35 rears following reinforced trials in the partial group ($F = 9.14$, $df = 1/360$, $p < .01$). For rears the effect of trials was greater than chance ($F = 2.27$, $df = 19/360$, $p < .01$); however, this effect was not differentially distributed among reinforced and nonreinforced trials in the PR group as indicated by a nonsignificant interaction between treatments and trials ($F = 1.69$, $df = 19/360$).

As predicted, more activity was observed following reinforced trials in the partial group than following comparable trials in the continuous group. The mean number of squares crossed on reinforced trials in the PR group of 21.61 was significantly different from the 17.56 traversed under CR ($F = 41.54$, $df = 1/360$, $p < .01$). The effect of trials was significant ($F = 4.98$, $df = 19/360$, $p < .01$), but the interaction between treatments and trials was not ($F = 1.12$, $df = 19/360$). The 7.35 mean rears observed following reinforced trials under PR was also greater than the 5.69 rears obtained under CR ($F = 34.84$, $df = 1/360$, $p < .01$). Again the effect of trials was significant ($F = 5.03$, $df = 19/360$, $p < .01$), but the interaction was not ($F = .77$, $df = 19/360$).

A summary of the extinction data is presented in Table 2. When the last eight continuously reinforced acquisition trials were compared with the eight extinction trials in the continuous group, significantly more ambulation was in evidence during extinction ($F = 4.46$, $df = 1/158$, $p < .05$). Using the same procedure, increased rears by continuously reinforced Ss were also noted during extinction ($F = 11.05$, $df = 1/158$, $p < .01$). However, during extinction there were no significant differences between the partial and continuous groups for rears ($F = 2.18$, $df = 1/144$), and although the effect of trials was significant ($F = 2.08$, $df = 7/144$, $p < .05$), the interaction was not ($F = 1.17$, $df = 7/144$). Likewise, for ambulation the differences between partial and continuous groups were not significant ($F = 2.59$, $df = 1/144$), the effect of trials was ($F = 3.26$, $df = 7/144$, $p < .01$), and the interaction was not ($F = 1.78$, $df = 7/144$).

Table 2
Means and Standard Deviations of Activity Measures During Extinction

		Partial Reinforcement	Continuous Reinforcement
Ambulation	$\bar{X}$	20.15*	18.78
	SD	6.31	5.53
Rears	$\bar{X}$	7.37	6.63
	SD	3.77	3.26

* *All means were based on 80 observations.*

DISCUSSION

The findings of increased activity following nonreinforced trials relative to reinforced trials under PR, and the absence of Treatments by Trials interactions, confirms an earlier report (Gallup & Altomari, in press). Such an effect could be interpreted in terms of residual or carry-over frustration resulting from prior exposure to nonreward. Moreover, increased activity on the part of continuously reinforced Ss during extinction would seem to constitute additional evidence for the idea of active motivational properties associated with nonreward.

Since, as others have suggested (Spence, 1960), primary frustration in the form of intermittent nonreward occurs in the presence of goal box cues and may become conditioned to such cues (e.g., Wagner, 1963), then exposure to these cues might be expected to elicit some form of conditioned frustration even on reinforced trials. Heretofore, this implication of Amsel's theory has received little if any attention. However, the fact that significantly more activity was found following reinforced trials in partially reinforced as compared to continuously reinforced Ss would seem to support such an interpretation. At short intertrial intervals similar residual effects of both primary and conditioned frustration might conceivably be involved in and contribute to apparent CEs obtained in single runway studies. It seems reasonable that such confounding could be controlled for by lengthening the intertrial interval. However, the intertrial duration of such residual effects is not currently known.

REFERENCES

AMSEL, A. The role of frustrative nonreward in noncontinuous reward situations. Psychological Bulletin, 1958, 55, 102-119.

GALLUP, G. G., JR., & ALTOMARI, T. S. Activity as a post-situation measure of frustrative nonreward. Journal of Comparative & Physiological Psychology, in press.

LUDVIGSON, H. W., & SYTSMA, D. The sweet smell of success: Apparent double alternation in the rat. Psychonomic Science, 1967, 9, 283-284.

McCAIN, G., & McVEAN, G. Effects of prior reinforcement or nonreinforcement on later performance in a double alley. Journal of Experimental Psychology, 1967, 73, 620-627.

SPENCE, K. W. *Behavior theory and learning.* Englewood Cliffs: Prentice-Hall, 1960.

WAGNER, A. R. The role of reinforcement and nonreinforcement in an "apparent frustration effect." Journal of Experimental Psychology, 1959, 57, 130-136.

WAGNER, A. R. Conditioned frustration as a learned drive. Journal of Experimental Psychology, 1963, 66, 142-148.