JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR VOLUME 7, NUMBER 1 JANUARY, 1964

SOME NOTES ON TIME OUT FROM REINFORCEMENT[1]

J. ZIMMERMAN AND C. B. FERSTER

INDIANA UNIVERSITY MEDICAL CENTER

Pigeons produced food on a fixed-ratio schedule by pecking at one key, and an S^{Δ} period by pecking at a second (switching) key. Switching behavior was examined as a function of (a) size of the fixed ratio, (b) whether the S^{Δ} was of fixed duration or could be determined by the bird, (c) the introduction of a novel food S^{D}, (d) extinction of food responding, and (e) the stimuli associated with the S^{D} and S^{Δ} conditions. No monotonic relationship was obtained between ratio size and switching behavior. Switching behavior was, however, influenced by many variables. The results suggest that an interpretation of switching behavior in terms of its being reinforced by the removal of aversive conditions, is open to considerable question.

Azrin (1961) reinforced pigeons on fixed-ratio schedules for pecking at a food key. His subjects occasionally pecked at a second (switching) key when one peck changed the conditions to S^{Δ} for food, and a second peck reinstated the S^{D} conditions. Switching responses usually occurred during the pause prior to a fixed-ratio run. The duration of time spent in S^{Δ} increased with the size of the fixed ratio from FR 60 to FR 200.

We examined a similar paradigm using a series of exploratory manipulations. The results were in part different from those of Azrin, but because experimental conditions were markedly different they do not directly bear on his results. The results do, however, raise some questions about the interpretation of results obtained with such a paradigm.

PRELIMINARY PROCEDURES

Four adult, White Carneaux pigeons (*Ss*) were maintained at 80% of free-feeding weight. The apparatus was a standard, two-key, experimental space for pigeons.

The *Ss* were given two sessions of continuous reinforcement for pecking at the right (food) key in the presence of a red light (S^{D}) projected on the key. They were then run on a multiple FR 15, Ext 180-sec schedule. The key was white during extinction and any responses emitted in the presence of the white S^{Δ} reset the 180-sec clock. All *Ss* stopped responding in the S^{Δ} within five daily sessions. Subjects were then exposed to a second (switching) key on which a green light was projected. (Throughout the preliminary procedures the switching key always remained green.) Subjects were reinforced on a given fixed-ratio schedule for responses on the red food key. Subjects 14R and 16R were placed on a "free-switching" schedule. A single response on the green switching key changed the conditions from S^{D} to S^{Δ} (the light on the food key changed from red to white) and the next switching response reinstated the S^{D} conditions. Subjects 1B and 2B were placed on a "minimum-duration" schedule. A single response on the green switching key changed the conditions from S^{D} to S^{Δ} for at least 10 sec. After no response on either key was emitted for 10 sec, the S^{D} conditions were automatically reinstated.

All *Ss* were run daily until they obtained 50 food reinforcements. Each reinforcement consisted of a 3½-sec magazine cycle. Because the experimental manipulations in this phase were done in survey fashion, the major variables manipulated and the major results obtained will be briefly summarized.

Switching behavior was examined as a function of (a) the size of the fixed ratio (FR

---

[1] This research was carried out with the support of grant G 19257 from the National Science Foundation. Reprints may be obtained from J. Zimmerman, Indiana University Medical Center, Institute of Psychiatric Research, 1100 West Michigan St., Indianapolis, Indiana.

[2] Now at the Institute for Behavioral Research, College Park, Maryland.

size was varied from 25 to 140), (b) the effect of substituting a blue (novel) S^D for the red S^D, and (c) the effect of extinction of food behavior (the magazine cycle was lowered to ¼ sec duration).

PRELIMINARY RESULTS

Switching behavior was measured in three ways. The percentage of sessions in which no switching behavior occurred at all was calculated. In addition, for each session in which switching behavior occurred, the number of switches per hour of S^D time and the time in S^Δ per hour of S^D time were calculated.

Under the survey conditions of these preliminary manipulations, there was no monotonic relationship between switching behavior and size of the fixed ratio. Switching behavior was extremely variable under most ratio values. The following results, however, were quite reliable. (A) The two *S*s on the minimum duration switching procedure did not emit switching responses in the large majority of sessions under any condition. (No switching occurred in 81% and in 68% of the sessions of 1B and 2B, respectively.) The two *S*s on the free switching condition emitted at least one switching response in a much larger percentage of sessions but failed to do so in many sessions. (No switching occurred in 36% and 27% of the sessions of 14R and 16R, respectivey.) (B) Switching frequency increased markedly for birds 14R and 16R (and to a slight extent for birds 1B and 2B) in the first and/or second session following an increase in ratio size. This effect was transient, however, and switching rapidly decreased by the fourth session on a given ratio. (C) Switching frequency decreased markedly for birds 14R and 16R following a decrease in ratio size. (D) The introduction of the novel (blue) S^D resulted in a marked increase in the switching behavior of birds 14R and 16R. (E) The extinction of food responding resulted in an early and marked increase in switching behavior of 14R and 16R. As extinction continued, however, switching behavior disappeared completely as food behavior was markedly weakened. (F) There were no differential effects of the independent variables on the dependent switching variables. The switching frequency was positively correlated with the duration of time spent in S^Δ.

Figure 1 illustrates two results representative of the above observations. The top cumulative records show the effect of increasing the ratio size on the switching behavior of 14R. The response pen reset at the end of a fixed-ratio segment and was deflected below the baseline by a switching response. Records 1a, 2a, and 3a present the behavior in the final three sessions on FR 50 and records 1b, 2b, and 3b present the behavior in the initial three sessions on FR 70. Switching frequency increased with the introduction of the FR 70 condition, but began to decrease by the third session. Only two switches occurred in the three final sessions (both in 2a) on FR 50. The lower records of Fig. 1 present similar data for bird 16R for the two sessions prior to and the two sessions following the introduction of the novel (blue) S^D.

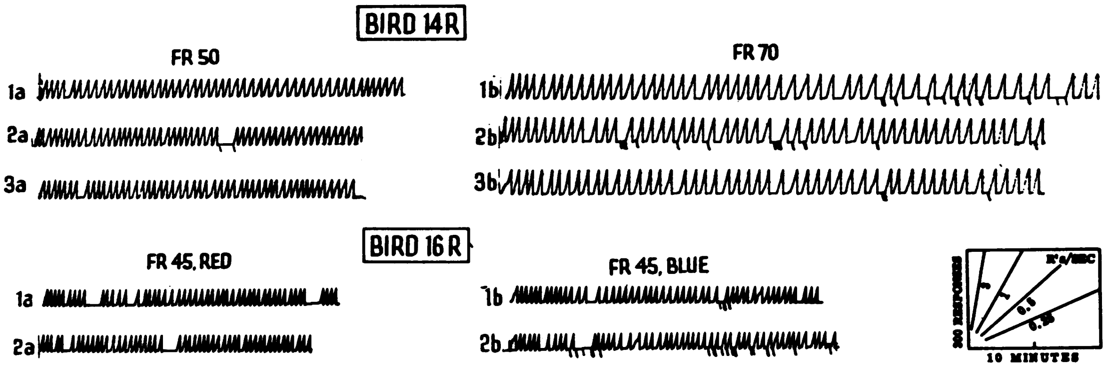

Fig. 1. Upper records: Cumulative records for bird 14R for three final sessions on FR 50 (left) and three initial sessions on FR 70 (right). Lower records: Cumulative records for bird 16R for two final sessions on FR 45 with the red S^D (left) and two sessions on FR 45 with the blue (novel) S^D (right). For all records the response pen reset at the end of a ratio and was deflected below the baseline by a switching response.

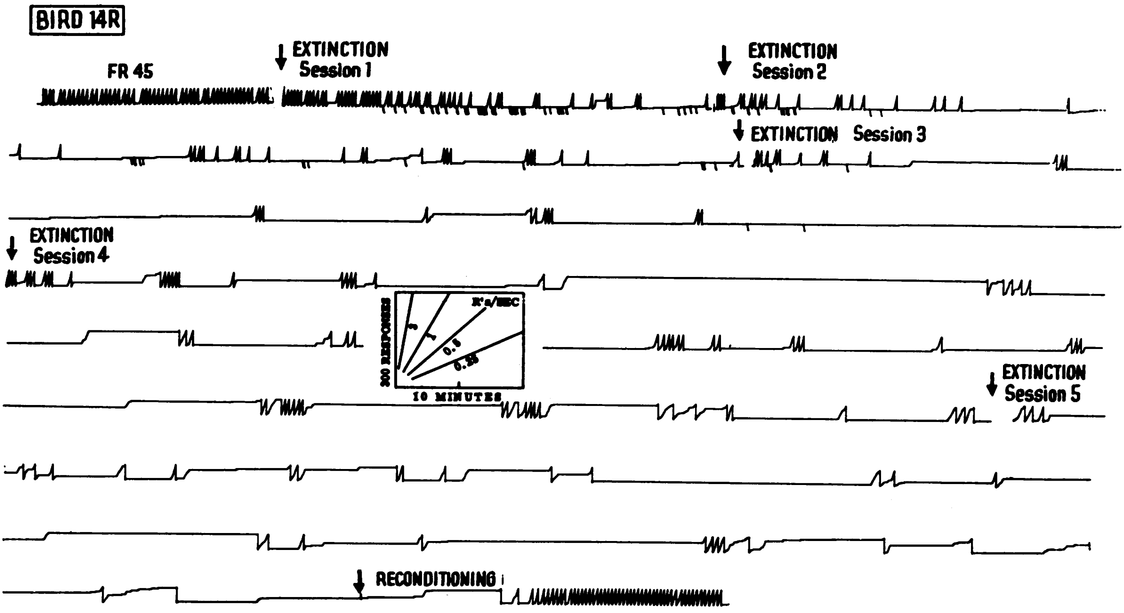

Fig. 2. Cumulative records for bird 14R for one session before and five sessions during extinction. Reconditioning occurred during the fifth session. The arrows indicate the beginning of a session. The final arrow indicates the onset of reconditioning.

Figure 2 presents similar records for bird 14R from the session before food extinction and the five sessions of food extinction. Reconditioning (in the fifth session) is also presented. During extinction, the ratio was held together as a unit by using a $\frac{1}{4}$ sec magazine cycle (the bird could not obtain food but did obtain the magazine light and sound) to signal the end of a ratio run. Switching responses were not emitted in the session prior to extinction nor during the reconditioning period shown. During the first extinction session 104 switching responses were emitted. These occurred in groups of two to ten or more responses and during the pause prior to a fixed-ratio run. Switching frequency diminished rapidly as extinction continued and fell to zero as the food behavior was markedly weakened.

In general, under the conditions of these preliminary investigations, birds 1B, 2B, 14R, and 16R had little disposition to "peck into S^{Δ}". When birds 14R and 16R emitted switching responses, these generally occurred in groups of 2, 4, or higher even numbers of responses. They rarely remained in S^{Δ} for extended periods of time even on the few occasions when an odd number of switching responses occurred (1, 3, 5, *etc*) in a group.

The effects of large values of fixed-ratio. After making the above observations, the ratio was rapidly and progressively raised from FR 100 to FR 550 for bird 14R and from FR 100 to FR 3350 for bird 1B. Bird 14R remained on the free-switching procedure. Bird 1B remained on the minimum-duration procedure until the ratio was raised to 2180 and then was put on the free-switching procedure on which it remained as the ratio continued to increase. Throughout this phase of the experiment, a daily session was terminated after 50 reinforcements or after a maximum of 12 hours elapsed, whichever occurred first. Bird 14R strained badly as the ratio increased and never obtained more than 20 food reinforcements when the ratio was above 300. Its switching behavior was extremely variable throughout this experiment and diminished markedly in frequency when the ratio was above 300. (No switching occurred at all in 20% of the sessions when the ratio size was 100 to 300 and in 50% of the sessions when the ratio size was 320 to 550.)

Bird 1B was able to meet the ratio requirements remarkably well until the ratio was above 3000. There was no appreciable disposition for this *S* to switch throughout this experiment in spite of the fact that it was placed on the free-switching procedure at FR 2180. (No switching occurred in 86% of all these sessions.)

FINAL PROCEDURES

While the ratio was raised from FR 1730 to FR 3350 for bird 1B, the ratio for bird 14R was lowered from FR 550 to FR 70 and the switching behavior of this *S* was again examined as a function of ratio size (FR 70, 120, or 170). After bird 1B was removed from the experiment (by illness probably related to malnutrition), birds 14R, 16R, and 2B (the latter two had not performed for five months) were all run on FR 70 for food with the free-switching procedure.

Throughout the rest of the experiment, all *S*s remained on the free-switching procedure. The switching behavior was examined as a function of the specific stimuli associated with the S^D and S$^\Delta$ conditions. For the purpose of summarizing the rest of the procedures and results, the procedure used above (with respect to the stimuli associated with S^D and S$^\Delta$) will be referred to as Procedure I. (In Procedure I, the switching key always remained green and the food key was red in S^D and white in S$^\Delta$.) Two other procedures were employed. In Procedure II, both the food key and the switching key were red in S^D and both were white in S$^\Delta$. In Procedure III, both the food key and the switching key were red in S^D. In S$^\Delta$ both were white but in addition, the house lights were turned off. The stimulus changes involved in Procedure III were similar to those employed by Azrin (1961).

Throughout this part of the experiment, a daily session was terminated after 70 reinforcements were obtained or occasionally when low rates of responding extended an experimental session beyond the available apparatus time. Under both Procedure II and Procedure III, several ratio sizes were programmed.

RESULTS OF FINAL PROCEDURES

Table 1 presents the order of the specific experimental manipulations for each *S*, together with the number of sessions run on each condition and the experimental results. Table 1 shows the following. (A) The percentage of sessions in which no switching responses occurred, markedly decreased from

Table 1

Summary of experimental conditions and results

	BIRD 14R					
PROCEDURE (S$^\Delta$ conditions)	FR Value	Number of Sessions A	Number of Sessions B	Median S$^\Delta$ Duration*	Median Number of Switches*	Median Food Rate R's/min
I Food Key White in S$^\Delta$	70	5	5	0	0	111
	120	13	6	1.2	0.36	88
	170	5	3	0	0	53
	120	5	5	0	0	62
	70	5	3	0	0	109
	120	8	2	0.69	0.003	37
	170	6	5	0	0	22
	70	6	5	0	0	50
II Food and Switch Keys White in S$^\Delta$	70	19	1	10.5	0.41	46
	70**	11	-	-	-	55
	70	7	0	8.5	0.58	66
	120	8	2	3.0	0.60	26
	70	5	3	0	0	65
	120	10	2	4.0	0.10	37
	70	5	2	1.1	0.12	55
III Food and Switch Keys White and House Lights Out in S$^\Delta$	70	7	0	23.2	1.14	79
	100	7	0	10.9	0.66	47
	130	7	0	10.5	1.65	40
	160	7	1	7.3	1.00	23

		BIRD 16R				
PROCEDURE (S^{Δ} conditions)	FR Value	Number of Sessions		Median S^{Δ} Duration*	Median Number of Switches*	Median Food Rate R's/min
		A	B			
I Food Key White in S^{Δ}	70	12	7	0	0	92
II Food and Switch Keys White in S^{Δ}	70	17	2	9.8	0.12	67
	70**	8	-	-	-	60
	70	7	0	16.9	0.15	81
	120	14	3	10.7	0.34	47
	170	8	1	18.4	1.40	27
	70	5	2	3.0	0.64	105
III Food and Switch Keys White and House Lights Out in S^{Δ}	70	7	0	28.6	2.40	95
	100	7	0	46.6	19.1	41
	130	7	0	17.9	5.5	20
	160	7	0	10.9	1.8	15

		BIRD 2B				
PROCEDURE (S^{Δ} conditions)	FR Value	Number of Sessions		Median S^{Δ} Duration*	Median Number of Switches*	Median Food Rate R's/min
		A	B			
I Food Key White in S^{Δ}	70	7	6	0	0	85
II Food and Switch Keys White in S^{Δ}	70	14	0	17.8	0.13	118
	120	5	1	7.4	0.07	88
	70	7	1	4.4	0.08	77
	120	16	4	2.0	0.13	45
	170	7	3	0.7	0.002	17
	70	5	5	0	0	120
III Food and Switch Keys White and House Lights Out in S^{Δ}	70	7	0	17.9	2.30	104
	100	7	0	8.2	0.22	81
	130	7	1	13.1	1.90	65
	160	7	0	10.8	0.99	15

A—Number of sessions run

B—Number of sessions in which no switching behavior occurred

*—per hour of S^{D} time

**—switch key was covered

the Procedure I sessions to the Procedure II sessions (bird 14R), and from the Procedure II sessions to the Procedure III sessions (all birds). (B) Switching behavior (as indexed by both the median number of switches per hour of S^{D} time and by the median duration of S^{Δ} time per hour of S^{D} time) increased from Procedure I to Procedure II to Procedure III. (C) Switching behavior increased significantly in all instances in which the FR size was held constant at FR 70 and the procedure was changed (Procedure I, FR 70 to Procedure II, FR 70 and Procedure II, FR 70 to Procedure III, FR 70). (D) Again in these experiments, there was no monotonic relationship between FR size and switching behavior in spite of the obvious negative correlation between FR size and food rate.

As shown in Table 1, the switch key was covered as one of the experimental manipulations. This was also done earlier (though not mentioned) in the experiment. No consistent or significant effects were observed as a result of this manipulation.

Figure 3 demonstrates the sudden change in switching behavior that occurred when the house lights were turned off in the S^{Δ} condition (transition from Procedure II FR 70

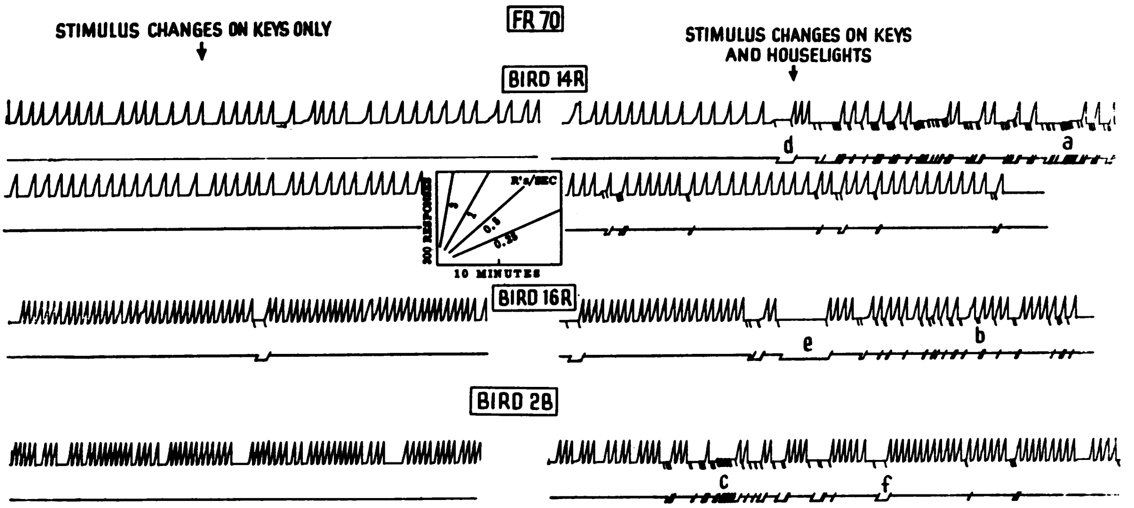

Fig. 3. Cumulative records for birds 14R, 16R, and 2B on FR 70 from the last session on Procedure II (left) and the initial session on Procedure III (right). The baseline pen was held down while the birds were in S$^{\Delta}$.

to Procedure III FR 70). The cumulative records for all *S*s from the last session on Procedure II are presented on the left and from the first session on Procedure III are presented on the right. For these records, the event pen was held down while the birds were in S$^{\Delta}$. Switching responses characteristically occurred in groups during a pause prior to a fixed-ratio run as at *a*, *b*, and *c*. At times, however, and especially characteristic of the results obtained with Procedure III, the *S*s responded once on the switching key and remained in S$^{\Delta}$ for periods of 1 min or more as at *d*, *e*, and *f*.

DISCUSSION

Switching behavior was examined as a function of:

Ratio size. There was no monotonic relationship between ratio size and switching behavior obtained in this set of studies. There were, however, several suggested second-order effects. When food behavior was extinguished, the switching behavior was markedly diminished or eliminated as the food behavior became extremely weak. When food behavior was extremely weak under conditions of high ratio values (bird 14R, FR 300 to 550) the tendency to switch was markedly lowered. When on the other hand, a ratio value was lowered from a moderate value to a lower value, the tendency to switch was also usually markedly lowered.

The degree of subject control over the removal of S$^{\Delta}$. The tendency to switch as measured by the percentage of sessions in which at least one switching response occurred was far lower for the two *S*s (1B and 2B) on the minimum-duration procedure than the two *S*s (14R and 16R) on the free-switching procedure.

Introduction of a novel stimulus as the S^{D}. A marked increase in switching behavior occurred with the introduction of the novel stimulus.

The stimuli associated with the S^{D} and S$^{\Delta}$ conditions. All measures of switching behavior increased and switching behavior occurred more consistently from session to session as the degree of stimulus change (S^{D} to S$^{\Delta}$) increased.

It must be emphasized that the experimental conditions employed in these studies were markedly different from those employed by Azrin (1961). The condition closest to that used by Azrin was Procedure III, but even here there were probably critical differences. Azrin terminated every daily session after a maximum of 1 hr. In the present study, *S*s usually ran until they obtained a given number of reinforcements. The session time, therefore, varied as a function of both the experimental conditions and the resulting behavior of the *S*s.

These differences might account for differences in the obtained results. (The different session times necessitated an analysis based upon number of switches and the S$^{\Delta}$ duration per hour of S^D time.) Furthermore, the results obtained under all stimulus conditions except those of Procedure III are even less relevant to the results obtained by Azrin. In addition, we examined, in survey fashion, many different variables and therefore *S*s were given past histories differing widely from those of Azrin's *S*s. Finally, the range and order of presentation of ratio values was different for the different *S*s and were usually (except for the Procedure III condition) unsystematically programmed while Azrin programmed a specific increasing series of ratio values for all his subjects.

The large number of variables which influence switching behavior makes it difficult to interpret switching responses as being reinforced because they remove the animal from an aversive schedule of reinforcement. Furthermore some of the present data (large ratio values, extinction) suggest that when the food schedule should be most aversive, there was little disposition on the part of our subjects to switch. In addition to this, the early data obtained from *S*s on the free-switching procedure indicates that *S*s were not usually "switching into S^Δ", but rather simply pecking on the switching key in groups of 2, 4 responses, *etc.* These bursts almost always involved an even rather than an odd number of responses and, therefore, *S*s were usually in S^D after emitting such responses. In addition to this, *S*s on the minimum-duration procedure (that could not reinstate the S^D conditions by a second peck on the switching key) seldom pecked at the switching key. The introduction of the Procedure III conditions (most like those of Azrin) resulted, however, in a greater frequency of the emission of odd number of switching responses and therefore in larger durations of time spent in S^Δ. Although the S^Δ duration was not directly a function of ratio size even under these conditions, it was higher in all Procedure III conditions, than in the other conditions.

The results can not be simply interpreted, but apparently stimulus change, *per se,* has much influence on the tendency for *S*s to switch. Some recent results of Appel (1963) may bear on this issue. Appel utilized a procedure similar to Azrin's and found that while switching frequency increased with ratio size from FR 80 to FR 240, time spent in S^Δ was not a function of ratio size. We did not obtain the former results but again Appel's subjects (like Azrin's) were run for maximum daily session durations of 1 hr. Appel also examined switching behavior when this behavior resulted in a stimulus change but did not result in S^Δ conditions. (His subjects could obtain food at all times.) Under these conditions, both switching frequency and S^Δ duration increased with ratio size. Appel stated that "stimulus change appears to be a sufficient explanation for the occurrence of the initial" switching key response. He further suggested, however, that the behavior on both keys may be related and that aversive aspects of higher-valued ratio schedules might account for the increase in responding on the switching key with an increase in ratio size. Present data (obtained under markedly different conditions) did not show any direct relationship between switching behavior and ratio size. It did indicate, however, the involvement of stimulus change.

The acceptance of a hypothesis which states that switching behavior is reinforced because it removes a subject from an aversive condition would depend upon independent measurements of the aversiveness of schedules in which, for example, an avoidance response is maintained by preventing a shift from one schedule to another. Only a correlation between switching behavior and such direct measurement of "aversiveness" could establish that escape from a positive schedule of reinforcement to extinction was reinforcing.

It seems possible that the switching behavior could represent temporary losses of control by the schedule of food reinforcement. Such losses of control could occur as a result of many conditions involving instability of the food reinforced behavior and would result in relatively weak behavior (switching) which is occurring because of a temporary disruption in the food maintained behavior.

REFERENCES

Azrin, N. H. Time out from positive reinforcement. *Science*, 1961, **133**, 382-383.

Appel, J. B. Aversive aspects of a schedule of positive reinforcement. *J. exp. Anal. Behav.*, 1963, **6**, 423-428.

Received September 26, 1962