SOME DATA ON BEHAVIOR REVERSIBILITY IN A STEADY STATE EXPERIMENT¹

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In conditioning experiments, steady state methodology presumes that behavior can be brought to equilibrium (defined as a state where any specified measure of the behavior no longer shows systematic change) under a given set of controlling variables, and that passing to a new set of values of the controlling variables will bring the behavior to another and different equilibrium point. A question of general interest in whatever science such a methodology may be used is whether data are recoverable, that is to say, whether or not return to an earlier set of controlling variable values (after an interlude with a different set) will yield the same measure of the dependent variable as was observed the first time. Outside behavior science, examples of reversibility and irreversibility of process are both to be found, and there is as yet no reason to think that the same is not true of behavior processes. Nevertheless, if one may judge from the comments of behavior researchers who have touched on the problem in their writing and personal discussion, it is probably fair to say the the suspicion is widespread that behavioral data, characteristically if not universally, cannot be recovered. A recent study (Clark, 1958) contains incidental data which may open the question somewhat, since it appears that, when extinction is interpolated before return to an earlier state, the earlier behavior measure is recovered. The present paper, however, is aimed at a detail within the broader issue, one that was suggested by a case of behavioral "inelasticity" previously reported by the writers (Schoenfeld & Cumming, 1957).

The latter study involved reinforcement schedules defined in terms of certain temporal independent variables, more specifically, the case where cycle length, $t^D + t^A$, was systematically varied while $t^D/(t^D + t^A)$, or $\bar{T}$, remained constant. In the particular study, $t^D + t^A$ took values of 30, 15, 7.5, 3.75, 1.88, and 0.94 seconds, in that order, with $\bar{T}$ constant at 0.05; in summary, it was found that response rates of key pecking by pigeons increased (by a factor of 6.75, on the average for three birds) as cycle length decreased over the indicated range. After the function was determined, one bird was tested for behavior reversibility by returning to two earlier $t^D + t^A$ values, but the earlier (and lower) response rates were not recoverable by a wide margin. A follow-up experiment, modeled after the first but centering on data recoverability alone, suggested itself; it is this experiment which is reported here.

METHOD

The subjects were three white Carneaux hen pigeons. Following arrival in the laboratory, the birds were maintained on a free-feeding regimen (diet: grain mix of 50% kaffir corn, 40% vetch, and 10% hempseed, with fresh water and grit always available) for several weeks to determine their weight norms; thereafter, each bird

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was reduced to 80% of its norm and held at that level throughout the experiment. Soon after weight reduction was begun, the key-pecking response was shaped for each bird and then given fifty regular reinforcements per day for five days before the experiment proper started. As in the related previous study (Schoenfeld & Cumming, 1957), each experimental session lasted 20 minutes, with the data of the last 15 minutes taken for treatment. The experimental room, apparatus, reinforcements (foregoing grain mix), reinforcement durations (3 seconds' access to grain mix), and other arrangements, were identical to those of the previous study. On any day, the experimental session was given the birds at the same hour, but only if each one's weight was within ± 15 grams of its free-feeding standard; only occasionally was it necessary to omit a day with any bird because the weight was outside of these limits. After each experimental session, if required, a ration (of maple peas) was given each bird to insure the bird's proper weight the next day. Response data were taken in the form of cumulative response curves, and of response rates computed for the last 15 minutes of the sessions; the latter rates were "corrected" by subtracting 3 seconds for each reinforcement obtained by the bird during the last 15 minutes and dividing the total responses during those minutes by the diminished time.

The day after the last fifty regular reinforcements had been given, each bird was put on the reinforcement schedule defined by $t^D + t^A = 30$ seconds, and $\bar{T} = 0.05$; it was kept thereon until the pre-stated criterion of response stability was reached. This criterion was the same as that used in the previous study. The first seven days on any schedule were not considered in computing stability. For the next six days, the mean of the first three days of the six was compared with that of the last three days; if the difference between these means was less than 5% of the six days' mean, the bird was considered to have stabilized and was shifted to the next schedule. If the difference between submeans was greater than 5% of the grand mean, another experimental day was added and similar calculations were made for that day and the five immediately preceding it. Such extensions of the experiment and calculations of stability were continued daily until the bird reached the aforementioned 5% criterion. With that criterion reached, the bird was moved, on the immediately following experimental day, to the reinforcement schedule defined by $t^D + t^A = 0.94$ second, $\bar{T} = 0.05$, and kept thereon until the same stability criterion was reached, whereupon it was moved back to the first reinforcement schedule. In this way, each bird was repeatedly alternated between the two reinforcement schedules, until some five alternations had been accomplished in all. The earlier study had tested recoverability of lower rates upon return from the 0.94-second cycle length (with its high response rate) to longer cycles at which lower rates had previously been recorded. The present experiment, using *only* the two extreme cycle lengths of 30 and 0.94 seconds, and affording repeated alternations, gave opportunity to observe the cumulating interactions of the two schedules.

RESULTS

Table 1 contains the experimental data averaged for the three birds. Columns 1 and 2 indicate the order of occurrence, hence alternations, of the two cycle lengths; Column 3 gives the mean corrected response rates per minute computed for the six stability criterion days of the three birds under each successive use of the cycle

TABLE 1

Recoverability of Response Rates under Alternating Reinforcement Schedules

<i>Alter- nations</i>	<i>Cycle Length (sec.)</i>	<i>Corrected Mean Rate (resp. per min.)</i>		<i>Rate Ratio</i>	<i>Mean Days to Criterion</i>
1	30.0	83.99	129.56	0.65	20.7
	0.94				
2	30.0	112.73	134.09	0.84	16.7
	0.94				
3	30.0	84.25	127.24	0.66	14.7
	0.94				
4	30.0	101.35	152.42	0.66	13.3
	0.94				
5	30.0	104.32	176.71	0.59	17.3
	0.94				
6	30.0	120.01		0.68	14.7
					13.3

lengths, as detailed in the text; Column 4 gives the ratio of response rates under each 30-second cycle to that under the immediately following 0.94-second cycle; lastly, Column 5 gives the average number of days (including the six criterion days) required by the three birds to achieve the response stability criterion under each cycle occurrence. The Table shows five complete alternations between cycle pairs, and the start of a sixth before the experiment ended.

The following points seem worth noting about the data in the Table:

1) After once reaching the response-stability criterion on the first cycle length to which they were exposed, the birds take less, but not systematically diminishing, time to reach the criterion under subsequent schedules. The same observation was made in the previous study, and has been remarked by other researchers in a variety of situations; some form of this behavioral effect has probably underlain such terms as "adjustment to learning situations," "learning to learn," and so on.

2) The first move from the 30- to the 0.94-second cycle produced, in this experiment, a rise in response rate by a factor of only about 1.5, whereas in the previous study the factor was 6.75; the discrepancy may be owing to the difference in procedures, since the previous study moved the birds through a succession of cycle lengths lying between 30 and 0.94 seconds.

3) In the first alternation, the response rate on the 30-second cycle is 65% of the rate on the 0.94-second cycle; during the second, however, this changes to 84%, largely because the rate on the 30-second cycle did not return to its original value. In succeeding alternations, the relative difference between rates is restored, showing that the failure to recover this value is a transient phenomenon during the first return to the lower value. That the low rate ratio (0.59) in the fifth alternation probably does not represent the start of a real drift, is suggested by the ratio (0.68) of the response rate under the sixth occurrence of the 30-second cycle to that under the preceding occurrence of the 0.94-second cycle.

4) Although the two rates under the alternating schedules maintained effectively the same ratio (except for the remarked disturbance on the first return to the longer cycle), the response rates under each cycle length tended to rise as the cycle alternations accumulated, showing that at least under some experimental conditions absolute rate values are not recoverable.

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