Patterns in avoidance extinction*

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Avoidance extinction was analyzed by classifying running times as fast, medium, or slow and determining the contingent probabilities of runs of various speed or extinction on the following trial. The most probable transitions were to runs of the same speed class. Extinction was much more probable following slow runs than after medium or fast runs. Increasing the amount of avoidance training contributed to resistance to extinction by lengthening the sequence of fast runs at the beginning of extinction.

In considering extinction following avoidance training, most emphasis has been put upon the analysis of factors which operate to maintain avoidance responding. Relatively little attention has been given to factors more closely related to the cessation of responding. Although both angles are important, focusing on the cessative aspects of extinction does suggest new methods of analysis. The general approach taken here was to scrutinize running times on trials preceding extinction to determine if there were any patterns indicating that extinction was about to occur. The utility of the technique is attested to by its ability to identify both perseverative and cessative factors in avoidance extinction.

EXPERIMENTAL METHOD

Although we conducted an explicit normative study of avoidance acquisition in the runway (cf. Beecroft & Bouska, 1967), comparable information on avoidance extinction had to be drawn from several nonpunished control groups in self-punitive behavior experiments (Beecroft, Bouska, & Fisher, 1967, Experiment 1; Beecroft, Fisher, & Bouska, 1967, Experiment 3; Beecroft & Fisher, 1969). All rats were trained by two Es within a period of 4 months. Since the rats were trained and tested individually with the same specifications, there is apt to be no more bias than in data for a single experiment collected over a comparable time period.

Avoidance training was conducted in a 6-ft alley with duplex startbox without using a warning signal (cf. Brown, Martin, & Morrow, 1964, for details). The S was trained to a criterion of one avoidance, with a 3-sec avoidance interval. Animals failing to meet the training criterion

within 30 trials were discarded. Although the avoidance interval was initiated by the drop to the bottom level of the startbox, running time was measured from the exit of the startbox to the entrance to the goalbox. Shock,

when the animal failed to avoid, was 55-V ac through 10K resistance. Goalbox detention comprised 30 sec of the 60-sec intertrial interval. The Ss were 55 female hooded rats, 84-105 days old, trained and extinguished in a single session. The extinction criterion was 60 sec without entering the goalbox.

METHOD OF ANALYSIS AND RESULTS

The basic record for each S consisted of running times on the extinction trials preceding the extinction criterion trial. For purposes of analysis each trial was classified as a fast run (less than 3 sec), a medium run (3.0 to 6.0 sec), or a slow run (more than 6.0 sec but less than 60 sec). Protocols were then made with the following notation: X (trial

Table 1
Protocols of Extinction Running Times

S	
199	MX
218	FX
414	FX
438	FX
480	SX
515	FX
189	FMX
465	FFX
374	MSSX
455	MSSX
468	MFSX
207	FFFFX
471	FFFFX
205	FFFMSMX
389	MSMMSSSX
439	FFFFMSSX
448	FFFFFMSX
394a	FFFFFMSSX
422	FFMMFMSSX
486	FFFF-MSMX
526	FFFFFFFFX
401	MFMSMSSSX
431	FFFSFSSSX
464	FFFFMMMFSX
474	FFFFSMMMSX
201	FFFFSMSSSX
397	FFFMFMSSFFX
483	FFFF-FFFFSX
451	FFFFFMFSSSX
461	FFFFFSMFFFSX
368	FFFFFFFFFSSSX
239	MFFMMSMSSMSSSX
386	FFFFFSSMMMSMF
521	FFFFFFFF-FFFFMX
503	FFFFFFFFFSSMSSSX
518	FFFFFFFFFFFFSSMF
229	FFMMMMMMMMMSSMMX
212	FFFFFFFFFFFFMFFFSX
216	FFFFFMFMFMFFMSSSSSX
500	FFFFFFFF-SSMSSSSS-SSSX
441	FFFFFFFFFFFFMFFFFFFFFSX
477	F-FFF-FFFFSMFFFFFFFFMMSMX
411	FFFFFFFFMFFFFFFFFMFFFSX
236	FFFFMFFFFSSMFMFSFSMSSSSSX
452	FFFFFFFFFFFFMFFFFSFFSMMMSX
490	FFFFFFFF-FFFF-FFFMFMSS-MMFX
510	FFFFFFFFFFFFFSSFMFSFSMSMX
435	FFFFFMFMFFFFFFFFFMMMMMMMMMMMSSMSSSX
496	FFFMF-FFFFFFFFFSMFMFSSSSSSMFMFMFMSSSSSMSSSSSX
384	FFFFFFFFFMMSFSSMMMFFFFFMFMSSSSSMSSSSMMMMMSSX

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Table 2
Acquisition and Extinction Measures

	Range	Mode	Median	Mean
First Avoidance Trial	2-28	6	7	8.8
First Avoidance Running Time (Sec)	1.2-2.6	2.0	2.0	2.0
First Extinction Running Time (Sec)	1.2-20.0	2.1	2.1	2.6
Extinction Trial	2-47	2	10.5	13.7

on which extinction occurred), F (fast run), M (medium run), S (slow run), and — (missing data due to photocell failure). Five of the 55 protocols were not really usable. One was for a rat which extinguished on the first extinction trial. We may surmise that the absence of shock on the preceding trial was a critical factor, but what else can be said about a protocol which consists of a single X? The other four protocols were discarded because of missing data from photocell failures. In three of these cases the trial before extinction was missing; in the remaining case, 11 trials were missing. The 50 usable protocols are shown in Table 1.

For these protocols, some acquisition and extinction measures are summarized in Table 2. Taking median performance for reference, the avoidance response was acquired on the seventh trial, and the running time was a flat 2.0 sec. The running time on the next trial, the first extinction trial, was 2.1 sec, which would have avoided shock had the avoidance contingency remained in effect. After the first avoidance, 19 rats ran faster and 30 rats ran slower; 10 of the slower running times would not have avoided shock. The median animal extinguished on the 10th trial; the mean was 13.7 trials. Although the animals trained to only a single avoidance do not display a lot of resistance to extinction, what is important for the analysis which follows is that the probability of extinction's occurring on the second trial of any pair of adjacent trials is $1/12.7 = .0787$. If we can find a pattern which gives us a greater contingent probability than .0787, we may have found a clue to predicting the trial on which extinction will occur.

The analytic procedure is a simple one which involves making an adjacent trial transition matrix. Every run is followed by another run or extinction (the 12 missing entries have been ignored). Pairs of successive trials were tallied, and the resulting intertrial transition matrix is shown in the top part of Table 3. The largest entries in the table are on the diagonal. Thus, most often, fast runs are followed by fast runs, medium runs by medium runs, and slow runs by slow runs. The frequencies above the diagonal are

larger than the corresponding frequencies below the diagonal. For example, there were 28 fast-slow transitions compared to 8 slow-fast ones. Transitions were more likely to be from faster-to-slower speeds than from slower-to-faster speeds. Finally, extinction occurred more often on trials following slow runs than on trials following fast or medium runs. This last point can be better appreciated when the transition matrix is cast into probability form, as is done in the lower part of Table 3. Something more than one-fifth of the slow runs are followed by extinction; the probability of extinction following fast or medium runs is much less.

Because the probability of a fast run on Trial 1 is high (.84 to be exact) and the probability of fast runs succeeding fast runs is also fairly high (.76 in the transition matrix, although the real F1F2 conditional probability is .88), it seems reasonable to assume that the length of the initial sequence of fast runs at the outset of extinction testing is an important correlate of resistance to extinction. The length of the initial sequence of fast runs varied from 0 to 15, with a mean of 5.0 and a median of 4. The distribution was pretty much geometric.

The role of the initial sequence of fast runs in avoidance extinction can be assessed further by considering data from an experiment in which 10 additional avoidance training trials were given beyond the first avoidance (Beecroft, Fisher, & Bouska, 1967, Experiment 1). The additional training increased resistance to extinction (mean extinction trial was 24.5, and the median was 20.5 trials) by about 11 trials, and we would expect that

much of this increase could be accounted for by a longer series of fast runs at the beginning of extinction. The mean length of the initial sequence of fast runs was 12.3, up about 7 trials, although the median length was only 6.5 trials. The transition probability matrix based on protocols for the 20 rats is shown in Table 4. Relative to the previous matrix, the probability of fast-fast transitions is higher and the fast-to-other probabilities are all lower. The probability of medium-medium transitions is also higher in this table. For a few rats, a series of medium runs is a secondary source of resistance to extinction. Table 4 also shows that extinction is much more probable following a slow run than either a fast or medium run. Although this probability is slightly lower than the corresponding entry in Table 3, the transition probabilities in the two tables for slow runs are quite similar.

In the two sets of data considered so far, the rat conforms to the training by running fast at the outset of extinction. Extinction without the element of fast running can be examined by utilizing data from a retention study (Beecroft & Fisher, 1970) in which we found that fast runs were virtually eliminated if the rat was returned to the home cage for a retention interval of 4 h or more. Specifically, we have records for 30 rats tested 4, 24, or 144 h after training to a one-avoidance criterion. Nine of these rats extinguished on the first extinction trial, so it seems clear that a retention interval substantially increases the probability of quick extinction. Protocols were analyzed for the 21 rats which did not extinguish on the first extinction trial. All protocols began with either a medium or slow run; the average running time for the first trial was approximately 8 sec. The transition probability matrix for medium and slow runs is shown in Table 5; the fact that there were only three fast runs altogether excludes the possibility of calculating meaningful probabilities

Table 3
Transition Matrix in Both Frequency and Probability Form (Trained to One Avoidance)

		Trial n + 1			Extinction
		Fast	Medium	Slow	
Trial n	Fast	263	42	27	12
	Medium	33	57	39	7
	Slow	8	28	73	31
		Trial n + 1			Extinction
		Fast	Medium	Slow	
Trial n	Fast	.7645	.1221	.0785	.0349
	Medium	.2426	.4191	.2868	.0515
	Slow	.0571	.2000	.5214	.2214

for fast runs. The matrix indicates that medium runs are followed by medium runs and slow runs are most often followed by slow runs. Again, one-fifth of the slow runs were followed by extinction.

DISCUSSION

In the analysis, two facts stand out: running fast forestalls extinction and running slowly foretells extinction. Running fast functions as a perseverative factor in that there is a high probability that the run on the next trial will also be fast. We expect that any variable which produces fast running will increase resistance to extinction. For example, short avoidance intervals produce the fastest running speeds and also seem to increase resistance to extinction (Beecroft & Brown, 1967). Running slowly functions as a cessative factor in that the probability that extinction will occur on the very next trial is fairly sizable. We expect that any variable which produces slow running will decrease resistance to extinction. We have shown that a retention interval decreases resistance to extinction (cf. Beecroft & Fisher, 1970, for details not touched upon in this paper), but we are pretty much in the dark about other variables correlated with slow running. However, the mechanism whereby slow running is related to extinction can be conjectured to be that in running slowly the animal learns the avoidance contingency is no longer in effect.

The conventional interpretation of avoidance extinction is that avoidance extinction occurs when conditioned fear extinguishes to the point that it no longer suffices to motivate the instrumental behavior. Without an independent measure of fear, the conventional theory has little or no predictive value. However, if running speed is taken to be an index of fear, then the conventional interpretation reduces to an assertion that an animal whose fear has more or less extinguished, as evidenced by slow running, will soon cease to run, the very point the transition probability matrix establishes without introducing the fear concept at all.

REFERENCES

- BEECROFT, R. S., & BOUSKA, S. A. Acquisition of avoidance running in the rat. *Psychonomic Science*, 1967, 9, 163-164.
- BEECROFT, R. S., BOUSKA, S. A., & FISHER, B. G. Punishment intensity and self-punitive behavior. *Psychonomic Science*, 1967, 8, 351-352.
- BEECROFT, R. S., & BROWN, J. S. Punishment following escape and avoidance training. *Psychonomic Science*, 1967, 8, 349-350.
- BEECROFT, R. S., & FISHER, B. G. Avoidable punishment and self-punitive behavior. *Psychonomic Science*, 1969, 15, 243-244.

		Trial n + 1			Extinction
		Fast	Medium	Slow	
Trial n	Fast	.8559	.0670	.0347	.0124
	Medium	.2386	.5568	.1591	.0454
	Slow	.0769	.1692	.5846	.1692

		Trial n + 1			Extinction
		Fast	Medium	Slow	
Trial n	Medium	.0172	.5172	.4483	.0172
	Slow	.0101	.1818	.6060	.2020

BEECROFT, R. S., & FISHER, B. G. Retention of avoidance running. *Psychonomic Science*, 1970, 20, 28-29.

BEECROFT, R. S., FISHER, B. G., & BOUSKA, S. A. Punishment continuity and self-punitive behavior. *Psychonomic*

Science, 1967, 9, 127-128.

BROWN, J. S., MARTIN, R. C., & MORROW, M. W. Self-punitive behavior in the rat: Facilitative effects of punishment on resistance to extinction. *Journal of Comparative & Physiological Psychology*, 1964, 57, 127-133.

Postdiscrimination gradients as a function of variation in reward schedules*

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Six pigeons were discrimination trained on wavelength stimuli and tested for postdiscrimination generalization gradients. Three were trained on Mult FI 30-sec (.50 reinforcements) extinction and three on VI 60-sec as a control. No peak shifts were found in the FI-trained birds. The VI-trained birds failed to show consistent peak shifts, a fact which suggests that the number of S+ days provided prior to discrimination training may be an effective variable in the production of peak shift.

There are very few studies in the literature which have investigated the shape of the postdiscrimination gradient (PDG) following variation of the schedule of reward associated with S+. Most studies provide VI 1-min schedule of reward for responding to S+, and the most common effect observed in the PDG is peak shift. The purpose of this study was to determine if peak shift occurs in the PDG following Mult FI 30-sec (.50) extinction discrimination training. The

designation, FI 30-sec (.50), indicates that the schedule of reward was basically an FI 30-sec schedule, but only half of the presentations of S+ were rewarded. The purpose of rewarding only half of the S+ periods was to provide a reinforcement density comparable to that provided by the VI 60-sec schedule and, in addition, to guarantee enough resistance to extinction to make a gradient determination possible.

Besides the fixed-interval discrimination group, a control group of Ss was trained with the usual VI 60-sec schedule associated with S+. The discrimination was trained between 550 nm (S+) and 570 nm (S-).

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