One-way versus shuttle avoidance conditioning¹

John Theios and James E. Dunaway
UNIVERSITY OF TEXAS

Abstract

Rats were trained to avoid shock with either a one-way procedure, a shuttle procedure, or both. One-way conditioning was found to be consistent with a two-step all-or-none process and was a much simpler task than shuttle conditioning which could not be accounted for by that process or by a linear operator process.

Problem

The use of a shuttle procedure in avoidance conditioning has become popular due to the convenience it allows in automating the experiment. In spite of the automation, many investigators have had difficulty in training rats to a level of 100% avoidance in a reasonable length of time. For example, with optimum shock intensities the rats of Moyer & Korn (1964) took an average of about 90 trials to reach a level of 90% avoidance responses.

By contrast, Theios (1963) reported it took only about 11 trials to reach a level of 90% avoidance responses when the rats were run in one direction rather than having them shuttle. In view of these differences, it is of interest whether the one-way procedure yields a different conditioning process than does the shuttle procedure.

The purpose of this research was to compare one-way and shuttle procedures under as nearly identical conditions as possible. Specifically, it was asked whether both these procedures would yield grossly discrete behavior changes such as predicted by a two-stage all-or-none learning model (Bower & Theios, 1964) or gradual changes predicted by a two-operator linear model (Bush & Mosteller, 1955).

Method

The Ss were 89 male albino rats between 120 and 190 days of age. The apparatus was an automated shuttle box divided into two 14 x 8 x 6 inch compartments by a guillotine door in the center. The CS consisted of the simultaneous raising of the door, the onset of a light, and the presentation of 89 db white noise. The US was a 2.5 ma scrambled shock delivered to the grids. The CS-US interval was 5 seconds and the intertrial interval was 30 seconds. Crossing responses with a latency of 5 seconds or less were scored as avoidance responses (CRs). Responses with latencies longer than 5 seconds were scored as errors. Following a pretesting period with no shock, each S was given training trials until he met a criterion of 10 consecutive CRs. The 75 Ss in the one-way (OW) condition were allowed to remain in the side responded to for 15 seconds and then were replaced in the original side. At the end of the criterion run, 57 of these Ss (Group OW-S) were given shuttle training until the criterion was met again. The 14 Ss in Group S received only shuttle training.

Fig. 1. Proportion of CRs as a function of trials.

Results

Figure 1 presents the mean proportion of CRs as a function of trials. As can be seen, one-way Ss learned very quickly, whereas shuttle Ss, by contrast, learned very slowly. In addition, it can be seen that having one-way training before shuttle training increased performance a little, but did not increase rate of learning since the curves for Groups S and OW-S reach asymptote at about the same time.

Table 1 presents means and unbiased standard deviations. All three differences between Groups OW and S were highly significant by t-tests, $p < .001$. Likewise, all three differences in the one-way and shuttle performance of the 57 OW-S Ss were significant by correlated t-tests, $p < .05$. None of the three mean differences between Groups S and OW-S reached significance at the

Table 1

Means and Standard Deviations

Statistic		Group OW	Group S	Group OW-S
	N	75	14	57
Trial of First CR	M	3.81	16.86	8.80
	SD	1.46	10.19	14.82
Total Errors	M	3.44	31.14	22.73
	SD	1.81	11.56	19.96
Trial of Last Error	M	4.31	39.43	32.53
	SD	3.08	14.12	25.71

Fig. 2. Proportion of CRs on trials between first CR and last error.

.05 level, largest $t(69) = 1.93$. However, all three differences were in the direction favoring a higher performance level for Groups OW-S. The major difference between Groups S and OW-S was that the OW-S Ss were more likely to avoid when they were in the side which had been the starting compartment during OW training and less likely when they were in the side which had been the safe compartment.

A powerful statistic for distinguishing between gradual learning models and one class of discrete learning models is the probability of a CR on the intermediate trials between S's first CR and last error. If learning is gradual the probability of CR should increase on these intermediate trials. If learning is a two-step all-or-none process (Bower & Theios, 1964; Theios, 1963), response probability should remain stationary over the intermediate trials. To test for stationarity, the trials between the first CR and last error of each S were divided into a first half and a second half and the number of CRs in each half was counted. There were significantly more CRs in the second half for Groups S and OW-S, $t(13) = -2.75$, $p < .02$ and $t(51) = -5.24$, $p < .001$. Thus, the hypothesis of stationarity must be rejected for these shuttle groups. On the other hand, Group OW had a total of 23 CRs in the first half and 19 in the second half indicating that the hypothesis of stationarity could not be rejected, $t(20) = 1.69$.

Since the data from the shuttle conditions are not stationary, it is inappropriate to use a Markov model

such as those of Theios (1963) and Bower & Theios (1964) to describe shuttle conditioning. One alternative model which was tested was the two-operator linear model of Bush & Mosteller (1955). The conditioning parameters α_1 and α_2 were estimated from the mean number of errors before the first CR and from mean total errors by the method of moments. Then 500 stat-rats having the properties of the two-operator model were generated by a computer. Figure 2 presents the mean proportion of CRs on the intermediate trials for the shuttle stat-rats, Group S and Group OW. There is no upward trend in the OW data. There is a slight upward trend in the data of the real shuttle Ss, and there is very marked upward trend in the data of the shuttle stat-rats. It is obvious that the two-operator linear model does not give a satisfactory description of shuttle avoidance conditioning.

Discussion

It is clear that compared to one-way conditioning, shuttle conditioning is difficult for the rat. There are aspects of the shuttle procedure which make it a complex learning task. For example, on many trials, S is required to run back to a place where he was just shocked on the previous trial. In addition to learning the instrumental response, S has to learn an orienting response of turning around between trials. If S learns to avoid one side of the apparatus, then that response is punished on alternate trials. This irregular punishment is analogous to partial reinforcement which yields behavior which is very resistant to change. If a researcher is interested in the basic structure of instrumental conditioning, then the shuttle procedure hardly provides a pure laboratory situation for experimentation. The one-way procedure yields a better approximation to pure instrumental conditioning since S has only to learn to run in one direction at the presentation of the CS.

References

- BOWER, G. H., & THEIOS, J. A learning model for discrete performance levels. In R. C. Atkinson (Ed.), *Studies in mathematical psychology*. Stanford: Stanford University Press, 1964, Pp. 1-31.
- BUSH, R. R., & MOSTELLER, F. *Stochastic models for learning*. New York: Wiley, 1955.
- MOYER, K. E., & KORN, J. H. Effect of UCS intensity on the acquisition and extinction of an avoidance response. *J. exp. Psychol.*, 1964, 67, 352-359.
- THEIOS, J. Simple conditioning as two-stage all-or-none learning. *Psychol. Rev.*, 1963, 70, 403-417.

Note

1. This research was supported by National Institute of Child Health and Human Development Research Grant HD 00950. A detailed technical report of this research is available from the authors.