Speed-contingent reinforcement¹

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Abstract

A description is provided of a pellet dispenser that automatically reinforces a rat on each trial with an amount of food that is directly proportional to the speed with which the rat has traversed a runway. Preliminary data indicate that Ss reinforced on such a speed-contingent basis run significantly faster and are less variable than yoked controls.

Introduction

The effects of amount of reward on the performance of rats have been studied in "between-subjects" designs with different Ss being fed different amounts (Crespi, 1942; Zeaman, 1949) and in "within-subjects" designs in which rate (Ferster & Skinner, 1957) or speed of response (Logan, 1960) have been differentially reinforced. Variations in reward magnitude have not, however, been keyed directly and in a continuously graded manner to the response speed of each individual S on each trial. To achieve a contingency of this kind a device is required that senses the speed with which the rat has traversed the major portion of the alley, and then, without delay, presents an amount of food that is directly proportional to that speed. This paper contains the description of a device that performs these functions along with preliminary results obtained through its use.

A speed-contingent feeding device

The feeder operates on a subtractive principle since a supply of pellets equal to the maximum reward to be given is held in storage in the goal box during a pre-selected delay period, after which pellets are

subtracted, two at a time, from that supply at regular intervals. If a rat reaches the goal before the end of the delay interval then all pellets are available. On slower runs, the process of subtraction starts while the S is in the alley but stops when the goal box is entered. As we have used the device, a high-speed run yields a maximum reward of 14 pellets, while slower runs are reinforced by proportionally smaller amounts, in two-pellet steps, down to a lower limit of 2. Ranges of 7 to 1, 12 to 0, and so on, can be obtained in addition to the 14 to 2 range simply by changing the size and distribution of the feeder's load.

The left-hand panel of Fig. 1 shows a cut-away drawing of the feeding platform in place in the goal box. This platform, which was open at the back and bottom, was formed of .025-in sheet metal and was 1.5 in high, 3 in long, and 1.125 in wide. Seven pairs of .25-in holes were drilled in the top and the entire device was positioned over a hole in the goal box floor which coincided with the opening in the bottom of the platform. A moveable metal tongue extended through the end wall of the goal box and was flush against the lower surface of the perforated panel. With the tongue in this position, a .045-gm Noyes pellet could be placed in each hole on the supporting tongue. When the tongue was moved backward on suitable bearings from its full forward position, pairs of pellets dropped successively into the hole beneath the platform. As the right-hand panel of Fig. 1 shows, a metal funnel was positioned under the hole in the alley floor to catch the pellets and return them through

Fig. 1. The left panel shows the feeder platform in position at the end of the goal box. The right-hand panel is a cross-sectional view illustrating the manner in which the feeder tongue supports the pellets in the holes of the platform and the mechanism by means of which the tongue is moved to control amount of reward. The drawings are not to exact scale.

Fig. 2. Mean running times of Ss in an experimental group given speed-contingent amounts of reward as compared with yoked control Ss for whom equal rewards were provided but on a noncontingent basis

a tube to a pellet reservoir. By changing the number of holes in the platform and their locations, reward ranges other than those mentioned above could be provided.

The tongue-retraction mechanism consisted basically of a reversible synchronous motor (140 rpm, Bodine, KC 1-23 RB), a variable-speed transmission with a pinion gear on its output shaft, and a fine-toothed section of rack gear mounted on that part of the tongue which protruded from the end of the alley. A Librascope ball-disc integrator served as the variable-speed drive, and in this application produced tongue-withdrawal times ranging from less than 1 to over 20 sec. To achieve precisely reproducible retraction speeds, a micrometer positioning device was connected to the integrator's control shaft so that it could be set to within $\pm .001$ in. of any desired position.

Tongue withdrawal started at the end of an electronically controlled delay period initiated by the opening of the start-box door. When the rat intercepted a light beam at the entrance to the goal box, the motion of the tongue ceased. After each trial the tongue was returned to its forward station by reversing the drive motor. The pellet-holding holes were then manually refilled. The constant of proportionality between speed and amount of reward was changed periodically by adjustments of both time and rate of tongue retraction. In this way, the largest and smallest rewards could be roughly matched to each S's fastest and slowest running speeds, respectively, at each stage of the learning process.

Performance as a function of speed-contingent reward

To obtain preliminary data on the effectiveness of speed-contingent rewards, the proportional feeder was installed in the goal box of a 4-ft runway that was inclined upward at an angle of 30° relative to the horizontal. The rats were required to run up hill in this manner to increase the work requirement, and hence, hopefully, the effectiveness of the speed-contingent reward system.

The Ss were 18 naive hooded rats (Long Evans) about 100 days old, with a mean weight of 260 gm. For each of the first three days, they were handled individually for a few minutes and were fed a limited amount to reduce their body weight toward a target level of 80 to 85% of ad lib weight. Over the next five days they were habituated to the runway, taught to eat pellets in the goal box, and given trials in running through progressively longer segments of the alley. On the 9th and 10th days, five full-length trials were given with four pellets per trial as reward. On Day 11, nine pairs of Ss were formed on the basis of median running speeds on Day 10. On Days 11 through 17 all Ss were given five rewarded trials per day. On each trial the experimental S of each pair received a speed-contingent reward whereas his yoked control received an equivalent amount regardless of running speed. For each experimental S the delay between the opening of the start-box door and the beginning of the feeder-tongue retraction was set to equal his previous day's shortest running time. Tongue-retraction speed was set so that the reward range, from 14 to 2 pellets, coincided approximately with the preceding day's range of speeds. Thus, if S equaled his previous day's top speed he obtained 14 pellets and if he ran at the previous day's slowest speed (or slower) he received 2 pellets. Intermediate speeds were rewarded proportionately.

Figure 2 shows that Ss run under contingent reward conditions performed consistently better than did yoked controls. Moreover, the trial-to-trial and day-to-day variability of the experimental Ss was considerably less than that of the controls. An overall analysis of variance (treatment by treatment by Ss) showed that the main effect of reward contingency was highly significant ($F=10.44$, $df=1/8$, $p<.025$) but the other sources of variance, i.e., "days" and the various interactions, were not. Additional research is underway to determine optimum delay intervals and ranges of food amounts, and the relations of these variables to the nature of the task and the degree of effort involved in its execution.

References

- Crespi, L. P. Quantitative variation of incentive and performance in the white rat. *Amer. J. Psychol.*, 1942, 55, 467-517
- Ferster, C. B., & Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Logan, F. *Incentive*. New Haven: Yale University Press, 1960.
- Zeaman, D. Response latency as a function of the amount of reinforcement. *J. exp. Psychol.*, 1949, 39, 466-483

Notes

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