Response force under fixed-interval reinforcement[1]

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The force of lever-pressing was measured under a 1-min. fixed-interval schedule of food reinforcement. The Ss, 6 rats, were tested under 4 conditions of response force requirement imposed in the following order: 22, 52, 22, and 7.4 gm. In one analysis, it was found that the average force of lever-pressing gradually increased in magnitude during the 1-min. intervals. Under the higher force requirements, it was found that criterion responses were less numerous and occurred closer to the end of the fixed-interval. Sub-criterion responses, however, remained numerous at higher force requirements. After the imposition of the highest (52 gm) requirement, it was found that a higher average force characterized the performance even after 5 weeks' exposure to lower values.

Problem

A growing area of interest in the field of operant conditioning is the study of the intensive properties of responding. We have been concerned with the measurement of the force of lever pressing in rats. Recently response force has been studied under continuous reinforcement and extinction (Notterman, 1959), discrimination (Notterman & Block, 1960; Notterman & Mintz, 1962), and fixed-ratio (Mintz, 1962) schedules. Goldberg (1959) has recorded fixed-interval performance, but only for a limited amount of time (one session). The present paper provides more complete information on the characteristics of response force during fixed-interval reinforcement.

The experiment was designed to study changes in stable-state responding as force requirement is varied. In the design, the performance was to be re-established under the original requirement after each variation. However, an apparent irreversibility occurred after exposure to a high (52 gm) force requirement. We therefore modified our design and tested the strength of this relatively permanent change in behavior by imposing a very low (7.4 gm) requirement.

An import feature of the experiment is the measurement of "sub-criterion responses." These are lever presses which are not of sufficient force to meet the force requirement for reinforcement and are distinguished from "criterion responses."

Method

Six adult, male, Wistar-derived rats from the colony of the Walter Reed Army Institute of Research were used as Ss. The rats were maintained at 80% of their free-feeding weights by feeding them an appropriate quantity of solid food at the end of each session.

The rats were tested in a Foringer rat experimental chamber. Reinforcement was the delivery of a 45-mg Noyes rat food pellet by a Gerbrands pellet dispenser and was accompanied by a 1-sec. buzzer. One end of a lever projected 15 mm from the wall into the chamber, was 15 mm in width, and was 13 mm in thickness except at the end where it was rounded. The other end of the lever pressed upward against a Grass Model FT.03 Force Displacement Transducer. The transducer was designed for isometric measurements and was displaced only 0.1 mm by a 100 gm force.

Signals from the transducer were recorded continuously by a Grass Model 5 polygraph and were analyzed by a system of Philbrick K2-W operational amplifiers into different amplitude categories, providing digital outputs for counters and programming equipment.

In our analysis, lever presses were recorded only if they met the following 3 criteria: (1) The peak value of the force of a downward lever press had to be greater than 7.4 gm. (2) The applied downward force must pass from 4 gm to the specified value in less than 0.15 sec. (3) It was arranged that a snapping action of the lever which began with an upward motion would not be recorded as a response. Counters were used to record the number of lever presses which exceeded each of 3 values: 7.4, 22, or 52 gm.

After magazine training, every lever-press meeting the 22-gm force requirement was reinforced. One-hour daily sessions were then conducted with reinforcement under an Fl-1 schedule. The force requirement was, successively, 22, 52, 22 and 7.4 gm, with each requirement in effect for 21, 12, 24, and 12 sessions, respectively.

Results and Discussion

For each S, the average force of lever-pressing during the 1-min. interval increased in magnitude.[3] In some cases, this gradient is apparent from an examination of the polygraph recordings for single intervals. The slope and form of the gradient varied for each S and was uncorrelated with force requirement.

Changes in force of response as a function of the requirement are shown in Fig. 1. The median number of responses for the 6 Ss in each of 3 ranges of peak force are shown. All the curves show a pronounced "hysteresis" effect. It can be seen, for example, that during the second exposure to the 22 gm requirement more responses of high force (52 gm or greater) were emitted than during the first exposure to this requirement. The number of responses exceeding 52 gm increased as response requirement increased, whereas the frequency of responses of the lowest forces (7.4 to 22 gm) tended to decrease.

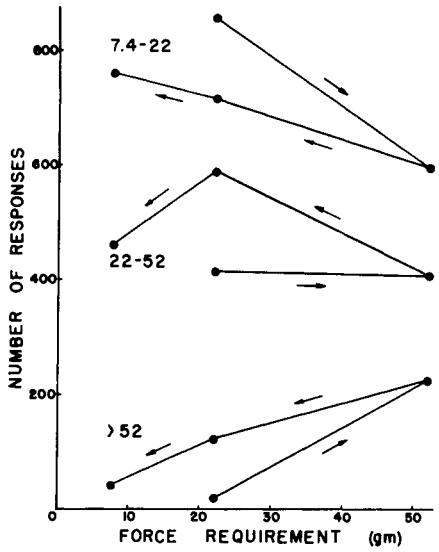

Fig. 1. Median number of responses for the 6 Ss in each of 3 ranges (7.4 - 22, 22 - 52, greater than 52 gm) of peak force. Values are medians for the last 6 sessions under each force requirement. The arrows show the order in which the requirements were imposed.

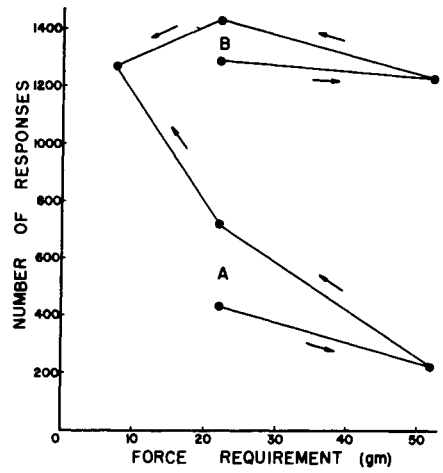

Fig. 2. Median number of criterion (curve A) and combined criterion and sub-criterion (curve B) responses for the 6 Ss. The minimum force recorded was 7.4 gm. Values are medians for the last 6 sessions under each requirement. The arrows show the order in which the requirements were imposed. Note that the point at the 7.4 - gm requirement is common to both curves.

The temporal distribution of responses within the fixed-interval was evaluated by the quarter-life measure (Herrnstein & Morse, 1955), which is a measure of the time necessary for the emission of one-fourth of all the responses emitted in an interval. It was found that the quarter-life computed for criterion responses tended to increase with higher force requirements, but the quarter-life computed for the combined criterion and sub-criterion responses remained relatively constant.

The number of criterion (Fig. 2, curve A), but not the number of all, i.e., combined criterion and sub-criterion, responses (Fig. 2, curve B) was a function of the force requirement. (Note, again, the "hysteresis" effect in both curves.) This result indicates that although increases in the force requirement of a response may reduce criterion response output (cf. Chung, 1965), the total number of responses, criterion and sub-criterion responses combined, may remain invariant. The generality of this finding for other schedules or other behavioral situations requires further investigation.

References

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Notes

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2. During the performance of the experiment, P. H. S. Fellow, IF1MH-20, 985-01.

3. Data on this aspect of the results, as well as greater details on other parts of the experiment is contained in the Laboratory of Psychopharmacology Technical Report No. 64-41, available on request.