runways reported by MacKinnon & Russotti (1967), in which with 2:1 magnitude ratio, run and goal speed measures showed small-reward superiority throughout training. It is tempting, particularly in view of the possibility of accounting for the faster-running-to-small-reward effect in terms of energizing effects of frustration (Amsel, 1967), to summarize this disparity between measures by the statement that start speed tends to reflect inhibitory effects while ratio speed tends to reveal energizing effects. In the present discrete lever-pressing situation, however, it must be noted that the one-over-five-pellet ratio speed difference may at least partly reflect the operation of an interfering response of approaching the foodcup prior to completing the ratio requirement on large-reward trials.

REFERENCES

AMSEL, A. Partial reinforcement effects on vigor and persistence: Advances in frustration theory derived from a variety of within-subjects experiments. In K. W. Spence and J. T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory*. Vol. 1. New York: Academic Press, 1967.

DAVENPORT, J. W., & FLAHERTY, C. F. Extinction of differential reward magnitude discrimination in a discrete bar-pressing situation. *Psychonomic Science*, 1969, 14, 29-30.

FLAHERTY, C. F. Interactive effects of reward magnitude in two- and three-stimulus discriminations. Unpublished doctoral dissertation, University of Wisconsin, 1968.

FLAHERTY, C. F., & DAVENPORT, J. W. Noncontingent pretraining in instrumental discrimination between amounts of reinforcement. *Journal of Comparative & Physiological Psychology*, 1968, 66, 707-711.

MacKINNON, J. R., & RUSSOTTI, J. S. An inverse performance pattern in a discrimination based on differential magnitudes of reward. *Psychonomic Science*, 1967, 7, 395-396.

PLATT, J. R., & GAY, R. A. Differential magnitude of reward conditioning as a function of predifferential reward magnitude. *Journal of Experimental Psychology*, 1968, 77, 393-396.

SPEAR, N. E., & SPITZNER, J. H. The influence of degree of training and prior reinforcer magnitude on contrast effects and resistance to extinction within S. *Journal of Comparative & Physiological Psychology*, in press.

NOTES

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Response duration differentiation during fixed ratio responding

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Eight albino rats were trained to pull a plunger for water reinforcements that were delivered on several fixed ratios from FR-4 to FR-32. The mean durations of the nonreinforced responses in the FR chain were significantly longer than mean reinforced durations. This differentiation also proved to be labile to exteroceptive stimulus cues.

A number of studies dealing with the intensive properties of the operant response have revealed that response durations are always greater during nonreinforced conditions, e.g., extinction and S^A periods of a discrimination (Kellicutt, 1967). The present study is an attempt to demonstrate this same effect during fixed-ratio schedules of reinforcement. In their study of different FI and FR reinforcement schedules, Millenson, Hurwitz, & Nixon (1961) failed to find any orderly response differentiation, based on duration within an FR chain. Perhaps one explanation to account for this is that the

manipulandum they employed did not provide sufficient "response availability."¹ In their apparatus, "A 3-gram downward force applied to the lever acting through 1 millimeter closed a microswitch." In view of the fact that response duration and amplitude are closely correlated, a system which permitted only minimum movement of the manipulandum would naturally reduce response variability; hence a reduction in the differentiation of response topographies.

Mintz (1962), however, has demonstrated that Wistar rats will show response differentiation between the reinforced and nonreinforced components of an FR schedule if peak force is measured. It appears that response durations should follow the same trends as response force in spite of the results of the Millenson study.

METHOD

The Ss were eight male albino rats of the Sprague-Dawley strain, approximately 125 days old. Each had served in the same condition of a previous acquisition-extinction study.¹ Their water ration was provided only by the experimental sessions.

The apparatus has been described in detail

elsewhere (Kellicutt, 1967). Basically, it consisted of a 5 x 12 x 8-in. cage enclosed in a ventilated plywood and Masonite box. One inch from the cage floor was a liquid delivery fountain contained within a recess in the front wall. When activated, the system would deliver approximately .02-ml water reinforcements. The manipulandum itself consisted of a Plexiglas rod 3/16 in. in diam terminating in an aluminum knob 5/8 in. in diam. Ss were required only to make a 1/8-in. pull with a force of about 18 g to activate the programming and recording equipment. The maximum possible excursion of the plunger was 2 in. Reinforcement, when available, did not occur until the plunger was returned to the home position. Therefore no reward cues were present during the response. The plunger was located 2 in. from the fountain at floor level and in the right hand corner of the cage. It was separated from the fountain by a 1-in.-high brass partition which effectively limited responses to the right forepaw. A 4 x 5-in. white translucent screen located directly above the water fountain was illuminated from behind with nine 24-V bulbs. Summed response durations and frequencies were recorded on separate timers and counters as a function of whether or not they were reinforced.

EXPERIMENT 1

Procedure

Each of the five Ss in this experiment were run daily for 1-3 h. Ss were run on an FR-4 schedule for 3-4 days. As soon as response rates became stable the schedule was changed to FR-8. Ss were run 4-5 days at FR-8 again until rates stabilized, and the schedule was shifted to FR-16. Similarly, after 5-11 days at FR-16, an FR-32 schedule was initiated. The experiment was terminated after 4-11 days at FR-32.

Results

Although terminal response rates were never terribly high (e.g., the mean terminal rate at FR-32 was 28.7 responses/min), cumulative records collected during each session showed the "scalping" typical of FR performance. The mean response durations for each reward condition collected for the last 2 days at each schedule value appear in Fig. 1. An analysis of variance performed on these data indicates that overall nonreinforced durations were significantly longer than reinforced values [$F(1,4) = 7.73$, $p < .05$]. The analysis detected no significant overall trend across schedule values nor any interaction of schedule value and reward condition. Clearly, then, FR reinforcement schedules can give rise to differential mean response duration emission.

EXPERIMENT 2

Procedure

To control for the possibility that the

Fig. 1. Mean response durations for reinforced (lower curve) and nonreinforced (upper curve) responses across the four ratios employed in Experiment 1. The individual points are the data for S 14 in Experiment 2.

duration differences of Experiment 1 were cued by some exteroceptive stimulus complex other than the reward schedule itself, three additional Ss were run under a somewhat modified procedure. For two of the animals, a relatively strong stimulus was deliberately paired with the reward contingencies of the schedule. In addition, a powerful blower was installed in the test cage enclosure to provide a masking noise (intensity of 76 dB re .0002 dynes/cm²).

For S 16, the light on the front of the chamber was always on during the nonreinforced portion of the FR chain. For S 20, the light was turned on immediately preceding each reinforced response and terminated when the response was completed. Two sessions of continuous reinforcement were provided primarily to accustom the Ss to the relatively intense masking noise. During the following four sessions, responses were rewarded on an FR-4 schedule. On the next day, Animals 16 and 20 were exposed to a series of discrimination reversals. The first 10-min period of the session was identical to the previous sessions. During the second 10 min the stimulus conditions were reversed so that now the light signaled reward for S 16 and nonreward for S 20. Conditions were reversed again after the 20th, 30th, 40th, and 50th min of the 1-h session. During the next 5 days the original stimulus contingencies were in effect and all Ss worked on an FR-8 schedule of reinforcement. On the next day Ss 16 and 20 were again subjected to five 10-min reversals.

Results

The duration behavior of Animal 14 was, on all sessions, similar to Ss in Experiment 1. In all cases the nonreinforced response durations were higher than reinforced ones. Mean performance during the last two sessions on FR-4 and FR-8 are plotted separately in Fig. 1.

During the first 10 min of the FR-4 reversal session Ss 16 and 20 showed the characteristic response duration differentiation. Mean reinforced duration for Animal 16 was .44 sec as opposed to .69 sec for nonreinforced responses. The corresponding values for S 20 were .47 and 1.44 sec, respectively. The successive reversals of stimulus conditions had the effect of attenuating the difference between mean reinforced and mean nonreinforced response durations, but did not affect the ordinal relationships.

On the second reversal day under FR-8 conditions, S 20 continued to show duration differentiation. Duration differences for S 16 were no longer related systematically to either the reward or stimulus conditions. Parenthetically, it might be noted that if such a breakdown were to occur it would be more likely under more stringent scheduling (e.g., FR-8 vs FR-4).

DISCUSSION

In general it appears that under the conditions of the present study Ss will emit response duration classes of different means depending upon whether the response is to be reinforced or not reinforced. In other words, intensive measures such as force (Mintz, 1962) and, in the present study,

duration are schedule controlled just as the frequency of response datum. Furthermore, contingent exteroceptive stimulation can enhance, attenuate, or obliterate such control. That Millenson et al (1961) were unable to provide evidence for such differentiation might have been related to the properties of their manipulandum. Kellicutt¹ has demonstrated convincingly that the difference between mean acquisition and extinction durations is primarily a function of the amount of movement available in the manipulandum after response definition requirements have been met. The available movement in the present manipulandum was 2 in. as compared with 1 mm in the Millenson study.

REFERENCES

- KELLICUTT, M. H. Response duration during an operant discrimination. *Journal of Experimental Psychology*, 1967, 73, 56-60.
- MILLENSON, J. R., HURWITZ, H. M. B., & NIXON, W. L. B. Influence of reinforcement schedules on response duration. *Journal of the Experimental Analysis of Behavior*, 1961, 4, 243-250.
- MINTZ, D. E. Force of response during ratio reinforcement. *Science*, 1962, 138, 516-517.

NOTE

1. Kellicutt, M. H. The effect of response availability on extinction. Submitted to *Journal of Experimental Psychology*.

Shock-induced response bursts and suppression¹

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The effects of signaled unavoidable shock on positively reinforced lever-pressing behavior were investigated. Rats were alternately presented with periods of "safe" and "warning" signals. During the "warning" periods brief shocks occurred randomly and independent of the animals' behavior. Rats with a history of positively reinforced lever-pressing showed both postshock bursts of responding (attack) and suppression of appetitive lever-pressing. These two effects of shock were described as occurring concurrently but with each predominating in one of two stages. Control Ss with no history of positively reinforced lever-pressing failed to attack the lever when shocked, suggesting that such a history was crucial to the production of aggressive behavior.

Operant behavior may be suppressed in

the presence of a stimulus which has been paired with unavoidable shock. Suppression of on-going behavior has been termed "anxiety" (Estes & Skinner, 1941). Electric shock has also been used to elicit attack, avoidance, and escape reactions (Ulrich & Azrin, 1962; Azrin, Hutchinson, & Hake, 1967). This may take the form of postshock bursts of responding which may be termed "aggression." However, these two types of behavior have not been studied in the same situation. In a traditional conditioned suppression procedure the shocks occur only at the termination of the warning signal. With such a design anxiety and aggression would not be pitted against each other. Lever-pressing for food has been thought to be incompatible with the fear or anxiety elicited by the warning stimulus and shock (Estes, 1944). On the other hand, postshock behavior may take the form of bursts of lever-pressing characteristic of aggression. Bidirectional effects of aversive stimuli on lever-pressing behavior were noted by Skinner (1938) and since then