Effects of shifts in magnitude and delay of reward upon runway performance in the rat

MITRI E. SHANAB* and SHARRON McCUISTION
Fresno State College, Fresno, Calif. 93726

Six independent groups of rats were first trained in a runway to receive either 1 or 12 pellets after a delay of 0, 15, or 30 sec (Phase 1). Subsequently (Phase 2), all Ss received 12 pellets under the same delay interval as in Phase 1. Finally (Phase 3), all Ss were delayed 15 sec before receiving the 12-pellet reward. In Phase 1 performance was a positive function of amount of reward and a negative function of delay of reward. The effects of magnitude and delay of reward were independent of each other. In Phase 2 no elation effects were obtained in the 0-, 15-, or 30-sec delay conditions. A depression, but not an elation, effect was obtained in Phase 3.

Numerous studies have reported an absence of positive contrast in the runway, i.e., Ss shifted from small to large reward in the runway do not perform at a higher level than do control Ss receiving large reward all the time (Dunham, 1968). The failure to obtain positive contrast has been attributed to a possible ceiling effect inherent in the running response (Bower, 1961). In a recent test of the ceiling-effects hypothesis, Shanab et al (1969) introduced the shift in magnitude along with a 30-sec delay. When shifted to large reward (22 pellets), both the previously small-reward (1 pellet) and the medium-reward (4 pellets) Ss ran significantly faster than did the control group, which received large reward (22 pellets) all the time.

The present study was designed to answer two questions: First, is delay a sufficient condition for the occurrence of positive contrast as occurred in the previous study (Shanab et al, 1969)? In other words, if delay is introduced at the beginning of training, would the shift in magnitude still produce an elation effect? An absence of positive contrast in such a situation would imply that the positive contrast effect reported above was not solely a result of the shift in magnitude but was also a function of a negative contrast effect experienced by the control group when shifted from a 0- to a 30-sec delay. Second, what is the functional relationship between delay and magnitude of reinforcement when delay is introduced at the beginning of training? In other words, do these variables combine in an additive or multiplicative fashion to determine performance in the runway? Except perhaps for one investigator (Logan, 1960), few investigators have studied this relationship in the runway. The findings by Logan are not conclusive because the study

did not include appropriate control groups which received larger rewards from the beginning of training.

DESIGN

The experiment consisted of three phases. In Phase 1 a 2 by 3 factorial design was employed in which two levels of reward magnitude (1 and 12 pellets) and three levels of delay (0-, 15-, and 30-sec intervals) were manipulated, thus yielding six groups of seven Ss each as follows: 12-0, 12-15, 12-30, 1-0, 1-15, and 1-30. In Phase 2 all Ss received 12 pellets per trial, while the delay interval remained unchanged. In Phase 3 all Ss were delayed for 15 sec and continued to receive 12 pellets per trial.

SUBJECTS

Forty-two 70-day-old naive male Sprague-Dawley rats were used.

APPARATUS

A 5-ft runway made of unpainted

redwood was used. The runway was covered with Plexiglas and was 9 in. high throughout. The startbox was 7 in. long and 6½ in. wide, while the goalbox was 12 in. long and 4½ in. wide. Four sets of photocells were installed in the runway. Interruption of any of the four photobeams started and/or stopped one of three standard electric clocks which measured start, run, and goal times. The first and second photocells were located 2½ in. and 8½ in. from the startbox, respectively. The third photocell was located 40½ in. from the startbox, and the last photocell was located 4½ in. within the goalbox.

PROCEDURE

Preliminary Training

Upon arrival from the supplier, Ss were given free feeding for 4 days. Thereafter, they were maintained on a daily ration of 10 g of food and had free access to water throughout the experiment. Proper adjustments were made for food eaten in the experimental situation.

The Ss were handled in random groups of three for 15 min per day for 12 days, and were additionally allowed during this time to explore the runway for 5 min, with both the start- and goalbox doors raised and all photocells and timers off. Then, for 5 additional days, each S was allowed to individually explore the runway for 2 min. However, during this period the equipment was turned on, and S's first running times were recorded.

Phase 1

Each S received one trial per day for the first 3 days and three daily trials thereafter until the end of the experiment. Each trial

Fig. 1. Mean total speed (Phase 2) as a function of a shift in magnitude of reward.

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Fig. 2. Mean total speed (Phase 3) as a function of a shift in delay of reward.

consisted of placing S in the startbox and allowing it to run to the goalbox. Ss received either 1 or 12 pellets after a delay interval of 0, 15, or 30 sec, each according to its group. The S was removed from the goalbox as soon as it consumed the reinforcer and returned to its home cage. The Ss were run in squads of 12, with an ITI of 10 min.

Each S was fed its maintenance ration at least 30 min after receiving its last trial. Phase 1 was continued until each S had received a total of 63 trials.

Phase 2

Each S was given 12 pellets per trial and delayed for the same interval as in Phase 1. This represented an upward shift in magnitude of reward for the three groups previously receiving 1 pellet per trial. Each S in Phase 2 received a total of 45 trials.

Phase 3

Ss continued to receive 12 pellets per trial but experienced a shift in amount of delay. All Ss were delayed 15 sec in the goalbox before receiving reinforcement. This represented an upward shift for the two groups previously receiving 30-sec delay and a downward shift for the two groups previously receiving no delay. Each S was given 51 trials in this phase.

RESULTS

All analyses are based on speed scores and only total speed is reported, since the

other measures were comparable.

Phase 1

The result of a two-way analysis of variance test on the mean total speed during the last five blocks of acquisition yielded a significant magnitude effect [$F(1,36) = 30.17$, $p < .001$] and a significant delay effect [$F(2,36) = 107.27$, $p < .001$]. The interaction of Magnitude by Delay was not significant [$F(2,36) = 1.55$, $p > .10$]. This lack of interaction indicates that speed is an additive function of magnitude and delay of reinforcement.

Phase 2: Shift in Magnitude

Examination of Fig. 1 shows that no appreciable change in trend took place throughout the shift phase.

Analysis of variance performed on Blocks 2-15 showed that only the delay variable was significant [$F(2,36) = 137.46$, $p < .001$]. Neither the magnitude variable [$F(1,36) = 1.63$, $p > .05$] nor the interaction of Magnitude by Delay was significant ($F < 1$). The lack of a magnitude effect indicates that a shift in magnitude of reward did not result in a positive contrast effect. However, the significant delay variable shows that delay continued to differentiate among the groups. Scheffé's comparisons ($p < .01$) indicated that, regardless of the prior magnitude of reward, the 0-delay Ss ran

faster than did the 15-sec and the 30-sec delay Ss and that the 15-sec delay Ss ran faster than did the 30-sec delay Ss.

Phase 3: Shift in Delay

It can be seen from Fig. 2 that, while no elation effect took place, a clear depression effect did, especially for the original 12-pellet groups. The depression effect for the original 1-pellet groups started to disappear after Block 9. An analysis of variance appropriate for a 2 by 3 design was performed on the mean total speed for Blocks 3-17, yielding nonsignificant main and interaction effects: $F(1,36) = 1.85$, $p > .05$ for magnitude; $F(2,36) = 2.38$, $p > .05$ for delay; and $F(2,36) = 1.01$, $p > .05$ for Magnitude by Delay interaction. Similar nonsignificant results were obtained when Blocks 10-17 were analyzed. However, the results of the analysis of variance on Blocks 3-9 revealed a significant delay effect [$F(2,36) = 4.39$, $p < .05$], while neither the magnitude [$F(1,36) = 4.05$, $p > .05$] nor the Magnitude by Delay effect ($F < 1$) was significant. Individual comparisons using Scheffé's test revealed significant differences ($p < .01$) between Groups 12-15 and 12-0 and Groups 1-15 and 1-0, reflecting negative contrast effects as a function of a shift in delay of reward. The same test also revealed significant differences ($p < .01$) between Groups 12-15 and 12-30 and Groups 1-15 and 1-30, the direction of the differences being in favor of the 15-sec delay groups. This finding suggests the occurrence of a "new" negative contrast effect where positive contrast was expected, a finding recently reported in human studies involving a two-choice probability task (Halpern et al, 1968).

DISCUSSION

The results of Phase 1 are clear in showing that speed is an additive function of magnitude and delay of reward. The literature contains hardly any studies investigating the interaction effects of magnitude and delay. Logan (1960, p. 58) concluded that "delay and amount of reward interact additively in determining response speed." This conclusion was based on a study in which independent groups of rats were run under different levels of delay, with all Ss receiving 2 pellets. Later, all Ss were shifted to 12 pellets but continued to receive the new reward at the accustomed delay intervals. The present study differs from Logan's study in two major respects: Independent groups receiving either 1 or 12 pellets were used for each delay interval, and the delay intervals were introduced from the very beginning of training. In view of the theoretical importance of the interaction of magnitude and delay of reward, it is

surprising that only a few investigations have been carried out in this regard.

When an upward shift in magnitude of reward was introduced in Phase 2, no elation effects were observed in the 0-, 15-, or 30-sec delay conditions. The absence of an elation effect in the 0-sec delay condition provides additional support for the growing number of studies showing an absence of elation effects under similar circumstances. The fact that an elation effect was also not obtained in either the 15-sec or the 30-sec delay condition indicates that delay per se is not a sufficient condition for the occurrence of positive contrast when an upward shift in magnitude of reward is made along with delay. Since a temporary negative contrast effect resulting from a shift in delay was obtained in Phase 3, the absence of a positive contrast effect in Phase 2 could be attributed to the fact that the control

groups (12-15 and 12-30) did not experience a negative contrast effect based on a shift in delay, as apparently was the case in the study by Shanab et al (1969). However, more direct tests of this hypothesis are being considered.

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masculine," at least in terms of mating behavior.

Mating, however, has not been the only behavior shown to be under gonadal hormone control in the male rat. Sexually experienced males exhibit a preference for the odor of receptive females, while castrates and prepuberal males do not (LeMagnen, 1952; Carr, Loeb, & Dissinger, 1965; Stern, 1970). Thus, behavioral preference for sex odors may be another index of masculinity in the rat. Since early androgen treatment could have masculinizing effects which are revealed in more subtle ways than in overt mating behavior, we have investigated the sex-odor preference of the neonatally androgenized female rat.

SUBJECTS AND PROCEDURES

Pregnant Sprague-Dawley rats were administered subcutaneous doses of 2 mg/day of testosterone propionate (TP)¹ in oil or oil alone on Days 16-20 of gestation. Female offspring from the TP-treated mothers (N = 10) received a single subcutaneous dose of 1 mg TP 96 h after birth; at the same time the female offspring of the oil-treated mothers (N = 8) were injected with oil. All Ss were ovariectomized at 60 days of age.

Starting at approximately 100 days of age all Ss were treated with progressively increasing doses of TP as follows: Week 1, 150 micrograms/day; Week 2, 300 micrograms/day; Week 3, 500 micrograms/day; Weeks 4 and 5, 1,000 micrograms/day. Rats were tested on Days 5 and 7 of each week in a dimly lit room during the dark phase of a reversed light-dark cycle.

The odor-preference tests took place in an opaque white Plexiglas straight alley, 36 x 5½ x 6 in., with a clear Plexiglas lid so the O could view the S. The alley was marked off in four equally sized areas. Two goal boxes were separated from the alley by clear Plexiglas doors with holes drilled in them so the S could see and smell, but not touch, the stimulus female. A female brought into behavioral estrus by exogenous hormones and an ovariectomized nontreated female, both anesthetized with Nembutal, served as stimuli and were placed in opposite goal boxes.

Ss, in a random order, were placed in the middle of the alley and allowed to move freely for a 5-min period. The O recorded the amount of time spent in each of the four areas of the straight alley. After the first preference test on Weeks 1-4, Ss were given a 15-min mating session with receptive females (see Whalen et al, 1969, for the results of mating tests). They were then given the second odor-preference test, similar to the first, except that the

Recent mating experience and olfactory preferences in androgenized female rats*

RICHARD T. ROBERTSON and RICHARD E. WHALEN
University of California at Irvine, Irvine, Calif. 92664

Neonatally androgenized female rats display a behavioral preference for the odor of sexually receptive female rats. This preference is not seen under conditions of low sexual arousal, but is evident after a brief mating session. The results are discussed in regard to the "masculinizing" effects of early androgen treatment.

Several recent studies have demonstrated that androgen treatment of the neonatal rat eliminates the display of female sexual receptivity in adulthood (Grady, Phoenix, & Young, 1965; Harris & Levine, 1965; Whalen & Edwards, 1967). Androgen

treatment in infancy does not, however, appear to increase the display of masculine sexual behavior. Whalen & Edwards (1967) and Whalen, Edwards, Luttge, & Robertson (1969) report no enhancement of male-type mounting behavior in females treated with testosterone at birth, as compared with control females. Thus, early androgen treatment produces an animal which is "less feminine" but not "more

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