Fig. 2. Mean per cent time responding for each group before, during, and after stimulation.

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NOTES

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Variations in secondary reinforcers as a function of temporal relationship to UCS and UCS intensity

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Two predictions were tested: (1) that stimuli paired with shock termination become positive reinforcers, and (2) that the attractiveness of the reinforcer will be proportional to the aversiveness of shock preceding it. Two experiments carried out various tone-shock pairings; speed in a runway was subsequently observed when the tone was presented as a reward. Both predictions were confirmed.

Mowrer's behavior theory (1961) suggests that stimuli preceding aversive stimulation acquire negative reinforcing properties, while stimuli paired with the termination of such aversive stimulation

become positive reinforcers through their contiguity with drive reduction. Mowrer & Aiken (1954) have shown that stimuli preceding shock are effective negative reinforcers, but they did not conclusively demonstrate that stimuli paired with shock termination were positive reinforcers. Goodson (1954), Smith & Buchanan (1954), and Murray & Strandberg (1965) have been able to demonstrate under several conditions that stimuli contiguous with shock offset are positive reinforcers.

It is claimed by Mowrer that the stimuli paired with the termination of noxious stimulation develop into positive reinforcers through their contiguity with "relief" resulting from the termination of discomfort or drive. This position implies that the amount of relief (and hence the attractiveness of stimuli paired with the relief) is proportional to the intensity of

aversive stimulation preceding the relief. Variations in the length or intensity of the UCS should produce differences in the reinforcing effectiveness of stimuli paired with the termination of aversive stimulation. Murray & Strandberg (1965) observed no relationship between shock length and the reinforcing properties of the stimulus paired with the termination of the shock; however, length of shock was not controlled and was allowed to vary between Ss.

The purpose of this study was to confirm the previous findings that stimuli paired with shock termination become positive reinforcers. The second and major purpose of the study was to test an associated hypothesis that the attractiveness of stimuli accompanying UCS termination is proportional to the aversiveness of the UCS. Both hypotheses were tested by the pairing of a tone with shock termination and subsequently observing the effect of the tone as a reward on speed of running in a runway.

EXPERIMENT 1

Subjects

Fifty male albino rats, 90-130 days old, were assigned randomly to five groups. All Ss were housed in pairs, with unlimited access to food and water except during training sessions.

Apparatus

Shock-tone conditioning was carried out in a sound-deadened ventilated compartment (Grason-Stadler E3125AA). Shock was administered through the grid floor by means of a shock-generator scrambler (Grason-Stadler E1064GS, set at 0.6 mA for all groups). The tone was presented in the chamber at -20 dB according to a General Radio sound-level meter. Performance in the 3 ft x 4 in. x 4 in. Hunter runway was measured by timers controlled by photocells placed 3 in. outside the start and goal boxes. Handling of each S between trials was eliminated by exchanging start and goal boxes at the completion of each trial. The sides of the runway were covered with black cardboard and the top was covered with glass.

Procedure

Group 1: Twenty Ss received 20 shocks of 3-sec duration, spaced at intervals ranging randomly from 40-80 sec at an average of 60 sec. A 1,000-Hz tone overlapped the termination of each UCS for 0.5 sec and continued for 2.5 sec after the termination of the UCS. After 10 min rest, each S was then placed in the runway start box. Half of the Ss received the CS as reward upon reaching the goal (Group 1A). The remaining Ss did not receive any tone in the goal (Group 1B). This procedure was

repeated for 15 trials or until an S was withdrawn after three consecutive runs of over 180 sec each.

Group 2: Ten Ss received the UCS unaccompanied by the CS delivered at the same intervals as in Group 1. All other procedures were identical to those of Group 1A.

Group 3: Ten Ss received the CS only, delivered at the same intervals as in Group 1. All other procedures were identical to those of Group 1A.

Group 4: Ten Ss received 20 quasi-random pairings of the tone and shock. The tone was presented randomly throughout the interval between shocks, but the randomness was controlled so that the tone was never coincident with the UCS.

EXPERIMENT 2

Subjects

Forty male albino rats, 90-130 days old, were assigned randomly to four groups and maintained on a 23-h water-deprivation schedule. Food was available ad lib.

Apparatus

The apparatus was identical to that used in Experiment 1 except that a runway, 8 ft x 4 in. x 12 in. high, constructed of corrugated cardboard, was used.

Procedure

Each S was trained over 10 trials to run for a 3-drop water reward in the runway goal box. After a 5-min rest, each S received the shock-tone conditioning.

Group 1: Using the same shock-tone intervals as in Experiment 1, Ss received 20 pairings of 0.1-mA shock and tone.

Group 2: Procedure was identical to Group 1 except that 0.6-mA shock was given.

Group 3: Identical to Group 1 except that the Ss received 1.0-mA shock.

Group 4: Identical to Group 1 except that the Ss received quasi-random sequences of 1.0-mA shock and tone.

After a 10-min rest, each S was returned to the runway start box and given 15 extinction trials. The 3-sec tone was presented when S reached the goal box with the empty water container.

RESULTS

For Experiment 1, all time scores were converted to their reciprocals for analysis with Duncan's Multiple Range Test (Edwards, 1962). Analysis revealed significant differences only when start-box latency and alley speed measures were combined. The differences in speed for the five groups is shown in Fig. 1. Group 1A (tone at shock offset, tone in goal) showed significantly greater running speed than any of the control conditions during the last block of three trials ($p < .05$). There were no significant differences in running speed between any of the groups during

Fig. 1. Mean runway speed as a function of extinction trials for the five treatment groups used in Experiment 1.

the first block of three trials. None of the control groups was significantly different from each other during the last block of trials.

For Experiment 2, the reciprocal of time scores was again used for analysis. No differences in speed were found to be significant during the initial training period or immediately after shock-tone conditioning. The differences in running speed during the 15 extinction trials are shown in Fig. 2. According to Duncan's test, all four groups were significantly different from each other during the last block of three trials ($p < .05$), with Group 3 showing the greatest resistance to extinction.

DISCUSSION

Experiment 1 confirms the proposal that a stimulus paired with shock termination becomes a positive rather than a negative secondary reinforcer. This conclusion is supported by the performance of Group 1A in the runway relative to all other conditions. Group 1A, reinforced in the runway by a tone previously associated with shock termination, showed least decrement in runway speed. The possible

Fig. 2. Mean runway speed as a function of extinction trials for the four treatment conditions used in Experiment 2.

reinforcing effects produced by stimulus change through the appearance of a tone in a novel environment can be discounted in view of the evidence from Group 2 in which a novel tone was presented in a novel environment. It would be reasonable to assume that if stimulus change or novelty was a valid explanation, Group 2 should show speeds comparable to those of Group 1A.

The results of Experiment 2 appear to indicate that the effectiveness of this secondary reinforcer is a monotonic function of the aversiveness of the stimulation with which it is associated.

Both studies showed that Ss exhibited no differences in speed during initial extinction in the runway, but speed differences did appear as training continued. This result indicates that the various conditioning procedures did not produce variations in motivational or arousal states that would be expected to produce initial speed differences as a result of prior exposure to shock. The differences appear to be solely a function of the reinforcing effectiveness of the tone offered in the goal box.

Among those studies that failed to support the results reported above were Littman & Wade (1955) and Nefzger (1955). These failures might be accounted for in terms of the differences in shock procedures. Specifically, Littman and Wade used a 0.5-sec shock in a confinement tube (where confinement could act as an effective stressor), and Nefzger used escapable shock in a T-maze; shock length was not controlled for each S.

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