OPERANT BEHAVIOR AND THE GALVANIC SKIN POTENTIAL UNDER DRL SCHEDULE¹

EMILE MEURICE,² HAROLD WEINER,³ AND WALTER SLOBODA⁴

SAINT ELIZABETHS HOSPITAL

Motor and galvanic skin potential (GSP) activity were investigated during the conditioning, extinction, and reconditioning of motor responses under a differential reinforcement of low rate (DRL) schedule of reinforcement. Interresponse time (IRT) distributions for motor responses during conditioning and reconditioning gradually stabilized at a peak just beyond the minimal IRT required for reinforcement. Few unreinforced motor responses and "bursts" of motor responses were observed during conditioning and reconditioning. Relative to conditioning and reconditioning, extinction effected larger IRTs and smaller GSP amplitudes. GSP amplitudes were greater for unreinforced than for reinforced motor responses during conditioning and reconditioning. However, GSP amplitudes associated with the unreinforced extinction responses were smaller than either the reinforced or unreinforced responses during conditioning and reconditioning.

Studies by Doehring and Helmer (1963a, 1963b) and Doehring, Helmer, and Fuller (1964), investigated physiological activity during operant behavior. The galvanic skin response (GSR) was found to be the most reliable index associated with motor responses conditioned under variable-interval (VI), fixed ratio (FR), and differential reinforcement of low rates (DRL) schedules. Under VI and FR schedules their findings indicated that GSR activity during conditioning was greater after reinforced motor responses compared to unreinforced motor responses. Under a DRL schedule, however, differential GSR activity did not occur after reinforced and unreinforced responding. The present study examined motor and galvanic skin potential (rather than resistance) activity during conditioning, extinction, and reconditioning, under a DRL schedule. Unlike the DRL data reported by Doehring *et al.* (1964), the present data were obtained

(1) on a DRL 25-sec rather than a DRL 1-min schedule (2) after explicit instructions which provided schedule information and required the subjects to discriminate temporally the inter-reinforcement interval by a specific counting procedure (3) from subjects without prior FR and VI conditioning histories and (4) during extinction and reconditioning as well as conditioning.

METHOD

Subjects

Two male psychiatric nursing assistants, S16 and S32, ages 36 and 37, respectively, were paid on an overtime basis at the hourly rate of \$2.50 to \$4.00, depending upon their salary level. Remuneration was independent of their operant performances.

Apparatus and Task

A microswitch button was mounted on a tripod adjacent to a wooden chair approximately 6 ft in front of an electronic five-digit add-subtract counter. The apparatus was housed in a 12 by 15 by 10 ft experimental room illuminated by a 100 w bulb. A shield fan operated throughout each session to mask noise. It also maintained the experimental room at a comfortable temperature.

Subjects sat alone facing the counter with their right arm on one of the chair armrests in a comfortable position to press the micro-

¹Reprints may be obtained from Harold Weiner, Dept. of Health, Education and Welfare, Saint Elizabeths Hospital, Washington, D.C. 20032.

²NATO Fellow, Clinical Neuropharmacological Research Center, National Institute of Mental Health; Guest Worker, Operant Conditioning and Psychophysics Lab., Saint Elizabeths Hospital.

³Program Director, Operant Conditioning and Psychophysics Lab., Saint Elizabeths Hospital.

⁴Research Assistant, Operant Conditioning and Psychophysics Lab., Saint Elizabeths Hospital.

switch button. An active GSP electrode (UNALEC Model 502-2B) was placed in the left palm. An inactive EKG electrode (a 1 by 2-in. zinc plate electrode) was attached to the left forearm. Decaderm paste was used as the electrolyte.

Subjects began each session with five zeros showing on the add-subtract counter. The task was to get the highest possible score by pressing the microswitch button as instructed. Repeated presses required repeated closures of the microswitch button.

Instructions. At the beginning of the first conditioning session, the following instructions were read to the subject:

"Your task in the experiment is to score as many points as possible on the counter during each 1-hr session. As the conditions are set at the present time, you will score 100 points each time you pause at least 25 sec between two presses. Each time you press before 25 sec have elapsed from a previous response you will not score 100 points and you'll have to wait a whole new period of 25 sec in order to score. On the other hand, if you wait longer than 25 sec, you waste time and at the end of the session your score may be lower. Hence, in order to get the highest score possible you should wait as close to 25 sec as possible between two presses, being especially careful *not* to wait *less* than 25 sec.

"In order to measure the delay between your responses, we ask you to count out silently 1001, 1002, 1003, 1004 . . . 1025.

"You are asked to keep quiet during the whole hour, with your eyes open, watching the counter. You may occasionally move slightly. When you must move, move quickly.

"Conditions may change. Do not think the machine is broken or not functioning properly. If the machine does break, we will know about it and will tell you that such is the case.

"Under some conditions you will do better, that is, get a higher score than under others. Just try to get the highest score you can under all conditions."

Subjects were then asked to repeat the instructions. Clarification was provided when necessary. The instructions were given only

before the first session and were the only instructions subjects received. The schedule information and counting method of timing provided by the instructions were designed to establish quickly stable low rates of temporally-spaced responding.

Procedure

Conditioning phase. Button presses were conditioned in this phase under a 25-sec differential reinforcement of low rates (DRL 25 sec) schedule (eleven 1-hr sessions). A single button press was reinforced by a 100-point addition to the subject's score and a concomitant brief tone (to indicate the 100-point reinforcement if the subject was not watching the counter) only when it followed a period of no-responding by 25 sec or more. A button press emitted before 25 sec had elapsed from the preceding press, postponed the 100-point reinforcement (and concomitant tone) for another 25 sec.

Extinction phase. After the conditioning phase, an extinction phase was introduced which consisted of five 1-hr sessions with no 100-point reinforcements (or tones). All other conditions were identical to the conditioning phase.

Reconditioning phase. After the extinction phase, the DRL 25 sec schedule described in the Conditioning Phase was re-introduced for five 1-hr sessions.

At the end of each session, each subject was given a card showing his name, session date, score for that session and the following printed sentence: "Remember your job—and only job—is to get the highest score that is possible."

Subjects were specifically requested to obtain their average amount of sleep the night before a session, to refrain from taking drugs, and to report any physical or emotional disturbances. Two 1-hr sessions were typically conducted for each subject per week.

Transistorized digital elements and networks (Weiner, 1963) were used to program the DRL 25 sec and extinction contingencies. GSP and button pressing responses were recorded continuously on separate channels of an Invengineering-Offner polygraph. Calibration was arranged so that 1 cm of deflection represented a 1 mv change in potential. All records were taken at a speed of 10 mm per sec. Button pressing responses were also recorded on a Gerbrands cumulative recorder.

RESULTS AND DISCUSSION

Interresponse Time Data

During the initial conditioning sessions, the IRTs associated with reinforcement greatly exceeded for both subjects the 25 sec required for reinforcement. These IRTs decreased as conditioning progressed, thereby in-

creasing the number of reinforcements obtained during each conditioning hour. In addition, the number of unreinforced responses of both subjects also decreased somewhat as conditioning progressed.

Figures 1 and 2 show reasonably stable IRT distributions for motor responses during the last three conditioning, extinction, and recon-

Fig. 1. Interresponse time distributions for S16 during the last three sessions under the conditioning, extinction, and reconditioning contingencies.

ditioning sessions for each subject. The general form of distribution was similar for both. The distributions during conditioning and reconditioning were skewed to the right with marked peakedness just beyond the 25-sec IRT required for reinforcement. During extinction, the IRT distributions flattened but remained somewhat skewed to the right (*i.e.*, the length of the IRTs tended to increase during extinction).

Subjects had a relatively high percentage of reinforced responses. Response "bursts" (very short IRTs) observed in humans by Holland (1958) under DRL contingencies were almost entirely absent in the present performances. These findings may be related to the nature of the instructions given. Similar findings have been obtained by Dews and Morse (1958). As in the present study, the Dews and Morse subjects were told the nature of the reinforcement

Conditioning

S 32

Fig. 2. Interresponse time distributions for S32 during the last three sessions under the conditioning, extinction, and reconditioning contingencies.

(DRL) contingency and were requested to time the inter-reinforcement interval by counting.

Galvanic Skin Potential Data

A GSP was defined as any absolute increase in electrical potential of at least 100 microvolts which was initiated within 5 sec after a button press. The amplitude of a GSP was determined by taking the difference in potential between the onset GSP level and the peak GSP level attained before 7 sec elapsed from the button press. Since a significantly higher percentage of GSP onsets occurred in the 5 sec after a button press than in any other 5-sec period, it seems reasonable to conclude that GSPs initiated within 5 sec after a button press were

related to the just-completed response rather than the next one.

Figures 3 and 4 present frequency distributions of the average GSP amplitudes for reinforced responses during the last three sessions of conditioning and reconditioning, and for unreinforced responses during the last three sessions of extinction. Figure 5 presents samples of polygraph records which show typical GSPs following unreinforced and reinforced responses during the last 3 hr of conditioning and unreinforced responses during the last 3 hr of extinction. GSPs following unreinforced and reinforced responses during reconditioning were similar to those shown for conditioning.

As Fig. 3-5 show, GSP amplitudes were

Table 1

Mean Differences for GSPs Following Unreinforced (UR) and Reinforced (RR) Responses During Conditioning (C) and Reconditioning (RC)

Subject	Contingency	N	Mean GSP Difference (UR-RR) (in MV)	t Value	Significance Level
S16	(C)	139	0.635	3.0411	<.01
	(RC)	38	0.584	2.2900	<.05
S32	(C)	44	2.5045	6.5511	<.01
	(RC)	30	1.1416	3.8936	<.01

For S16, reinforced and unreinforced responses during the last three conditioning and reconditioning sessions were compared. For S32, reinforced and unreinforced responses were compared only for Session 10 of conditioning and Sessions 9 and 10 of reconditioning. S32 emitted no unreinforced responses during Sessions 9 and 11 of conditioning and Session 11 of reconditioning.

Table 2

Mean Differences for GSPs During Conditioning (C), Extinction (E), Reconditioning (RC).

Subject	Contingency	N	Mean GSP Difference (in MV)	t Value	Significance Level
S16	(C)	235	1.614 (C-E)	15.371	<.001
	(E)	239	1.016 (RC-E)	10.695	<.001
	(RC)	309			
	(C)	267	1.006 (C-E)	8.290	<.005
S32	(E)	273	.615 (RC-E)	5.212	<.005
	(RC)	284			

This table compares the GSPs for reinforced responses during the last three sessions of conditioning and reconditioning with the GSPs for the unreinforced responses during the last three sessions of extinction.

Fig. 3. S16's galvanic skin potential (GSP) amplitude distributions for reinforced responses during conditioning and reconditioning compared to an equal number of unreinforced responses during extinction. These distributions were obtained during the last three sessions under conditioning, extinction, and reconditioning.

S 32

Fig. 4. S32's galvanic skin potential (GSP) amplitude distributions for reinforced responses during conditioning and reconditioning compared to an equal number of unreinforced responses during extinction. These distributions were obtained during the last three sessions under conditioning, extinction, and reconditioning.

Fig. 5. Sample segments of polygraphic records showing galvanic skin potentials (GSPs) following reinforced (R.R.) and unreinforced (U.R.) motor responses during conditioning (C) and following unreinforced responses during extinction (E). Polygraphic records obtained during reconditioning were comparable to those shown for conditioning.

larger after reinforced responses during conditioning and reconditioning than after unreinforced responses during extinction. The diminution of GSP amplitudes during extinction did not appear to be related to the general lengthening of IRTs during extinction. Pearson correlation coefficients computed between S16 and S32's IRT and GSP magnitudes for all responses during conditioning, extinction, and reconditioning were not significant. Thus, size of GSP was not related to time since previous response.

Table 1 shows *t* test analyses for the mean differences between GSP amplitudes after unreinforced and reinforced responses during conditioning and reconditioning. For S16, reinforced and unreinforced responses during the last three conditioning and reconditioning sessions were compared. For S32, reinforced and unreinforced responses were compared

only for Session 10 of conditioning and Sessions 9 and 10 of reconditioning. S32 made no unreinforced responses during Session 9 and 11 of conditioning and Session 11 of reconditioning. Following Doehring *et al.* (1964), reinforced responses occurring mid-way in time between two unreinforced responses were chosen for the mean difference analysis shown in Table 1 to reduce the confounding effects of GSP fluctuations. For both subjects, GSP amplitudes were significantly greater after unreinforced responding than after reinforced responding during conditioning and reconditioning.

Table 2 shows *t* test analyses for the mean differences in GSP amplitudes for the reinforced responses which occurred during conditioning and reconditioning compared to the unreinforced responses at comparable IRTs during extinction. Table 2 reveals that unrein-

forced extinction responses were associated with significantly smaller average GSP amplitudes than the reinforced responses (which Table 1 showed to be smaller than the unreinforced responses) during conditioning and reconditioning.

A tentative suggestion in terms of the relative frequency of response-produced consequences may be offered to account for the discrepancy between the present data and those of Doehring and associates who reported greater GSR activity after reinforced responses compared to unreinforced responses under VI and FR schedules, but no differential GSR activity for reinforced and unreinforced responses on a DRL schedule.

In the VI and FR studies of Doehring and Helmer (1963a, 1963b), a substantially greater number of unreinforced responses compared to reinforced responses were emitted. In these studies, reinforcement was the infrequent event and was associated with greatest GSR activity. In the DRL study of Doehring *et al.* (1964), the number of unreinforced and reinforced responses was approximately equal. Here, in the absence of an "infrequent" response-produced consequence during conditioning, no differential GSR activity was observed.

In the present study, unreinforced responses during conditioning and reconditioning were

infrequent since most responses under the DRL 25-sec schedule were reinforced. As in the VI and FR studies of Doehring and Helmer, GSP activity in the present study was greatest after the infrequent event (*i.e.*, non-reinforcement). It appears that GSR activity in the present study as well as in the studies of Doehring and his associates may have been more related to the relative frequency of events than to reinforcement *per se*.

REFERENCES

- Dews, P. B. and Morse, W. H. Some observations on an operant in human subjects and its modification by dextro-amphetamine. *J. exp. Anal. Behav.*, 1958, 1, 359-364.
- Doehring, D. C. and Helmer, J. E. Psychophysiological responses to variable-interval reinforcement in a human operant situation. *Psychol. Rec.*, 1963a, 13, 283-292.
- Doehring, D. G. and Helmer, J. E. Psychophysiological responses to fixed-ratio reinforcement. *Psychol. Rec.*, 1963b, 13, 289-297.
- Doehring, D. G., Helmer, J. E., and Fuller, E. A. Physiological responses associated with time estimation in a human operant situation. *Psychol. Rec.*, 1964, 14, 355-362.
- Holland, J. G. Technique for behavioral analysis for human observing, *Science*, 1957, 125, 348-350.
- Weiner, H. Operant programming with transistorized digital elements. *J. exp. Anal. Behav.*, 1963, 6, 193-195.

Received June 14, 1965