STIMULUS CONTROL OF SKIN RESISTANCE RESPONSES ON AN ESCAPE-AVOIDANCE SCHEDULE¹

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The effects of discrimination and avoidance training on the skin resistance response were studied in eight humans. Responses occurring during one stimulus delayed the interruption of music for 30 sec; responses during a second stimulus either had no effect or interrupted the music for 15 sec. The results showed stimulus control in all subjects and an increased discrimination between the first one-half and last one-half of the sessions for seven of the eight subjects.

Recent reviews of the literature (Kimmel, 1967; Miller, 1969) indicate that responses mediated by the autonomic nervous system can be controlled by operant conditioning procedures, although questions remain regarding the exact mechanisms responsible for such control (Katkin and Murray, 1968; Crider, Schwartz, and Shnidman, 1969).

Few of the studies on humans have investigated operant conditioning of an autonomic response under schedules other than continuous reinforcement. Greene (1966) reported a study of operant conditioning of a skin resistance response using fixed-ratio schedules of 1, 2, and 3 responses. The results of that study, while indicating some influence of the schedules, were difficult to interpret because the conclusions were based upon group averages and the responses of each subject were conditioned for only 16 min. More recently, Shapiro and Crider (1967) reported data for individual subjects in a study that assessed the effects of two multiple schedules of reinforcement. On the first schedule the subject earned 10 cents for every three responses during the positive stimulus and lost 10 cents for every three responses during the negative stimulus. They reported that five of the seven subjects had a higher response rate during the positive stimulus. The second multiple schedule, using seven different subjects, consisted of a variable-ratio 3 schedule under one

stimulus and differential reinforcement of interresponse times of at least 20 sec under a second stimulus. Results indicated that all seven subjects formed the discrimination, with higher rates controlled by the variable-ratio schedule. McMullin and Greene (1970) reinforced skin resistance responses on a multiple schedule and reported data for each of four subjects. In the presence of one stimulus, responses were reinforced on a fixed-ratio schedule the values of which progressed from continuous reinforcement to fixed-ratio 4 over 20 sessions. Alternating with the first stimulus, a second stimulus was presented during which the reinforcer was delivered whenever 30 sec passed without a skin resistance response. The results indicated that three of the four subjects had higher rates under the fixed-ratio stimulus. However, the control of responding by the stimuli was at best quite tenuous and the conclusions were based upon data averaged over several days.

The present study was designed to provide a description of the changes that occur in the rate of skin resistance responses with an escape-avoidance schedule. Music was played continuously as long as interresponse times were shorter than 30 sec. If more than 30 sec elapsed between responses, the music was interrupted until a response occurred.

METHOD

Subjects

Eight male college students between the ages of 18 and 25 and with normal hearing volunteered under the pretext that their

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nervous activity would be measured while they listened to music. All subjects were enrolled in lower division psychology classes and received class credit for their participation.

Apparatus

An Industrial Acoustics sound-proofed chamber containing a comfortable upholstered chair, an intercom, and illuminated by a 7.5 w light, served as the experimental space. Two zinc electrodes in Lucite cups filled with Fels Electrode paste were attached to the subject's ring and index fingers. Changes in skin resistance were detected and amplified by a Fels Dermohmmeter which applied a constant current of 38 μ A through the subject. The Dermohmmeter output was recorded on an Esterline-Angus Rectigraph recorder series S601R. Popular music was played on a tape recorder. The music varied in tempo and type. Stimuli were presented by a Lehigh Valley multi-stimulus panel (Model LVE 111-06). Timers and solid state modules controlled events.

Procedure

A response was defined as a decrease in skin resistance of at least 500 ohms within a maximum of 2 sec. A response was counted by an observer who closed a switch as soon as the recording pen indicated that a 500-ohm change had occurred. Changes in resistance during the first 5 sec of identifiable random events including visual stimuli, detectable movements, sneezes, and coughs by the subjects, or loud noises, such as a door slamming, were omitted from analysis. The frequency of these events, excluding stimulus changes, was about one per session. When checks were made by a second observer on these events, virtually 100% agreement was obtained.

Each subject was studied for 10 consecutive days at the same time each day. Each session lasted 35 min with 5 min of habituation, and 15 min each of the experimental and control conditions. The experimental and control periods alternated within each session. Each experimental and control period was either 4, 5, or 6 min long and the order was determined randomly.

Upon entering the laboratory the subject was seated in the sound-proof chamber and, at the first session, non-informative instruc-

tions were read. These instructions merely told the subject to remain awake, alert, and not to move. The chamber door was closed and recording of the 5-min habituation period began; simultaneously the tape recorder was started and the subject was presented with music over the speaker located within the chamber. A female observer monitored the responses, music, and any vocalizations through the intercom. At the end of the habituation period the experimental or control stimulus was turned on. In the presence of three horizontal dots (experimental stimulus) on the stimulus panel, music was presented. Each time the subject responded, interruptions of the music were delayed for 30 sec. In the absence of responses, interruptions of the music continued until onset of the control period. Interrupted music consisted of repeated cycles of 0.5 sec of silence followed by 0.5 sec of music. The 30-sec music interval was analogous to Sidman's (1953) response-shock interval.

To evaluate possible eliciting and/or arousing effects of the music, several different control conditions were employed. Two subjects were randomly assigned to each control condition. In the presence of three vertical dots, Group 1 received continuous music, Group 2 received only interrupted music, and Group 3 a combination of continuous and interrupted music, *i.e.*, 2 min of music followed by 1 or 2 min of interrupted music. Group 3's control condition simulated the experimental condition closely. For these three groups, responses emitted during the control period had no scheduled consequences; *i.e.*, these subjects were on an extinction schedule. For Group 4, music was presented at the start of the control period; each response produced 15 sec of interrupted music. If the subject emitted a response during the interruptions, another 15-sec interval of interrupted music began. At the end of the tenth session, each subject was asked to complete a questionnaire designed to evaluate his awareness of the experimental contingencies.

RESULTS

During each daily session, the total number of responses was tabulated in each period. Although no reliability check was made of the observer's counting procedure, inter-judge re-

liability indices in a similar study (Greene, 1966) were found to be 0.96 and 0.97 for experimental and control conditions respectively. To determine whether differential responding occurred, the data were divided into two five-day blocks—the first five days of training and the last five days of training. Figure 1 presents for each subject by each group the difference in mean response rate between experimental and control conditions. Figure 1 shows that in every case the mean response rate was higher during the experimental stimulus. Figure 1 also indicates that the difference between experimental and control rates increased for seven of the eight subjects over days. Group 4 showed the greatest change from the first five days to the last five days for both subjects.

Differences in rates during each stimulus condition were also seen over successive sessions. The rates were calculated for each stimulus condition during the last two-thirds of Sessions 1, 3, 7, and 9. The control stimulus rate was then subtracted from the experimental stimulus rate and plotted in Fig. 2. For

each of the four subjects (one from each group) the differences were small during Session 1. With each successive session, however, the general trend was towards larger and larger rate differences.

Figures 1 and 2 present only the difference in response rates. When the rates during the first five sessions were compared with the rates during the last five sessions an interesting relationship appeared (Table 1). The differential response rate changes between experimental and control conditions from the first five sessions to the last five sessions resulted from two types of response rate changes. Four of the Subjects (DT, BH, GC, and BK) increased their rates of responding both during experimental and control condition from the first to the last five sessions. However, the increase in rate during the experimental period exceeded the increase during the control period. The response rates of three of the four remaining subjects (DG, RB, and DM) decreased from the first five sessions to the last five sessions in both conditions. However, the

Fig. 1. Mean rate of responding during the experimental stimulus (S+) minus the mean rate of responding during the control stimulus (S-) for each subject. The mean was calculated by averaging over five-day blocks. The group numbers over each pair of subjects refer to the different control conditions (see text for explanation).

Fig. 2. Mean rate of responding during the experimental stimulus (S+) minus the mean rate of responding during the control stimulus (S-) for one subject from each group over successive alternate sessions. The data for rate calculation were taken from the last two-thirds of each session.

decrease during the control stimulus exceeded that during the experimental stimulus. The remaining subject (FC) decreased only during the experimental period and no change occurred in the control period, indicating slightly less control by the schedule during the second five sessions.

To determine if initial rates were related, the average response rate of each subject was computed for the first half of Session 1. Assuming that rates during this period were indicative of preconditioning rate, then it might be assumed further that subjects with high initial rates might show habituation over sessions that was greater than subjects with low initial rates. When the initial rates were examined it was found that three of the four subjects who showed an overall increase had initial rates below the median when all eight subjects were ranked. Thus, three of the four subjects who increased their overall average rates had low initial rates and three of the four subjects who decreased their overall aver-

age rates had high initial rates. This outcome is in agreement with previous reports (Crider, Shapiro, and Tursky, 1966; Mandler, Preven, and Kuhlman, 1962).

Another measure of behavioral sensitivity to the reinforcement schedules was the length of time the music was interrupted. As control developed, the amount of time that the music was interrupted during the experimental stimulus was expected to decrease over sessions. Table 2 presents the mean number of minutes that the music was interrupted for each subject for the first five and last five sessions. For the four subjects whose general rates increased from the first five sessions to the last five, there was a decrease in the total time the music was interrupted over sessions. The results are not so clear for the four subjects whose overall rates decreased. For one subject (FC), the total time that the music was interrupted decreased; for two subjects (DM and DG) the time increased; and for one subject (RB) there was no change.

Table 1

The mean number of responses emitted per session during S+ (Experimental) and S- (Control) for the first five sessions and the last five sessions for each subject. The first four subjects increased their overall rates from the first five sessions to the last five sessions in both S+ and S- while the second four subjects decreased their overall rates during the same period except for Subject FC whose rate did not change in S-.

Subject	Session	S+	S-
DT	First 5	7.7	5.7
	Last 5	13.3	10.2
BH	First 5	10.3	7.4
	Last 5	11.0	7.8
GC	First 5	6.2	5.6
	Last 5	17.3	7.0
BK	First 5	19.6	15.8
	Last 5	27.5	17.6
DG	First 5	6.0	4.4
	Last 5	5.1	2.3
RB	First 5	11.8	11.0
	Last 5	11.3	7.6
DM	First 5	23.4	23.2
	Last 5	17.0	9.0
FC	First 5	5.3	3.1
	Last 5	5.2	3.1

A similar analysis of interrupted music time was made during the control stimulus for Subjects GC and BK. For these subjects a response during the control stimulus changed the music to interrupted music. For BK, this time increased from an average of 3.2 min during the first five sessions to an average of 4.4 min during the last five. Subject GC indicated no change (8.4 min and 8.4

Table 2

The average number of minutes per session the music was interrupted during S+ for each subject for the first and last five sessions. The first four subjects are increased responders and the last four subjects are decreased responders as explained in the text and Table 1.

Subject	First 5 Sessions (min)	Last 5 Sessions (min)
DT	7.0	5.2
BH	5.2	3.7
GC	6.8	4.8
BK	3.2	0.4
DG	8.0	8.6
RB	4.0	4.0
DM	2.0	2.2
FC	8.6	8.2

min) from the first five sessions when compared to the last five sessions. It should be noted that both of these subjects had a general increase in response rate over sessions, and had fewer and fewer music interruptions over sessions during the experimental stimulus.

DISCUSSION

The present results lend further support to the hypothesis that responses mediated by the autonomic nervous system are amenable to operant conditioning. This study used a reinforcement procedure and a reinforcer not previously used in any other study of operant autonomic conditioning. The results thus broaden the generality of the phenomenon.

The data in Fig. 1 and 2 show that subjects learned despite their initial operant level. This conclusion is not in agreement with some previous studies (Mandler *et al.*, 1962; Rice, 1966). This discrepancy can be accounted for when it is realized that when only initial operant levels or absolute rate changes are used as a criterion for conditioning, high initial rate subjects may not indicate conditioning. Therefore, within-subject comparisons are recommended to assess the effects of relevant variables. In addition, subjects should be run more than one session to allow habituation to occur. After habituation, the influence of the experimental variables are more likely to be apparent because they are not judged on top of a changing baseline.

One of the factors that makes evaluation of operant autonomic conditioning studies difficult is the eliciting and/or arousing effects of the reinforcing stimulus. In the present study, four different conditions were imposed during the control condition to allow evaluation of the influence of music and interrupted music patterns upon responding. For example, it could be argued that the pattern of playing 30 sec of music followed by *n* sec of interrupted music, typical of the experimental condition, may have an arousing effect that results in elicited skin resistance responses during this period that would not occur during a silent period. Therefore, different control conditions were imposed. No large differences were found among the four control conditions. The arousal factor either was not significant in the production of skin resistance responses or all control conditions were

equally influential and the experimental design allows the conclusion of differential responding beyond whatever influence arousal may have had.

There remains the possibility that skin resistance responses were being mediated by another response system, *e.g.*, movement or breathing. Although in this particular study we only monitored skin resistance responses, previous evidence in a variety of laboratories indicates that when these particular response systems are monitored (Birk, Crider, Shapiro, and Tursky, 1966; Van Twyver and Kimmel, 1966) their relationship to the skin resistance response is minimal and in most cases absent. Questioning at the end of the experiment showed that only one subject (BK) felt that his breathing might have influenced the music. All other subjects gave no indication that they might have influenced their skin resistance responses in any manner. It is interesting to note that Gavallas (1968) specifically examined the influence of respiration in operant skin response conditioning and found that it was not a significant factor in her study.

The data presented show that under the conditions of this experiment response rate changes can be interpreted as showing operant conditioning. The records are less clear than records usually obtained with response systems other than the autonomic. After nine or 10 sessions of training with a human subject on such a schedule, using a response such as a bar press, we would expect more control by the schedule. Certainly the experiment by Baer (1960) showed the development of good control even after one session on a similar schedule.

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