PUNISHMENT SHOCK INTENSITY AND BASAL SKIN RESISTANCE¹

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The relationship between punishment shock intensity and basal skin resistance (BSR) was investigated in two sessions with human females selected for their ability to maintain a fairly substantial operant rate under a wide range of shock intensities. In both sessions each button-pressing response was reinforced with a counter tally. Subjects were paid one cent for each 20 counts. In session 1, punishment followed each response during alternate 4-min periods; in session 2 punishment was programmed in all 4-min periods. Shock intensities were presented randomly among the 4-min shock periods, with the restriction that the first three presentations occurred in ascending order. Operant responding showed some suppression at higher shock intensities in session 1, with substantial recovery in most subjects during session 2. Respondent behavior was characterized by greater activity at successively higher intensities, with recovery at all shock levels, especially the lowest levels, apparent during the second session.

The suppressive effects of shock punishment on operant responding are directly related to intensity of the punishing shock. Appel (1963), Azrin (1960), and Kaufman (1964a, 1964b). The present investigation, utilizing human subjects in a free operant situation with contingent shock, was concerned with the extent to which autonomic activity, as measured by basal skin resistance (BSR) changes, reflects the intensity of electric shock punishment.

One difficulty in assessing the relationship between punishment shock intensity and BSR arises from the phenomenon of suppression. In a punishment paradigm, when the subject fails to respond under higher intensities, no shock is delivered. The subject is then, effectively, in a safe period, where it is unlikely that BSR would reflect the programmed shock intensity. The question of whether BSR does reflect the intensity of the programmed shock punishment when behavior is suppressed is an empirical one, as yet unanswered. The present

study sought to assess the punishment intensity—BSR relationship in subjects who responded throughout a fairly broad range of shock intensities. Thus, it was possible to measure BSR when shock was being delivered throughout the session with minimal suppression. It is recognized that this strategy severely restricts the generality of any findings, since subjects are obviously selected on the basis of their ability to respond in the face of shock punishment which produces virtually complete suppression in many other individuals. One advantage is the understanding of operant-respondent interactions in those situations where organisms do respond in the face of severe contingent aversive stimulation.

METHOD

Subjects

Six female college students were used. A job description was placed with the college part-time employment office, indicating that exposure to electric shock was a condition of employment and that remuneration, based on behavior in the situation, averaged about \$3.00 per hour. Subjects contacted the experimenter to arrange schedules.

Apparatus

The experimental booth, measuring 5 ft by 5 ft by 3 ft, was enclosed on three sides. The

¹This investigation was partially supported by U.S. Public Health Service Research Grants Nos. M-2961 and MY 3673. The data was collected while the author was a U.S.P.H.S. Post-Doctoral Fellow at Columbia University under USPHS Grant No. MPD-10,211. I thank Drs. R. Berryman, R. Hefferline, and F. Keller for their continuous support and encouragement and Mr. Brian Keenan and Dr. T. Stern for their invaluable technical assistance. Reprints may be obtained from the author, Dept. of Psychology, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53211.

subject entered through the open rear side and sat facing an upright panel on which were mounted two push buttons and an add-subtract counter. Curtains were drawn across the back to isolate the subject. The booth was illuminated by a 60-w lamp in the right rear corner and ventilated by exhaust and intake blowers in the ceiling. Keys were two black plastic push buttons $\frac{1}{2}$ in. in diameter, separated by about 15 in., and mounted about $2\frac{1}{2}$ in. off the top of the table on which the subject's hands rested.

Output of the shock generator, a 2400-v transformer connected to a variac, ranged from 0 to 2400 v ac. To deliver a shock, voltage was applied to a resistor matrix controlled by a stepping switch. As this switch stepped, it placed the subject in series with decreasing amounts of resistance, thus providing 18 approximately equal increments of current for each shock intensity range defined by the variac setting. The following resistance values, given in kilohms, are for each of the 18 steps in the sequence: 751, 627, 536, 466, 414, 373, 340, 310, 283, 261, 243, 225, 210, 197, 186, 176, 168, and 160.

With these resistance levels, a change of 5 K ohms in internal resistance, representing for most subjects a change of approximately 65 to 100% in their skin resistances, would produce a variation of only 3% at the highest current and .67% at the lowest.

The shock pulses, at a constant duration of 50 msec, were delivered through electrodes placed on the right ankle. Electrodes were two stainless steel discs, $1\frac{1}{4}$ in. in diameter, coated with electrode jelly (Sanborn's Redux), and held firmly on the ankle with a perforated rubber strap. Radiating potential from the shock electrodes was grounded with a large aluminum foil band secured below the right knee (Kaufman, 1964c).

Skin resistance was monitored throughout the two sessions with an Airborne Instruments Laboratory tissue resistance monitor, Model 152. This unit operated by passing an 8 cps square wave through stainless steel electrodes coated with electrode jelly and placed on the palmar and volar surfaces of the subjects' left hands. Voltage changes necessary to maintain a constant current of 20 microamps were indicated as resistance changes.

Programming of the response contingencies and recording of operant responding were

automated through the use of relay circuitry. Basal skin resistance was recorded on an Esterline Angus recording milliammeter.

Procedure

The two sessions each consisted of a number of 4-min periods separated by 1-min TO's. In both sessions each response on the left button was reinforced by a count on the add-subtract counter. The counts cumulated within each 4-min period and the counter was reset to zero at the end of each period. Subjects were paid at the end of each session at the rate of one cent for each 20 counts cumulated on the counter.

During the first session, shock punishment following each response was programmed in only half of the 4-min periods, with the subject able to respond unpunished in alternate 4-min periods. Thus, the first session was composed of a four-ply repeating multiple schedule, the components of which were 4-min CRF, 1-min TO, 4-min CRF PUN, 1-min TO. During the second session, the no punishment component was dropped, and the multiple schedule was reduced to 4-min CRF PUN, 1-min TO. Within each session the variac settings were programmed in random sequence, with the restriction that the first three shock periods during the first session were programmed in ascending order of intensity.

During each shock period, response increased the shock intensity until a maximum intensity was reached at the 18th response. The intensity at any given step in the sequence varied among shock periods as a function of the variac setting. The current value for each successive step within any shock period may be obtained by dividing the voltage output of that period by the 18 resistance values listed earlier. Subjects, at the cost of five counts, could at any time reset the shock to its lowest level and begin the sequence again, or could respond while tolerating the maximum shock intensity. They were also free not to respond at all.

Before each session, subjects were shown the apparatus and the electrodes. They were then seated in the booth and given the following instructions:

"You will notice what happens when I press this left hand button. As you see,

the counter registers a count for each press, and they add up. You will be paid one cent for every 20 counts, and this will be based on the actual counter reading when each period is over. Right now there is no shock connected with this button. When you sit in this chair the electrodes which I showed you before will be attached to your right ankle. That is where you will feel the shock. You will never feel shock anywhere else. The electrodes on your left hand have nothing to do with the shock.

"The total session, which will take slightly more than one hour, will be divided into a number of periods of several minutes each. During some of the periods, and I will tell you which beforehand, you will receive a shock each time you press the left hand button. This is the only time you will receive shock. The shock will increase with each press until it reaches a maximum level. You may return the shock to its lowest level by pressing the right hand button. Each time you do this, however, five counts will be subtracted from your total on the counter. You may practice pressing the buttons now, and you needn't worry about shock, since the electrodes are not attached."

After these instructions and several minutes of practice responding without shock, the session began. If the subject did not respond at a rate of 30 per min or more during the first three shock periods, the session was terminated. For the six of 13 subjects who did meet the response criterion, session length varied between 80 and 100 min, depending on how many shock periods were used.

During each TO period, subjects were told whether there would or would not be shock in the next period. At the end of each 4-min period, the experimenter said "Stop", took the counter reading, reset the counter, cumulative recorder and shock variac, and told the subject about the next 4-min period. Each 4-min period began when the experimenter said "Start". During the 4-min periods, the level of BSR was recorded on the Esterline Angus meter. A potentiometer was used to keep the meter needle on the chart paper within recording range.

RESULTS AND DISCUSSION

The effects of shock intensity on both operant and respondent behavior are summarized in Fig. 1. The upper graphs for each subject show, as might be expected with the response criterion used in selection, only moderate

Fig. 1. The effect of punishment shock intensity on operant rate (top graph for each subject) and BSR (bottom graph for each subject). Note the difference between the ordinates of the BSR graphs for S2 and S4 compared to the others. Subjects 2 and 4 displayed somewhat higher BSR levels than the others and the lower portion of the ordinate has been eliminated for them.

suppression during shock. Even with the selection criterion subjects 2, 3, 4, 5, and 6 all show a substantial lowering of rate at the highest shock intensity in the first session. With the exception of S6, all showed higher response rates during session 2, with S1, S2, and S3 responding throughout the range of shock intensities at a higher rate than under the no punishment periods of session 1. Again, it is not surprising that subjects selected for their ability to respond in the face of shock punishment show virtually complete recovery from the initial effects of such punishment.

The data on shock reset responding, shown in Table 1, mirror the operant rate data:

Table 1

Number of shock reset responses at lower and higher shock levels in each of two sessions.

Subject	Session 1		Session 2	
	Low Shock	High Shock	Low Shock	High Shock
S1	0	3	0	5
S2	0	31	0	0
S3	8	154	1	6
S4	0	0	0	0
S5	4	32	0	76
S6	0	2	102	150

Low shock responses are all resets in all periods of lower half of rank ordered shock intensities. High shock responses are all of the resets during the more intense shock periods. Entries under 10 indicate that the subject tolerated maximum intensity throughout most of the periods.

subjects who used the reset button tended to reset the shock in the higher intensity periods where they showed the lowest operant rates. This finding replicates an earlier one (Kaufman, 1964a), although the number of subjects utilizing the reset button was reduced in this study through the selection of those able to tolerate fairly high levels of shock. Of the subjects who did respond with any frequency on the reset key, *i.e.*, S2, S3, and S5 in session 1 and S5 and S6 in session 2, most of the reset responding came at the higher shock intensities. These subjects showed the major suppressive effects.

The lower graphs reveal a systematic decrease in BSR as a function of increasing shock intensity. The curves for S1 and S3 are somewhat flatter than the others, but again all subjects show some decrease at successively higher intensities. As with the operant rates,

there is a consistent difference from the first to the second session, with all subjects showing higher BSR levels during session 2. Unlike the operant data, the BSR levels during session 2 continue to be affected by differences in punishment shock intensities, even in those cases where response rates at all shock intensities rose above the unpunished level of session one. Even S6, the only subject whose operant responding was more suppressed in session two, shows a higher level of skin resistance in the second session.

It is obvious that the decrease in BSR at higher shock intensities is not a simple function of an increasing number of shocks. Operant responding at the higher shock levels, when compared to the lower, was characterized by the same or lower rates, meaning that if anything, fewer shocks were being delivered at the higher intensity levels. On the basis of shock frequency alone, the BSR might be expected to rise during the higher intensities, reflecting a reduced amount of autonomic activity in the presence of less frequent aversive stimulation. The actual drop observed probably indicates that the magnitude of the skin resistance drop in response to individual shocks at higher intensities is great enough

Fig. 2. Ratios of total number of resistance drops greater than 5% of baseline to total key pressing responses in all periods at same shock voltage. Rising curves indicate a greater average number of large magnitude GSR responses per key press at higher shock intensities.

to offset the decreased shock frequency produced by suppression. One indication of this may be seen in Fig. 2, which shows the ratios of large magnitude GSR drops to total responses as a function of shock voltage. In the curve for S5, it is apparent that the number of large magnitude GSRs per response is greater at the higher intensities, in spite of the fact that S5 responded at greatly reduced rates and thus received fewer shocks at those intensities. The same relationship is evidenced by S6, although the high operant rate she main-

tained during the first session is matched by a relatively flat curve of large magnitude resistance drops at the three lowest shock levels in session one.

Another analysis reveals the role played by recovery within 4-min periods in maintaining the relationship between BSR and shock intensity level. Figure 3, which shows the average BSR at 1-min intervals during periods of the same shock intensity, reveals the sequential pattern of skin resistance changes at each intensity level. The consistent pattern

Fig. 3. Average BSR at sequential points in shock periods of same intensity. Each graph represents for one subject in one session the average resistance at 15 sec, 1 min, 2 min, 3 min and 4 min in periods at the same shock intensity. Curves show varying degrees of recovery within periods in the same session based on intensity level, and also show recovery from first to second session, most apparent at the 840 v level.

indicates that the subject tended to show less recovery of BSR level within 4-min periods as shock intensity increased. Most marked recovery occurred during the no punishment periods of session one and the 840 v periods of session two; both levels represent the lowest end of the shock intensity continuum in the session in which they were programmed. On the other hand, there is virtually no recovery evident in the sequential patterns exhibited at the highest intensity levels, most of the curves being quite flat.

That a good deal of recovery from the initial effect of shock occurred from the first to the second session, matching the increase in operant responding, can be clearly seen in the differences in reaction to the 840 v shock intensity between the two sessions. Whereas the BSR pattern at 840 v during the first session revealed a sharp break after 1 or 2 min, there is virtually no change in the sharply rising resistance level throughout the 840 v periods of the second session.

The results point to several tentative conclusions. First, BSR decreases systematically as a function of punishment shock intensity, presumably mirroring a widespread increase in autonomic activity under increasing aversive stimulation. Second, the effect of shock intensity on BSR is reduced with a second exposure. During the second session all subjects showed higher levels of skin resistance at each shock intensity as compared to the first session. The only exceptions were the 2280 v level for S1 and the 1800 v level for S4, where the second session levels were lower than the first. The second session recovery

of average BSR level was especially evident at the lower shock intensities, a phenomenon which appears to be attributable to the failure of the baseline to level off during the course of the lower intensity periods of the second session, as compared to a consistent pattern of leveling off in the first session. This data, then, indicates that in exposure to varying intensities of shock punishment, there is an initial autonomic reaction to shock which is greater at higher intensities, and later recovery which occurs to a greater degree at lower shock intensities. These conclusions should be restricted to the conditions under which subjects were selected, i.e., those situations in which subjects are able to maintain a fairly substantial rate of responding in the presence of shock punishment varying from 5 to 15 ma.

REFERENCES

- Appel, J. B. Punishment and shock intensity. *Science*, 1963, 141, 528-529.
- Azrin, N. H. Effects of punishment intensity during variable interval reinforcement. *J. exp. Anal. Behav.*, 1960, 3, 123-142.
- Ferster, C. B. and Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Kaufman, A. Effects of punishment intensity on human operant behavior. *Psych. Reports*, 1964a, 15, 287-294.
- Kaufman, A. Increased suppression during punishment applied to the responding member. *Psychon. Sci.*, 1964b, 1, 311-312.
- Kaufman, A. Elimination of shock produced electrical noise from psychophysiological recordings. *J. exp. Anal. Behav.*, 1964c, 7, 14.

Received October 21, 1964