EFFECTS OF PUNISHING ELEMENTS OF A SIMPLE INSTRUMENTAL-CONSUMMATORY RESPONSE CHAIN¹

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Rats were trained to press a lever, with every response reinforced with water. After responding was established, nine rats were administered a brief shock after each lever press, and nine others were shocked after drinking. The two procedures resulted in similar suppression of responding, and examination of the latency data when responding was partially suppressed indicated that under both conditions response suppression was due primarily to an increase in the latency of the instrumental response, rather than to pausing between the instrumental and consummatory responses. Thus, punishment following either the instrumental or consummatory component of the simple response sequence reduced the number of sequences initiated, rather than selectively suppressing the punished behavior.

Changes in rate of responding for food or water in a simple, continuous reinforcement, free-operant situation may be due to variation in either the latency or the duration of either the instrumental response or the consummatory response. Thus, suppression of responding by punishment may be due to increases in the amount of time spent performing the instrumental response, between the instrumental response and the consummatory response, performing the consummatory response, or between the consummatory response and the instrumental response. Punishment could be made contingent upon any components of the behavior sequence, although in laboratory experiments it is almost always contingent upon performance of the instrumental response. It is possible that punishment of different components of the response sequence might have different overall suppressive effects in terms of the total number of response sequences completed, and also might differentially affect the durations of various components of the sequence.

Solomon (1964), on the basis of the scant evidence then available, suggested that consummatory acts are more readily suppressed by punishment than are instrumental acts. A number of more recent studies (see Myer, 1971, for review) have clearly shown that a variety

of consummatory and species-typical behaviors can be suppressed by punishment, but because of procedural variations it is difficult to compare these studies with more traditional experiments on punishment of instrumental behaviors. Comparisons of punishment of instrumental and consummatory behavior in simple learning situations have yielded rather contradictory results. Bertsch (1972), employing rats in a free-operant situation with a water reinforcer, found punishment of the first lick after a reinforced lever press produced more suppression of both pressing and licking than punishment of lever pressing. Church (1969), trained rats to press a lever in a chamber in which the food reinforcer was delivered to a cup mounted on the wall opposite the bar. After responding was established, some of the rats received a mild shock after each lever press, and others were shocked as they seized the food pellet. Both punishment conditions reduced response rates, and punishment of the instrumental response produced considerably more suppression of responding than punishment at the beginning of the consummatory response. DeCosta and Ayres (1971), employing a conditioned suppression paradigm, also found greater suppression of lever pressing than of the consummatory response, licking at a dipper. Feirstein and Miller (1963), reported that rats previously trained to run an alley for food, and then presented an intense shock at the middle of the alley on each trial, displayed more suppression than rats that were shocked after they reached the food. Two other groups

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of rats also were shocked either at the middle of the alley or in the goal box, but the intensity of the shock was slowly increased over a number of trials, with shock trials interspersed with non-shock trials. Under these conditions, shock in the food area was more suppressive than shock at the center of the alley.

Little attention has been addressed to the question of whether the effect of punishment is to suppress selectively the punished element of the instrumental-consummatory response chain or to interfere with initiation of the chain. Church (1969) measured the amount of time that elapsed between the instrumental and the consummatory response (consummatory response latency) and the amount of time between the consummatory response and the instrumental response (instrumental response latency). He found that punishment of the instrumental response resulted in an increase in instrumental response latency, and that punishment of the consummatory response resulted in an increase in consummatory response latency. These observations suggest that the major effect of punishment is to suppress the particular component of the behavior sequence that is punished, rather than having a general effect of reducing the number of sequences initiated.

Church's results are somewhat surprising if one views the effects of punishment simply as the opposite of those of reinforcement (Logan, 1969; Rachlin and Herrnstein, 1969). Such a view suggests that superimposing punishment on positive reinforcement is analogous to reducing the magnitude of reinforcement, and should reduce the rate of instrumental responding by interfering with the initiation of the response sequence. The present experiment was conducted to compare the effects of punishment administered after the instrumental response with the effects of punishment administered after the consummatory response on the latencies of the components of a simple sequence of instrumental and consummatory behavior.

METHOD

Subjects

Female Long-Evans hooded rats, from a colony maintained by the author, were 5 to 6 months old, and weighed 253 to 317 g at the beginning of the study. They were individually

caged and totally deprived of water for five days, then were given sufficient water each day to reduce them to and maintain them at 80% of their pre-deprivation body weights. Purina laboratory chow pellets were continuously available in the living cages.

Apparatus

The rats were trained in 7.5 by 9 by 8 in. (19 by 24 by 20 cm) high chambers with a lever and a dipper mounted at one end. The dipper was mounted behind a 2.25-in. (5.5-cm) diameter opening centered 1.5 in. (3.25 cm) to the left of the left edge of the 2-in. (5-cm) wide lever, which was mounted at the center of the wall. When a rat inserted its head in the opening, a beam of light that normally fell on a photocell was interrupted, closing a relay. Pressing the lever raised a 0.025-ml capacity water cup to a point immediately behind and below the light beam, where it remained until the photocell relay closed and opened again. Thus, the dipper was accessible from the occurrence of a lever press until the animal withdrew its head from the drinking area. If the lever was pressed several times without interruption of the photocell beam, the dipper simply remained raised from the first press until the photocell relay was closed and opened. Four identical units were employed, and were enclosed in sound-attenuating boxes.

Procedure

Daily sessions of 15 min in the lever boxes began 10 days after water deprivation was instituted. Responding was hand shaped for periods ranging up to 12 days, at which time 18 rats that were responding reliably were selected for further study. The rats were given 15-min sessions with continuous water reinforcement for the next 16 days, after which they were assigned to two groups, matched on the basis of the median response rate of each animal on the last three days of the pre-punishment period. Beginning the next day, 15-min sessions with water reinforcement for every response continued, and punishment was introduced. In the punishment sessions, Grason-Stadler model E1064GS shock generators and scramblers were used to administer shock through the grid floors of the chambers. The rats in one group received shock contingent upon termination of the instrumental response, lever pressing (Group I), and the remaining rats re-

ceived shock upon termination of the consummatory response, drinking (Group C). Shock was administered to the rats in Group I when the lever was released, and to the rats in Group C when the photocell relay opened.

As the primary aim of the study was to compare the latencies of the instrumental and consummatory responses during partial suppression, a procedure of gradually increasing shock intensity over successive daily sessions was followed. This assured that no animal would either fail to display any suppression or would be so completely debilitated by punishment that it would fail to respond at all, as might happen if a fixed shock intensity were employed. Shock duration was always 0.2 sec, and intensity on the five successive daily 15-min punishment sessions was 0.15, 0.20, 0.25, 0.30 and 0.40 mA, respectively.

RESULTS

Figure 1 shows the mean number of instrumental-consummatory response sequences that occurred on the last three pre-punishment days and the five days of punishment. As the figure shows, both punishment conditions produced an increased degree of response suppression over successive sessions, and punishment of lever pressing (Group I, broken function) produced slightly more response suppression than punishment of drinking (Group C, solid function). An analysis of variance indicated that the decline in responding over days was statis-

tically significant ($F = 44.32$, $df = 4/64$, $p < 0.005$), whereas neither the effects of location of punishment in the response sequence nor the interaction term attained statistical significance ($F = 2.72$, $df = 1/18$, $0.10 > p > 0.25$; $F = 2.21$, $df = 4/64$, $0.05 > p < 0.10$).

The latency data of primary interest were those obtained when responding was partially, but not severely, suppressed. Accordingly, a "pre-punishment control session" and a "partial suppression session" were selected for each animal, and the latency data for these sessions were examined in detail. The control session was that one of the last three sessions of the pre-punishment period in which the median number of responses for the three-day period occurred. The partial suppression session selected for each rat was the one in which the number of responses was nearest 50% of the number of responses emitted during the control session. For the instrumental response punishment condition these values ranged from 24 to 60%, and for the consummatory response punishment condition they ranged from 20 to 62%.

Pressing Latencies

The pressing latency is the time that elapsed from the time the rat withdrew its head from the drinking cup until it again pressed the lever. Cumulative frequency distributions of the pressing latencies on the control and partial suppression days for three rats in Group I are illustrated in the top row of Figure 2, and similar distributions for three rats in Group C appear in the second row. The subjects selected for illustrative purposes were those that displayed the highest, the median, and the lowest per cent suppression in their partial suppression sessions. In the control condition (broken functions), the individual pressing-latency distributions were strikingly similar. Almost all of the latencies fell within a range of 0.4 to 1.0 sec, with occasional latencies of greater magnitude ranging up to several seconds. Of a total of 3852 pressing latencies analyzed in the control condition, 318 were longer than 1 sec, including 45 longer than 5 sec. Typically, the rats responded in bursts, rapidly moving between the cup and the lever, then paused for a few seconds before resuming responding. The median pressing latencies of the 18 rats during the pre-punishment tests ranged

Fig. 1. Mean number of instrumental-consummatory response sequences initiated on the last three days of training and five days of punishment of the consummatory response (Group C, solid function) or the instrumental response (Group I, broken function).

Fig. 2. Per cent frequencies of latencies of lever pressing (top two rows) and drinking (bottom two rows) cumulated over 0.1-sec intervals during a control session (broken functions) and a session when responding was partially suppressed by punishment (solid functions). I15, I8, and I6 were shocked after performance of the instrumental response, and C23, C20, and C1 were shocked after performance of the consummatory response. Fractions indicate ratio of responses in the punishment session to responses in the control session.

from 0.4 to 0.8 sec. Because of the occasional pauses, the means were somewhat higher, ranging from 0.48 to 1.78 sec.

When responding was suppressed by punishment, the individual pressing-latency distributions of both groups were flatter, although

Table 1

Comparisons of latency distributions of groups punished after instrumental response (I) and consummatory response (C).

Measure	Press Latencies				Drink Latencies			
	Median		Mean		Median		Mean	
	C	I	C	I	C	I	C	I
Median Latency in sec: Control	0.5	0.6	0.57	0.54	0.4	0.4	0.47	0.41
Median Latency in sec: Punishment	0.9	1.0	1.55	1.64	0.6	0.5	0.57	0.53
Per cent Over 1 Sec: Control	6.7	10.5	8.2	10.2	0.7	0.3	1.2	0.4
Per cent Over 1 Sec: Punishment	46.1	43.4	44.7	50.6	10.0	1.8	11.5	8.2
Per cent Over 5 Sec: Control	0.9	1.7	1.1	1.4	0.0	0.0	0.3	0.0
Per cent Over 5 Sec: Punishment	8.0	7.6	15.6	16.7	0.9	0.0	3.2	0.2

most of the latencies were still below 5 sec. Most of the rats exhibited several long pauses before returning to the lever after drinking. As latencies longer than 10 sec are not shown in Figure 2, some of the cumulative frequency distributions do not reach 100%. The long pauses increased the mean pressing latencies of the rats in the instrumental response punishment condition to a range of 1.79 to 10.22 sec, and those of the rats in the consummatory response punishment condition to a range of 2.25 to 19.78 sec. Because of skewness and the presence of a few extremely deviant scores in the distributions, several different comparisons of the two groups were undertaken, and are summarized in Table 1. Mann-Whitney U tests were used to test for significance of differences between the two groups in these various measures, and none approached statistical significance. Sign tests applied to the pressing-latency data summarized in Table 1 indicated that the increases from control to punishment sessions on all six measures were statistically significant under both punishment conditions.

Drinking Latencies

Drinking latency refers to the time that elapsed from the time the rat released the bar until it inserted its head into the drinking area. The lower half of Figure 2 shows the drinking latencies for the six rats whose pressing latencies appear in the upper half of the figure. In the control sessions, the median drinking latencies for the individual animals ranged from 0.3 to 0.7 sec, and only 26 of the 3852 drinking latencies were over 1 sec. When responding was partially suppressed by punishment, there was some increase in the drinking latencies, but the effect was small as compared

with that which occurred with the pressing latencies. Although the average drinking latencies increased somewhat during punishment relative to the control session, the reduction in the number of response sequences initiated resulted in decreases in the total amount of time spent between the lever and the cup for all but one rat. The drinking latencies were analyzed in the same manner as the pressing latencies, and the results are summarized on the right in Table 1. Mann-Whitney U tests failed to reveal statistically significant differences between the two punishment conditions on any of the measures. Sign tests indicated that within both punishment conditions, the increases in drinking latencies summarized in Table 1 were statistically significant on all measures except per cent of latencies greater than 5 sec, in which case the large number of zero scores in both the control and punishment sessions precluded analysis.

Drinking Duration

The duration of a bout of drinking was the period of timing during which the rat's head interrupted the beam of light projected on the photocell, and, accordingly, the period of time during which the dipper was accessible to the animal. In the control period, the mean drinking duration was 3.08 sec, and the median was 2.62 sec. During punishment, all but one rat displayed increased median drinking durations. The mean and median increases in median drinking latencies for Group I were 1.72 and 1.70 sec, respectively, and the corresponding values for Group C were 2.22 and 2.10 sec. Mann-Whitney tests indicated that the two groups did not differ significantly in the increase in median drinking duration.

Because of the reduction in the number of bouts of drinking during punishment relative to the control session, the total amount of time spent drinking was lower during punishment for all but three rats.

Press Duration

Lever-press duration was not directly measured, but mean lever-press durations were obtained by summing the durations of the other three components of the sequence, subtracting from total session length of 900 sec, and dividing by the number of responses. In the control condition, the mean press durations ranged from 0.16 to 0.45 sec for the rats in Group I, and from 0.22 to 0.41 sec for the rats in Group C. During partial suppression, the corresponding ranges were 0.24 to 0.41 sec and 0.19 to 0.44 sec. There were no significant differences between the two groups in mean of mean lever-press duration in either the control or the punishment condition, nor was there a significant difference between the means of the control and punishment conditions for either group.

DISCUSSION

In the present experiment, punishment after the instrumental response and punishment after the consummatory response had similar effects on the initiation of an instrumental-consummatory response sequence. Under both conditions of punishment there was a suppression of responding that was due primarily to an increase in the time that elapsed between the initiation of the consummatory response and the initiation of the next instrumental response. This delay in the initiation of the instrumental response was due to an increase in the amount of time that elapsed after withdrawal from the drinking area, and also to an increase in the length of time the animals' heads were in the drinking area. Under both conditions of punishment there was also a small increase in the latency of entering the drinking area after the lever was pressed.

The finding that during punishment sessions the animals in both groups displayed a substantial and similar increase in the average length of time they kept their heads in the drinking area was rather surprising. Had the increase been displayed only by the rats punished upon removing their heads from the

area, the interpretation would be obvious. However, the rats punished after lever pressing also increased their "drinking durations", and the only rat that did not display some increase in the mean duration of the drinking bouts was one that was punished after drinking. In view of the small amount of water contingent upon each response, the increase in "drinking duration" probably was due to pausing before withdrawing from the drinking area, rather than to an actual increase in the time spent consuming the water. If so, such pausing might be considered as summing with the increase in pressing latencies in delaying the initiation of the next behavior sequence.

In the present experiment, the water dipper was very close to the lever, so the animals were able to alternate rapidly between the two. Punishment at different points in the sequence of behavior reduced the number of sequences initiated, but had only a small effect on the time that elapsed between depressing the lever and entering the drinking area. This finding is reminiscent of the effects of punishment on short sequences of instrumental responses with low interresponse times. For example, the primary effect of punishment of responding maintained by fixed-ratio schedules of positive reinforcement is to increase the pause characteristically exhibited after reinforcement, rather than to increase interresponse times within the ratio run (Azrin, 1959; Dardano and Sauerbrunn, 1964). Similarly, Migler and Brady (1964) found that conditioned suppression of a sequence of two instrumental responses, the second of which was reinforced, was due to a reduction in the number of sequences initiated, rather than to an increase in the time intervening between the two responses. By contrast, Church (1969) found a selective effect of punishment on the punished component of an instrumental-consummatory response chain in a situation in which the component responses were spatially separated.

As indicated in the introduction, Bertsch (1972) found consummatory response punishment more suppressive than instrumental response punishment, Church (1969) obtained the opposite result, and Feirstein and Miller (1963) obtained both results, depending upon the intensity and frequency of punishment. In the present experiment, there was little difference in the suppressive effects of shock con-

tingent upon lever pressing and shock in the drinking area. Numerous differences in procedure among these experiments preclude any generalization concerning the source of these discrepant results. It should be noted, however, that in all of these studies the behavior that immediately preceded "consummatory response punishment" was some instrumental component of the behavior sequence, rather than the consummatory behavior itself. Feirstein and Miller (1963) and Church (1969) punished approach to food, Bertsch (1972, Experiment 2) punished the first lick at the drinking tube after a reinforced lever press, and in the present study, punishment was contingent upon withdrawing from the drinking area. The effects of punishment administered during the occurrence of the consummatory component of an instrumental-consummatory response sequence remain to be determined.

REFERENCES

- Azrin, N. H. Punishment and recovery during fixed-ratio performance. *Journal of the Experimental Analysis of Behavior*, 1959, 2, 301-305.
- Bertsch, G. J. Punishment of consummatory and instrumental behavior: Effects on licking and bar pressing in rats. *Journal of Comparative and Physiological Psychology*, 1972, 78, 478-484.
- Church, R. M. Response suppression. In B. A. Campbell and R. M. Church (Eds.), *Punishment and aversive behavior*. New York: Appleton-Century-Crofts, 1969. Pp. 111-156.
- Dardano, J. F. and Sauerbrunn, D. Selective punishment of fixed-ratio performance. *Journal of the Experimental Analysis of Behavior*, 1964, 7, 255-260.
- DeCosta, M. J. and Ayres, J. J. Suppression of operant vs. consummatory behavior. *Journal of the Experimental Analysis of Behavior*, 1971, 16, 133-142.
- Feirstein, A. R. and Miller, N. E. Learning to resist pain and fear: Effects of electric shock before versus after reaching goal. *Journal of Comparative and Physiological Psychology*, 1963, 56, 797-800.
- Logan, F. A. The negative incentive value of punishment. In B. A. Campbell and R. M. Church (Eds.), *Punishment and aversive behavior*. New York: Appleton-Century-Crofts, 1969. Pp. 43-54.
- Migler, B. and Brady, J. V. Timing behavior and conditioned fear. *Journal of the Experimental Analysis of Behavior*, 1964, 7, 247-251.
- Myer, J. S. Some effects of noncontingent aversive stimulation. In F. R. Brush (Ed.), *Aversive conditioning and learning*. New York: Academic Press, 1971. Pp. 469-536.
- Rachlin, H. and Herrnstein, R. J. Hedonism revisited: On the negative law of effect. In B. A. Campbell and R. M. Church (Eds.), *Punishment and aversive behavior*. New York: Appleton-Century-Crofts, 1969. Pp. 83-110.
- Solomon, R. L. Punishment. *American Psychologist*, 1964, 19, 239-253.

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