SOME BEHAVIORAL EFFECTS OF A CONCURRENTLY POSITIVE AND NEGATIVE STIMULUS[1]

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An experimental organism may adjust in several ways when one of its responses is both rewarded and punished. Two extreme adjustments are: (a) the subject may stop responding, thereby preventing both reward and punishment; and (b) the subject may persist in its response, thereby continuing to produce both reward and punishment. Between these extremes are many possible intermediate effects which may be observed by manipulating such variables as frequency or magnitude of reward and punishment, and deprivation (Miller, 1959).

In the present experiments, two levers were available to the subjects. They were sometimes rewarded and sometimes punished for pressing the first lever. Pressing the second lever brought them into a neutral situation where they could receive neither rewards nor punishments. Though escape responding of this sort would appear to have effects similar to alternative (a) above, i.e., in its prevention of rewards and punishments, the subjects possibly would "prefer" a neutral situation to one which is concurrently positive and negative. Escape from a "conflictful" situation might in itself be positively reinforcing.

The present study will illustrate a variety of effects obtainable with this procedure. The experiments may be considered more exploratory than definitive, since we have not been able to identify the relevant variables precisely enough to produce similar effects in all subjects.

METHOD

Subjects

The subjects were 10 experimentally naive, albino rats, 90–100 days old at the beginning of experimentation. Rats AW-40 through AW-43 were laboratory-bred descendants of the Wistar strain, and Rats AA-1 through AA-6 were descendants of Sprague-Dawley stock. All subjects were maintained throughout the experiment at 80% of their normal, free-feeding weights by the use of condensed milk reinforcements during experimental sessions and supplementary Purina rat pellets.

Apparatus

The experimental box was a commercially produced model (Foringer), and its essential features have been described elsewhere (e.g., Herrnstein & Brady, 1958). The levers were two modified telegraph keys. Milk rewards, each 0.1 milliliter presented for 3 seconds, were delivered by a motor-driven dipper located below and midway between the two levers. The milk solution was an equal mixture of sweetened condensed milk and tap water. A clicking noise and tone (Foringer Multiple Stimulus Panel No. 1166-1) were used as stimuli when appropriate. Programming of shocks, reinforcements, stimuli, etc., was achieved automatically through a system of timers and relays. Sodeco counters and a Gerbrands cumulative recorder provided records of performance.

Procedure

All 10 subjects received essentially the same preliminary training, but were subsequently run on several different experimental procedures. During preliminary training, subjects were rewarded on a variable-interval schedule for pressing Lever A whenever one stimulus (S^D) was on, and were never rewarded when another stimulus (S^Δ) was on. The VI tape ran only during S^D throughout all phases of the experiment.

For Rats AW-40 through AW-43, S^D was a tone and S^Δ a period of silence. The 5-minute S^D periods alternated with 15-minute S^Δ periods, and the variable-interval schedule in effect during S^D had a mean interval of approximately 2 minutes. Rats AA-1 through AA-6 were exposed to alternations of 2-minute silent periods (S^D) and 6-minute clicker periods (S^Δ) with a 1-minute VI in effect during S^D. Lever B was not present in the box during discrimination training.

After 75–100 hours of experience in this discrimination situation, all subjects attained a high degree of proficiency, characterized by rapid responding on Lever A when S^D was on and very low response rates in S^Δ.

With 8 of the 10 subjects, attention was then centered on a situation in which the animals were punished (mild grid shocks, less than 0.5 milliampere in intensity) as well as rewarded for pressing Lever A when S^D was on. The variable-interval schedule still determined the availability of milk, but, in addition, the animal was shocked for every nth response on Lever A. Pressing Lever A, then, had two consequences for the animal: (1) occasional milk rewards, programmed by a variable-

interval schedule; and (2) occasional shocks, programmed concurrently by a fixed-ratio schedule.

Along with the initiation of the concurrent food and shock schedules on Lever A, Lever B was also made available to the subject. Lever B had only one function. If the animal pressed Lever B when S^D was on, S^D was terminated and replaced by S^Δ for a fixed period of time. During S^Δ, Lever A was nonfunctional; the animal could produce neither food nor shock. Each session began with S^D, and S^Δ's occurred only as a result of Lever B responses; if subjects never pressed Lever B, S^D remained on throughout the entire session.[2]

When the animal terminated S^D by pressing Lever B, it in no way affected the number of Lever A responses remaining before the next shock. For example, if the subject was due for a shock after 10 more Lever A responses in S^D, production of S^Δ did not change this contingency, since the next S^D began with shock scheduled after 10 responses. One of the two remaining subjects (AW-41), however, was exposed to a procedure in which it not only produced S^Δ by pressing Lever B but also reset the counter that programmed the shock. Results from this procedure are described in a later portion of this report.

Another animal (AA-2) persisted in producing S^Δ's even when no shock contingency had ever been in effect in S^D. The subject was continued permanently on procedures without shock to check on possible reasons for this sort of escape behavior.

Different animals of the eight in the major experiment were exposed to several different fixed-ratio schedules for shock, S^Δ lengths, mean inter-reinforcement intervals on the variable-interval schedule, shock intensities and durations, etc. Specific procedures or differences in procedure from animal to animal will be discussed in the context of individual results.

Experimental sessions were 6 hours for Rats AW-40 through AW-43 and 4 hours for Rats AA-1 through AA-6.

RESULTS

Of the eight subjects exposed to the concurrent VI punishment contingency in S^D and given the opportunity to escape into S^Δ by pressing Lever B, four (AW-40, AW-43, AA-4, and AW-42) clearly showed the development of S^D escape behavior. The data of AW-42 however, are complicated by the possibility that the tone used as S^D was aversive.

Figures 1, 2, 3, and 4 summarize the specific procedures and results for each of these four subjects individually. The first panel of Fig. 1–4 shows the number of time-out periods produced by each subject during the final five sessions of the initial procedure; if subjects pressed Lever A in the presence of S^D, they were concurrently rewarded with condensed milk on a variable-interval schedule and punished on a fixed-ratio schedule. Since each S^Δ was fixed at 15 minutes for the 6-hour-session animals and at 10 minutes for the 4-hour-session animals, the maximum number of time outs possible per session was 24. It can be noted that all subjects showed a strong tendency to "escape" into S^Δ, the number of time outs per session averaging between 16 and 20 at the end of this experimental phase.

To further isolate the variables responsible for S^D escape behavior, Rats AW-40, AW-43, and AA-4 (Fig. 1–3) were put through a series of control procedures. First, either the shock or reward component for Lever A responding in S^D was removed. Then both components were reinstituted, and, finally, the other component was removed. With the removal of either component alone, the animals produced many fewer time outs per session. This effect usually occurred within a session or two after the procedural change. Only when the subjects were both rewarded and punished for pressing Lever A during S^D did they produce a very large number of time outs per session, a result which was completely reversible and could be recaptured after the tests with either component alone.

Neither reward nor punishment alone, therefore, can account for S^D escape behavior in these animals. Rather, some sort of interaction between the positive and negative aspects of the S^D situation seems to be the important factor.

Each subject was also exposed to several other variations in the experimental parameters. After AW-40 had demonstrated S^D escape behavior when it had to press Lever B only once to produce each time out (first five panels, Fig. 1), successively larger numbers of responses (FR's) were required on Lever B to produce time outs. As the final panels of Fig. 1 show, the subject adjusted to FR's of 2, 3, 4, 5, and 6 by an increase in Lever B responding sufficient to keep the number of time outs per session at a relatively stable and high value.

Before completion of experimentation with Rat AW-40, all consequences for Lever B responding were eliminated; S^D remained on for the entire session, since the animal could no longer produce S^Δ's by pressing Lever B. Under these conditions, the subject pressed Lever A at a significantly lower rate than previously, so that the number of shocks per session did not increase very much over former levels (up from 4 to about 6). As a result of Rat AW-40's adoption of a slow, steady rate of response, it received approximately twice as many milk reinforcements per session as it did during prior sessions when S^D was terminated often. This finding shows that the subject could have maximized rewards and not affected shock density too greatly by keeping S^D on continuously in the previous

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[2]The AW animals were placed on this general procedure immediately after discrimination training. The AA animals were first put in a situation where VI 2 minutes or VI 1 minute was in effect in S^D (with no shock contingency) and "operant-level" production of S^Δ's noted. None of these subjects produced S^Δ's very frequently, *i.e.*, more than three or four times per session. See AA-2, however, for an example of an animal which did.
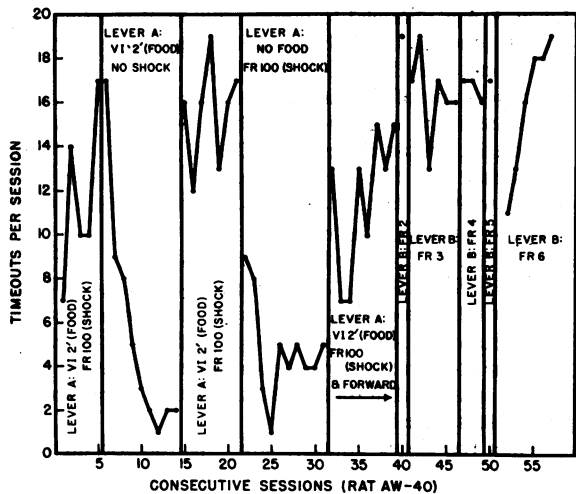
Fig. 1. Number of time outs per session produced by Rat AW-40 under the different experimental procedures.

Fig. 3. Number of time. outs per session produced by Rat AA-4 under the different experimental procedures. All conditions are for Lever A.

situation, where escape was possible. However, when given the opportunity to escape from the positive-negative aspects of the situation, the subject consistently did so.

After Rat AW-43 had demonstrated S^D escape behavior, the FR for shock was increased from 200 to 500 (Fig. 2). There was an initial decline in S^D terminations, but the animal subsequently recovered its former levels. When the shock component was then removed, the number of S^D terminations eventually declined to a much lower but not particularly stable value.

The last three panels of Fig. 3 show the results of changes in the mean interval of the VI schedule for Rat AA-4. This subject terminated S^D's most often

under the shortest VI, suggesting that an increase in the tendency to depress Lever A (indicated by a higher rate on shorter VI's) may make S^D conditions even more aversive.
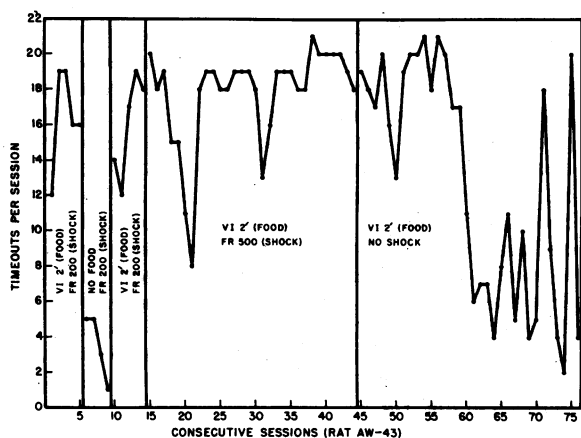

Fig. 2. Number of time outs per session produced by Rat AW-43 under the different experimental procedures. All conditions are for Lever A.

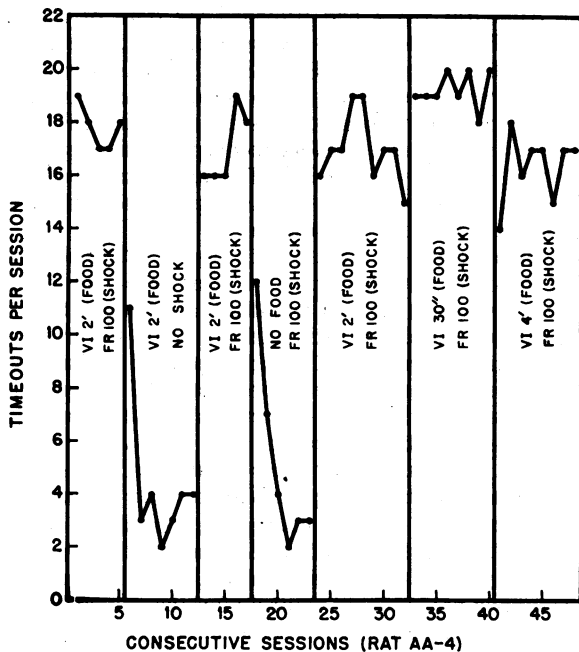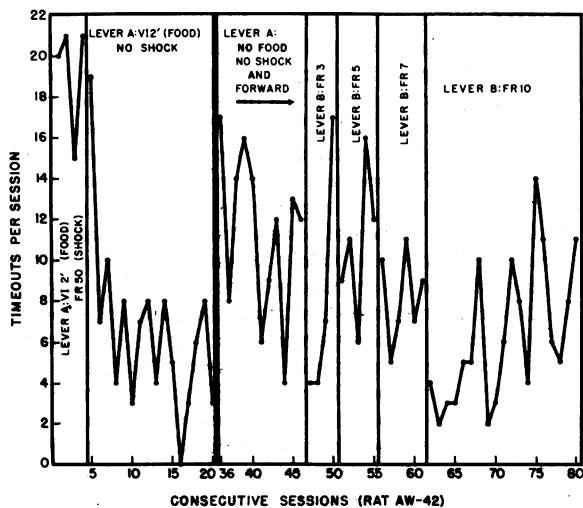Fig. 4. Number of time outs per session produced by Rat AW-42 under the different experimental procedures. At the vertical double line, 15 sessions are omitted, during which satiation tests were occasionally given.

After Rat AA-4 had provided the data of Fig. 3, Lever B responding was extinguished; i.e., presses on Lever B no longer produced S^Δ's. Like Rat AW-40, this subject subsequently responded on Lever A at a steady pace throughout the session and received about three times as many reinforcements per session as it had when S^D escape was possible. The number of shocks per session rose from its previous average of 1 per session to a mean of about 3.5 per session.

Data for AW-42 are shown in Fig. 4. Close analysis of the daily records during the time when the shock component was omitted revealed that whatever S^D terminations did occur were likely to come towards the end of a session, when the subject seemed to have become satiated on milk reinforcements. To check this observation further, the subject was permitted to drink condensed milk to satiation prior to several experimental sessions. Under these conditions, the subject terminated S^D more frequently than when it had been food-deprived. These findings suggested the possibility that the tone used as S^D may itself have been somewhat aversive for this subject, with the aversion assuming predominant control after the animal's tendency to press Lever A had been reduced by food satiation. Both the reward and shock contingencies were then eliminated, and the only effect of Lever B responses was escape from the tone for 15 minutes. The subject terminated tones quite frequently under this procedure and continued to do so even when successively larger FR's (up to FR 10) were required on Lever B. (See Fig. 4.) Although it is true that the subject most consistently and frequently produced time outs when the concurrent reward and punishment procedure was in effect (first panel, Fig. 4), the apparent aversiveness of the tone itself renders interpretation of a complicated situation even more complicated.

The observation that the subjects of Fig. 1–3 no longer produced S^Δ's when no reward was given during S^D is strong evidence that the physical properties of S^D (the same tone for Rats AW-40 and -43, a silent period for Rat AA-4) were not aversive for these subjects. This observation also appears to eliminate the possibility that the physical properties of S^Δ, or "stimulus change," were in themselves positively reinforcing.

Rat AA-2 was completely anomalous. This animal continued to produce frequent time outs even though no shock was ever administered to it, i.e., only positive reinforcement schedules were in effect during S^D. Numerous experimental manipulations were attempted: The time out was increased from 10 to 30 minutes; the VI interval was raised from 1 to 2 minutes; the reinforcement schedule was changed from VI to FR 55, then to FR 13, and subsequently to extinction; the animal was deprived of food for as long as 70 hours; Lever B responses were extinguished for 8 sessions, i.e., these responses no longer produced S^Δ. None of these operations reduced the frequency with which the animal pressed Lever B. When the reinforcement schedule for

Lever A was changed to continuous reinforcement, the animal produced slightly fewer S^Δ's per session but still spent more than 50% of its time in S^Δ.

Observation of the cumulative records of Rat AA-2 during sessions when VI schedules were in effect revealed that almost all terminations of S^D occurred after the animal had been responding for a relatively long period without reinforcement, i.e., during one of the longer intervals on the VI tape.

Rats AA-1, -3, -5, and -6, which had silence as S^D and clicker as S^Δ (just like AA-4 above but unlike AW-40, -42, and -43, which had tone as S^D and silence as S^Δ), never showed stable and strong tendencies to escape from the concurrent reward-punishment situation, even though many different values of the experimental parameters were tested.

When the shock contingency (FR 100 for all these animals) was added to the reward contingency, response rates in S^D for all four subjects dropped and stabilized at about 25% of their former values. Number of reinforcements per session did not suffer a similar decrement, however, since the slow, steady VI rate adopted by each subject ensured up to 80–90% of the previous total reinforcements. Each of these subjects occasionally terminated 5 or 6 S^D's per session, but for the most part S^D was left on for the entire session and virtually no Lever B responses occurred.

Several values of FR for shock, VI mean interval for milk reward, shock intensities and durations, and lengths of S^Δ were used with each of these subjects in an attempt to determine "optimal" reward-punishment values for each individual. No subject reacted to any of these experimental changes by producing a significantly greater number of S^Δ's. As might be expected, however, decreases in the FR for shock and increases in shock intensity and duration led to decreases in S^D response rate on Lever A; conversely, increases in FR for shock and decreases in shock intensity and duration facilitated response rates on Lever A.

Before experimentation with these subjects was terminated, the procedure was changed so that the animals were punished for *every* Lever A response in S^D, and the shock intensity and duration were raised gradually from a minimal value, to which the subject gave little or no overt response, up to a value which clearly produced vigorous escape attempts. Responses on Lever A continued to be reinforced on VI 30 seconds, and depression of Lever B in S^D produced 30-second time outs (clicker, as before). Most subjects reacted to several of the higher shock values by producing more S^Δ's than usual, i.e., 4 or 5 instead of one or two, but the production of S^Δ's was variable and unstable and clearly did not even approach the same order of magnitude as that of the four subjects whose data are summarized in Fig. 1–4.

Escape Response Also Resets FR for Shock

After initial discrimination training, Rat AW-41 was placed on a procedure exactly like that of the other AW

subjects, except that when it pressed Lever B during S^D, it not only produced S^Δ but also reset the FR for shock back to zero. The animal could avoid all shocks by terminating S^D before it had pressed Lever A sufficiently often to complete the FR for shock. Each S^D period (after 15 minutes of S^Δ) began with the number of responses until the next shock set at its maximum value.

This subject very rapidly learned to press Lever B, thereby terminating S^D and resetting the ratio for shock. During the last five sessions (first panel, Fig. 5), it produced approximately 15 time outs per session and received no more than 1 or 2 shocks per session for well over 600 Lever A responses in S^D.

When the reset function was removed and this animal was therefore on exactly the same general procedure as AW-40, -42, and -43, S^D terminations fell to a low value. The second panel of Fig. 5 shows the last 5 sessions on this procedure. The animal again produced frequent S^Δ's when the resetting function of Lever B responses was reinstituted (third panel of Fig. 5). Punishment extinction (i.e., no shock) had an effect similar to removal of the "reset," the number of time outs per session decreasing markedly, as the fourth panel shows.

The final panels of Fig. 5 show the effects of varying the FR for shock. When the FR for shock was increased from 100 to 500, the animal produced fewer time outs, as was the case when shock was eliminated completely. There was little difference between FR 50 and FR 100. Productions of S^Δ never regained their earlier, higher levels (i.e., on FR 100) after exposure to FR 500.

Lever A response rate in S^D was highest under the "no shock" condition, and lowest under the "non-reset" procedure, although both of these procedures produced the smallest number of S^Δ's per session. Response rate in S^D was highest for FR 500 and lowest for FR 50, with the FR 100 condition producing an intermediate rate.

A print-out counter provided fragmentary data concerning the number of Lever A responses from the time of S^D presentation until the animal reset the FR for shock by pressing Lever B (FR 100, 10 sessions during the fifth panel of Fig. 5). The modal number of responses per S^D (or, equivalently, between "resets") was approximately 50 responses, which indicates that the subject usually reset the FR shock value far in advance of the FR 100 maximum.

DISCUSSION

Approximately half of our subjects exhibited clearcut conditioning of a response which permitted them to terminate a stimulus situation in which another response was concurrently rewarded and punished. The escape response did not occur under conditions of either reward or punishment alone. Other subjects adjusted to the situation by adopting a much slower response rate in S^D and rarely, if ever, escaped into the neutral S^Δ condition.

Although the FR punishment contingency had a suppressive effect on VI responding, the resulting slow VI rates still ensured the subjects a reasonable number of reinforcements. If the reward schedule had been a ratio rather than an interval contingency, a slow response rate would have procured the subject only very few reinforcements. Perhaps a combination of VI reward and VI punishment, or VR reward and VR punishment, would have been more "conflictful," since changes in rate on Lever A would then have had equivalent effects on food and shock frequency; such combinations certainly merit comparison, as far as S^D escape responding is concerned, with the reward-punishment contingencies used in the current study.

Shock density is another variable which was only superficially considered in the present design. Decreases in mean VI interval (with the FR shock held constant) would, if the subject reacted to the greater likelihood of reward with an increased rate, increase the number and density of shocks as well. In this connection, it must be noted that when VI extinction was programmed with FR shock retained in Fig. 1–4, extinction of Lever A responding because of lack of reward also led to a virtual absence of shocks. It may have been misleading, therefore, to label the procedure as "FR shock, VI extinction" since (as extinction progressed rapidly) practically no shocks were received either. For this reason, an interval schedule of shock ought to be studied in combination with an interval contingency for
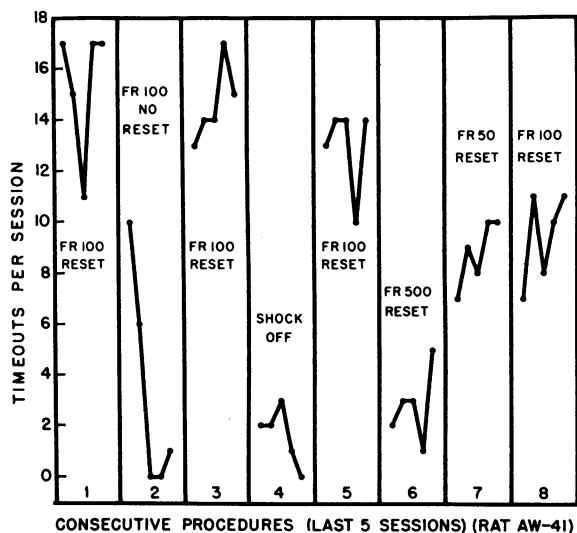

Fig. 5. Number of time outs per session produced by Rat AW-41 under the different experimental procedures. The food-reinforcement schedule on Lever A was VI 2 minutes. The FR value is the FR for shock on Lever A, and the "reset" and "no-reset" conditions refer to Lever B. The data are from the last 5 sessions on each procedure.

reward, since in this case shock density may be better controlled while VI reward schedules are systematically varied.[3]

SUMMARY

Rats were permitted to escape from a stimulus (S^D) in the presence of which they were concurrently rewarded and punished for pressing Lever A. The escape response, depression of Lever B, produced a fixed-duration time out (S$^\Delta$) from both reward and punishment on the other lever.

1. At least three subjects learned to escape with great regularity from the concurrently positive and negative stimulus. When either the shock or reward contingency was eliminated for Lever A responding, escape responses very seldom occurred. These results suggest that neither the positive or negative aspects of the situation alone can account for the escape behavior; rather, the simultaneous presence of both aspects seems critical.

2. Other subjects reacted to the concurrent reward-punishment schedule with a marked decrease in response rate on Lever A as compared with their behavior on the reward schedule alone. These subjects never showed a consistent tendency to escape into the "neutral" S$^\Delta$ situation, despite their exposure to different values of several experimental parameters.

[3]Egger and Miller (1960) have reported briefly on results obtained with procedures similar to the ones we have described, and Professor Miller has been kind enough to send us a detailed summary of these and other findings. Many of the manipulations we performed on AA rats were suggested by this summary. Miller suggests that animals never exposed to a time-out condition may be reinforced by stimulus change only, and that "conflict may have a marked potentiating effect on pressing for mere stimulus change." We did not run a specific control for the latter possibility; however, it has been our prior experience that subjects are not normally reinforced by the clicker and tone used here, even in strongly aversive situations.

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