THE EFFECTS OF A PRE-TIME-OUT STIMULUS ON MATCHING-TO-SAMPLE OF HUMANS^{1,2}

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In each of two experiments human subjects were intermittently reinforced with money on a fixed-ratio schedule for emitting correct matching responses. A pre-time-out stimulus which signaled removal of positive reinforcement was periodically superimposed. In the first experiment the superimposed pre-time-out stimulus was paired with a 1-min or 4-min response-independent time out. In the second experiment the pre-time-out stimulus was paired with a 1-min or 4-min time out contingent on the incorrect responses. The pre-time-out stimulus did not markedly influence performance when the time out was response independent. In contrast, the pre-time-out stimulus markedly suppressed incorrect responding when the time out was contingent on the incorrect responses. When duration of this time-out was increased from 1-min to 4-min, suppression of incorrect responding increased and correct responding was suppressed. Therefore, behavioral suppression by a pre-time-out stimulus was obtained only when the signaled aversive event—time out—was response produced. In this case, suppression was influenced by time-out duration.

Time out (TO) from positive reinforcement (a period of time in which positive reinforcement is no longer available) can serve as an aversive event. Ferster (1958, Exp V) using chimpanzees demonstrated that TO could be employed to reduce the frequency of responses which were spaced less than a given interval from a previous response. Baer (1962) weakened thumbsucking in two five-year old boys by turning off cartoons as long as thumbsucking was occurring. Holz, Azrin, and Ayllon (1963) markedly suppressed the response rate of two out of four mental patients who were being reinforced with cigarettes on a variable-interval schedule by punishing every tenth response with a TO. Responding of all four patients was virtually eliminated by this punishment procedure when an alternative re-

sponse concurrently produced cigarettes on the same schedule of positive reinforcement but did not produce TO. Other studies have shown that avoidance behavior which postpones a TO from positive reinforcement can be maintained in pigeons, chimpanzees, children, and monkeys (Morse and Herrnstein, 1956; Ferster, 1958; Baer, 1960; and Zimmerman, 1963). Finally, several investigators (Herrnstein, 1955; Ferster, 1958, Exp III; Ferster, 1960; and Ferster, Appel, and Hiss, 1962) have demonstrated that a neutral stimulus can be converted into an aversive stimulus by pairing it with a response-contingent TO. The latter investigators showed that a pre-TO stimulus, which signals presentation of a TO, suppressed the response rate of pigeons, chimpanzees, and monkeys.

Several recent studies have extended the use of TO as punishment to complex discrimination performance by employing matching-to-sample procedures. In each of these studies, incorrect matching responses were punished by presenting TO and matching performance was examined as a function of TO duration. Ferster and Appel (1961) employed pigeons to demonstrate that TO could effectively punish incorrect matching responses when correct matching responses were reinforced with food on a variable-interval schedule of reinforcement. Matching accuracy increased as the duration of TO produced by each incorrect re-

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sponse increased from 1 sec to 60 sec, but then decreased when the duration was increased to 120 sec. Incorrect responses decreased in frequency as TO duration was increased from 1 sec to 120 sec. Zimmerman and Baydan (1963, Exp I) obtained similar results with humans under conditions in which correct matching responses were reinforced with money on a variable-interval schedule and incorrect responses were continuously punished with a TO whose duration was either 2, 10, 60, or 120 sec. The frequency of incorrect responses decreased as TO duration was increased, while the frequency of correct responses was not influenced by TO durations of 2, 10, and 60 sec but was slightly suppressed by the 120-sec TO. Zimmerman and Ferster (1963) using pigeons and Zimmerman and Baydan (1963, Exp II) using humans, systematically replicated the above results in the context of experiments in which both TO duration and the frequency (ratio value) with which incorrect responses produced TO were independently varied.

These results indicate that under given sets of experimental conditions, TO can be employed as an aversive stimulus to (a) punish behavior which produces it, (b) maintain behavior which results in its postponement, and (c) convert a neutral stimulus into an aversive stimulus by pairing it with the neutral stimulus. These effects of TO are similar to those usually found when other aversive stimuli such as shock are employed in behavioral studies (*e.g.*, Azrin, 1960; Sidman, 1953; Estes and Skinner, 1941). However, the studies which employed pre-TO stimulus procedures to suppress ongoing behavior have all examined the effect of the stimulus under conditions in which the associated TO was presented on a response-contingent basis. In contrast, the classic pre-aversive stimulus paradigm first introduced by Estes and Skinner (1941) and employed extensively by Brady and Hunt (*e.g.*, 1955) involves superimposing a stimulus which is paired with a response-independent shock. Suppression of behavior in the presence of the pre-shock stimulus in these studies appears to represent an "emotional effect" of the stimulus on the overall disposition to respond rather than a punishing effect of the shock on a specific response, since shock presentation is programmed independently of responding. In each of the pre-TO stimulus studies cited above, subjects could avoid TO by not re-

sponding in the presence of the pre-TO stimulus. The suppressive effects of that stimulus could, therefore, have been obtained as a consequence of the direct punishment of specific responses, rather than on the basis of an "emotional effect" which might have decreased the overall disposition to respond. The studies which employed matching-to-sample procedures to study the effects of punishment with TO have not only demonstrated the direct suppressive effect of punishment on the TO-contingent punished response but have also shown that the overall disposition to respond can be suppressed when TO duration is set at high values.

Several questions are suggested by the above results. Does a neutral stimulus associated with TO acquire aversive properties for humans? Does the suppressive effect of a pre-TO stimulus depend upon the response-contingent presentation of TO or would such suppression be similarly obtained under conditions in which TO is presented independently of ongoing performance? The present study sought information pertinent to these questions.

METHOD

Subjects

Four undergraduate students, one medical student, and one secretary served. Subject 5 served previously in the Brady, Levitt, and Baydan study (1962), and Subject 6 served previously in the Zimmerman and Baydan study (1963).

Apparatus

The matching-to-sample apparatus was described in detail by Zimmerman and Baydan (1963). Briefly, it was a console with three stimulus display windows, three telegraph keys mounted below the display windows, and a digital counter centered above the windows. A jeweled light housing, 1-in. in diameter was mounted in the upper right corner of the console.

Procedure

The baseline matching-to-sample task was the same as that utilized in the Zimmerman and Baydan study (1963). As each matching sequence began, one of four geometric stimuli was projected upon the center window as a sample. Pressing the center key removed the

sample and projected a stimulus on each of the side windows. These were either projected against a dark background or upon a red circle. When the stimuli were projected upon the red circles, correct responses were those on the key beneath the stimulus which matched the original sample. When the stimuli were projected against the dark backgrounds, correct responses were those on the key beneath the stimulus which did not match the sample.

Subjects were given the following instructions: "When this machine is turned on, one of four geometric figures (i.e., Δ , ∇ , $\circ$, $\otimes$), will appear on the center window. Pressing the switch below the center window will remove the figure and present a figure on each of the two side windows. Your task is to make correct choices by pressing the switch under the appropriate side window. The correct choice depends upon whether the figures on the side windows appear in the presence or absence of red circles. If the red circles are present, respond to the figure that is the same as the original figure. If the red circles are absent, respond to the figure which is different from the original figure. Whenever you make an incorrect choice all the lights will go out for a little while. Whenever you make a correct choice, the side figure will disappear but a new figure will immediately appear upon the center window. Every now and then the counter above the windows will add a count. Each tally on the counter is worth \$0.20. Do your best to make as much money as you can."

Throughout the study, each subject performed in a 2-hr session, two to three times per week. Each was paid at the end of every session with a cashier's receipt which could be cashed immediately in a separate building.

Baseline procedure. Correct (S^D) responses were reinforced with a counter tally on a fixed-ratio schedule. That is, reinforcement was contingent upon emission of a given number of S^D responses. Every incorrect (S^A) response was punished by a brief, 5-sec TO. During this TO, all matching stimuli were absent. The reinforcement ratio was gradually increased for each subject as response rate increased over sessions so that a minimum of \$4.50 but no more than \$10.00 could be earned each session. Each subject except Subject 6 (see below) was exposed to this baseline procedure until performance stabilized. Stability was defined as follows: the between-session variability

of the matching performance (indexed by the ratio of S^A to S^D responses) was no greater than the within-session variability in the preceding session, for five consecutive sessions. For each session, the mean value of the S^A/S^D measure was obtained for the first and second hour. The difference between the first- and second-hour measures were used as an index of variability within a given session. The mean value for the whole session served as the measure of performance for that session.

Introduction of the "neutral" stimulus. After behavior stabilized on the baseline procedure, the white light in the upper right corner of the console was turned on for a fixed period of time after a given number of S^D responses were emitted. This particular method of presentation allowed the subjects to be exposed to the white light approximately 15 times per session. This could easily have been accomplished by presenting the white light on a response independent temporal basis. But this method was rejected because it could have artifactually increased the number of incorrect responses emitted in the presence of the white light as a possible consequence of the interaction between its onset and the point in a matching sequence at which it was introduced. Instead, by introducing the white light on a response-contingent basis, the probability that a subject would start to perform in its presence at the beginning of a matching sequence was maximized. This was especially crucial for the conditions (see below) in which the first S^A response in the presence of the pre-TO stimulus would immediately produce a TO of long duration.

Control and experimental procedures. In each of two experiments, the white light was presented without an associated TO during control sessions and served as a pre-TO stimulus during experimental sessions. In Exp I, the TO signaled by the pre-TO stimulus was response independent. It always occurred at the termination of the pre-TO stimulus. In Exp II, the TO was response contingent. The first incorrect response in the presence of the pre-TO stimulus produced it. Time out could be avoided if no incorrect response was emitted in the presence of the pre-TO stimulus. In both experiments the white light was associated with a 1-min TO and a 4-min TO.

Table 1 presents the order and nature of conditions to which each subject was exposed

Table 1
Order and Description of Control (C) and Experimental (E) Conditions for Each Subject

	Exp I (Response-Independent TO)				Exp II (Response-Contingent TO)			
Condition	C ₁	E ₂	C ₃	E ₄	C ₅	E ₆	E ₇	C ₈
White Light Duration	1'	1'	2'	2'	1'	1'	1'	1'
TO Duration	—	1'	—	4'	—	1'	4'	—
Number of Sessions								
Subject 1	7(150)**	6	5	5	5(170)	6	6	5
Subject 2	5(200)	9	5	5	5(230)	5	5	5
Subject 3	7(150)	5	6	5	5(170)	6	5	5
Subject 4	9(150)	5	—	—	5(170)	5	5	5
Subject 5	8(200)	8	5	5	5(200)	5	5	5
Subject 6	—	—	—	—	5(300)	5	5	5

*Maximum duration.

**Fixed-ratio values throughout a given experiment appear in parentheses.

together with the number of sessions under each condition. After Subjects 1 through 4 completed Exp I sessions, their fixed-ratio values were raised to maintain the maximum earnings per session in Exp II at approximately \$10.00.

Experiment I. In the first and second control conditions (C₁ and C₃) the white light was presented alone for 1-min and 2-min durations, respectively. In the first experimental condition (E₂) the white light was presented for 1-min durations and an unavoidable 1-min TO always occurred at its termination. In the second experimental condition (E₄) the white light was presented for 2-min durations and an unavoidable 4-min TO always occurred at its termination. In all conditions of Exp I, S^D responses both in the presence and absence of the white light produced a counter tally on the same fixed-ratio schedule and each S^A response in the presence and absence of the white light produced a brief, 5-sec TO. The white light remained illuminated during each 5-sec TO produced in its presence.

Experiment II. The two control conditions (C₅ and C₈) were exactly the same as the first control condition (C₁) of Exp I. In the two experimental conditions the white light served as a pre-TO stimulus which was associated with an avoidable TO of long duration. The white light was presented for a maximum duration of 1 min but the first S^A response emitted in its presence immediately produced the long TO. The TO duration was 1 min in the first experimental condition (E₆) and 4 min in the second experimental condition (E₇). The

TO was not presented if an S^A response was not emitted during the pre-TO stimulus.

Subjects 1, 2, 3, and 5 were exposed to each of the eight conditions described above. Subject 4 was exposed to the first two conditions of Exp I and to each of the four conditions of Exp II. Subject 6 was exposed only to the four conditions of Exp II. Her experience as a subject in the Zimmerman and Baydan study (1963) permitted her use in this experiment (her available time was limited) without giving baseline training. Each subject was exposed to a given condition for a minimum of five sessions and was shifted to a subsequent condition after no consistent trend in the ratios of S^A to S^D responses was obtained for five successive sessions.

RESULTS

Baseline performance. For each baseline session, the rates of S^D and S^A responding, in responses per minute, were calculated by dividing the total number of S^D responses and S^A responses, respectively, by the running time. The latter excluded the time spent in TO. Each subject exposed to the baseline procedures met the criterion of stability within 10 sessions. Each performed with high accuracy within the first 10 min of the first baseline session. Final S^D and S^A rates ranged from 52.8 to 84.8 and 1.3 to 4.4 responses per min, respectively.

Experiments I and II. For each session, the rates of S^D and S^A responding in the presence and absence of the white light were calculated

as described above. Running times used in the calculation of each of the four measures excluded both the time spent in TOs which followed each S^A response and the time spent in TOs, if any, associated with the white light.

Each subject met the criterion for stability under a given condition within nine sessions and no subject failed to meet the criterion within more than six sessions under a given condition after being exposed to at least two prior conditions. Figures 1 and 2 summarize the results obtained for each subject under each condition. Figure 1 presents the S^A rates obtained in the presence and absence of the white light. Each point is the median value for all sessions under the given condition. Figure 2

presents similar data with respect to the S^D rates.

The following is a summary of the results presented in Fig. 1 and 2:

The effects of the white light as a "neutral" stimulus. During the control conditions of both Exp I and II, most subjects emitted S^A responses at a slightly higher rate and S^D responses at a slightly lower rate in the presence of the white light. These differences in performance were generally small in magnitude and inconsistent across subjects.

The effects of the white light as a pre-TO stimulus associated with response-independent TOs. Terminating the white light with the presentation of an unavoidable 1-min TO and

Fig. 1. Incorrect response rates in the presence and absence of the white light for each subject under control conditions (white light not associated with TO) and experimental conditions (white light as pre-TO, PTO, stimulus). Experiment I (response independent TO): in control conditions C₁ and C₃, white light durations were 1 min and 2 min, respectively. In experimental conditions E₂ and E₄, white light durations were 1 min and 2 min, respectively, and TO durations were 1 min and 4 min, respectively. Experiment II (response contingent TO): control conditions C₅ and C₇ were the same as control condition C₁. In experimental conditions E₆ and E₈, maximum duration of the white light was 1 min, and TO durations were 1 min and 4 min, respectively.

Fig. 2. Correct response rates in the presence and absence of the white light for each subject under control conditions (white light not associated with TO) and experimental conditions (white light as pre-TO, PTO, stimulus). Experiment I (response independent TO): in control conditions C₁ and C₃, white light durations were 1 min and 2 min, respectively. In experimental conditions E₂ and E₄, white light durations were 1 min and 2 min, respectively, and TO durations were 1 min and 4 min, respectively. Experiment II (response contingent TO): control conditions C₅ and C₆ were the same as control condition C₁. In experimental conditions E₆ and E₇, maximum duration of the white light was 1 min, and TO durations were 1 min and 4 min, respectively.

4-min TO in the first and second experimental conditions (E₂ and E₄), respectively, did not effect any marked differential changes in performance. For Subjects 1, 3, and 5, however, S^A rates both in the presence and absence of the white light increased over all conditions of Exp. I. Similar increases in S^D rates over these conditions were obtained for Subjects 1, 2, and 3. These concurrent increases in S^A and S^D rates merely continued trends observed during the previous baseline sessions. Increasing the duration of the unavoidable TOs from 1 min to 4 min did not significantly influence performances.

The effects of presenting the white light by itself in the first condition of Exp. II. Removing the unavoidable, 4-min TO in the first

control condition (C₅) of Exp. II effected some performance changes, but these were usually small in magnitude and inconsistent across subjects. The only consistent performance change observed was a slight decrease in S^D rates both in the presence and absence of the white light. The S^A rates of Subjects 1 and 2 increased markedly both in the presence and absence of the white light. The increase was differentially greater in the presence of the white light, however. These results were probably influenced, in part at least, by the increase in the value of the fixed-ratio schedule of money reinforcement (see Table 1).

The effects of the white light as a pre-TO stimulus associated with response-contingent TOs. In contrast to the results of Exp. I, some

consistent performance changes of large magnitude were obtained when the white light was associated with a response-contingent TO in Exp II. When the white light served as a pre-TO stimulus in the presence of which the first S^A response produced a 1-min TO, S^A responding of all subjects decreased in frequency. The white light differentially suppressed S^A responding of each subject, however, while these rates were substantially lowered in its absence only in the case of Subjects 1 and 3. S^D rates were not influenced by this pre-TO stimulus, except in the case of Subject 4 whose rate in its presence was markedly suppressed. When the duration of the avoidable TO was increased to 4 min, the S^A rates of five of the six subjects further decreased. In the case of Subjects 2, 3, and 4 this further decrease occurred only in the presence of the white light and the S^A rate of Subjects 2

and 3 actually increased in the absence of the white light. The S^D rates of all subjects decreased slightly in the presence of the white light when duration of the avoidable TO was increased to 4 min. The S^D rate in the absence of the white light actually increased in the case of Subjects 1 and 3, and was not altered or only slightly decreased in the case of the other four subjects.

The effects of presenting the white light alone in the final control condition. When the avoidable, 4-min TO was removed in the final control condition (C_8), performances were altered in the direction of those obtained in earlier control conditions.

To simplify the comparison of performance in the presence and absence of the white light under each of the conditions, relative measures of S^A and S^D responding in each session were calculated by dividing the rates obtained in

Fig. 3. Relative values of incorrect responding (upper row) and correct responding (lower row) for Subject 2 in each session under control conditions (white light not associated with TO) and experimental conditions (white light as pre-TO stimulus). Relative values were obtained by dividing the rate in the presence of the white light by the corresponding rate in its absence. Experiment I (response independent TO): in control conditions C_1 and C_3 , white light durations were 1 min and 2 min, respectively. In experimental conditions E_2 and E_4 , white light durations were 1 min and 2 min, respectively, and TO durations were 1 min and 4 min, respectively. Experiment II (response contingent TO): control conditions C_5 and C_8 were the same as control condition C_1 . In experimental conditions E_6 and E_7 , maximum duration of the white light was 1 min, and TO durations were 1 min and 4 min, respectively.

the presence of the white light by the respective rates obtained in its absence. Figure 3 presents the resulting daily relative values of S^A and S^D responding for a representative subject (subject 2). Each point is the mean value for the given session. Relative values close to 1.00 indicate that rates in the presence of the white light were equal to rates in its absence. On the other hand, values greater than 1.00 or less than 1.00 indicate that rates in the presence of the white light were, respectively, greater or smaller than rates in its absence. Figure 3 shows that the rate of S^A responding for Subject 2 was usually slightly higher in the presence of the white light (relative values were usually greater than 1.00) under all conditions except the two in which the white light was associated with the avoidable TO. Relative values of S^A responding were de-

creased markedly in the avoidable, 1-min TO condition (E_6) and were further decreased in the avoidable, 4-min TO condition (E_7). Relative values of S^D responding were almost always close to 1.00 indicating that S^D responses in the presence and absence of the white light were emitted at approximately equal rates. S^D responding was slightly but consistently suppressed, however, in the presence of the white light when it was associated with the avoidable 4-min TO. These relative S^D values ranged from .86 to .95 with a median value of .91. Figure 3 shows one other typical result. When the white light first served as a pre-TO stimulus in the unavoidable 1-min TO condition of Exp I (E_2), the relative S^A value first increased, then decreased, and then increased again. The median of the daily values in this condition did not differ much, however, from

Fig. 4 Relative values of incorrect responding (upper row) and correct responding (lower row) for each subject under control conditions (white light not associated with TO) and experimental conditions (white light as pre-TO stimulus). Relative values were obtained by dividing the rate in the presence of the white light by the corresponding rate in its absence. Experiment I (response independent TO): in control conditions C_1 and C_3 , white light durations were 1 min and 2 min, respectively. In experimental conditions E_2 and E_4 , white light durations were 1 min and 2 min, respectively, and TO durations were 1 min and 4 min, respectively. Experiment II (response contingent TO): control conditions C_5 and C_7 were the same as control condition C_1 . In experimental conditions E_6 and E_7 , maximum duration of the white light was 1 min, and TO durations were 1 min and 4 min, respectively.

those obtained in the other conditions of Exp I. Similar transient effects were obtained in four of the five subjects exposed to this condition, but the direction of changes was not consistent and the magnitudes were small. Figure 4 presents a summary of the results obtained for each subject in both Exp I and II in terms of the relative S^A and S^D values obtained under each condition. Each point is the median value for all sessions under the given condition. Figure 4 demonstrates that the most consistent and obvious result was the marked relative suppression of S^A responding in the presence of the white light when the latter served as a pre-TO stimulus which signaled an impending avoidable TO. Figure 4 also shows that increasing the duration of the avoidable TO from 1 min to 4 min effected (a) a further increase in the relative suppression of S^A responses (Subjects 1, 2, 3, and 6) and (b) a slight relative suppression of the S^D rates (all subjects except Subject 5). Finally,

Fig. 4 shows that these changes are reversible. When the avoidable TO was removed in the final control condition, relative S^A and S^D values for all subjects changed in the direction of those obtained in the earlier control conditions. In contrast to the results of Exp II, relative changes obtained throughout Exp I were small in magnitude and inconsistent in direction.

Figure 5 presents cumulative records of S^D responding for Subjects 4, 5, and 6. These illustrate some of the typical characteristics of behavior generated under two of the conditions of Exp II. The left records represent responding in the first hour of the final session under the first control condition (C_5), and the right records represent responding in the first 1 to 1½ hr of the final session under the avoidable, 4-min TO condition (E_7). In all records the pen is displaced downwards when the white light is present and pips indicate counter tallies. To facilitate observation of

Fig. 5. Cumulative records of correct responding of Subjects 4, 5, and 6. Left records show performances during the first hour of the final session under control condition C_5 . The white light was presented for 1 min and was not associated with TO. Right records show performances during the first 1 to 1½ hr of the final session under experimental condition E_7 . The white light was presented for a maximum duration of 1 min and was associated with a 4-min response-contingent TO. In all records the pen is displaced downward during the white light. Pips indicate counter tallies. Arrows indicate complete cessation of responding in the presence of the white light.

slope changes during the pre-TO stimulus, dashed lines were extrapolated in the right records to represent the local rate of response in the absence of the pre-TO stimulus. The S^D rate in the presence of the pre-TO stimulus was occasionally suppressed for Subject 5, frequently suppressed for Subject 6, and almost always suppressed for Subject 4. Subject 4 actually stopped responding completely during some pre-TO stimulus presentations. The vertical arrows indicate extreme examples of this last observation. In contrast, the white light had little influence on behavior in the control condition. The records show that the S^D rates in the absence of the white light were not differentially influenced by the nature of the white light contingencies. Rates in the absence of the white light were similar under both of the represented conditions for each subject. Finally, the records show no post-reinforcement pauses. This last observation was characteristic of all performance under all conditions of the present experiment and indeed is characteristic of all fixed-ratio performances ever generated in this laboratory.

DISCUSSION

In the present investigation, a white light was periodically superimposed upon matching-to-sample performance of human subjects. It served either as (a) a "neutral stimulus", (b) a pre-TO stimulus which signaled an impending response-independent TO, or (c) a pre-TO stimulus which signaled an impending response-contingent TO.

When the white light served as a "neutral stimulus" in the control conditions, the rates of S^A responding were generally slightly higher in its presence than in its absence. It is possible that superimposing an additional visual stimulus on the complex, conditional, visual-discrimination task may have increased errors through visual distraction. Since the major purpose of this investigation was to examine behavioral effects of the white light when it was paired with TO, performances in the control conditions were simply employed as base-lines against which to assess the effects of the white light as a pre-TO stimulus. The control conditions were similar both in purpose and operations to the control procedure employed by Ferster with chimpanzees and pigeons (1958, Exp I).

When the white light first served as a pre-TO stimulus paired with a response-independent TO (first experimental condition of Exp I) transient changes in the S^A rate were observed in its presence in the case of four subjects. These temporary effects appeared to be similar to those observed by Azrin (1958) when he superimposed a response-independent noise upon the ongoing operant performance of human subjects. Neither his nor the present subjects were permanently influenced by the response-independent presentation of an aversive event. In this study, neither pairing the white light with a response-independent TO nor increasing the duration of this TO produced behavioral changes of greater consistency or magnitude than those produced by presenting the white light as a "neutral stimulus". The pre-TO stimulus procedure employed in Exp I is analogous to the pre-shock stimulus procedure employed by Estes and Skinner (1941). They superimposed an auditory stimulus which signaled an impending response-independent shock upon the ongoing food reinforced performance of rats and observed that responding was strongly suppressed in the presence of the pre-shock stimulus. Since in the present study no such suppression of performance in the presence of the white light was observed, it is suggested that either (a) TO does not have the aversive or "emotional" properties for humans that shock has for rats, or (b) the particular measures used may not have been sensitive to any such effects, were they generated. It is interesting to note in this connection that one of the subjects, without prompting, reported that she was not too happy with what happened to the light (transition from the first control condition to the first experimental condition) but "after a while I realized that there was nothing that I could do about it, so I simply ignored it."

When the white light first served as a pre-TO stimulus paired with a response-contingent TO (first experimental condition of Exp II) it set the occasion for the avoidance of S^A responding since the first such response in its presence was always immediately punished with a 1-min TO. Under these conditions the S^A rates of all subjects decreased markedly in its presence. The corresponding S^D rates of five of the six subjects, however, were neither markedly nor consistently altered. These results

might be compared to results obtained by Holz *et al.* (1963) with mental patients. They examined the effects of punishment with a response-contingent TO under conditions in which the patients had either one way or two alternative ways of producing intermittent cigaret reinforcement. When responses to only one response mechanism produced cigaretts and when every tenth response also produced a TO, response rate decreased for only two of the four patients. On the other hand, when responding to either of two concurrently available manipulanda produced cigaretts, all patients stopped responding completely on the one which also produced TO. The authors suggested that TO is a relatively mild punishing event (compared to electric shock) but that even a mild punishing event could be an extremely effective suppressive stimulus under conditions in which an organism is taught to produce reinforcement by emitting an alternative, unpunished response. The present subjects always had two available ways of responding (correctly and incorrectly). Although S^D responses only produced reinforcement and S^A responses only produced TO, it was generally observed that under fixed-ratio reinforcement of correct matching responses, subjects emit S^D and S^A responses at high rates and at low rates, respectively, but that the two rates are positively correlated, other things being equal. The consistent and differential suppression of S^A responding obtained in the presence of the pre-TO stimulus paired with the avoidable, 1-min TO, therefore, may be analogous to the differential suppression of responding obtained by Holz *et al.* as a function of introducing the second manipulandum. Thus, the present results may represent a systematic replication of the Holz *et al.* results with subjects who were not hospitalized and who performed on a different task and under different reinforcement contingencies.

When the duration of the avoidable TO was increased from 1 min to 4 min (second experimental condition of Exp II), a further decrease in the S^A rates of four subjects and a slight decrease in the S^D rates of all subjects was obtained in the presence of the pre-TO stimulus. These results were consistent with and systematically replicated those obtained in the matching-to-sample studies of Ferster and Appel (1961), Zimmerman and Ferster (1963), and Zimmerman and Baydan (1963). Each of these

studies showed that the punishment effectiveness of a response-contingent TO increased with an increase in the duration of the TO. The present investigation extended these findings to a procedure which was, in effect, a multiple schedule of punishment. That is, the experimental conditions of Exp II examined the effect of different TO durations, two at a time, on performance in the same subjects within the same session. In effect, the effects of a 5-sec, response-contingent TO were compared with those of a 1-min TO (first experimental condition) or a 4-min TO (second experimental condition) under conditions in which a different exteroceptive stimulus (presence or absence of the white light) was associated with the different punishment conditions. In contrast, the previous studies involved either the programming of different TO durations in different sessions (Ferster and Appel, 1961; Zimmerman and Ferster, 1963), or of two different TO durations in the same sessions but in the absence of differential exteroceptive stimulation (Zimmerman and Baydan, 1963).

The S^D rate results of Exp II are consistent with those obtained by Zimmerman and Baydan (1963) who observed that neither a 10-sec nor a 1-min incorrect-response-produced TO differentially influenced the rate of S^D responding relative to the effects of a 2-sec TO, whereas a 2-min TO differentially suppressed S^D rates of most subjects at least temporarily. Finally, the S^A rate results of Exp II were consistent with the results obtained by Ferster (1958, Exp V) and Herrnstein (1955) which showed that under some conditions a pre-TO stimulus which signals an impending response-contingent TO will suppress behavior in its presence.

The present results obtained under the final control condition showed that the effects of punishment by TO are reversible. Performance in the presence of the white light was altered in the direction of that obtained in previous control conditions after the 4-min TO was removed. Similar results have been obtained by many investigators (*e.g.*, Estes, 1944; Azrin, 1958; Azrin, 1960; Zimmerman and Ferster, 1963) with different organisms and different aversive stimuli.

One response contingency mentioned only briefly in the procedure section bears some discussion. Under all conditions of both experiments the white light was superimposed on

the basis of a fixed number of S^D responses rather than on a response-independent temporal basis. If the white light was assumed to be an aversive stimulus when it served as a pre-TO stimulus, then it could be argued that in each of the experimental conditions, S^D responding was punished on a fixed-ratio schedule. The results of other studies, however, suggest that such punishment would probably not alter the rate of punishment-producing responses. Weiner (1964) for example, showed that response rates of humans, generated by a fixed-ratio schedule of points reinforcement, were not altered when each response was punished with the loss of a point. Under the conditions of Weiner's experiment, however, points could only be maximized if response rates were maximized whether or not each response produced loss of a point. Holz *et al.* (1963, one-manipulandum experiment) observed that the response rates of two of their four patients were not lowered when every tenth response was punished with a 30-sec TO. The failure of this punishing event to reduce the rate of responding was obtained in spite of the fact that responses produced cigarettes on a variable-interval schedule. Thus, by maintaining their previously unpunished rates, these patients markedly reduced the number of cigarettes they could earn per session. The matching-to-sample studies of Zimmerman and Ferster (1963) and Zimmerman and Baydan (1963, Exp II) have shown that incorrect-response-contingent TO has little effect on incorrect response rates when it is delivered less frequently than after every fifth to tenth response. Finally, the data obtained in the present experiment (in which the pre-TO stimulus was never presented more frequently than after every 100th S^D response) certainly does not indicate that fixed-ratio punishment of S^D responding by presentation of the pre-TO stimulus was effective, if indeed it was occurring. S^D responding in the absence of the white light during the experimental conditions did not differ in rate or pattern from S^D responding in the absence of the white light during control conditions. The only behavioral change in the absence of the white light, which appeared to be partly explained by the nature of the white light contingencies, was the slight reduction in S^A rates.

The present results indicate that the major finding was the marked differences between

the behavioral effects of a pre-TO stimulus associated with a response-independent TO and the behavioral effects of a pre-TO stimulus associated with a response-contingent TO. Only the latter pre-TO stimulus effected predictable and marked changes in the performance of all subjects. These results are analogous to those of Azrin (1958) who compared the effects of response-contingent noise with response-independent noise on the performance of human subjects. Azrin found that noise predictably modified ongoing behavior only under conditions in which it was presented or removed on a response-contingent basis.

Present and previous results strongly suggest that a TO no longer than 1 or 2 min in duration is a relatively mild punishing event. Unlike intense (or even mild) shock, TO does not appear even moderately to incapacitate an organism. It certainly does not appear to evoke responses whose elicitation would be incompatible with emitting or acquiring other positively reinforcing responses. It is therefore suggested that TO of moderate duration might be applied to control and shape behavior in clinical or field situations under conditions in which an individual emits several different responses, one or more of which is considered undesirable.

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