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PUNISHMENT OF S^{Δ} RESPONDING OF HUMANS IN CONDITIONAL MATCHING TO SAMPLE BY TIME-OUT[1]

J. ZIMMERMAN AND NURAN T. BAYDAN[2]

INDIANA UNIVERSITY MEDICAL CENTER

Human subjects were intermittently reinforced with money for performing correctly on a conditional matching-to-sample task. The matching performance was examined as a function of a) the duration of Time-Outs (TOs) which followed every incorrect response and b) the frequency (FR value) with which TOs followed incorrect responses. The matching accuracy increased with longer TOs and decreased with less frequent presentation of TOs.

Ferster and Appel (1961), using pigeons, observed that the accuracy of matching to sample was a function of the duration of TOs which followed incorrect (S^{Δ}) responses, when correct (S^{D}) responses were intermittently reinforced with grain on a VI 3 schedule. Matching accuracy was highest with TO durations between 10 and 60 sec but was appreciably lower with durations of 1 sec or 120 sec. Zimmerman and Ferster (1963), using the same animals, observed that matching accuracy was a function of the frequency with which TOs followed S^{Δ} responses. The schedule of punishment was either CRF, FR 2, FR 4, FR 6, FR 12, FR 25 or FR 50. At intermediate values of TO duration (10 sec, 60 sec or 120 sec), accuracy decreased as the FR value increased. Under these conditions, the best matching was therefore obtained when TOs continuously followed S^{Δ} responses. At the extreme values of TO duration (1 sec or 10 min), accuracy was poor over the entire frequency range.

Two studies have utilized matching procedures in the evaluation of the effects of "therapeutic" variables on human performance. Ferster and DeMyer (1961) reported that prochlorperazine increased the total matching performance of an autistic child. Ferster, Levitt, Zimmerman, and Brady (1961) reported that hypnotic suggestions differentially affected several characteristics of the matching performance of a student nurse. The performance also served as a sensitive baseline in the measurement of the duration of effectiveness of the hypnotic suggestions.

These two studies demonstrated the potential use of matching procedures for assessing the behavioral effects of therapeutic procedures on human behavior. The present series of studies was therefore begun to examine the effect of behavioral and pharmacological variables on the matching performance of human subjects. This report presents the results of the first two behavioral experiments. Matching performance was examined as a function of the duration and frequency of TOs which followed S^{Δ} responses of human subjects.

METHOD

Six undergraduate college students served as subjects (*Ss*). The apparatus (previously described in Ferster, *et al*, 1961) is shown in Fig. 1. Colored stimuli and geometric patterns can be projected on the three stimulus display windows by I.D.D. units. Subjects respond to the stimuli by pressing the appropriate telephone-type keys which are mounted directly below the windows. Conditioned reinforcement is provided by the operation of the counter, the flash of one of the lights, and the click of a relay. The relay (not shown) is mounted inside the front panel. Subjects sit facing the panel and can be observed through a one-way mirror from an adjacent room which houses the control equipment.

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[2]Now at the University of Maryland School of Medicine.

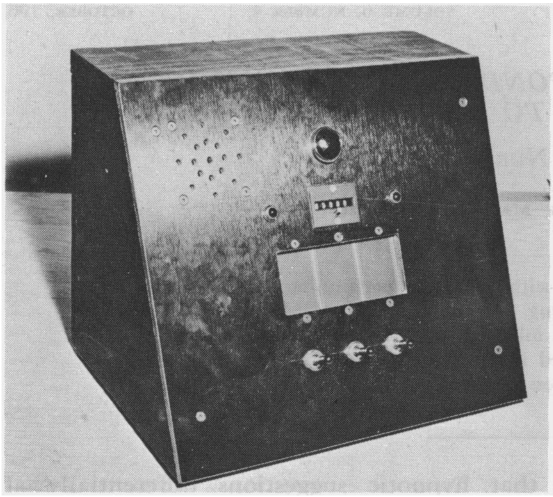

Fig. 1. The matching to sample apparatus.

General Procedure

The matching baseline was similar to that reported by Ferster *et al,* (1961) except that a conditional discrimination was added. At the start of each matching sequence, one of four geometric stimuli was projected on the center window. An observing response to this stimulus resulted in its removal and in the projection of two of the stimuli on the side windows. The latter were presented in the presence or absence of superimposed red stimuli. In the presence of the red stimuli, *S* responded to the stimulus that matched the sample. In the absence of the red stimuli, *S* responded to the stimulus that did not match the sample. The stimuli projected on the center and side windows were presented in random order.

Correct (S^D) responses were continuously reinforced with the click of the relay, the flash of the green light (small light directly to the right of the counter), and the immediate appearance of the next center-window stimulus. They were intermittently reinforced with a tally of the counter and the flash of the red light (large light above the counter). Incorrect (S^Δ) responses were punished by a TO (apparatus was turned off) of a fixed duration.

Subjects were run for 2 hr from one to three times per week. They were paid at the end of each 2-hr session at the rate of $0.20 for each counter tally.

EXPERIMENT I

The matching performance of five *S*s was examined as a function of TO duration. S^D responses were intermittently reinforced with a counter tally on a VI 3 schedule. To establish initial baselines, all *S*s had three or four sessions in which every S^Δ response was punished with a 10-sec TO during both the 1st and 2nd hr of each session. Following the initial sessions, *S*s were run through a series of experimental sessions in which a TO of a given duration (2, 10, 60, or 120 sec) was programmed in the 1st hr and a TO of the same or other duration (2, 10, 60, or 120 sec) was programmed in the 2nd hr. All *S*s were exposed to all of the four durations at some time during the experiment. The specific order of experimental conditions was different for each *S*.

Results

The rate of S^D and S^Δ responses, in responses per minute, and the accuracy of matching (indexed by the ratio of S^Δ/S^D responses) was calculated for each hour of each session. The results to be presented are taken from all the 1-hr samples starting with the samples from the last baseline session (session 3 or 4).

Table 1 presents the median accuracy of matching (S^Δ/S^D) and the range of the accuracies for each *S* under each TO duration. For four out of the five *S*s, the median accuracy increased (the lower the value the higher the accuracy) with an increase in TO duration. Examination of the range of the values in adjacent columns, however, indicates that there was often considerable overlap in the accuracies obtained under different TO durations. This result was obtained because the measures for each cell were taken from different sessions and were based upon markedly different numbers of 1-hr exposures (N) to the different TO durations.

The results of the experiment were therefore analyzed in a different way. For each of the four *S*s who had at least eight 1-hr exposures to the 2-sec TO condition, relative functions were plotted in which the performance measures obtained in the 2-sec TO condition served as standards. Relative measures of the accuracy, S^Δ rate, and S^D rate were calculated by dividing the measures obtained in the other TO condition by the corresponding measure obtained in the 2-sec TO condition. The resulting ratios were then plotted against TO duration of the other condition. Figure 2 presents the resulting function for

Table 1

Median Matching Accuracy (S$^{\Delta}$/S^{D}) as a Function of TO Duration Over Experiment I

	TO 2 sec	*TO 10 sec*	*TO 60 sec*	*TO 120 sec*	*SUBJECT*
median	.070	.043	.028	.025	
range	.067 to .085	.025 to .066	.022 to .038	.021 to .042	M.H.
N*	11	13	9	3	
median	.113	.098	.053	.044	
range	.077 to .148	.063 to .103	.049 to .056	.032 to .062	P.H.
N	10	12	2	6	
median	.078	.048	.017	.003	
range	.028 to .134	.021 to .100	.008 to .020	.002 to .007	S.Y.
N	8	7	6	3	
median	.043	.041	.020	.013	
range	.024 to .063	.029 to .057	.014 to .026	.010 to .016	J.F.
N	8	4	4	2	
median	.029	.028	.024	.028	
range	.017 to .050	.021 to .070	.018 to .029	.024 to .033	J.R.
N	4	10	4	2	

*N refers to the number of 1-hr exposures.

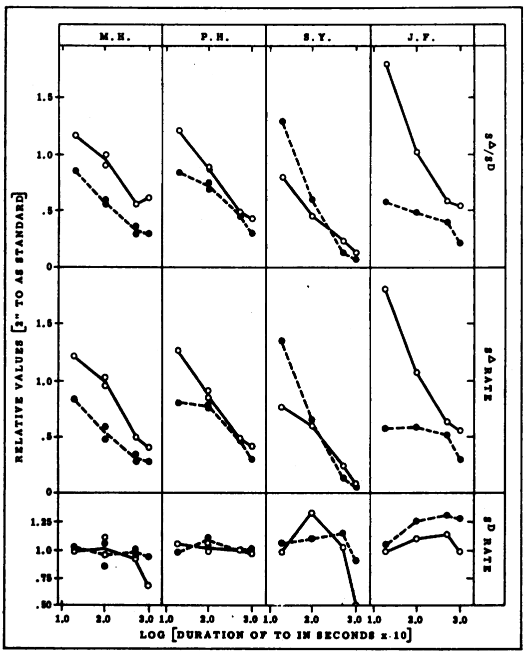

Fig. 2. Relative matching to sample performance (2-sec TO condition as standard) as a function of TO duration. Solid curves are from sessions in which the 2-sec TO was programmed in the 1st hr and dotted curves are from sessions in which the 2-sec TO condition was programmed in the 2nd hr. Top row: Relative accuracy of matching (S$^{\Delta}$/S^{D}). Middle row: Relative S$^{\Delta}$ rate. Bottom row: Relative S^{D} rate.

the four *S*s. The accuracy of matching, S$^{\Delta}$ rate, and S^{D} rate functions appear in the top, middle, and bottom rows, respectively. Because of the tendency for most *S*s to emit more errors in the 2nd hr of a session than in the 1st hr, other things being equal, two functions were plotted in each cell. The solid curves connect the ratios derived from sessions in which the 2-sec TO was programmed in the 1st hr, and the dotted curves connect the ratios derived from sessions in which the 2-sec TO was programmed in the 2nd hr. Ratio values below 1.0 in the top row indicate that the accuracy of matching was poorer in the 2-sec TO condition than in the other condition. Ratio values below 1.0 in the middle and bottom rows, indicate that the response rate was higher in the 2-sec TO condition than in the other condition.

Figure 2 shows that the relative matching accuracy increased with an increase in the TO duration, regardless of the order of experimental conditions within a session. The S$^{\Delta}$ rate functions clearly parallel the accuracy functions. The S^{D} rate was not consistently affected by the TO duration. The accuracy results, therefore, were primarily accounted for by the effect of the TO duration on the rate of S$^{\Delta}$ responding.

When relative functions were plotted for each of the four Ss who had at least seven exposures to the 10-sec TO condition similar results were observed. Once again the relative matching accuracy increased with TO duration and the results were accounted for by the effect of duration on S^{Δ} responding.

Although this study was designed to examine the effects of TO duration using Ss as their own controls, the effect of the independent variable on matching accuracy was found to be extremely consistent across Ss. The absolute accuracies from each session for each S were plotted in a matrix in which each cell represents one type of experimental session (Fig. 3). The A conditions (columns) are the TO durations that occurred in the 1st hr of a given session, and the B conditions (rows) are the TO durations that occurred in the 2nd hr of a given session. For example, cell 2-2 presents the accuracy data for all sessions in which the 2-sec TO appeared in both hours and similarly cell 60-10 presents the accuracy data for all sessions in which the 60-sec TO appeared in the 1st hr and the 10-sec TO appeared in the 2nd hr.

Figure 3 shows that matching accuracy was almost always lower in the condition of shorter TO duration for sessions in which two different durations were programmed. (All cells except 2-2, 10-10, 60-60, and 120-120.) Figure 3 further shows that accuracy usually decreased very slightly from the 1st to the 2nd hr when the TO duration was the same in both hours (cells 2-2, 10-10, 60-60, and 120-120). The performance of S S.Y. in the 2-2 session was the only notable exception to this. Finally, Fig. 3 shows that there was an interaction between the duration effect and the order effect. The contrast between the accuracies obtained under two different TO durations increased with an increase in the difference between the durations (*e.g.*, cell 2-10 *vs.* cell 2-60 or cell 10-2 *vs.* cell 60-2). The contrast between the accuracies obtained under two different TO durations was greater when the shorter duration was programmed in the 2nd hr than in the 1st hr (*e.g.*, cell 2-10 *vs.* cell 10-2 or cell 10-60 *vs.* cell 60-10).

In general, the matching baseline generated behavior which was well maintained throughout a given session. The S^D rates were fairly constant over a session for most Ss under most conditions. Figure 4 presents cumulative re-

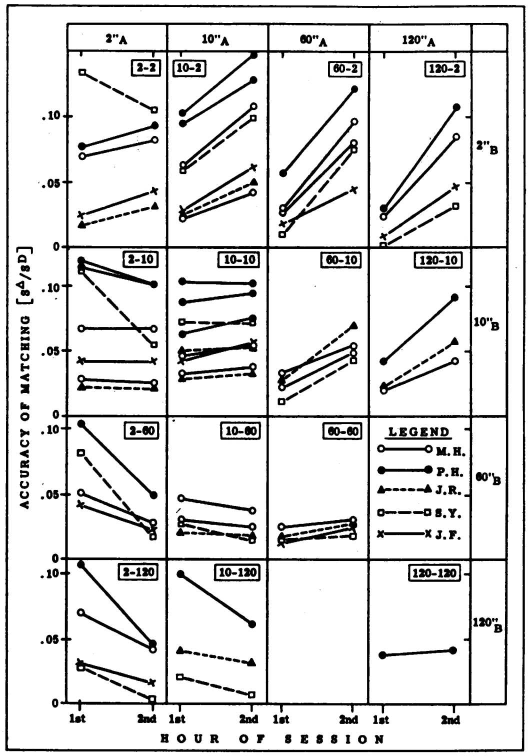

Fig. 3. Accuracy of matching as a function of the particular experimental conditions in a given session. Columns: TO duration in the 1st hr of the session (A). Rows: TO duration in the 2nd hr of the session (B).

sponse records for a representative S (M.H.) from the 60-2 session (top records) and the 2-60 session (bottom records). The response pen recorded S^D responses and the pips indicate counter tallies. The event pen pips indi-

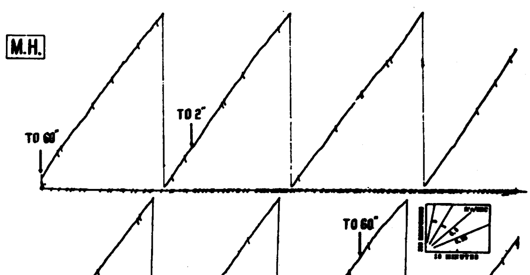

Fig. 4. Cumulative records of S^D responding for M.H. from two sessions in which the 60-sec TO and 2-sec TO conditions were compared. Pips indicate counter (money) reinforcements. Event pen pips indicate S^{Δ} responses.

cate S^Δ responses. The rate of S^D responses was not affected by the TO duration in the top record (54.3 responses per min in the 60-sec TO condition and 54.4 responses per min in the 2-sec TO condition). The S^D rate decreased from the 2-sec TO condition to the 60-sec TO condition in the bottom record (55.1 to 49.3) but this change was not atypical of *S*s in general. Such changes were inconsistent in direction and low in relative magnitude (per cent change) compared to the changes obtained in the S^Δ rate. The density of the pips in the event pen records was higher in the 2-sec condition than in the 60-sec condition in both records. (The S^Δ rate was 1.45 and 5.25 for the 60-sec and 2-sec conditions respectively, in the top record and 2.82 and 1.28 for the 2-sec and 60-sec conditions, respectively, in the bottom record.)

The 120-sec TO condition had marked suppressive effects on the S^D rate in several instances. This marked effect, however, was usually observed only in the first exposure of an *S* to the 120-sec TO condition and especially if this condition was programmed in the 2nd hr. Subjects M.H., S.Y., and J.R. had extremely low rates in the 120-sec condition compared to the other condition in the session in which they were first exposed to the 120-sec TO. In the case of P.H., the second exposure to this condition produced the greatest suppression (here the 120-sec TO was programmed in the 2nd hr) but all other exposures had less relative effect. Figure 5 presents cumulative records of S^D responding for M.H. (upper left two records), P.H. (upper right two records), and S.Y. (lower two records) from the sessions in which the 2-sec TO was compared with the 120-sec TO. The "S" indicates the start of a session. An upward arrow indicates the onset of the 120-sec TO condition, while a downward arrow indicates the onset of the 2-sec TO condition. These records contrast the different magnitudes of the effect of the 120-sec TO condition. The left record for M.H. is from the first session in which he was exposed to the 120-sec TO condition. The introduction of this condition produced a marked lowering of the S^D rate. The right record for M.H. indicates that there was only a slight increase in S^D rate when the 2-sec TO condition followed the 120-sec TO condition. Little change in rate occurred with the change of TO duration in the two records for P.H., but these records were from his fourth and fifth exposures to the 120-sec condition. The left record for S.Y. (first exposure to the 120-sec TO condition) presents an extreme effect of the 120-sec condition on her S^D rate. With the onset of this condition, the rate decreased markedly and pauses of up to 30-sec occurred frequently. The second exposure (right record) resulted in less relative effect, but the S^D rate increased somewhat with the onset of the 2-sec condition.

In general, whenever the 120-sec TO was programmed, the S^D rate was lowered to some extent. Such a consistent effect on S^D rate was not obtained with any other TO duration. The one notable exception to these findings was obtained in the case of J.F.

In her second exposure to the 120-sec TO condition, the S^D rate was markedly higher in this condition than in the other (2 sec) con-

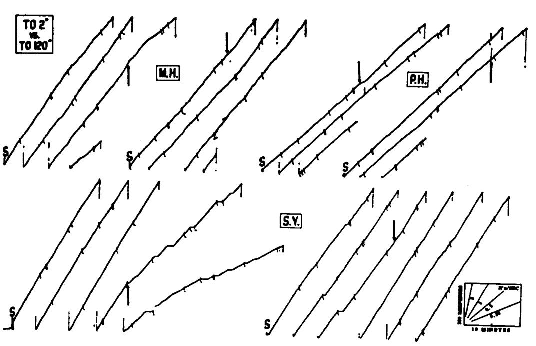

Fig. 5. Cumulative records of S^D responding for M.H. (upper left), P.H. (upper right), and S.Y. (lower) from the two sessions each in which the 120-sec TO and 2-sec TO conditions were compared. "S" indicates the start of a session. An upward arrow indicates the onset of the 120-sec condition. A downward arrow indicates the onset of the 2-sec condition.

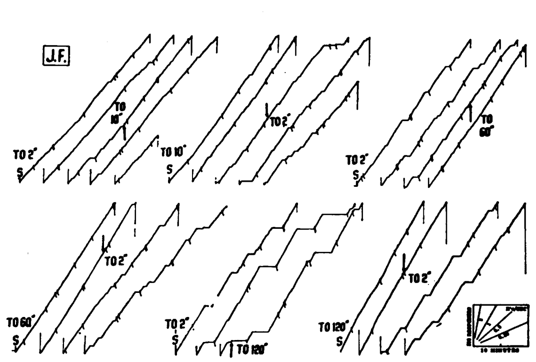

Fig. 6. Cumulative records of S^D responding for J.F. from the six sessions in which the 2-sec TO condition is compared with the 10, 60, and 120-sec TO condition, respectively.

dition. This result, however, can be accounted for by the idiosyncratic effect of the 2-sec TO condition on her S^D rate. Figure 6 presents cumulative records of S^D responding for J.F. from the six sessions in which the 2-sec TO was compared with the 10, 60, and 120-sec TOs. J.F. tended to pause in the 2-sec TO condition in every session and this resulted in lower overall S^D rates in this condition compared to every other TO condition with the exception of her first exposure to the 120-sec TO condition (middle record of bottom row). In the latter session, pausing also occurred during the 120-sec TO condition. The second exposure to the 120-sec condition did not result in pausing, but the idiosyncratic pauses in the 2-sec condition were still present and therefore the rate in the 120-sec TO condition was higher. The apparently deviant results for J.F. with respect to the 120-sec TO condition was, therefore, not inconsistent with the results obtained from the other *S*s.

Discussion

The accuracy of matching of human *S*s was observed to increase with longer TO durations. This result was primarily accounted for by the effect of TO duration on S^Δ responding. The S^D rates were not consistently affected (if at all) by the TO duration except when the duration was 120 sec. This duration suppressed the S^D rate, especially on initial exposure of an *S* to the condition.

These results confirm, in part, those obtained by Ferster and Appel (1961) with pigeons. The accuracy of matching of pigeons was poor with a TO duration of 1 sec and increased with a TO duration of either 10, 30, or 60 sec. Accuracy decreased, however, with a TO duration of 120 sec. The poor matching obtained with the 1-sec TO was accounted for by the high level of S^Δ responding. The poor matching with a 120-sec TO was accounted for by the effect of the TO on total responding. The long TO duration suppressed behavior and differentially lowered the S^D rate. The S^D rate was not influenced by the shorter TO durations. In the present study, the 120-sec TO suppressed S^D responding (especially on initial exposure) while shorter durations did not. However, the 120-sec TO did not differentially lower the S^D rate relative to the S^Δ rate and therefore matching accuracy did not decrease at this duration. It is possible that a longer TO duration would have resulted in a decrease in matching accuracy. Some of the accuracy functions plotted in Fig. 2 suggest that the relative accuracy was decreasing more slowly from TO 60 sec to TO 120 sec and that an inflection point might have been approaching.

The absolute levels of accuracy were much higher (*i.e.*, the S^Δ/S^D values were much lower) for the humans than for the pigeons. The values varied from .002 to .150 for the humans (depending upon *S* and TO duration) while they varied between .08 and 1.0 plus (chance level) for the pigeons.

EXPERIMENT II

The matching performance of two *S*s was examined as a function of the frequency (FR value) with which TOs followed S^Δ responses. One of the two *S*s, P.H., had been an *S* in Exp. I. Both *S*s were exposed to CRF, FR 2, FR 5, FR 10, and FR 50 schedules of punishment in the experiment. For P.H., these frequencies were examined holding the TO duration at either 2, 10, 60, or 120 sec, while for C.W., these frequencies were examined holding the TO duration at either 2, 10, 30, or 60 sec. The S^D responses of C.W. were intermittently reinforced with a counter tally on the VI 3 schedule while the S^D responses of P.H. were intermittently reinforced with a counter tally on an FR 100 schedule.

In this experiment, TO duration was held constant throughout a given experimental session and in every session the CRF punishment schedule was compared with a given FR punishment schedule. Each session was divided into four, ½ hr segments and S^Δ responses were punished on the CRF schedule in the 1st and 3rd ½ hr. S^Δ responses were punished on a given FR schedule in the 2nd and 4th ½ hr. Different TO durations were programmed in different sessions. The order of experimental conditions with respect to both the duration and frequency of TOs was different for the two *S*s but both had a session at every FR value and at every duration value.

Results

Figures 7 and 8 summarize the results for C.W. and P.H., respectively. The matching accuracy (top row), rate of S^Δ responses (middle row) and rate of S^D responses (bottom row)

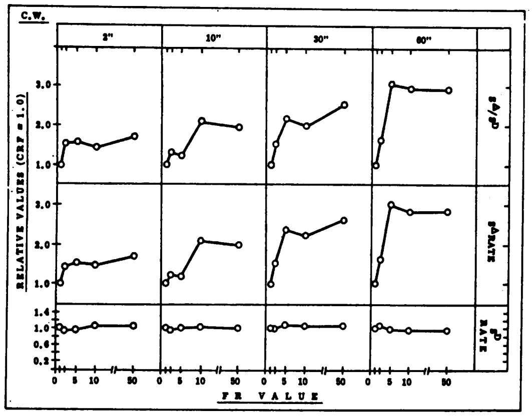

Fig. 7. Relative matching to sample performance (CRF condition as standard) for C.W. as a function of the frequency (FR value) of TOs and of the duration of TOs. Top row: Relative accuracy of matching (S^{Δ}/S^{D}). Middle row: Relative S^{Δ} rate. Bottom row: Relative S^{D} rate. The first point in each function is artifactually plotted at 1.0.

were plotted as a function of frequency (FR value) of TOs for each TO duration (column) examined. The individual points in each function were derived by dividing the average measures from the two FR quarters by the average measures from the two CRF quarters of each session. The CRF condition was therefore used as the standard and the value of the first point of each function was artifactually set at 1.0. Ratio values of greater than 1.0 in the top row indicate that the accuracy of matching was poorer in the FR condition than in the CRF condition. Ratio values of greater than 1.0 in the middle and bottom rows indicate that the response rate was greater in the FR condition than in the CRF condition.

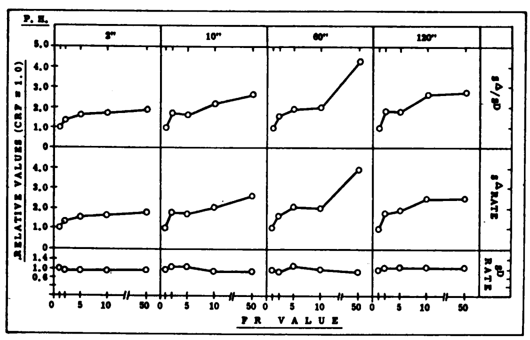

Fig. 8. Relative matching to sample performance (CRF condition as standard) for P.H. as a function of the frequency (FR value) of TOs and of the duration of TOs. Top row: Relative accuracy of matching (S^{Δ}/S^{D}). Middle row: Relative S^{Δ} rate. Bottom row: Relative S^{D} rate. The first point in each function is artifactually plotted at 1.0.

For both *S*s, matching accuracy in every session was always poorer in the FR condition than in the CRF condition. The accuracy generally decreased with an increase in FR value for P.H., and decreased up to an FR value of 5 or 10 and then leveled off for C.W. All accuracy functions were negatively accelerated for both *S*s with the exception of the 60-sec TO function for P.H. The 2-sec functions were the shallowest for both *S*s. The accuracy results were primarily accounted for by the effect of the TO frequency on the rate of S^{Δ} responses. The TO frequency had little effect on the S^{D} rate.

In initial baseline sessions (2 hr of the CRF condition) both *S*s tended to emit more S^{Δ} responses as the session progressed. To partially offset this effect, the CRF and FR conditions were programmed in the ABAB order within each session. The functions in

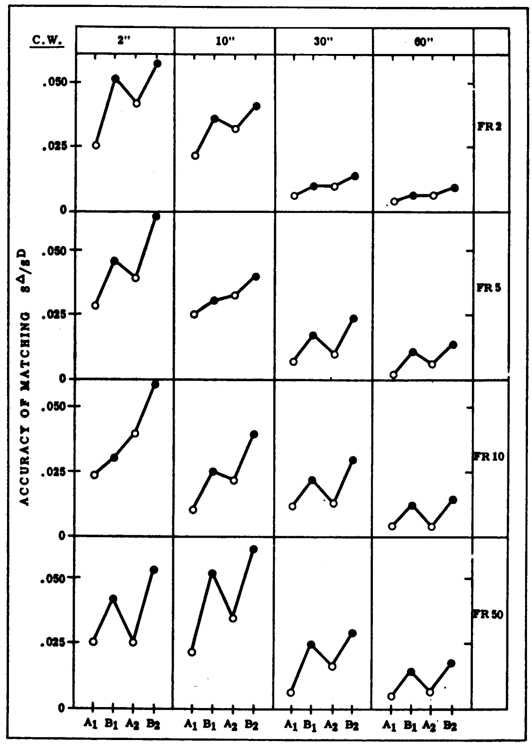

Fig. 9. Accuracy of matching for C.W. as a function of the particular experimental conditions in a given session. Columns: TO duration. Rows: TO frequency (FR value) in the second and fourth half hours of the session. Open circles are from the CRF condition and filled circles are from the FR conditions. A_1, B_1, A_2 and B_2 refer to the successive half hours of the session.

Fig. 7 and 8 may have been influenced by the fact that the CRF condition was always programmed first. Figures 9 and 10 demonstrate, however, that the punishment schedule made the major contribution to the functions. These figures present the absolute accuracy values for every ½ hr of each session in which the CRF schedule is compared with an FR schedule. Each cell presents the results of a particular session. The columns include sessions in which particular TO durations were programmed and the rows include sessions in which particular FR values were programmed. A_1, B_1, A_2, and B_2 refer to the four successive half hours of a session. For both *S*s and especially for C.W. (whose initial baseline sessions were characterized by marked increases in S^{Δ} rate over a session) the accuracy decreased from A_1 to A_2 and from B_1 to B_2 in most sessions. On the other hand, with few exceptions, the accuracy increased from B_1 to A_2 demonstrating the effect of the punishment schedule. Figures 9 and 10 also indicate that

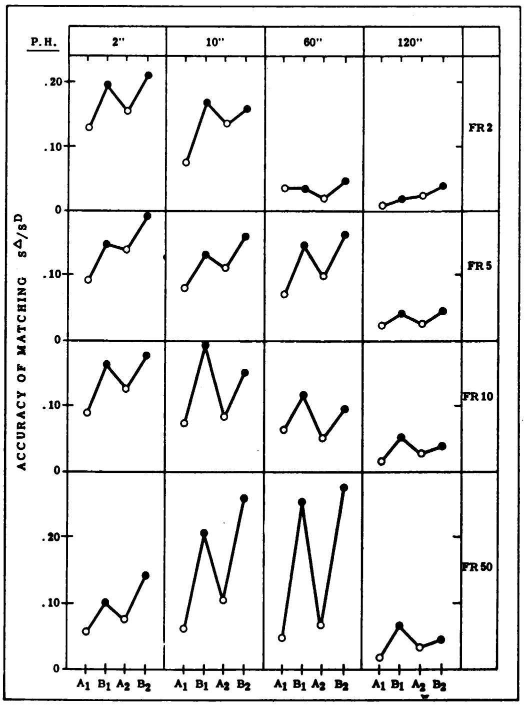

Fig. 10. Accuracy of matching for P.H. as a function of the particular experimental conditions in a given session. Columns. TO duration. Rows: TO frequency (FR value) in the second and fourth half hours of the session. Open circles are from the CRF condition and filled circles are from the FR conditions. A_1, B_1, A_2, and B_2 refer to the successive half hours of the session.

the accuracy generally increased with an increase in TO duration (especially for the CRF conditions) as observed in Exp. I.

Figure 11 presents cumulative records of S^D responding (response pen) and records of S^{Δ} responding (event pen) for P.H. for two representative sessions. The overall S^D rate did not change with punishment schedule change. The grain of the S^D records was rougher in the FR condition, however, because more S^{Δ} responses were emitted under this condition and at times these were emitted in groups of two or more. (The density of the event pen pips is higher in the FR conditions.) Unlike FR behavior of animals, there were very few cases of pausing after a positive reinforcement.

Discussion

The accuracy of matching of human *S*s was observed to decrease with less frequent presentations of TOs when the TO duration was held constant. The frequency functions at given TO durations were negatively accelerated and the 2-sec TO functions were the shallowest for both *S*s. The accuracy results were primarily accounted for by the effect of TO duration on the rate of S^{Δ} responding. These results confirm those obtained by Zimmerman and Ferster (1963), with pigeons. The matching accuracy of pigeons increased with an increase in frequency of TO and the functions were negatively accelerated. The functions obtained under the 1-sec TO condition were shallower than those obtained under 10, 60, or 120-sec TO conditions.

Again, the accuracy was much higher for the humans than those obtained for the pigeons. The absolute accuracy values ob-

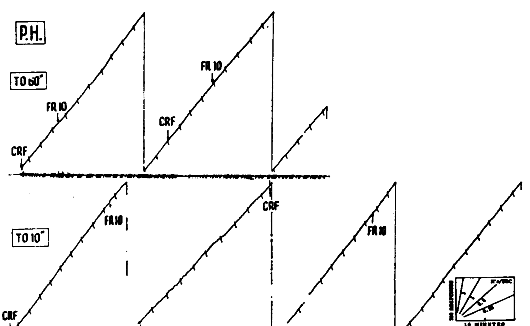

Fig. 11. Cumulative records of S^D responding for P.H. from two representative sessions during Exp. II. S^D responses were reinforced (pips) on an FR 100 schedule. Event pen pips indicate S^{Δ} responses.

tained for the humans varied from .002 to .250 while those from the pigeons varied from .07 to 1.0 plus (chance levels).

Implications

The results of the present investigation with humans and the results of the studies by Ferster and Appel (1961) and Zimmerman and Ferster (1963) with pigeons, indicate that punishment (as defined by the removal of the opportunity to obtain positive reinforcement) can be utilized as a powerful technique in the control of complex operant behavior.

The results indicate that if punishment is to be used to lower the rate of or eliminate particular responses, it should be applied continuously after the emission of those responses. With more intermittent application, punishment has less effect on the emission of the punishable responses. The intensity (defined here as the duration of TO) of punishment is also an important variable in the control of complex behavior. An optimal intensity should be chosen. Punishment of too great an intensity will result in the suppression of overall behavior.

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