HUMAN OBSERVING BEHAVIOR AFTER SIGNAL DETECTION[1]

by

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In certain tasks, sometimes called vigilance tasks, *S* must monitor a signal indicator and perform a designated response each time a signal occurs. Holland (1957, 1958) demonstrated that in such tasks the signal detections reinforce the observing responses that make them possible. Both in Holland's work and in the present experiments the signals were deflections of a meter pointer. The *S*s were instructed to press a key in order to reset these deflections to zero as quickly as possible. Since the *S*s worked in a dark room, their observing responses could be counted by recording their responses on a second key, which, when pressed, briefly illuminated the meter face.

Holland showed further that the temporal distribution of the observing responses depended upon the way in which the signals were programmed. For instance, a fixed-interval schedule typically produced a high response rate just before the detection of the signal and a pause in responding after it had been reset. Skinner (1957) reported that Holland's *S*s sometimes made a few observing responses after reset. We have seen the same phenomenon. The experiments reported below were attempts to discover some of the variables that influence the frequency of such responses.

METHOD

Apparatus

The *S* faced two telegraph keys mounted 7 inches apart and a voltmeter with a 2-inch-diameter face placed 12 inches behind them. The pointer of the meter moved noiselessly from zero to about two-thirds of the distance across the dial whenever a deflection was programmed. In all the experiments reported here, these deflections occurred on fixed-interval schedules. The pointer remained deflected until *S* reset it by depressing the left-hand telegraph key. Reset was silent. A force of approximately 370 grams was needed to close the circuit.

The subjects performed in a dark room. The right-hand telegraph key, which could be closed by a force of approximately 1675 grams, was connected in a circuit that could be used to flash a light 0.13-second long upon the meter face. For all but one *S*, four presses of this key produced a single flash of light (FR 4); S4 worked with the light flashes on an FR 8 schedule.

Three dim neon bulbs furnished a surround that decreased the unpleasant flicker produced by rapid responding on the light-flashing key. These were located behind the meter, and did not provide enough light to allow inspection of the meter face. A noise generator masked the sounds of the programming and recording equipment located in an adjoining room.

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Subjects

Eight *S*s took part: seven were male medical students, and one was the wife of a staff physician. Their pay ($2.50 per session) was not contingent upon their performance. Each experimental session lasted approximately 40 minutes. All *S*s were experienced on fixed-interval schedules, their response rates increased toward the end of the interval.

General Procedure

The following instructions were given when *S*s first came to the laboratory:

"Every once in a while the pointer on that dial will go to about 30 and stay there. Your job is to reset it to zero by hitting this button here (indicating the reset key). Do this as quickly as possible after it goes up there. You will work in the dark. The only way you can get light to see the dial is by pressing this key here (indicating the light-flashing key). The right-hand (light-flashing) key will not give you light every time you press it."

Key-pressing responses were recorded both on a Gerbrands cumulative recorder and on counters. The response that reset the pointer to zero also returned the recorder pen to the base line. The *S*s were not told how long it took them to reset deflections. The event pen of the recorder deflected momentarily whenever responses on the light-flashing key activated the lamp within 6 seconds after a reset response. These flashes, called *postreset observing responses* (PRORs), comprised the data of the experiments reported below.

The following observations are not in chronological order because the procedure used at a particular time was dictated in part by the frequency of PRORs during the preceding sessions. For instance, a low rate of PRORs was needed in order to test the effect of a procedure likely to raise the rate. Not all *S*s were run through each procedure: S1 worked on Experiment 4 and Experiment 2, in that order; S2 and S3 worked only on Experiment 2; S4 worked successively in Experiments 2, 3, 4, and 1; S5 worked first in Experiment 1, then in Experiment 3; S6 and S7 worked only in Experiment 1; and S8 worked successively in Experiments 3, 4, and 1.

EXPERIMENT 1

Effect of Reinforcing Postreset Observing Responses (PRORs)

Procedure. During one arbitrarily selected interval, the experimeter disconnected the reset key so that the pointer would remain deflected after the reset key was pressed. If a PROR was made, the key remained disconnected until *S* made two or three reset responses. If no PROR was made, the experimenter reset the pointer and the procedure was repeated on succeeding intervals until a PROR occurred. This procedure was used with four *S*s. It was modified for a fifth, S5, however. His operant level of PRORs was so low that the pointer was allowed to remain deflected until he made a PROR and the subsequent reset responses. In all cases the procedure was repeated on one of the next several intervals. All *S*s worked on a 60-second, fixed-interval schedule except S5, who worked on a 30-second, fixed-interval schedule.

Results. The procedure described in the preceding paragraph served to reinforce the occurrence of PRORs. Their frequency increased for all five *S*s. Figure 1 shows records from three *S*s.

The performance of S4 is presented most fully. During the immediately prior session, he had been through a procedure described under EXPERIMENT 4. The record of that performance is reproduced in Fig. 5, where it is apparent that PRORs were infrequent. Figure 1 reproduces complete records from the session in which reinforcement occurred near its beginning, and the following session, 6 days later. The PRORs were most frequent just after two had been reinforced. None occurred on the last 12 intervals of the session. By the end of the next session, PRORs had disappeared.

The short sections from the records of two other *S*s further illustrate the immediate increase in PRORs after reinforcement. One subject, S8, had made only one PROR during the immediately previous session; but after reinforcement, he made PRORs on the eight intervals shown in the figure and on all but two intervals during the remainder of the session. He extinguished during his next session (not shown), making 5, 3, 2, and 0 PRORs in successive 10-minute portions of the session.

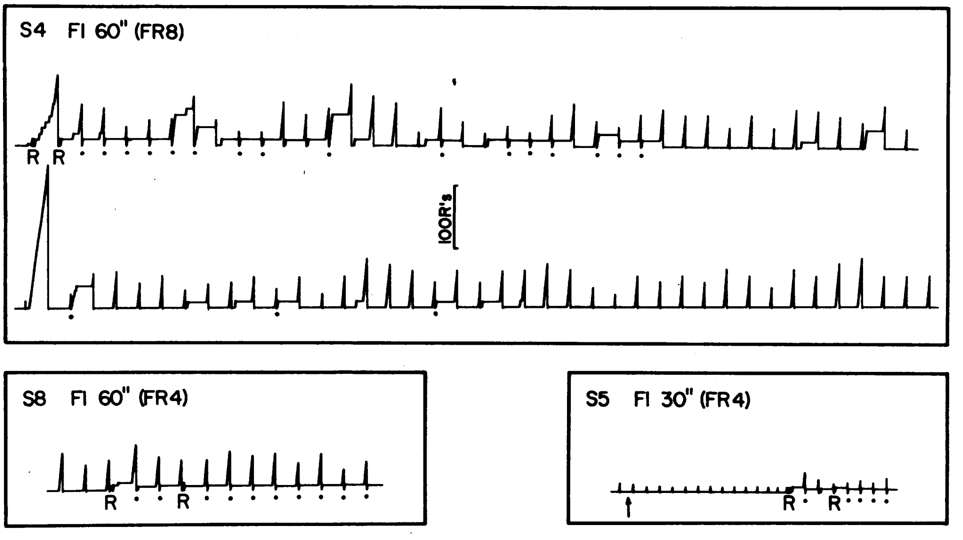

Figure 1. Effect of reinforcing PRORs on subsequent emission of such responses. Records are cumulative; the pen returned to base line at each reset. A dot below a reset indicates that an observing response occurred within 6 seconds following reset. Reinforcement is indicated by R. The arrow on the record of S5 indicates that the reset key was disconnected at this time. (See text for details of these procedures.)

The other record shows the performance of S5. He had started his session by making three PRORs, but not another for 16 successive intervals. Figure 1 shows his performance after this. The reinforcement procedure started him making PRORs again, and these occurred after all but one reset for the rest of the session. (The last 36 intervals have been omitted.) At his next session, he made 40 resets in a row without a PROR.

EXPERIMENT 2

Effect of Adding an Auditory Signal to Reset

Procedure. This experiment occupied three sessions. During the first, the pointer return was, as usual, silent. During the second, a brief tone sounded on reset. During the third session, reset was again silent. Four *S*s were run through this procedure. They worked on a 1-minute, fixed-interval schedule.

Results. Data for all four *S*s are summarized in Fig. 2. In each case, fewer PRORs were made when the signal was present than when it was absent. Figure 3 shows in detail how the

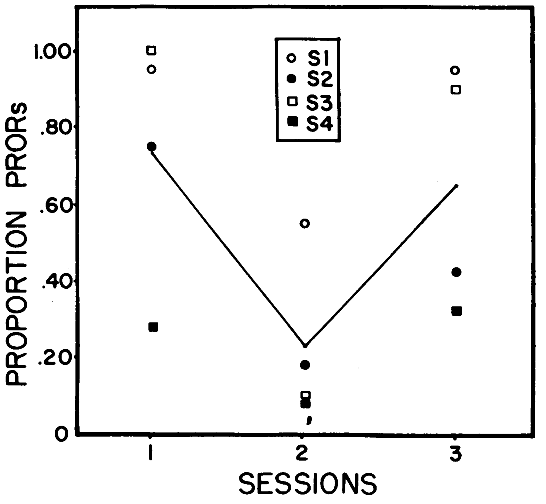

Figure 2. Effect on PRORs of adding an auditory signal to the reset of the deflected pointer. Session 1: reset silent. Session 2: tone added to reset. Session 3: reset silent. Ordinate: proportion of resets followed by observing response within 6 seconds. The means are connected.

tone affected the frequency of PRORs made by S2, whose performance is typical. The frequency of observing responses made at other times during the interval was unaffected.

The performances of S1 and S3 also indicate the high incidence of PRORs shown by S2 near the beginning of the session in contrast to their almost complete absence near its end; but S4 distributed his PRORs more evenly.

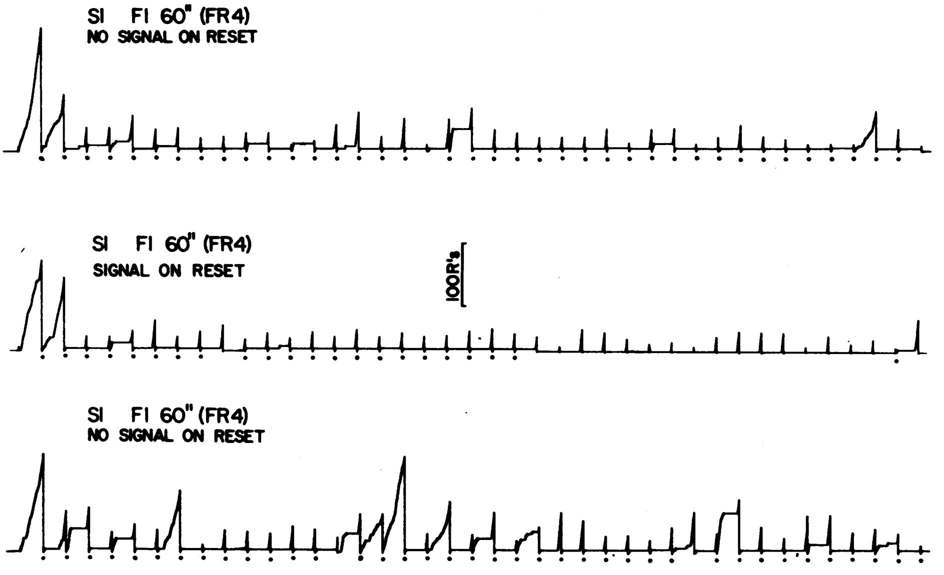

Figure 3. Effect on PRORs of adding an auditory signal to the reset of the deflected pointer. Top cumulative record was made first, and bottom one, last. Resets returned the pen to the base line. A dot below a reset indicates that an observing response occurred within 6 seconds following reset.

EXPERIMENT 3

Effect of Statements that the Reset Key is Unreliable

Procedure. Before the start of the session, *S* was told: "We are having trouble with the reset button. Each time you press it, hold it down for 1 or 2 seconds." Three *S*s were exposed to this procedure. (They had first been run through a session without such instructions.) A 1-minute, fixed-interval schedule was used.

Results. Casting doubt on the reliability of the reset key increased the frequency of observing responses made after the reset response (Fig. 4). Observing responses made at other times during the interval were unaffected by this procedure.

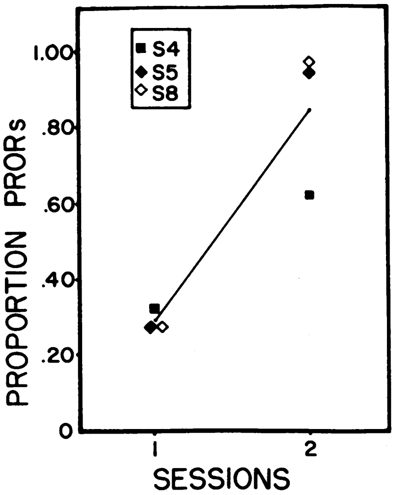

Figure 4. Effect on PRORs of statements that reset key may be unreliable. Session 1: control. Session 2: unreliability indicated to *S* before session began (see text). Ordinate: proportion of resets followed by observing response within 6 seconds. The means are connected.

EXPERIMENT 4

Effect of Switching S from Using Two Hands to Using Only One

Procedure. The usually high response rate on the light-flashing key was interrupted at reset by having *S*s who had been using both hands, one on each key, use only one hand for both functions. Several times during a 40-minute session, they were asked to switch from one procedure to the other. Three *S*s were run through this procedure, all on a 1-minute, fixed-interval schedule.

Results. All three records obtained are reproduced in Fig. 5. The use of only one hand did not change the frequency of PRORs.

DISCUSSION

We have shown that several operations change the frequency of postreset observing responses (PRORs), i.e., observing responses made just after *S* has detected a signal and has made a reset response. The presence of a deflection was shown to reinforce PRORs just as it reinforces any other observing behavior with which it coincides (Experiment 1). The effect was quite specific, with no noticeable alteration in the frequency of observing re-

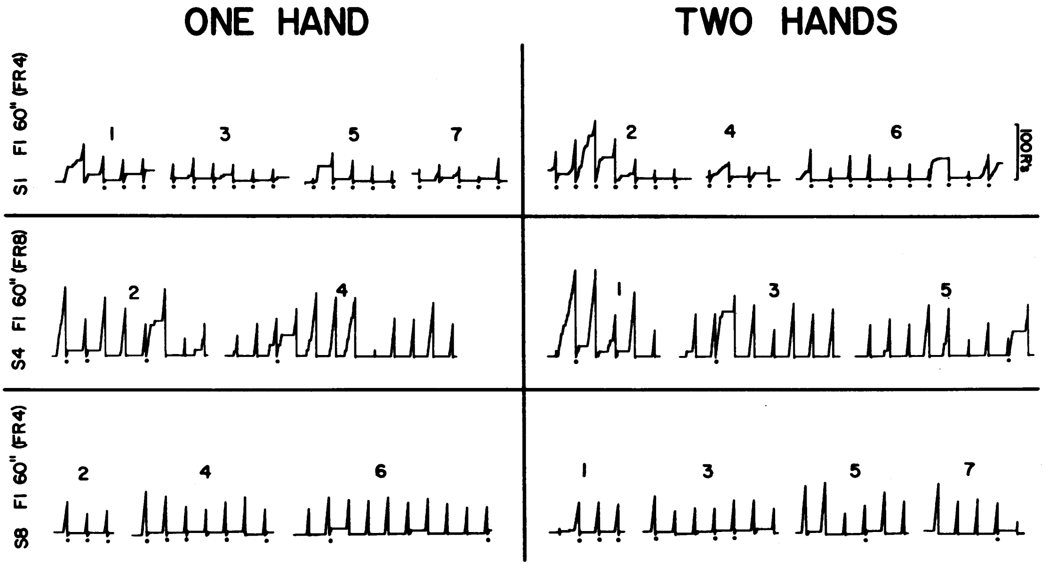

Figure 5. Effect on PRORs of having *S* use one hand for both light and reset keys rather than one hand for each. Cumulative records of three *S*s are shown, with portions of these rearranged as indicated. The numbers refer to the original order of the separate sections. Resets returned the pen to the base line. A dot below a reset indicates that an observing response occurred within 6 seconds following reset.

sponses made at other times during the interval. This specificity indicates that PRORs were under the control of different stimuli than observing responses made at other times. One could think of the situation as a multiple schedule with two components (Ferster & Skinner, 1957). Observing responses occurred at times other than immediately after the reset response were under the control of stimuli produced by *S* (e.g., counting, singing) as he attempted to estimate when the next deflection would appear. The PRORs were under the control of stimuli associated with the reset of the pointer. Experiment 2 demonstrated how the frequency of PRORs varied with the distinctiveness of the stimuli produced by the reset response. Normally, reset could be neither seen nor heard, and PRORs occurred relatively frequently. They occurred much less often when each reset response produced a tone. The absence of new stimuli following a reset response acted as a discriminative stimulus for the emission of PRORs.

The independence of these two instances of observing behavior was further demonstrated in Experiment 3, where a verbal insinuation that the reset key was unreliable was shown to lead to an increase in PRORs but to leave other observing behavior unaffected.

The running-through phenomenon sometimes seen in pigeons working on fixed-interval schedules (Ferster & Skinner, 1957) may also be partly a function of the distinctiveness of the reinforcement. Ferster and Skinner showed that the introduction of a time out, if long enough, would stop running through. Their procedure consists of turning off the lights in the experimental chamber, thereby leading the pigeon to roost. However, it does more than just offer the bird a set of stimuli greatly altered from that present just before reinforcement. The effect is confounded with all the other effects of varying the time between reinforcement and resumption of the usual experimental conditions. Therefore, while the time-out evidence is consistent with a reinforcement distinctiveness explanation, it is not explained by it.

An alternative explanation of our data is that PRORs occur simply because at the moment of reset *S* cannot halt his high rate of responding on the light-flashing key. This type of running through the reset would produce PRORs that in this context would be artifacts. Such an hypothesis does not explain why the frequency of PRORs fell when a tone accompanied the return of the pointer to zero. Nor does it explain why PRORs sometimes decreased within sessions (e.g., Fig. 1, top record). This hypothesis would also lead one to believe that forcing *S* to move his hand from the light-flashing key to the reset key and back again, as was done when he was required to use only one hand for both functions, would break up the rapid responding on the light-flashing key and reduce the frequency of PRORs. But this procedure had no perceptible effect (Experiment 4). At best, this explanation accounts for only a small proportion of PRORs.

Situations similar to the one described above can be found outside the laboratory, because operant behavior sometimes leaves a person in such a position that he must make an observing response if he is to see the results of his behavior. A letter dropped into a full mailbox will produce neither visual nor auditory evidence that the letter has cleared the chute. An observing response—here, tipping the lid—would be reinforced by the sight of any letter that had not gone into the box. Such a discovery would strengthen observing behavior under similar circumstances in the future. But if the mailbox were empty, the fall of the letter would make a distinctive noise. An observing response would then not be reinforced by the discovery of a jammed letter, and the strength of such responses would decrease. In the terminology of the discrimination experiment (Skinner, 1938), the absence of a distinctive event following the response of mailing letters would be an S^D for the subsequent observing responses while the presence of such an event would be an S^Δ. We must appeal to histories of such discrimination training to account for the initial strength of PRORs in our experiments.

SUMMARY

The *S*s were instructed to monitor a meter on which the pointer would occasionally deflect from zero. When a deflection occurred, they were to press a telegraph key that silently reset the pointer to zero. However, the task was performed in a dark room. In order to flash a light that enabled them to inspect the meter face, the *S*s had to press a second key. Responses that produce light in this situation are called observing responses.

When deflections occur on a fixed-interval schedule of reinforcement, observing responses are sometimes made just after a reset response. The current experiments demonstrate that appropriate observations can greatly change the frequency of observing responses made at such a time. For example, an increase in frequency occurs if *S* makes an observing response just after his response on the reset key has been made to fail to return the pointer to zero: presence of the still-deflected signal serves as a reinforcement. Another way to decrease the frequency of postreset observing responses is to accompany each resetting of the pointer with a tone; a way to increase it is to cast doubt on the reliability of the reset key.

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