EXPERIMENTAL CONTROL OF SUPERSTITIOUS RESPONDING IN HUMANS¹

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Superstitions were demonstrated with human subjects when presses on one button were reinforced on a VI 30-sec schedule while presses on a second were never reinforced. Superstitious responding, on the second button, was often maintained because presses on that button were frequently followed by reinforcement for a subsequent press on the first button. The introduction of a changeover delay (COD), which separated in time presses on the second button and subsequent reinforced presses on the first button, reduced or eliminated the superstitious responding of these subjects. Some complex superstitions were also demonstrated with other subjects for which the COD was in effect from the beginning of the session.

Superstitious responding, or responding that is maintained through accidental correlation with reinforcement (Skinner, 1948), usually is demonstrated in situations in which frequent reinforcement is independent of an organism's behavior. A superstition also can arise, however, when reinforcement is not independent of behavior. The accidental correlation of one response with subsequent reinforcements for other responses is sometimes sufficient to maintain the first response. This kind of superstition is especially likely when two or more responses are reinforced concurrently. For example, when a pigeon's pecks on one key are reinforced on a fixed-interval schedule of reinforcement (FI), while pecks on a second key are reinforced concurrently on a variable-interval schedule (VI), the pigeon pecks on the FI key throughout each interval. Although pecks on the FI key are never reinforced early in an interval, the occasional succession of a peck on the FI key and reinforcement for a peck on the VI key is sufficient to maintain the early pecking on the FI key. A changeover delay (or COD: Herrnstein, 1961), a procedure that guarantees that pecks on the FI key are separated in time from subsequent reinforced pecks on the VI

key, eliminates the superstitious pecking. With the COD, the FI pecking early in each interval becomes less frequent; the performance becomes more like the FI performance on a single key (Catania, 1962).

The present experiments demonstrated, with human subjects, a similar "concurrent superstition", in a two-button situation in which only one of the two responses produced reinforcement. Presses on one button were reinforced on a variable-interval schedule (VI 30-sec). Presses on the other, frequently followed by reinforced presses on the first button, were often maintained superstitiously. The introduction of a COD reduced or eliminated the superstitious responding.

METHOD

Apparatus

Figure 1 shows the subject's panel, a 7-by 7-in. chassis on which were mounted two push-buttons, a counter, and three DC lamps (one yellow, one green, and one red). An AC relay within the chassis clicked whenever either button was pressed. The panel was placed on a table in a small, dimly-lit room. Sounds from the programming apparatus (see Ferster and Skinner, 1957) located in an adjoining room were masked.

Subjects

Male and female students at Harvard University during the summer and fall of 1961, primarily drawn from introductory

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Fig. 1. Subject's panel. Details in text.

psychology courses, served voluntarily and without compensation. To minimize the effects of lectures and of the circulation of details of the experiment among the students, subjects were generally taken from courses in which reinforcement had not been discussed. They were taken in only limited numbers from any one section, and were distributed among the procedures below and other exploratory procedures.

Procedure

For each subject, button-pressing was reinforced on a concurrent VI ext schedule: VI 30-sec for responses on the right button, and no reinforcement for responses on the left button. The reinforcer was a count, accompanied by a flash of the green light, on the subject's counter. Subjects were instructed that the red light would come on, indicating that the session was over, when 100 counts had been accumulated.

For several subjects who were available for only a limited period of time, the frequency of reinforcement provided by the VI schedule was increased during the last few minutes of the session, or the session was terminated prior to a count of 100.

The subject's overall rate of responding was controlled by the yellow light on the panel, which flashed at a rate of about 100 flashes per minute. The subject was instructed to press one or the other button, but not both, each time the yellow light flashed. Most subjects kept pace with the flashing yellow light with only occasional lapses, and infrequently pressed both buttons together. Simultaneous

presses on the two buttons could not produce reinforcement.

Thirteen subjects served under these conditions. For the remainder, a changeover delay, or COD, also was in effect for all or part of the session. The COD provided that a press on the VI button could not be reinforced if it followed a press on the ext button, or if it occurred within a fixed period of time after the changeover from the ext to the VI button. For 26 subjects, a COD of from 2 to 15 sec was introduced about halfway through the session, and in some cases was later increased in duration. For 13 additional subjects, a COD of 4.5 sec was in effect from the start of the session.

RESULTS

No COD

Figure 2 shows cumulative records of the responding on each button during full sessions with no COD. The subjects have been numbered approximately in order of the relative amount of responding maintained on the left (ext) button. For almost all subjects, responding on this button was maintained superstitiously throughout the session.

In an extreme example of superstitious responding (S2), most presses were on the ext button, several successive presses on the ext button usually alternating with single presses on the VI button. Approximately equal rates of responding on the two buttons were obtained from S5 and S8. The response pattern of S5 was, however, much more variable than that of S8, who maintained, through most of the session, single alternation between the two buttons. A substantial rate of responding on the ext button was maintained by S11, whereas the ext-button responding of S13 did not come under the accidental control of the VI-button schedule.

The particular form taken by each subject's superstition depended, in general, upon the particular sequences of responses accidentally reinforced early in the session. Some superstitions were more stably maintained than others, however. These were usually superstitions in which one or more responses on the ext button were alternated with single responses on the VI button. Once established, such superstitions did not vary greatly, because sequences of responses involving several

Fig. 2. Cumulative records of the responding of human subjects during full sessions of a conc VI 30-sec ext schedule with no COD.

successive presses on the VI button rarely occurred and therefore were not likely to be accidentally reinforced.

The procedure also tended to favor superstitions involving several successive presses on the ext button, because the longer the subject

Fig. 3. Cumulative records of the responding of human subjects during full sessions of a conc VI 30-sec ext schedule. Arrows show the points at which the indicated CODs were introduced.

responded on the ext button, the greater was the probability that the VI schedule had arranged reinforcement for the next response on the VI button.

No COD followed by COD

With all 26 subjects, the introduction of the COD in this procedure was followed by a decrease in the rate of responding on the ext button. Figure 3 shows the pairs of records for four subjects. The decrease for S21 and S30 proceeded gradually. For S21, the slight effect of the COD may be a testimony to the strength of this subject's superstition. The decrease in the rate of S21's ext-button responding might have proceeded further if the COD had been introduced earlier or if the session had lasted longer.

For a few subjects, the introduction of the COD was followed by an abrupt cessation of responding on the ext button. This effect of the COD generally occurred if the COD had a large effect on the frequency of reinforcement, as for S28. The COD had only a slight effect on S32's ext-button rate until it was increased to 15 sec, at which point the frequency of reinforcement became zero. Shortly thereafter, S32 ceased responding on the ext button. This subject might have maintained a superstition with the COD (as did some subjects with COD 4.5-sec for full sessions) if the COD had not been increased to 15 sec.

COD 4.5-sec.

The performances obtained with COD 4.5-sec in effect are represented in Fig. 4. Superstitions were generated with this COD, but less frequently than with no COD in effect. Superstitions were most likely for those subjects who, early in the session, changed over to the ext button after each reinforcement for a press on the VI button. The superstitions were usually very stable (*e.g.*, S66 and S68). The stability may be attributed in part to the COD, which arranged that a sequence of responses on the ext button could be followed by reinforcement only after 4.5 sec of responding on the VI button (or about seven presses, because the pacing procedure fixed the overall rate of responding). The COD therefore restricted the sequences of responses that could be maintained superstitiously.

For some subjects whose responding was infrequently reinforced early in the session

(*e.g.*, S50), no superstition was established. For others (*e.g.*, S62), responding on the ext button quickly dropped to a lower rate than was maintained by any of the subjects with no COD throughout.

Fig. 4. Cumulative records of the responding of human subjects during full sessions of a conc VI 30-sec ext schedule with COD 4.5-sec.

Verbal reports

Subjects, after the session, generally gave accurate reports on their own behavior but were unable to describe the procedure. For example, subjects for whom the COD was introduced part way through the session usually reported that, early in the session, a press on the VI button produced a count only if it followed a certain number of presses on the ext button, whereas, later in the session, the ext button had no effect (in fact, the ext button did have an effect only later in the session; it initiated the COD). Although this report was most reliably obtained from subjects whose rates of responding on the ext button had declined, with the COD, almost to zero, the report also was received occasionally from

subjects who, at the end of the session, still were responding at an appreciable rate on the ext button. No subjects reported that presses on the ext button delayed reinforcement for subsequent presses on the VI button.

One report suggests that the subjects' naïveté regarding schedules of reinforcement was not crucial to the present findings. A subject who (it was learned later) had previously taken a course which covered reinforcement schedules came out of the experimental room after 20 min, to disqualify himself because he knew that the schedule was a short VI. His record showed about twice as much responding on the ext button as on the VI button, however; and, before he was asked to return to the experimental room, he was asked which response was being reinforced. He replied, "I press twice on the left button and once on the right."

Reports of counting or of timing with a wristwatch, particularly from subjects with stable superstitions (e.g., S68, Fig. 4), were frequent.

DISCUSSION

The present experiments employed a relatively weak reinforcer; a count on a counter. The overall rate of responding was not maintained by this reinforcer, but rather by instructions to the subject to keep pace with the flashing light. The reinforcer, however, did determine the distribution of responses on the two buttons; the pacing procedure allowed small changes in the contingencies of reinforcement, such as those brought about by the introduction of the COD, to change the relative rates of responding on the two buttons. This sensitivity to the changes in reinforcement contingencies suggests that the pacing concurrent procedure may be generally useful in experiments with human subjects, which frequently involve only weak reinforcers.

It may be worthwhile, nevertheless, to compare the performances of the human subjects with a performance in which the overall rate of responding is maintained by reinforcement rather than by instructions. Cumulative records of the performance of a pigeon on a concurrent VI 1-min ext schedule of reinforcement are shown in Fig. 5. Reinforcement was the 4-sec presentation of grain, in a two-key

box similar to that described by Catania (1962). Figure 5 compares responding on the ext key during sessions with COD 1-sec with responding during sessions with no COD. Preceding the 12 sessions of ext with COD 1-sec and also the 12 later sessions with no COD, responding on the ext key had been reinforced on a VI 2-min schedule of reinforcement. Records a and b show the 7th and 12th sessions of ext with COD 1-sec; records c and d show the 7th and 12th sessions of ext with no COD (in b and d, the VI records have been omitted). With the COD, responding on the ext key was infrequent by the 7th session (a), and had declined to a rate near zero by the 12th session (b). In the subsequent extinction with no COD, however, responding continued on the ext key, although at a low rate, through the 12th session (d). Record c shows an increase in the rate of responding on the ext key that occurred during the 7th session.

Fig. 5. Cumulative records of a pigeon's key-pecking maintained by a conc VI 1-min ext schedule. The extinction on the second key followed VI 2-min reinforcement. Records a and b show the 7th and 12th sessions of ext with COD 1-sec. Records c and d show the 7th and 12th sessions of ext with no COD. In b and d, the concurrent VI records are omitted.

The general results of the human and the pigeon data are in agreement. In the absence of a procedure that separates in time the responses on one operandum from subsequent reinforced responses on another, the responding on the first operandum may be strengthened superstitiously by the reinforcements scheduled for the second.

For both humans and pigeons, the response on the ext operandum and the changeover to the VI operandum were maintained by close temporal contiguity with reinforcement. For the pigeon, the absence of reinforcement for changeovers from the VI to the ext key accounts for the eventual extinction, even with no COD, of ext-key pecking. For some human subjects, however, long sequences of responses were maintained on the two buttons even with COD 4.5-sec. This may have been in part because the human subjects were observed only in single short sessions, but presumably more important were their extensive histories of counting and other mediating behavior, and their capacities for maintaining chains of responses involving long delays of reinforcement for the early responses in the chain. The performance of S32 (Fig. 3), for example, certainly did not depend only on the effects of the experimental procedures, but also on a complicated prior history of counting and other sequential behavior. For this reason, the COD may not always be sufficient for eliminating concurrent superstitions of human subjects.

This complexity of human performances does not, however, appear to affect the generality of the present demonstrations. Concurrent superstitions occur in other situations in which two or more responses can occur in rapid succession. Bruner and Revusky (1961) have demonstrated the ease with which a concurrent superstition may be established when several operanda are made available to a human subject whose responding is reinforced on a *drl* (differential reinforcement of low rate) schedule. In two-operandum experiments with pigeons, a COD has been shown to be critical in the study of the relation between reinforcement frequency and response rate (Herrnstein, 1961) and of

the independence of concurrent performances (Catania, 1962). Matching-to-sample experiments with pigeons (e.g., Ferster, 1960) have usually incorporated a different kind of delay to cope with concurrent superstition: an incorrect response produces a time out that separates temporally the incorrect response and subsequent reinforced correct responses. Teaching machines that involve matching (see Holland, 1960) also require this kind of programming in order to prevent concurrent superstitions from interfering with behavior to be taught. Finally, probability-matching literature contains reports that probability-matching in human subjects deteriorates as the intertrial interval is shortened (Anderson and Grant, 1957; Gardner, 1957; Jones, 1961). This is consistent with the present demonstrations: the shorter the interval between trials, and therefore the less the time between responses with and responses without consequences, the more likely that a concurrent superstition will be established that will interfere with the matching.

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