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RESPONSE REDUCTION THROUGH THE SUPERIMPOSITION OF CONTINUOUS REINFORCEMENT: A SYSTEMATIC REPLICATION

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Prior clinical research suggests that superimposition and subsequent removal of a schedule of continuous reinforcement (CRF) may be a viable rate-decreasing procedure in that an extinction-like condition is arranged. The arrangement of similar conditions in the laboratory, however, resulted in the quick recovery of baseline rates. Lever-pressing patterns of eight male rats maintained by different schedules of variable-ratio and variable-interval food reinforcement were examined in an A-B-A experimental design of CRF food superimposition and removal. Responding was substantially reduced during the superimposition of CRF. Upon removal of the superimposed schedule, responding quickly approached presuperimposition baseline rates.

DESCRIPTORS: superimposition, schedules of reinforcement, continuous reinforcement, extinction, variable ratio, variable interval, lever press, rats

The superimposition of two contingencies upon a single operant is common in experimental and applied behavior analysis. For example, it is usually prevalent when procedures are examined that decrease the frequency of a particular behavior. In a laboratory experiment examining the effects of punishment, an operant baseline is established through the use of an intermittent schedule of reinforcement. A punishment contingency is then superimposed on that operant response by adding to the programmed reinforcers the delivery of aversive stimuli contingent on a response. The frequency of responding can be assessed during the baseline and superimposition of the punishment contingency, as well as after the removal of the punishment contingency. Analogous approaches in clinical settings may utilize such superimposition procedures. Rate-reducing events are often contingently superimposed upon existing maintenance arrangements when, for example, time-out (Mace, Page, Ivancic, & O'Brien, 1986), overcorrection (Azrin & Wesolowski, 1974), or any of a host of punishment procedures are used to decrease disturbing operant patterns. The experimental literature contains numerous related examples of superimposition procedures including conditioned suppression and response-independent food delivery (e.g., Azrin & Hake, 1969; Coleman, Hemmes, & Brown, 1986; Edwards, Peek, & Wolfe, 1970; Estes & Skinner, 1941; Herrnstein & Morse, 1957; Lattal, 1974; Lolordo, 1971; Van Hest, Van Haaren, Kop, & Van der Schoot, 1986).

Contingency superimposition procedures are not necessarily limited to the examination of response elimination. For example, a differential reinforcement of high rate (DRH) contingency that selectively reinforces higher rates of a particular operant behavior may be superimposed upon the initial baseline of that operant (Wilson & McReynolds,

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1973), or a token system may be superimposed on existing, and often unspecified, reinforcement contingencies for a set of target behaviors in applied settings (Winkler, 1970). Such reinforcement contingency superimposition procedures are the focus of the present experiment, which is a laboratory replication of a clinical research study.

Neisworth, Hunt, Gallop, and Madle (1985) explored the clinical utility of a procedure designed to decrease the frequency of disturbing behavior. Based on the observation that the effects of removing reinforcement are greatest when reinforcement has been delivered on a continuous rather than intermittent schedule (Ferster & Skinner, 1957), the authors explored whether targeted clinical behaviors, assumed to be maintained by unidentified reinforcement contingencies, might be decreased by first introducing and then withdrawing a schedule of continuous reinforcement (CRF). Neisworth et al. entitled the process "reinforcer displacement" and conceptualized the introduced reinforcer as potentially "displacing" the unidentified maintaining event. This, in turn, provided the opportunity for a rate-decreasing effect when "extinction" was abruptly occasioned by removal of the introduced reinforcer. Because the CRF reinforcement schedule was superimposed on an existing but unidentified reinforcement schedule that was maintaining the target behaviors, this is an example of reinforcement contingency superimposition.

Neisworth et al. (1985) reported substantial decreases, at least initially, in the frequency of selfstimulatory behavior (finger flicking and hand flapping) by two institutionalized retarded men upon removal of the previously superimposed CRF (food) schedule. In a subsequent follow-up 2 weeks later, self-stimulatory responding by 1 of the 2 subjects was still decreased. For the other subject, however, the initial decrease was temporary; a response frequency commensurate with the presuperimposition baseline rate was observed not only during follow-up but also the day after removal of the superimposition contingency. The authors suggested that, although further research is necessary because of the equivocal results, the procedure may be a clinically valuable ameliorative technique if tied into a more comprehensive intervention stressing the reinforcement of alternative behaviors during the extinction-like condition.

The present research is an attempt to analyze more formally the effects of reinforcement contingency superimposition under controlled laboratory conditions. It was hoped that laboratory-based research on procedures with applied relevance would allow further evaluation of the potential clinical efficacy of CRF superimposition. Although certain contingent and noncontingent superimposition procedures have been extensively studied in the operant animal laboratory, the effects of superimposed reinforcement contingencies and their removal upon responding maintained by positive reinforcement baselines have not been well documented. This study examines the effects of CRF superimposition and its subsequent removal on responding maintained by variable-interval and variable-ratio schedules. These schedules were selected because they approximate conditions potentially observed in clinical settings where variable rather than fixed response requirements are likely.

METHOD

Subjects

Eight naive male Sprague-Dawley rats served as experimental subjects. The rats were approximately 90 days old at the beginning of the experiment, with weights ranging between 315 and 340 g during unrestricted feeding.

Procedure

Standard operant chambers were used. One panel in each chamber included a lever and a food dispenser. Bioserv food pellets (45 mg) were delivered via a protruding food magazine. The rats were maintained at 84% (±8%) of their free-feeding weights during the experiment. Experimental sessions were conducted once daily, 7 days a week. On three occasions (prior to Sessions 92, 93, and 98) daily experimental sessions were skipped to maintain body weights within the specified range.

Prior to the experiment, the subjects were divided

into two groups of equal number, a variable-interval (VI) group and a variable-ratio (VR) group. In the VI group, baseline responding was established under the control of a VI 25-s schedule of food reinforcement for 2 subjects and a VI 75-s schedule for the other 2 subjects. Likewise, in the VR group, baseline responding was maintained under a VR 25 for 2 subjects and a VR 75 for the other 2 subjects.

Standard operant shaping procedures were used when establishing initial lever pressing. Response requirements were then gradually increased during the first 10 sessions until the baseline schedule parameters were met. Following this, the animals were exposed to the baseline schedules for an additional 75 sessions to ensure stable patterns of responding. Stability was defined by the absence of general upward or downward trends in overall response frequency.

Experimental design and conditions. The effects of CRF superimposition and removal on baseline responding maintained by the intermittent schedules were investigated in an A-B-A experimental design. Following the establishment of stable baseline responding, a schedule of CRF was introduced and later withdrawn. A reversal to the initial baseline arrangement was then in effect.

During the superimposition of CRF, two reinforcement schedules were simultaneously in effect. Because the same operant response (lever pressing) satisfied the requirements of both schedules, two food pellets, rather than one, were periodically delivered following a single lever press.

The experiment was 125 sessions in length; for summary purposes, only the final 65 sessions (Sessions 61 through 125) are reported here. In the initial 60 sessions, standard training was programmed to establish responding under the baseline schedules and to ensure stability of responding. These sessions were 30 min in duration. Formal experimental baseline sessions began with Session 61 when session duration was decreased from 30 to 15 min. This short session duration allowed more precise maintenance of baseline weights through all three conditions, including CRF superimposition. Following 25 sessions (Sessions 61 through 85) of the baseline schedule alone, CRF was superimposed over a 15-session period (Sessions 86 through 100). Finally, following the removal of the CRF schedule, 25 additional sessions were conducted with only the baseline schedule in operation (Sessions 101 through 125).

RESULTS

Relative to baseline performances, responding was substantially and consistently reduced during the superimposition of CRF (see Figure 1). Rates of responding remained reduced throughout the superimposition period. Upon removal of the superimposed schedule, responding quickly approached the presuperimposition baseline rates. In general, response rates following the removal of the CRF superimposition phase eventually approximated the initial baseline rates. These changes occurred, for the most part, within the first few sessions following removal of the CRF superimposition.

This general effect occurred across all 8 subjects, across both ratio and interval schedules, across parameter values within schedules, across performances maintained at several distinct response rates, and across reinforcement densities. Responding was maintained under baseline conditions at a considerably higher response rate by ratio schedules (with rates between 125 and 275 responses per minute) than by interval schedules (35 to 100 responses per minute). Conversely, generally similar response rates for all subjects (approximately 20 responses per minute) were generated under each schedule during the CRF superimposition. The reduced patterns of responding engendered during the superimposed CRF phase were typical of those maintained by CRF schedules alone (Skinner, 1938).

DISCUSSION

The observed effects of CRF superimposition and removal on patterns of ongoing responding differ from the results reported by Neisworth et al. (1985) in several ways. In that study, during the introduction of continuous reinforcement the occurrence of responding by 1 of 2 subjects decreased only slightly, whereas the occurrence of responding by

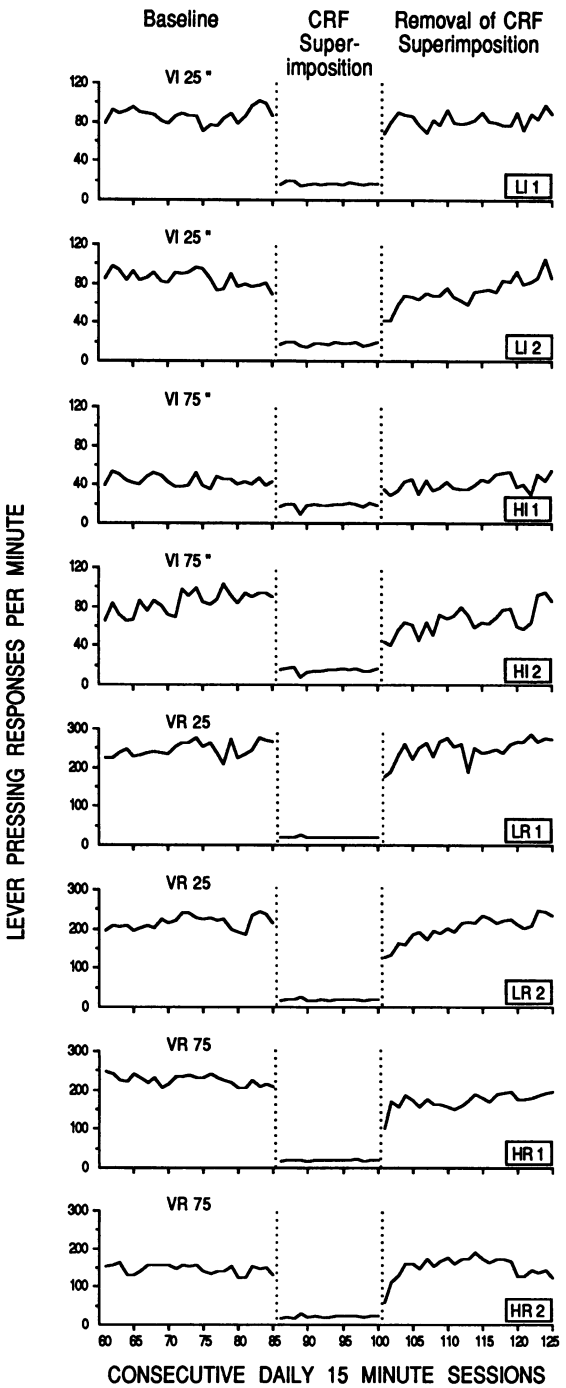

Figure 1. Effects of continuous food reinforcement (CRF) superimposition and removal on responding maintained by variable-interval and variable-ratio schedules of food reinforcement. Response-rate information for eight rats is shown. Subject identification and baseline schedules in effect across experimental conditions are indicated on each graph. Experimental conditions, similar for each subject, are indicated across the top of the figure.

the second subject increased. In the present study, superimposition of continuous reinforcement on baselines maintained by intermittent reinforcement substantially decreased responding. Relative to ongoing patterns during baseline (and during the CRF phase), Neisworth et al. also reported a decrease in the occurrence of responding during the "extinction-like" withdrawal of the schedule of continuous reinforcement. In contrast, response frequencies quickly returned to baseline levels following removal of CRF superimposition in the present study.

There are several plausible explanations for these divergent results. First, the present study was undertaken in the animal laboratory. Human subjects and patients have extensive histories that may be determinants of performance, as well as extensive verbal repertoires. Specific determinants of human performance in a given situation may be sufficiently complex as to limit the conclusions of relatively straightforward animal models.

Second, in the present experiment the superimposed consequent event (food) was functionally and topographically similar to the consequence maintaining the baseline schedules. Such similarity was rather unlikely in the Neisworth et al. (1985) study, because the consequences maintaining the self-stimulatory behaviors were unidentified and food was superimposed during the CRF phase. These differences may be important in understanding the different effects observed between the two studies and when analyzing effects during CRF superimposition in general.

Third, response decrement during the superimposition of continuous reinforcement in the present study may be largely attributable to an opportunity to engage in the "consummatory response"; a greater amount of time was spent in reinforcer collection and in other interresponse activities not directly related to lever pressing. However, it should be noted that the Neisworth et al. (1985) study also superimposed a contingency requiring a consummatory response. (It should also be noted that there may have been an initial response-decreasing effect of CRF superimposition in the Neisworth et al. study. During the first few sessions of the CRF superimposition phase only, Neisworth et al. reported that the procedure and

observational sessions had to be suspended because subjects did not emit a criterion rate of the target behavior.)

Finally, the pre- and postsuperimposition baseline contingencies in the Neisworth et al. (1985) study were not identified; discrepancies with the present results may be due to the nature of the unidentified contingencies. Data were reported by Neisworth et al. showing a decrease in self-stimulatory behavior following removal of CRF superimposition for two institutionalized retarded males; variability of effect was displayed in that the decrease was immediate but not enduring for 1 subject, whereas the decrease occurred later and was enduring (at a 2-week follow-up) for the second subject. The contingencies in effect following removal of CRF superimposition may have been influential in the obtained results. For example, decreased rates of self-stimulation may have contacted and been maintained by ongoing "natural" reinforcement contingencies. However, such a premise is speculative in the absence of a detailed examination of the contingencies.

In the present study the positive reinforcement baseline was critical to the ongoing maintenance of performance before and after the CRF superimposition phase. One might expect a different outcome during and following the removal of CRF superimposition under alternative maintaining arrangements. For example, the present results may not adequately represent the effects of such a procedure on behavior maintained by other types of consequences (McKearney, 1968), other types of schedules of positive reinforcement (Herrnstein & Morse, 1957), other contingencies involving negative reinforcement (Sidman, 1953), or when behavior is maintained by other arrangements (Foster, 1978; Pellon & Blackman, 1987).

In summary, the present results suggest that the rate decreases reported by Neisworth et al. (1985) may not have been the result of an "extinction" created by introducing and then removing a schedule of continuous reinforcement. Although several procedural differences have been noted between the present study and the study reported by Neisworth et al., we believe that the divergent results suggest caution in applying CRF superimposition procedures to clinical problems. This type of procedure may require a great deal of staff time when continuously monitoring ongoing patterns in the delivery of CRF and, as such, may be of limited applicability. However, of more concern at this point is the lack of research supporting clinical application. The present results support those of Neisworth et al. in questioning the reliability of the procedure.

Widespread adoption and uncritical application of procedures based on CRF superimposition would be, at this point, misguided. Our knowledge of the conditions necessary to produce clinically desirable effects is limited. In related research, evidence from the experimental laboratory suggests that it is unlikely that we will be able to capitalize clinically on the "CRF-Extinction" effect given complex histories of reinforcement. CRF has been interpolated prior to extinction but following a history of intermittent reinforcement; patterns during extinction more closely resemble those of the distant intermittent schedule rather than the CRF schedule (Jenkins, 1962; Keller, 1940; Likely, 1958; Quartermain & Vaughan, 1961; Theios, 1962). Additional research focusing on the nature of baseline maintenance arrangements and the relevance of qualitatively similar or dissimilar reinforcers in reinforcement superimposition processes may clarify those conditions under which clinically desirable results may be expected. We suggest that the laboratory may prove particularly useful in further exploring the utility of reinforcement superimposition and removal in the reduction of behavior. If clinically relevant results can be obtained in the laboratory, supporting clinical research can investigate the reliability and generality of findings to the human condition.

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